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Opportunities for Gas in Sub-Saharan Africa

1. Introduction

In his December 2017 paper entitled "Challenges to the Future of Gas: unburnable or unaffordable?"[1], Jonathan Stern noted that "For the period up to 2030, the principal threats to the future of gas (outside North America) will be affordability and competitiveness. Beyond that date – and particularly beyond 2040 – carbon (and potentially also methane) emissions from gas will cause it to become progressively 'unburnable' if COP21 targets are to be met."

Stern noted further that in the period to 2030 and beyond, for gas to fulfil its potential role as a transition fuel, then it has to be delivered to high-income national markets below $8/MMbtu and to low-income markets below $6/MMbtu, and that "the major challenge to the future of gas will be to ensure that it does not become (and in many low-income countries remain) unaffordable and/or uncompetitive, long before its emissions make it unburnable".

In many low-income countries, especially in Asia, gas is often competing with coal in the power generation market, and to have any chance of competing, then gas has to be priced very competitively. There are examples, such as China, where a combination of policies related to improving air quality and mandated closure of some older plant have allowed the expansion of gas in the power, industry and heat sectors. In the UK, a high carbon support price has boosted gas-fired generation, aided by the closure of a large proportion of coal-fired capacity. However, as Stern notes, "these are isolated examples and, despite repeated arguments from the gas community, there is no clear indication from the Nationally Determined Contributions submitted post-COP21 that substantial numbers of countries intend to use gas on a large scale to solve either air quality or carbon reduction problems".

However, there are countries around the world where there is little or no coal-fired power generation and the principal means of generating electricity is often oil and hydro. Many of these countries are in Sub-Saharan Africa. The OIES Gas Programme has already published a short paper, by Mike Fulwood and Thierry Bros, covering the Future Prospects for LNG in Ghana[2], although this concluded that LNG into Ghana may be some way off. There was also a short piece on the Ivory Coast, where there is existing gas demand, by Thierry Bros in the Oxford Energy Forum, published in August 2017[3].

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[1] "Challenges to the Future of Gas: unburnable or unaffordable?" available at https://www.oxfordenergy.org/publications/challenges-future-gas-unburnable-unaffordable/

[2] https://www.oxfordenergy.org/publications/future-prospects-lng-demand-ghana/

[3] Can small LNG meet the challenge of empowering Africa?", Oxford Energy Forum – Searching for Natural Gas Demand in the Next Decade – Issue 110 pages 46-47 available at https://www.oxfordenergy.org/publications/oxford-energy-forum-searching-natural-gas-demand-next-decade-issue-110/

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This paper takes a wider look at Sub-Saharan Africa as a whole to assess the opportunities for gas in the power generation sector. The paper is structured in 4 sections: the first section describes power generation by fuel type in Sub-Saharan Africa. This is followed by a section considering the prospects for gas demand in power, whether using indigenous gas resources or imports by pipeline and/or LNG. A third section discusses the issues and challenges the region faces in developing gas demand. The final section brings together the analysis and seeks to identify the most promising candidates for gas demand growth.

2. Power Generation in Sub-Saharan Africa

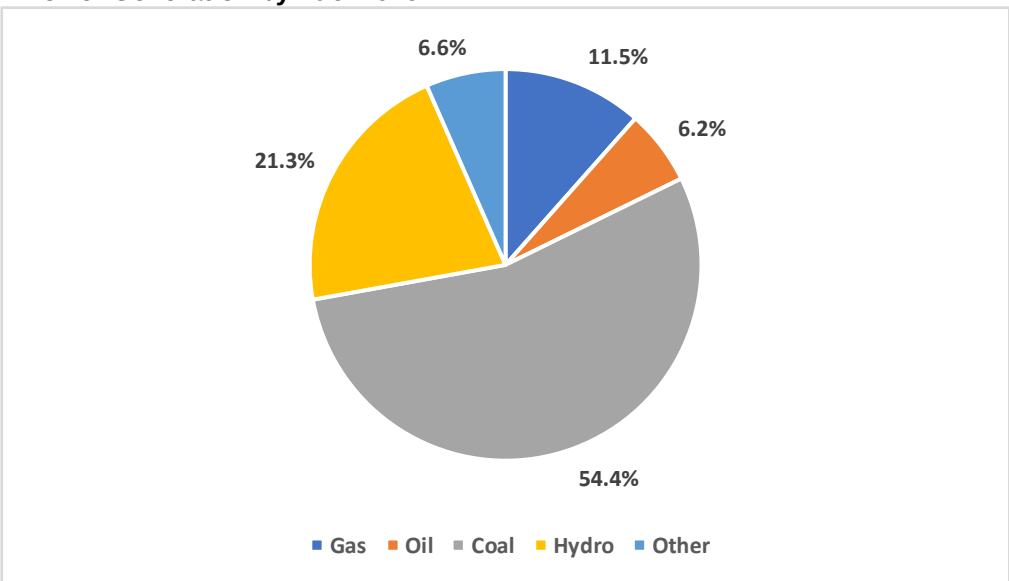
This analysis of power generation in Sub-Saharan Africa is based on data from the International Energy Agency (IEA) World Energy Statistics and Balances[4]. The countries included in the IEA data are Angola, Benin, Botswana, Cameroon, Republic of the Congo, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Mali, Mauritius, Mozambique, Namibia, Niger, Nigeria, Senegal, South Africa, South Sudan, Sudan, United Republic of Tanzania, Togo, Zambia and Zimbabwe.

There are many other countries in the region, mainly smaller ones, for which the IEA does not collect data[5]. There is some data on generating capacity in these countries on the Power Africa website, which is used to supplement the IEA data. Power Africa is a USAID project focused on connecting Africa to electricity grids[6].

Generation by Fuel Type – IEA Data

The IEA data for 2016, the latest year for which detailed data is currently available, at first glance suggests that coal is the dominant fuel type for power generation in the region, as shown in Figure 1.

Figure 1: Power Generation by Fuel 2016



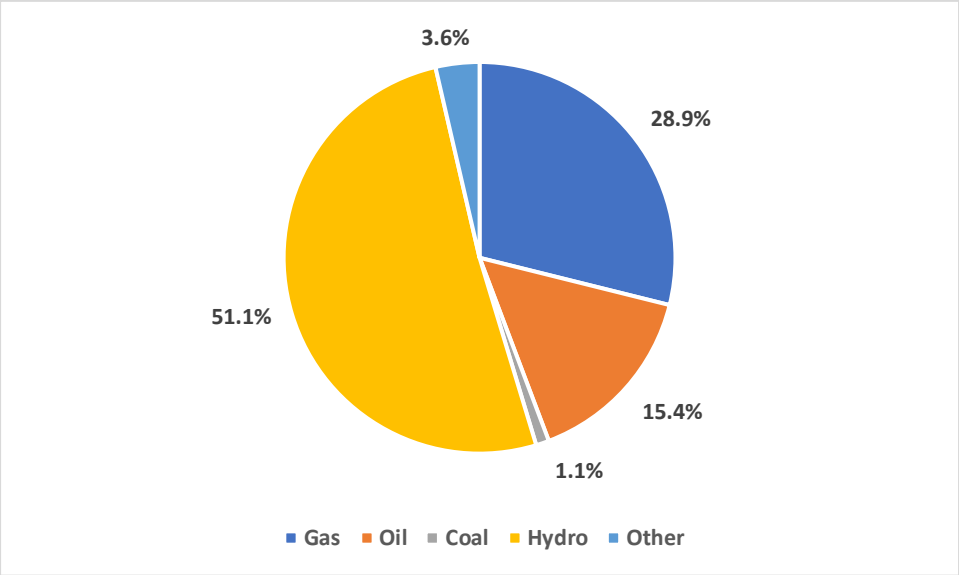
Source: IEA World Energy Statistics and Balances 2018

[4] https://webstore.iea.org/publications
[5] Burkina Faso, Burundi, Cabo Verde, Central African Republic, Chad, Comoros, Djibouti, Equatorial Guinea, Gambia, Guinea, Guinea-Bissau, Lesotho, Liberia, Madagascar, Malawi, Mauritania, Réunion, Rwanda, Sao Tome and Principe, Seychelles, Sierra Leone, Somalia, Swaziland, Uganda and Western Sahara.
[6] https://www.usaid.gov/powerafrica/wherewework

Well over half the generation in 2016 came from coal, followed by hydro and then natural gas at 11.5%. The Other category includes nuclear in South Africa, geothermal in Kenya, but is largely biofuels and waste[7]. The only pure renewables – i.e. solar and wind – are found in Ethiopia and small amounts in South Africa.

The dominance of coal, however, is fundamentally in South Africa and the impact on the data of the sheer size of that market. Coal is also dominant in South Africa's neighbours, Botswana and Zimbabwe. Once these three countries are excluded, the picture changes significantly.

