

# Identifying the Roadblocks for Energy Access: A Case Study for Eastern Africa's Gas

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# Key Points

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**N**atural gas resources in Tanzania and Mozambique have emerged as a new source of gas supply. While they are poised for export to global gas markets, they can also provide a key source of energy to the rest of Eastern Africa (defined in this paper to include Burundi, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, South Africa, Tanzania, and Uganda), where millions of inhabitants are currently living without access to electricity and clean cooking. Natural gas could also potentially be a driver for industrialization and economic growth. But before delving into the potential gas demand and opportunities for gas utilization in the region, it is important to take a step back to analyze the current energy picture in Eastern Africa and look into the social and development plans in place in the region.

Despite large natural resource potential across the region of Eastern Africa (except South Africa), low electricity access and energy access rates have hampered economic growth and increased dependency on traditional biomass. This scoping study investigates energy access issues in the residential, industrial and transport sectors. We find that:

Almost all the socio-economic development plans of the nine countries in this study include the development of energy resources and electricity access as an instrument to promote growth. However, the rollout of planned power capacity additions has been slow, and countries are unlikely to reach their respective capacity targets.

Reasons for low energy access vary but are tied mostly to the financial capacity of governments, inadequate revenues for utilities, tariffs being lower than costs, and a weak regulatory framework to implement energy policies.

Penetration of prepaid meters in households offers benefits to utilities and consumers in terms of payment collection and flexibility respectively. Almost all governments in Eastern Africa have committed to policies to support the widespread installation of prepaid meters, which will be a key driver of increased electricity access.

Economic growth and development hinges on the industrial sector having access to reliable and affordable energy. Industrial and energy access policies have to be interlinked to spur economic activities in each country and to maximize the benefits of energy access.

Urbanization and population growth are key drivers to improving energy access in the transport sector. The biggest challenge facing this sector has been poor infrastructure. Development policies oriented toward urbanization and the growth of cities must link with transportation policies to adequately expand transport infrastructure and increase other modes of transport, including mass transportation.

# Executive Summary

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Improving access to reliable, modern energy is among the highest priorities of Eastern African countries' economic growth plans and energy strategies. In particular, developing access to electricity – including in rural areas – is the cornerstone of most strategies. On average, only 35 percent of the population in sub-Saharan Africa (SSA) has access to electricity; lower than any region in the world including developing Asia, the Middle East and Latin America. In the group of nine Eastern African countries considered, only South Africa and Kenya are above this average, while most countries have a rate below 20 percent. This implies that the majority of the population still has to meet its primary demand for cooking and lighting from unsustainably harvested biomass. The process of fuel collection is also time-consuming and comes at the expense of education and income generation (IEA 2006, 419).

The paradox is that, against this bleak demand picture, Eastern Africa is endowed with large energy resources ranging from oil, gas, uranium and coal to a variety of renewable energy sources, including solar, hydro, wind and geothermal. In theory, these resources should be sufficient to meet a large part of the region's energy needs, contributing not only to the development of power generation but also to that of other sectors such as the industrial and transportation sectors. However, as of 2017, most of these resources are largely underdeveloped, except for coal and uranium in South Africa and some hydro potential.

Low electricity access finds its roots in many issues, including a slow development of power capacity due to lack of investments, high technical losses and theft, difficulty covering the cost of electricity for utilities, high electricity tariffs in some countries,

and the poor financial health of utilities. This is compounded by specific issues experienced in each region, such as low incomes, the large size of the countries, the remoteness of some energy resources from demand centers, and high rural populations. Energy efficiency also poses a challenge: on the supply side from low-efficiency power plants, and on the demand side from issues such as inefficient transport fleets and industrial processes. Deployment of prepaid meters to households has increased electricity access in Eastern Africa. Almost all countries in the region have programs in place to support this initiative. It makes it easier for utilities to collect revenue, reduces connection costs and manages demand for consumers.

While industries linked to the agriculture sector (agro-processing) have an important role in many countries, the transport and industrial sectors are also key drivers of the economic development of Eastern Africa. These sectors need energy to develop. The total energy use in transportation in all nine countries accounts for only 10 percent of their total energy consumption. Africa's road infrastructure is quite underdeveloped. Under 20 percent of roads are currently paved, and many roads are in poor condition. Thus public and non-motorized transport are widely used. Some energy strategies of the countries studied suggest plans to expand mass transportation, including trains and buses. However, these initiatives may face some of the challenges experienced by countries trying to improve electricity access, including limited financial capacity and the need to implement policies to satisfy all stakeholders. Meanwhile, natural gas discoveries may open the door to industrial development.