Figure 2: Power Generation by Fuel 2016: Excluding South Africa, Botswana, Zimbabwe



Source: IEA World Energy Statistics and Balances 2018

Hydro now becomes the dominant fuel source for generation, with natural gas now at 29%, and oil and oil products at 15%. Coal has almost disappeared, with the only significant consumers for generation being Mauritius and Niger. The share for natural gas is dominated by Nigeria, which accounts for over half the 29% share. Other significant users of natural gas for power generation are Cote d'Ivoire, Ghana, Mozambique and Tanzania. Apart from Ghana, all these countries have relied on indigenous gas resources.

In the countries without natural gas, and for some who use some gas, the default fuel for generation becomes oil, once hydro is exhausted. Table 1 shows the shares by each fuel for 2016 in each country. Oil has significant shares of the generation mix in numerous countries, including those which have significant natural gas resources.

[7] Not really renewables but burning wood.

Table 1: **Fuel Shares for Power Generation 2016**

	Gas	Oil	Coal	Hydro	Other	Total Elec
Angola	0.0%	43.9%	0.0%	56.1%	0.0%	100.0%
Benin	2.3%	92.2%	0.0%	4.1%	1.4%	100.0%
Botswana	0.0%	0.2%	99.7%	0.0%	0.1%	100.0%
Cameroon	19.2%	25.7%	0.0%	55.1%	0.0%	100.0%
Congo	45.3%	0.0%	0.0%	54.7%	0.0%	100.0%
Cote d'Ivoire	82.7%	0.7%	0.0%	14.9%	1.7%	100.0%
DR Congo	0.0%	0.1%	0.0%	99.6%	0.2%	100.0%
Eritrea	0.0%	99.5%	0.0%	0.0%	0.5%	100.0%
Ethiopia	0.0%	0.0%	0.0%	92.7%	7.3%	100.0%
Gabon	49.7%	9.0%	0.0%	40.8%	0.6%	100.0%
Ghana	39.5%	17.6%	0.0%	42.7%	0.2%	100.0%
Kenya	0.0%	20.7%	0.0%	34.3%	45.0%	100.0%
Mauritius	0.0%	36.5%	41.7%	3.3%	18.5%	100.0%
Mali	0.0%	55.2%	0.0%	42.7%	2.1%	100.0%
Mozambique	16.6%	0.1%	0.0%	83.3%	0.0%	100.0%
Namibia	0.0%	0.6%	3.7%	95.6%	0.0%	100.0%
Niger	0.0%	58.2%	40.9%	0.0%	1.0%	100.0%
Nigeria	81.9%	0.0%	0.0%	18.1%	0.0%	100.0%
Senegal	1.7%	87.6%	0.0%	8.1%	2.6%	100.0%
South Africa	0.0%	0.1%	90.8%	0.3%	8.9%	100.0%
South Sudan	0.0%	99.5%	0.0%	0.0%	0.5%	100.0%
Sudan	0.0%	44.2%	0.0%	55.8%	0.0%	100.0%
Tanzania	58.5%	7.0%	0.0%	33.8%	0.7%	100.0%
Togo	15.1%	8.4%	0.0%	74.7%	1.8%	100.0%
Zambia	0.0%	2.9%	2.8%	94.3%	0.0%	100.0%
Zimbabwe	0.0%	0.6%	55.4%	42.3%	1.7%	100.0%
Total	11.5%	6.2%	54.4%	21.3%	6.6%	100.0%

Source: IEA World Energy Statistics and Balances 2018

The prospects for natural gas in the region are not just dependent on displacing oil in the generation mix. It is well known that the level of electrification in Sub-Saharan Africa is very low. Table 2 outlines the consumption of electricity per head in the region.

Table 2: Electricity Consumption 2016 – MWH per head

	Total Electricity Consumption (TWH)	Population (000s)	MWH/Head
Angola	10.361	27,859	0.372
Benin	0.363	10,576	0.034
Botswana	2.688	2,209	1.217
Cameroon	8.367	22,835	0.366
Congo	1.753	4,996	0.351
Cote d'Ivoire	10.253	23,108	0.444
DR Congo	9.135	76,197	0.120
Eritrea	0.421	4,847	0.087
Ethiopia	11.226	99,873	0.112
Gabon	2.336	1,930	1.210
Ghana	13.023	27,583	0.472
Kenya	9.752	47,236	0.206
Mauritius	3.042	1,259	2.415
Mali	2.578	17,468	0.148
Mozambique	18.732	28,011	0.669
Namibia	1.421	2,426	0.586
Niger	0.526	19,897	0.026
Nigeria	30.897	181,182	0.171
Senegal	4.457	14,977	0.298
South Africa	249.453	55,291	4.512
South Sudan	0.439	11,882	0.037
Sudan	14.429	38,648	0.373
Tanzania	6.998	53,880	0.130
Togo	0.273	7,417	0.037
Zambia	11.695	16,101	0.726
Zimbabwe	7.055	15,777	0.447
Total	431.673	813,464	0.531

Source: IEA World Energy Statistics and Balances 2018 and UN Population Database

In total electricity consumption is only 0.531 mwh/head, with South Africa by far the largest at 4.512 mwh/head. If South Africa is excluded then average consumption drops to some 0.240 mwh/head. As a comparison, a developing country like Vietnam in 2016 had consumption of 1.638 mwh/head. In the event that Sub-Saharan Africa, excluding South Africa, achieved the Vietnam level of electricity consumption per head, then total electricity generation would need to rise seven-fold.

Power Africa Generation Data

As noted, Power Africa has some data on countries in the region where there is no IEA data. Table 3 shows data on installed capacity for selected countries which Power Africa covers.

Table 3: Installed Capacity for Selected Countries

	GW Capacity			
	Oil	Hydro	Solar	Notes
Burkina Faso	0.253	0.032		Power Africa focussing on solar, 33MW project under construction
Chad	0.125			Wind and solar planned, has oil resources
Djibouti	0.126			Geothermal resources plus solar and wind potential
Liberia	0.038	0.088		Focus on renewables in rural areas
Madagascar	Mostly			Capacity not known but diesel prominent - hydro, solar and wind potential
Malawi		0.346	0.017	Hydro constrained by drought and low water levels
Mauritania	0.263	0.117		Renewables includes hydro, solar and wind. Gas project under development
Rwanda	0.098	0.11		Prospects for hydro, solar
Somalia	0.1		0.0039	Prospects for onshore wind
Swaziland		0.06		Imports power from South Africa and Mozambique
Uganda	0.1015	0.645		Liberalized energy market and IPPs have 58% of market

Source: Power Africa

The pattern for the selected countries is very similar to that of the IEA-covered countries with, if anything, even more emphasis on use of oil as support to hydro or as the primary generation source.

Equatorial Guinea is not covered by Power Africa nor by the IEA's World Energy Statistics and Balances. Power generation is thought to be a mixture of hydro and largely oil-fired generation although there is a gas-fired plant at Punta Europa next to the LNG export plant.

The Challenges for Gas in Sub-Saharan Africa

The challenge for almost every country in Sub-Saharan Africa is the electrification of their existing and growing populations. In Asian markets, coal has played a key role in the electrification, largely based on indigenous reserves. Apart from South Africa, Zimbabwe and Botswana, there is very little coal used in power generation in the region and, again outside those countries, no widespread coal reserves[8]. This makes the region somewhat different from Asia.

The Power Africa programme is focussed on the electrification of the region with an emphasis on renewables, especially solar, but does also support natural gas projects. Currently, solar and wind are not found in the region outside Ethiopia and South Africa, although that is changing.

The scale of the electrification challenge means that more than one source of fuel will be required to achieve the objective. Utility-scale solar and wind is likely to have a key role as will increased distributed power generation, which includes mini-grids[9]. Mini-grids are banks of batteries often charged by solar arrays, and can provide round-the-clock electricity capable of powering machinery, irrigation systems and freezers, as well as lighting. It is noted that they are currently expensive, but could become cheaper as they become more common, and are well placed for rural electrification where it is expensive to connect to the main grid. They are becoming more popular in Asia, particularly India, and also in some African countries including Mozambique, Nigeria and Togo.

Gas is not really competing with renewables in Sub-Saharan Africa, whether on a large-scale solar or wind farm basis, or even for mini-grids. Given the scale of the electrification required there is more than enough room for renewables and "cleaner" fossil fuels. The question for gas is whether it can take over from oil as the primary and/or secondary generation fuel in conjunction with renewables – solar and wind especially. Hydro remains an option in some countries but the timescales to develop means there is a window of opportunity for gas.

There are many other issues associated with developing power generation and natural gas upstream and downstream projects in Sub-Saharan Africa and we will return to these in the final section.

[8] Mozambique is reported to have potential substantial reserves
[9] The Economist, July 14th-20th 2018, pp 14, 63-64

3. Prospects for Gas Demand in power in Sub-Saharan Africa

Existing Gas Countries

The existing gas consuming and producing countries are shown in Table 4.

Table 4: Sub-Saharan Africa Supply-Demand Balance 2017

BSCM	Consumption	Production	Pipe Imports	LNG Imports	Pipe Exports	LNG Exports
Angola	0.810	5.700				4.956
Benin	0.044		0.044			
Cameroon	0.545	0.545				
Congo	0.248	0.259			0.001	
Cote d'Ivoire	2.352	2.352				
DR Congo	0.001		0.001			
Equatorial Guinea	1.200	6.000				4.454
Gabon	0.448	0.551				
Ghana	0.980	0.652	0.330			
Mozambique	0.745	4.912			4.440	
Nigeria	12.135	43.019			0.410	30.571
Senegal	0.050	0.050				
South Africa	5.411	1.126	4.440			
Tanzania	0.848	0.848				
Togo	0.040		0.040			

Source: IEA Natural Gas Information 2018 and OIES Analysis

Gas consumption in the region is largely supplied by domestic production from within each country. LNG exports are sent outside the region to the Americas, Europe and Asia Pacific largely. Angola's and Equatorial Guinea's gas industries largely exist to export LNG. Only Nigeria has a relatively well-developed market which both consumes gas in significant quantities and also exports by both LNG and pipeline.

Pipeline trade within the region is limited. There is the West African Gas Pipeline (WAGP), through which Nigeria exports gas to Benin, Togo and Ghana, and a pipeline from Mozambique to South Africa and, apparently, Congo exports a small quantity to DR Congo.

Currently there are no LNG imports within the region, although a number of the countries in Table 4 are considering importing LNG – Benin, Cote d'Ivoire, Ghana and South Africa – plus a number of countries currently not consuming gas. Cameroon has begun exporting LNG and Mozambique and Tanzania are expected to join them in the 2020s. There are also prospects to develop FLNG in Congo and Senegal (jointly with Mauritania).

It would appear, from Section 1, that almost all the Sub-Saharan African countries could potentially use natural gas for power generation to spread electrification and/or displace oil as a generating fuel. How this demand could be met can be divided into different categories:

- From domestic gas sources where countries have significant gas reserves;
- Imports by pipeline;
- Imports by LNG, for those countries with coastlines; and potentially
- Gas by wire, using the electricity interconnections between neighbouring countries.

The rest of this section will consider these various options and also look at gas pricing in the existing gas consuming countries.

The map below shows how the countries are divided into the various categories[10].

Figure 3: Sub-Saharan Africa Gas Demand Prospects

Source: OIES Analysis and mapchart.net

Demand from Domestic Gas Supply

Nigeria

Nigeria has the largest proved reserves in the whole of Africa at some 5.3 trillion cubic metres[11]. Its power sector is 82% gas-fired already, with the rest hydro. While renewables, including mini-grids, are likely to become increasingly widespread, gas will continue to be the main fuel source, with demand depending on the growth of the power sector. Nigeria has had significant problems with reliability of its

[10] The Unsure category represents those countries where there is no clear development of gas demand and is discussed further in Section F below.
[11] IEA, Natural Gas Information 2017

own gas supplies, and this has often led to reducing exports by WAGP to Benin, Togo and Ghana, as well as interrupting their own power plants. Fundamentally any growth will depend on expanding the electricity network as well as ensuring that the gas supply is developed to meet the demand reliably.

Mozambique

Mozambique also has large proved reserves at some 2.8 trillion cubic metres[12]. Some gas is already used in power generation but hydro dominates. Mozambique also exports gas by pipeline to South Africa. These activities are largely in the south of the country around Maputo – the capital. The onshore LNG facilities will be constructed in the Palma district of Cabo Delgado province, which is over 2,500 kilometres from Maputo. While it would be possible to construct a pipeline to bring gas to the south the economics of this may be questionable[13]. One alternative could be to put a FSRU in Maputo and then the LNG could be shipped south to it. Gas would then be available to support the growth of power. This may be a quicker solution than a pipeline and may be more cost effective, but in either case it may be the late 2020s before domestic gas demand can grow significantly

Tanzania

Tanzania is also developing LNG projects, in the south of the country, with Shell and Equinor leading them. They are somewhat behind the Mozambique projects and may be unlikely to start up before 2030. The reserves these projects are based on have not yet been booked as proved, according to Cedigaz and Oil and Gas Journal, but some reports put them at 1.6 trillion cubic metres[14]. The onshore plants will be built at Lindi, which is less than 500 kilometres from the main centre of population in Dar-es-Salaam. There is an existing pipeline from Mnazi Bay, which is south of Lindi, taking gas to Dar-es-Salaam, which could be expanded or looped to evacuate more gas from the area. Gas already has the largest share as a fuel for power generation, based on the Mnazi Bay gas, but additional demand is likely to depend on the offshore fields. Once the offshore fields have been developed, therefore, there would be scope for some of the gas to be consumed domestically, displacing oil-fired generation and increasing electrification, but it could be the late 2020s before the reserves are developed.

Angola

Angola currently generates no power using gas, with hydro and oil being the two fuels. Proved natural gas reserves are over 300 billion cubic metres[15] but are devoted almost exclusively to LNG export using associated gas. Angola is well endowed with oil reserves, although it may look to preserve more of this for export. The Ministry of Energy's plan is to install 1.9GW of natural gas-fired generation capacity by 2025 or 19% of the total[16]. The 1.9GW is comparable to the existing level of generating capacity in the country. Operating at a 60% load factor this could amount to some 3 bcm/year of gas demand, but the timetable for this remains uncertain, despite the stated plans.

Equatorial Guinea

Gas in Equatorial Guinea is focussed on LNG exports. The level of proved reserves is uncertain, ranging from 50 billion cubic metres according to Cedigaz and reports of around 120 billion cubic metres for the Alba offshore field[17]. That would be enough for additional LNG exports and also expansion of the domestic use of gas. There are plans to expand gas-fired power on a small scale by converting and expanding an existing oil-fired plant, but only to the extent of around 100 megawatts, which is less than the current capacity at Punta Europa.

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[12] IEA, Natural Gas Information 2017
[13] A JV was signed for the $6 billion Renaissance project to transport gas from the Rovuma basin to South Africa, to be constructed by the Chinese.
[14] https://oilprice.com/Energy/Natural-Gas/Tanzanias-344M-Natural-Gas-Plant-Is-A-Game-Changer.html
[15] IEA, Natural Gas Information 2017
[16] http://www.angolaenergia2025.com/en/conteudo/generation-0
[17] https://oilprice.com/Latest-Energy-News/World-News/Equatorial-Guinea-Joins-OPEC.html

Cameroon

Cameroon's proved natural gas reserves are put at 135 billion cubic metres by Oil and Gas Journal. The existing production – before the FLNG export facility started up – was onshore and used in power facilities and industry in the Douala area. The main supplier – Victoria Oil and Gas – estimates that the market could increase ten-fold in a short period of time[18], which would increase their sales from 100 million cubic metres/year to around 1 billion cubic metres. The use of the offshore reserves would support the development of the existing onshore reserves.

Gabon

Gabon's gas reserves are put at 28 billion cubic metres by Oil and Gas Journal. Much of the production is used in the power sector, together with hydro and some oil. Power Africa is supporting the development of additional gas-fired power, utilising domestic production.

Senegal/Mauritania

The Tortue/Ahmeyim development has estimated resources of 15 trillion cubic feet (around 420 billion cubic metres)[19]. The offshore development straddles the Senegal/Mauritania border. The LNG export project is FLNG[20], as the first option, but with gas also piped to the shore to supply the domestic markets in both countries. This would enable the displacement of oil in both countries' power sectors as well as assist in further electrification. Senegal and Mauritania both use significant amounts of oil in power generation. The FLNG plant is expected be online as early as 2024 with prospects to deliver gas to the domestic markets in a similar timeframe.

Congo

Much of Congo's existing gas production is used in the power sector, which also utilises hydro. ENI have discovered oil with associated gas offshore and the gas is planned to be used in gas-fired power[21] and potentially also in New Age's small scale FLNG project.

Future Potential for Domestic Supply

The initial potential for gas in these countries is to displace oil in the power generation mix. Excluding Nigeria, which does not use oil in power generation, the total generation in 2015 by oil, in these countries, amounted to some 11,000 GWh. If all this was displaced by gas then this could amount to some 3.2 bcm/year of additional gas demand. In Section 5 below, the potential demand is discussed further.

Imports by Pipeline

As noted earlier, pipeline trade within the region is limited to the West African Gas Pipeline (WAGP), through which Nigeria exports gas to Benin, Togo and Ghana, Mozambique exports to South Africa and, apparently, Congo exports a small quantity to DR Congo. The history and issues surrounding WAGP were discussed in the recent OIES paper on Future Prospects for LNG in Ghana[22].

West African Gas Pipeline

WAGP is owned and operated by the West African Gas Pipeline Company (WAPCo) Limited, which in turn is owned by Chevron (36.9%), Nigerian National Petroleum Corporation (NNPC) (24.9%), Shell (17.9%), Takoradi Power Company Limited (16.3%), Société Togolaise de Gaz (2%), and Société BenGaz (2%). The pipeline is 678 km long and links into the existing Escravos-Lagos pipeline at the Nigeria Gas Company's (NGC) Itoki Natural Gas Export Terminal and then proceeds to a beachhead in Lagos. From there it moves offshore to Takoradi, in Ghana, with gas delivery laterals from the main

[18] http://www.victoriaoilandgas.com/sites/default/files/VOGAR16_Web.pdf
[19] https://www.bp.com/en/global/corporate/media/press-releases/major-milestone-achieved-for-bp-operated-tortue-ahmeyim-gas-project.html
[20] BP and partners have recently taken FID on a 2.5 mtpa FLNG facility
[21] https://www.eni.com/enipedia/en_IT/international-presence/africa/enis-activities-in-the-republic-of-congo.page
[22] https://www.oxfordenergy.org/publications/future-prospects-lng-demand-ghana/

line extending to Cotonou (Benin), Lome (Togo), and Tema (Ghana). The pipe was initially supposed to carry a volume of 160 mmscfd and peak over time at a capacity of 470 mmscfd. The project was underpinned by a foundation contract of 133.6 mmscfd, of which 123.2 mmscfd was destined for Ghana and 5.2 mmscfd each to Benin and Togo.

The start date of WAGP was meant to be 2006 but the project was considerably delayed, with interruptible gas supplies only starting in late 2008 (when the pipeline was completed but not all the receiving stations or the compressor station in Nigeria were operational). The actual start date, when the contractual commitments were triggered, was not achieved until November 2011.

Since the 2011 start date, Nigeria has consistently failed to supply gas under the terms of the contract. This has been in part due to vandalism and terrorist action in blowing up the NGC pipelines, partly due to gas supply issues, and also due to Nigeria diverting the gas meant for WAGP to its own power plants. There was also a pipeline breach in August 2012 when pirates hijacked a tanker and dragged an anchor over the pipeline, resulting in long delays while the pipeline was repaired. Because of these continuing issues, the contracts have been operating under force majeure effectively since the start date, with none of the parties concerned showing much willingness to try and enforce the contractual terms.

In August 2014 the VRA (Volta River Authority) – the sole purchaser of gas in Ghana - stopped paying for the gas[23] as it was not receiving payment from the electricity distributors, who in turn were not being paid by most of their customers, principally the Government of Ghana. VRA resumed paying current bills in Q3 2016, and the large accumulated debt is slowly being paid.

There is currently a project underway to create an entry point at Takoradi to receive gas from the Ghana pipeline system for onward delivery to Tema. This project will also increase the Tema offtake capacity to 240 mmscfd and was ready in time for the start-up of gas from the big Sankofa (or OCTP) field in the third quarter of 2018.

Ghana has production from the Jubilee and TEN fields and the Sankofa project is just starting up. The recent OIES paper on Future Prospects for LNG in Ghana concluded that, with the domestic production growth and imports from Nigeria, LNG imports would not be required until 2021 at the earliest, even if gas completely displaced oil in power generation where it could. This has not prevented a number of proposals to develop LNG import projects in Ghana at Tema but also at Takoradi. Golar had initially moored the Golar Tundra offshore Tema but there was no progress on commercial arrangements with Ghanaian entities nor the onshore facilities. Hoegh had an agreement with GNPC to supply a FSRU and construction of the onshore facilities was supposed to begin in 2017. However, as no approval was forthcoming from the Ghanaian authorities, Hoegh allowed the agreement with Quantum Power and Ghana gas to expire[24]. Earlier there had been the Ghana 1000 project which had planned to supply natural gas to a 1300MW power plant at Takoradi, with Excelerate providing the FSRU, but there are no signs of this proceeding. MOUs on LNG supply agreements had been signed with Gazprom and Rosneft, but without any infrastructure these are also stalled.

The fact that all the Ghanaian LNG import projects has stalled may not matter that much as domestic production ramps up and if Nigerian volumes through WAGP are stabilised at reasonable levels, even if they are below the contracted volumes. There has also been some discussion in respect of the offshore Aje field in Nigeria, which is close to WAGP near the Benin border, tying into WAGP and exporting volumes. Ghana would appear to have a strong appetite to increase gas demand in power, even to the extent of exporting electricity via the West African Power Pool (see below).

Benin also had a proposed FSRU project with Gasol, which would have imported gas into Benin, but also re-exported any surplus gas via WAGP, principally to Ghana. However, this project stalled, although the Benin government has recently resurrected the prospect of a FSRU connecting into WAGP offshore.

[23] It should be noted that Benin and Togo customers have continued paying.
[24] http://interfaxenergy.com/gasdaily/article/31115/hoegh-lng-formalises-ghana-exit

Not wanting to miss the LNG party, Togo signed a MOU with Equatorial Guinea to study the possibility of LNG imports[25].

If LNG imports are to happen in this area, probably only one project is likely, since if this is also connected into WAGP, then the regasified LNG could be delivered anywhere along the pipeline, commercially at least if not technically.

Mozambique to South Africa Pipeline

The Mozambique to South Africa gas pipeline is operated by ROMPCO, which is a joint venture company with three shareholders – the South African Gas Development Company (iGas), Companhia Limitada Gasoducto (CMG) and Sasol Gas Holdings, Pty Ltd. The 856 kilometre high-pressure pipeline connects the onshore gas fields in Pande and Temane, Mozambique to Sasol's operations in South Africa at Secunda. Gas supplies started in 2004 and gas is also delivered to domestic power stations and industrial customers. Annual volumes started at the 1 to 2 bcm range before ramping up to 3 bcm and now flows are just over 4 bcm. There has been discussion about expanding pipelines and trade between the two countries[26], including Chinese involvement in the pipeline from the Rovuma basin – Renaissance pipeline – noted above.

Tanzania to Kenya Pipeline

As long ago as 2008 there were reports that Tanzania would export gas to Kenya by extending the Mnazi Bay to Dar-es-Salaam pipeline, which was completed in 2016. However, agreeing the details with Kenya proved problematic and this project now appears to be on hold. Tanzania has recently been talking about a pipeline to Uganda. This may have a reasonable prospect of being developed since Tanzania has the offshore reserves, although they may not be developed until the late 2020s, and Uganda has a liberalized electricity market which seems to cover all its costs, despite significant losses. It would seem likely, however, that any cross-border pipeline from Tanzania would have to await the development of the offshore reserves for the LNG export plants.

Trans-Saharan Pipeline

The Trans-Saharan pipeline has been planned for a number of years, running from Nigeria, through Niger to Algeria. Despite Nigeria having ample reserves, there seems little prospect of it happening anytime in the near future, given the issues with exporting gas along WAGP and the difficulties in meeting its own domestic demand. In 2016, there was also a proposal to build a Nigeria to Morocco pipeline but this has not met with much support from NGOs and other African organisations[27], so again this is not likely to go ahead.

Future Potential for Pipeline Imports

The likelihood of any new pipeline projects in the region seems remote. Mozambique might export more to South Africa if the Rovuma basin reserves can be delivered to the south of the country, but this may take some time. Exports from Nigeria to Benin, Togo and Ghana amounted to some 0.4 bcm in 2017, which was down on the peak of 0.65 bcm in 2014. However, this peak was only around half the contracted volumes, because of the almost permanent issues with Nigerian supply. In 2018 flows have been much higher and are likely to exceed the 2014 high. Section 5 will further consider the potential for demand to be met by pipeline imports.

[25] https://globenewswire.com/news-release/2018/04/09/1466764/0/en/Togo-and-Equatorial-Guinea-Sign-Liquefied-Natural-Gas-Deal-Promote-Regional-Gas-Trade.html
[26] https://www.iol.co.za/business-report/new-sa-and-mozambique-gas-pipelines-to-meet-demand-11535938
[27] https://www.moroccoworldnews.com/2018/03/243071/40-european-african-organizations-say-no-nigeria-morocco-gas-pipeline/

Imports by LNG

Ghana/Benin/Togo

As noted above, in addition to domestic production in Ghana and pipeline imports from Nigeria, a number of LNG import projects have been proposed. By the mid-2020s LNG may be needed in Ghana as electricity demand increases and gas increasingly displaces oil in all three countries. Additionally, if Ghana were to "export" gas by wire (see below), the requirement could become larger.

Cote d'Ivoire

Power generation in Cote d'Ivoire is dominated by gas at 83% in 2016. Domestic gas production, however, has plateaued at just over 2 bcm/year and as power demand grows, the country is turning to importing gas. When the WAGP was being planned, there was some discussion of extending the pipeline to Cote d'Ivoire, but given the problems with gas supply from Nigeria, this seems an unlikely option. A Total-led consortium is close to taking FID on a 3 mtpa FSRU, but is waiting on final government approval.

Namibia

Almost all Namibia's electricity usage comes from hydro production and electricity imports from South Africa, but as electricity demand grows, they will need another fuel supply. There are proposals to build a gas-fired plant at Walvis Bay, supplied by LNG. There has been little new news on this since 2017.

Madagascar

Madagascar has good potential for hydro, wind and solar but currently most of the generating capacity is diesel and electricity remains expensive. There are no known proposals to develop LNG imports into Madagascar. However, given where it is located in relation to Mozambique and Tanzania, the prospect of lower cost LNG may be appealing.

Mauritius

Outside South Africa, Botswana and Zimbabwe, Mauritius is the only country to burn coal in any significant quantities, with most of the remaining generation being oil-fired. Mauritius also has the second highest mwh/head consumption, behind South Africa, in the region, reflecting the high level of tourism. In 2017, the Central Electricity Board (CEB) initiated a request for information (RFI) to potential developers for the setting up of an LNG facility to supply natural gas to a newly constructed CCGT plant at Fort George. It is not yet known what the outcome of the RFI has been but it has been reported that Petronet from India have been shortlisted to set up the LNG terminal. The earliest start date now would be 2020 or later.

Kenya

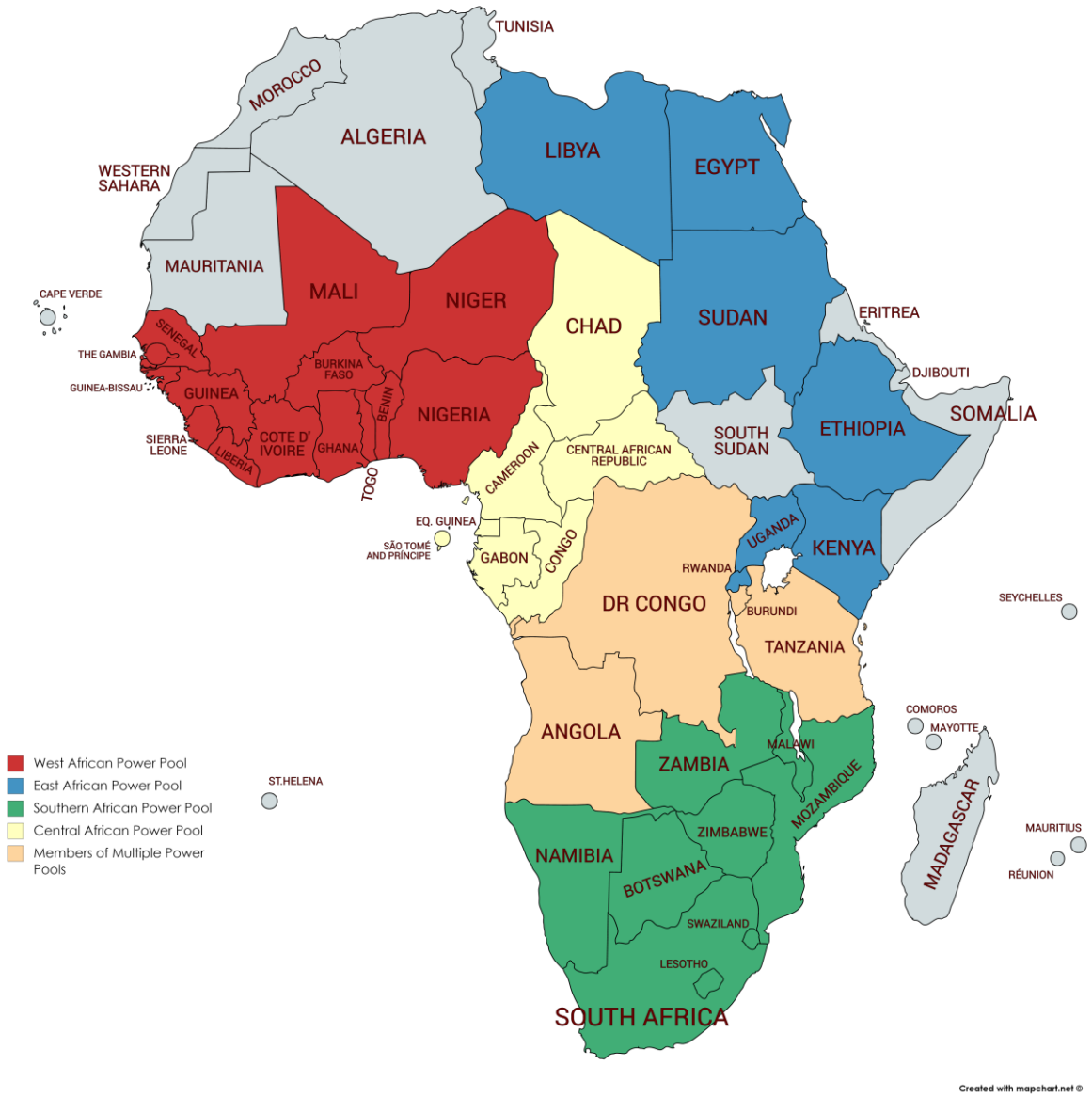
Kenya has a lot of geothermal and hydro in its generation mix, supplemented by oil. As noted above, there had been discussions with Tanzania on a pipeline project but these appear to be on hold. Kenya had planned to build an LNG terminal in Mombasa and a tender was issued in 2014 but the bids were reportedly not acceptable. In 2015, Kenya postponed signing an agreement with Qatar following the discovery of 1.8 tcf of domestic gas by Africa Oil and Marathon Oil Corporation. Earlier this year, however, it was reported that the project had been revived[28].

Gas by Wire

Sub-Saharan Africa has a number of power pools where member states interconnect their power systems. The map below shows the current power pools.

[28] https://www.businessdailyafrica.com/economy/3946234-4264098-j9qfwt/index.html

Figure 4: Sub-Saharan African Power Pools



Source: OIES Analysis and mapchart.net

Some countries are members of more than one power pool:

- Angola – Central and Southern
- DR Congo – Central, East and Southern
- Burundi – Central and East
- Tanzania – East and Southern

The power pools are at various stages of interconnecting their systems.

Especially for land-locked countries with no direct access to LNG, it may be easier to import power from neighbouring countries than gas itself. With many issues surrounding pipeline projects in the region, the use of existing electricity transmission infrastructure may be a more realistic option. Clearly not all

this export of power would come from gas-fired plants, but the flexibility of importing LNG would allow the power pools to optimise their systems so could be an attractive option.

In West Africa, this may be especially true for Niger, Burkina Faso and Mali and even the coastal countries of The Gambia, Guinea-Bassau, Sierra Leone and Liberia, in view of the gas reserves and production in Nigeria, Ghana, Cote d'Ivoire, Senegal and Mauritania, together with LNG import potential in Cote d'Ivoire and Ghana.

For other countries such as DR Congo and Burundi, this may also be true because of their membership of multiple power pools.

Remaining Countries

In Figure 3 there were a number of countries identified as not falling easily into any one category. These were Zambia, Malawi, Rwanda, Uganda and the Horn of Africa countries of Sudan, South Sudan, Eritrea, Ethiopia, Djibouti and Somalia.

- Zambia is heavily dependent on hydro and geographically is unlikely to import natural gas.
- Malawi is again mostly hydro but could possibly access gas indirectly via neighbouring Mozambique and Tanzania from the Southern African Power Pool.
- Rwanda is a mixture of oil and hydro in its current generation mix, with prospects for solar and wind. According to the Oil and Gas Journal it has some 57 billion cubic metres of proved gas reserves[29], reportedly near Lake Kivu, although there are no plans as yet to develop them. As a member of the East African Power Pool it would be well placed to import gas by wire from Tanzania.
- Uganda is mainly hydro supplemented by oil, with a liberalized energy market and many IPPs. There are small proved gas reserves and, as noted above, the possibility of a gas pipeline from Tanzania, although this seems unlikely for 10 years or more, given the slow pace of developing the reserves. Similar to Rwanda, as a member of the East African Power Pool it would be well placed to import gas by wire from Tanzania.
- The Horn of Africa presents some interesting possibilities for LNG:
    - Sudan currently depends on around 2/3rds hydro and 1/3rd oil for its power generation. Oil and Gas Journal has 85 billion cubic metres of proved reserves for Sudan[30] and the government announced in 2014 that LNG imports were being investigated for power and industry, with a terminal at Port Sudan on the Red Sea. China has been approached to help develop the reserves. Recently a formal tender has been issued to provide a FSRU at Port Sudan. Sudan is closely allied with Qatar, having sided with Qatar rather than the other Gulf states in the recent Qatari blockade.
    - South Sudan took most of the oil when it gained independence from Sudan and is totally reliant on oil for power generation. With no discernible gas reserves, and no coastline, this situation is unlikely to change.
    - Eritrea is also totally reliant on oil for power generation, all of which is imported. It has been in conflict with Ethiopia for many years and the two countries only formally ended the conflict on July 9 2018. Given the need for electrification and its coastal position on the Red Sea it would be well placed to import LNG. Eritrea had sided with Saudi Arabia in the Gulf dispute with Qatar, as did Djibouti, so may need to look outside the Gulf elsewhere if it were to import LNG.
    - Ethiopia is one of the few countries in the region to have any significant solar capacity but is heavily dependent on hydro. Oil and Gas Journal reports 37 billion cubic metres of

[29] IEA, Natural Gas Information 2017
[30] IEA, Natural Gas Information 2017

proved natural gas reserves[31], but other estimates are much higher[32]. As well as developing the reserves for domestic use, Ethiopia is looking to build a pipeline to Djibouti where the gas will be liquefied and exported.

- Djibouti is totally dependent on oil for power generation but has potential for geothermal and solar and wind. If the LNG project with Ethiopia goes ahead then it may be able to import gas for its own use. The UAE had helped broker the peace deal between Ethiopia and Eritrea and DP World had built a port in Djibouti. However, China is now investing heavily in Djibouti, building much of the new free trade zone as part of its Belt and Road initiative. Earlier this year Djibouti seized the port from DP World as it said that DP World had not developed the port fast enough and may need to hand it over to China to repay the debt[33].
- Somalia's power generation sector is totally private sector and almost all oil. The political instability and security issues exacerbate the situation. Given that LNG tankers currently avoid the Somalian coast because of piracy, the likelihood of any LNG imports would seem remote.

South Africa

South Africa is very different from the rest of Sub-Saharan Africa, in terms of its economic development and it heavy use of coal in power generation. South Africa produces small quantities of gas itself but imports larger volumes from Mozambique. The country still suffers from power shortages and its coal fleet is ageing. There is a gas-to-power programme with the aim of building and supplying 3.126 GW of gas-fired plants, to be run baseload and/or mid-merit (South Africa DOE, 2016)[34]. The gas required for these power plants will come from both imported and domestic gas resources. In May 2016 the DOE invited expressions of interest for the construction of a new 600 MW gas power plant at either the port at Saldanha, or at Richards Bay. However, at the end of 2017 the decision was delayed since the integrated resource plan (IRP) had not been finalised by the government[35]. In September 2018, however, the IRP was published[36]. This suggested that gas-fired power would become increasingly important in the generation mix in South Africa, initially driven by LNG imports. However, this was unlikely to develop before 2025 but by 2030 could lead to gas demand of some 10 bcm/year.

South Africa is also reported to have a large quantity of shale gas reserves. The EIA in 2015 estimated a technically recoverable shale gas resource of the Karoo basin at 390 trillion cubic feet, but more recently geologists at the University of Johannesburg estimated reserves at only 13 trillion cubic feet[37]. In any event, the shale reserves may take many years to develop, so this may not impact on the decision to import LNG.

Gas Prices

For existing gas consuming countries in the region, the annual IGU Wholesale Gas Price Survey provides useful information on price mechanisms and price levels. Table 5 shows the average wholesale price for each country included in the 2017 survey.

[31] IEA, Natural Gas Information 2017
[32] http://www.xinhuanet.com/english/2018-04/12/c_137104383.htm
[33] The Economist, July 21st 2018, pp 39-40
[34] https://www.kapsarc.org/wp-content/uploads/2016/11/KS-1658-DP052A-LNG-for-Africa.pdf
[35] https://www.icis.com/resources/news/2017/11/09/10162122/south-africa-delays-decision-on-lng-imports-to-next-year/
[36] http://www.energy.gov.za/IRP/irp-update-draft-report-2018.html
[37] https://www.reuters.com/article/safrica-shalegas/south-africa-karoo-shale-gas-deposits-seen-less-than-earlier-estimates-idUSL8N1M92P3

Table 5: Sub-Saharan Africa Wholesale Gas Prices 2017

	2017 $/MMBTU	PRICING DETAILS
Benin	8.30	Price of delivered gas via WAGP - commodity oil linked, rest is mostly regulated transmission tariff
Cameroon	3.89	Bilaterally negotiated prices for power and industry - wieghted average of $9 and $2.50
Cote d'Ivoire	5.90	Now mostly fixed price negotiated price, some oil indexation remains
Equatorial Guinea	0.25	Regulated, used in power and feedstock
Gabon	0.80	Regulated, used in power
Ghana	8.65	Mixture of WAGP price and domestic production, which is regulated and includes transportation and processing charges
Mozambique	1.66	Regulated formula price with cap and floor - narrow range
Nigeria	3.08	Price to power regulated, for industry gas-on-gas competition
South Africa	6.41	Negotiated import price from Mozambique - domestic production linked to alternative fuels prices
Tanzania	3.43	Protected legacy gas sold at $2 fixed price to state power plants - remainder linked to oil prices and sold to other power plants and industry
Togo	8.30	Price of delivered gas via WAGP - commodity oil linked, rest is mostly regulated transmission tariff

Source: IGU Wholesale Gas Price Survey 2018[38]

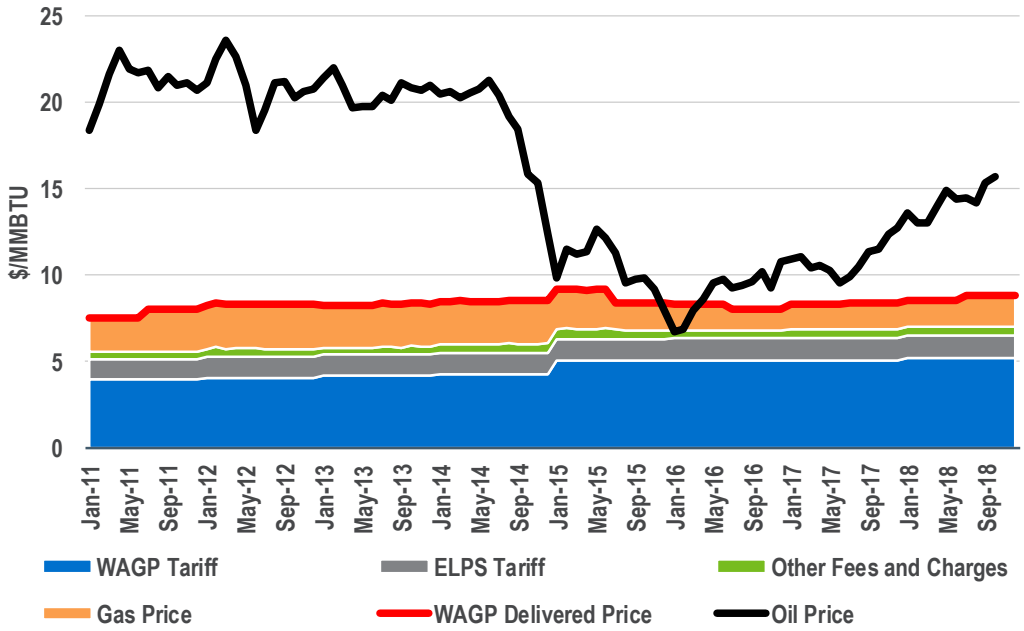
While there are a few countries – Equatorial Guinea, Gabon and Mozambique – with very low regulated prices, all the other countries have prices which could be said to be at more economic levels. Ghana, Benin and Togo have the highest prices, largely reflecting the price of imported Nigerian gas along WAGP, although 2/3rds of this price relates to transportation tariffs.

Gas prices in Nigeria have been increased gradually over the last 10 years to encourage exploration and outside the power sector are determined by the market, although the price to power plants is set to encourage market prices to rise to at least the same level. Cote d'Ivoire has had a long history of market-based prices, initially mostly linked to oil prices, but now largely negotiated. Cameroon also has bilaterally negotiated prices as does Tanzania apart from the initial protected contract to power plants. Finally, South Africa fixes its wholesale price of gas in relation to competing fuel prices.

In terms of gas being affordable in the Sub-Saharan African markets, it is argued in this paper that the key competing fossil fuel in the power sector is oil rather than coal. Figure 5 compares the price of Light Crude Oil burnt in Ghana's power plants with the price of natural gas delivered to the same power plants.

[38] https://www.igu.org/publications-page

Figure 5: Delivered Oil and Gas Prices to Power Plants in Ghana



Source: West African Gas Pipeline and OIES analysis[39]

The delivered oil price to Ghana's power plants is Bonny Light plus $8/barrel to cover the offloading and delivery costs. The delivered WAGP price – the red line in the chart – has been remarkably stable since the beginning of 2011, mostly in the $8 range, only going above $9 in the first half of 2015, as a revised tariff was introduced[40]. The delivered gas price has been kept down, to some extent, by the decline in oil prices impacting the gas commodity price. The only period when the competing oil price went below the WAGP delivered price was when the Bonny Light oil price fell below $40/barrel, at the beginning of 2016.

The gas commodity price element of the WAGP delivered price – the orange area in the chart – went below $1.25 in the first half of 2016, as oil prices declined, but has since recovered to $1.80 for the second half of 2018 – reflecting an oil price of $70/barrel. This is somewhat below the current market price in Nigeria which is above $3. If this latter wholesale price was used in the calculation then the delivered WAGP price would be closer to $10, which is comparable to a Bonny Light price of around $50/barrel.

The WAGP transportation tariff currently is above $5 and accounts for 60% of the delivered price. However, a new tariff period starts at the beginning of 2019 and the tariff structure and levels are being changed significantly, as a new entry point is added to the pipeline at Takoradi, with the tariff from Nigeria to Ghana falling to $3.4305/MMbtu. This will bring the delivered gas price to just over $7/MMBtu under the current contract. New contracts are likely to be signed at higher gas commodity prices, bringing the delivered gas price up to just over $8/MMbtu.

The conclusion to be drawn from this analysis is that, if the objective is for gas to replace oil as the preferred fuel for power plants, then a delivered gas price of $8, or even slightly higher, is competitive with oil prices at just under $50/barrel. In countries with indigenous gas resources, economic prices would seem to be much less than this. A key question is whether imports, especially of LNG, can be delivered at the $8 level.

[39] The ELPS tariff is on the Nigerian Escravos to Lagos pipeline
[40] The tariff is fixed in real terms for the tariff period and then only escalated in line with inflation.

4. Issues and Challenges

The Sub-Saharan Africa gas market is faced with many issues if gas is to increase its share of the power generation market. Some of the issues relate to the electricity industry rather than the gas industry, but the potential for gas demand in the region depends on the countries dealing with issues in their power sectors.

Quality and Reliability

While there is a need for providing more of the population in many countries with access to electricity, even customers who have access to power suffer from power outages, as a result of a lack of investment in ageing infrastructure, whether it be power plants, transmission or distribution networks. The utilities in many countries are cash-strapped and unable to fund the necessary investment. The losses from the ageing infrastructure are further exacerbated by electricity theft and illegal connections. The extent of the losses in East Africa was identified in a KAPSARC report[41]. The picture is similar in the rest of the region.

Revenue, Tariffs and Collections

Despite the fact that power prices in many of the Sub-Saharan African countries are high, the tariffs still do not allow companies to recover their costs. Tariffs can vary depending on the countries' generation mix, but the prevalence of oil-fired generation in many has kept tariffs high. Even then there is widespread non-collection of revenues which threatens companies' finances and their ability to make further investment. Table 6, from a World Bank report, highlights the differences between cash collected and the costs of supplying electricity.

Table 6: Comparison of Electricity Supply Cost versus Cash Collected 2014 (US cents/kwh billed)

Country	Operating and Capital Expenditure	Cash Collected	Commercial Losses
Nigeria	0.21	0.06	0.15
Mauritania	0.31	0.18	0.13
Ethiopia	0.17	0.04	0.13
Senegal	0.35	0.22	0.13
Benin	0.36	0.23	0.13
Tanzania	0.14	0.04	0.10
Cote d'Ivoire	0.21	0.11	0.10
Sudan	0.15	0.05	0.10
Togo	0.34	0.25	0.09
Congo	0.17	0.09	0.08
Kenya	0.22	0.15	0.07
Cameroon	0.16	0.11	0.05
South Africa	0.11	0.06	0.05
Gabon	0.25	0.21	0.04
Mozambique	0.12	0.08	0.04
Ghana	0.14	0.11	0.03
Mauritius	0.21	0.19	0.02
Uganda	0.16	0.17	- 0.01

Source: World Bank Report 2016: Financial Viability of Electricity Sectors in Sub-Saharan Africa

[41] https://www.naturalgasworld.com/ggp-identifying-the-roadblocks-for-energy-access-a-case-study-for-eastern-africas-gas-62812

Uganda is the only country to have been able to cover the costs – shown as a negative commercial loss – of supplying electricity, even though it has reported heavy losses due to electricity theft. Interestingly, Uganda is the only country in the region with a liberalized electricity market and many IPPS.

In all the other countries in Table 6 a picture of commercial losses is repeated. With already high tariffs, increasing tariffs to cover the losses would not appear to be an option. In some countries there has been a culture of "public services being free", especially in post-apartheid South Africa. There is also a "won't-pay" as opposed to a "can't-pay" issue. Many consumers could afford to pay but refuse to do so, either because they are used to not paying and/or they don't see why they should pay for a service which is unreliable and only turns up a few hours a day. This creates a vicious circle where people don't pay which leads to no investment, which makes the reliability issue even worse.

Creditworthiness

The commercial losses the utilities face in many countries, raises the issue of creditworthiness. This is compounded by the fact that no country in Sub-Saharan Africa is deemed to be investment grade by the ratings agencies[42]. Indeed, apart from South Africa, no country is even in the non-investment grade speculative category (BB or higher), with some in the highly speculative B category.

Investment in infrastructure in these countries, whether pipelines, LNG terminals or even upstream (at least for sales in the country), is likely to require the assistance of aid agencies such as the World Bank to provide guarantees. Entities only selling LNG into Sub-Saharan African countries may have a somewhat easier time since cargoes could be underpinned by Letters of Credit or other financing mechanisms.

Regulatory Framework

While many countries in Sub-Saharan Africa have electricity regulators, there are very few with energy regulators covering both gas and electricity or just a gas regulator. Even Nigeria, which is the largest consumer of gas in the region, has no gas regulatory body, although the Nigeria Electricity Regulatory Commission (NERC) exerts some influence on gas prices since it sets the delivered price of gas that power plants can pass through in electricity prices. Only South Africa has a regulatory body (NERSA) which explicitly includes gas in its remit and regulates the industry and prices. Cote d'Ivoire has domestic gas production, predominantly sold to power plants, but there is no gas regulatory body. In Ghana, where domestic gas production and infrastructure is developing, the Public Utilities Regulatory Commission (PURC) appears to have taken over responsibility for regulating gas transmission tariffs and gas prices, but with no legally established regulatory framework, such as there is in electricity.

The only properly constituted gas regulatory body in the region, outside South Africa, would appear to be the West African Gas Pipeline Authority (WAGPA), which was set up by an International Project Agreement between the governments of Nigeria, Benin, Togo and Ghana together with the pipeline company, and provided for each country to incorporate in their domestic legislation the West African Gas Pipeline Acts, which established WAGPA as the regulatory body with the relevant powers to regulate all aspects of the pipeline.

In Mozambique and Tanzania, where offshore reserves are being developed, primarily to feed LNG plants, progress in setting up regulatory frameworks for gas has been slow, although Mozambique appears to be more advanced.

Geopolitical Issues

A number of countries in the region are currently involved in conflicts or have recently come out of conflicts. Nigeria, in particular has terrorist issues in the Delta region, as well as with Boko Haram in

[42] https://tradingeconomics.com/country-list/rating

the north. Boko Haram are also active in Cameroon and there is increasing tension between the majority French-speaking elements in the country and the minority English-speaking population. The Democratic Republic of Congo has an ongoing rebellion of the Kamwina Nsapu militia against the state security forces. There is ongoing conflict between Northern and Southern Mali. Eritrea and Ethiopia have only recently signed a peace deal which ended decades of war and conflict. Djibouti and Eritrea have also been involved in border disputes. Somalia has been in a constant state of insurgency and civil war for many years. South Sudan continues in a state of civil war. Mozambique has also recently seen terrorist activity in the north close to where the onshore LNG facilities are likely to be constructed.

5. Identifying the Key Prospects

While Sub-Saharan Africa is faced with many issues and challenges, noted above, in growing gas demand, there are a number of good opportunities. Electricity demand is expected to grow as electrification spreads, but in addition to that, gas could gain an increasing share with its ability to displace oil and oil products in a number of markets, providing the delivered gas price can be kept below $8/MMBtu. The prospects for increasing gas demand can be divided into those countries where domestic production prospects are good, countries which might import gas either via pipeline or LNG, and finally countries which might import gas by wire, increasing gas demand in neighbouring countries.

In terms of potential gas demand, the timing will vary country by country, but to give a broad idea of the potential, the quantity from displacing oil can be calculated and also from 10 years of growth in electricity demand, assuming 10% per annum growth and gas getting half that growth[43].

Demand from Domestic Resources

Table 7 reviews the demand potential from countries with domestic resources over the next 10 years in total.

Table 7: Potential Gas Demand (Bcm) - Domestic Resources

Country	Oil Displace	Growth
Angola	1.096	1.990
Cameroon	0.518	1.607
Congo	-	0.337
Gabon	0.051	0.449
Mozambique	0.005	5.758
Nigeria	-	9.497
Senegal	0.941	0.856
Tanzania	0.118	2.151
Mauritania	0.333	0.425
Total	3.062	23.070

Source: OIES Analysis

10% per annum growth in electricity demand is assumed for all countries but gas is assumed to get 80% of the growth in Mozambique, Nigeria, Tanzania and Mauritania. In Mozambique, Senegal, Tanzania and Mauritania the displacement of oil and growth is likely to depend on the development of the offshore resources for LNG export. For Tanzania this may not be until the late 2020s, reflecting the lack of progress with the Tanzanian government, while Mozambique, Senegal and Mauritania could start up in the mid-2020s. Nigeria has significant reserves but the ability to grow gas demand in power

[43] For specific countries demand growth might be less and the gas share might be different.

will depend on infrastructure development. The total increased gas demand outlined above may not be achievable until 2030 at the earliest, with maybe 5 to 10 bcm (out of 28.5 bcm) achievable by 2025.

Importers

Table 8 reviews the demand potential from importing countries over the next 10 years

Table 8: Potential Demand (Bcm) - Importing Countries

Country	Oil Displace	Growth
Benin	0.081	0.112
Cote d'Ivoire	0.018	2.758
Eritrea	0.101	0.032
Ghana	0.553	2.665
Kenya	0.487	1.124
Mauritius	0.268	0.778
Namibia	0.002	0.273
South Africa		9.455
Sudan	1.538	1.109
Togo	0.006	0.084
Djibouti	0.160	0.127
Uganda	0.129	0.041
Total	3.341	18.558

Source: OIES Analysis

Slower than 10% per annum electricity growth is projected for Ghana, Mauritius and South Africa. However, gas is likely to potentially get a larger share of the electricity growth in Benin, Cote d'Ivoire, Ghana, Mauritius and Togo, but a lower share – below half – in the other countries. However, the IRP in South Africa envisages significant growth in gas-fired power, which may be the biggest driver of LNG imports in the region, albeit post-2025.

Benin, Togo and Ghana already import gas by pipeline from Nigeria, while oil displacement and growth in Ghana will also be supplied by increasing domestic gas production. LNG import projects in Cote d'Ivoire, Namibia. Mauritius, South Africa and potentially Ghana and Kenya may be scheduled for early to mid-2020s start up. Imports into Eritrea, Sudan, Djibouti and Uganda are more speculative and, on balance, are more likely for the late 2020s, if at all, with Uganda likely dependent on a pipeline from Tanzania. LNG imports might reach between 3 and 5 bcm by 2025 in Cote d'Ivoire, Ghana, Namibia and Mauritius and South Africa, with potentially another 10 to 15 bcm by 2030. This assumes that any LNG imports continue to be priced at a discount to oil, which is the main fuel being displaced in most cases.

Gas by Wire

Table 9 reviews the demand potential from countries importing gas by wire over the next 10 years.

Table 9: Potential Demand (Bcm) from Gas by Wire

Country	Oil Displace	Growth
Mali	0.343	0.198
Niger	0.074	0.040
Burkina Faso	0.321	0.102
Total	0.737	0.341

Source: OIES Analysis

The share of gas in the electricity growth is likely to be lower and more speculative than opportunities for direct imports of gas. The three countries are all part of the West African Power Pool and most likely to import power from Cote d'Ivoire and/or Ghana. This could potentially lead to some increase in LNG imports into those countries but this is very speculative and wold be unlikely to be more than 0.5 bcm/year, unless these countries relied totally on electricity imports for their growth and oil displacement and then all of this came from gas-fired power.

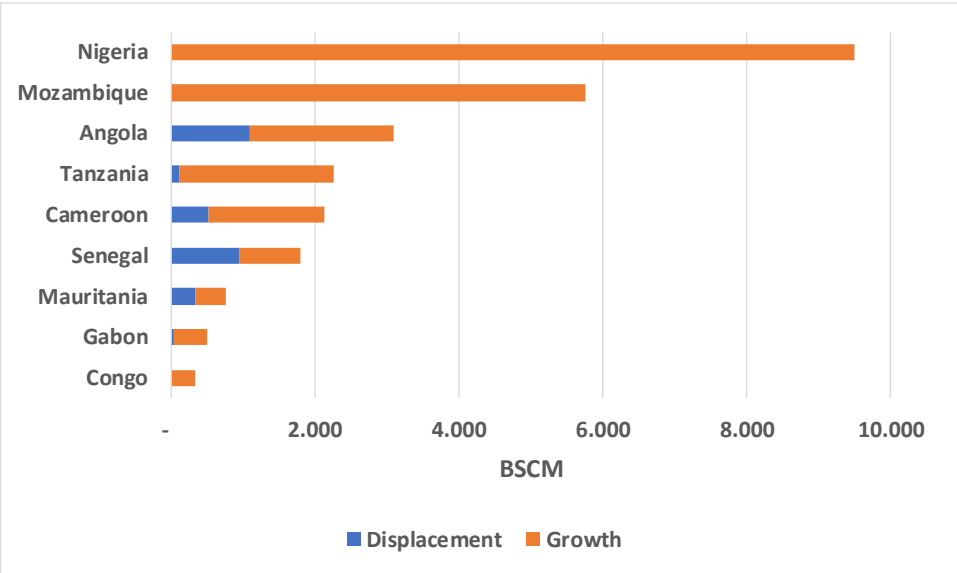
6. Conclusions

Outside the coal dominated countries of South Africa, Botswana and Zimbabwe, Sub-Saharan Africa power generation fuel is just over 50% hydro, 27% gas and 14% oil. Renewables are very small at the moment although developments are beginning. Most of the gas-fired power is in Nigeria, followed by Cote d'Ivoire, Ghana (where gas is displacing oil), Mozambique and Tanzania, with some generation in Benin, Togo, Gabon, Senegal, Cameroon and Congo. Oil-fired generation is widespread in most countries, supplementing hydro and also gas.

Use of oil in power generation is one of the reasons why electricity is expensive in many Sub-Saharan African countries. A delivered gas price of around $8/MMBtu is competitive with oil-fired power at an oil price as low as $50/barrel. For countries with significant domestic production, gas prices are already competitive, but LNG would need to be delivered at $8 or less to start displacing oil. Oil displacement potential may be around 7 bcm/year in total and up to 2025 mainly in West and Central Africa and Mauritius, from both LNG imports and domestic sources. In East Africa the displacement is more likely post 2025.

Gas demand growth is expected to be positive in countries with high levels of gas reserves such as Nigeria, Mozambique, Tanzania, Senegal and Mauritania, although in the case of the last 4 countries the timing of the growth will depend on the development of reserves associated with LNG exports.

Figure 6: Potential Demand Growth from Domestic Production

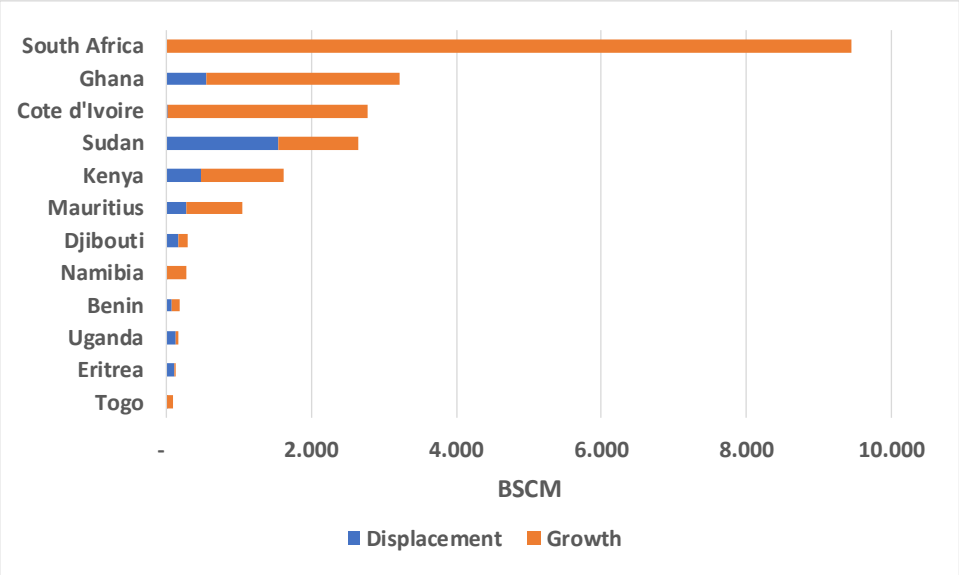


Source: OIES Analysis

A number of LNG import projects have been promoted in Sub-Saharan Africa but progress on them has been slow with constant deferrals. Cote d'Ivoire seems likely to be the first to come onstream in 2020, if government approvals are given. Projects in Namibia and South Africa are on hold at the moment, although the Integrated Resource Plan in South Africa has resurrected the prospects for LNG imports post-2025 with demand of around 10 bcm/year from LNG imports. Ghana has had a number of false

starts but would not appear to require LNG anyway until the mid-2020s. On the east coast of Africa, Kenya has resurrected its LNG import project and the island of Mauritius is also keen on developing LNG imports. Further north, Sudan is looking at an import project at Port Sudan, possibly with Qatar as the supplier. The Horn of Africa also looks to have some interesting opportunities with a peace deal being signed between Ethiopia and Eritrea, potentially opening up LNG exports from Ethiopia via Djibouti, and Eritrea could maybe look to LNG to displace oil.

Figure 7: Potential Demand Growth in Gas Importing Countries



Source: OIES Analysis

Overall, the move towards multiple countries importing LNG in Sub-Saharan Africa remains prospective but by the mid-2020s this may well have changed, with Cote d'Ivoire, Ghana, Namibia, South Africa and Mauritius being the most likely projects. This would be timely for the new LNG export projects, taking FID in the next twelve months and seeking new markets, especially for some of the export projects in the region.

It is important to note, however, that the scale of the developments for LNG imports would seem to be relatively small – maybe around 20 bcm/year at most and 10 years away – and not on a par with the prospects in the new and growing markets in Asia, even ignoring the big 5 importers of Japan, Korea, Taiwan, China and India. Sub-Saharan African markets, therefore, may provide useful niche opportunities for LNG exporters but not on a scale to underpin FIDs for new export projects.