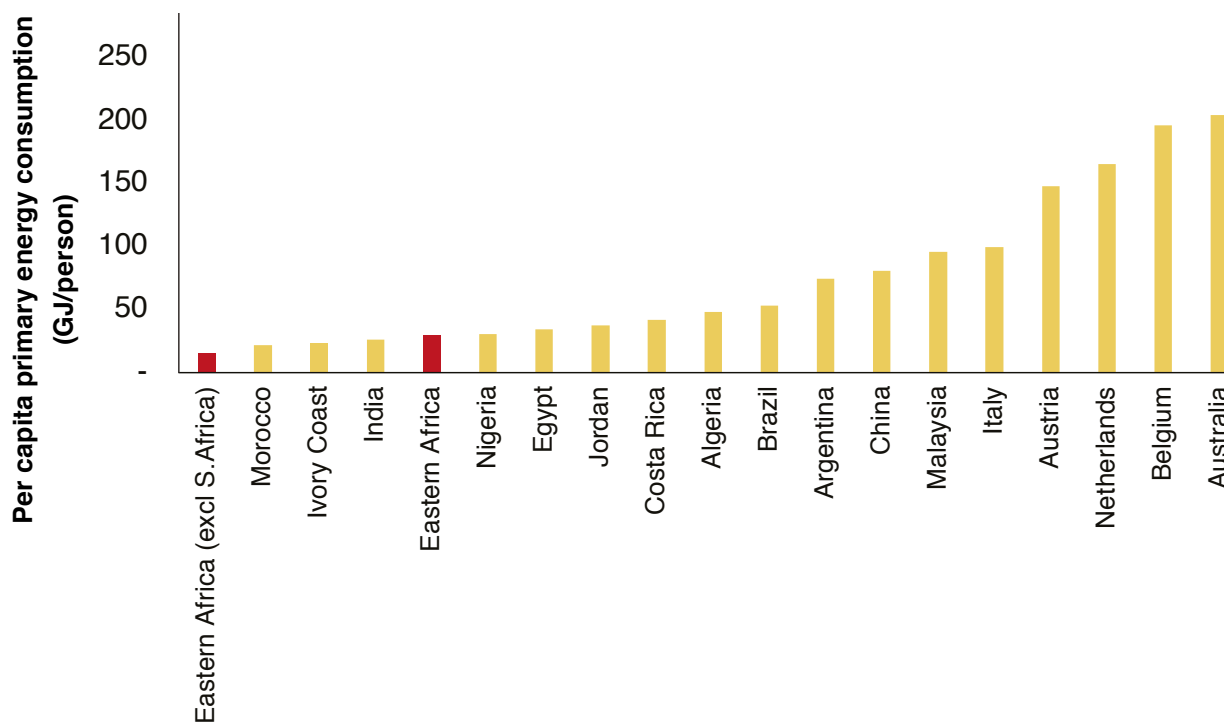
# Eastern Africa's Energy Profile

## A low energy demand dominated by biomass

Like the rest of Africa, Eastern Africa (defined in this paper to include Burundi, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, South Africa, Tanzania, and Uganda), is rich in energy resources, but their development has been lagging (IEA 2014). The region represents 2.9 percent of the world's energy demand and 4.9 percent of the world's population as of 2015 (United Nations 2017). In comparison, North America with about the same population consumes roughly 20 percent of the world's energy demand. Excluding South Africa, the energy picture is even more striking: the eight remaining countries represent 4.2 percent of the global population but only 1.3 percent of energy demand. To put this in perspective, Figure

1 shows how low Eastern Africa's primary energy consumption is compared to individual countries. South Africa's primary energy consumption skews the averages of the rest of Eastern Africa: without South Africa, the remaining eight countries consume less energy on a per capita basis than other countries in the African continent.

Due to population and economic growth in the region, energy demand grew from 7,850 Petajoules (PJ) in 2000 to 11,301 PJ in 2015. Despite what appears to be healthy growth (44 percent over 15 years), it was actually similar to the increase in the world's energy demand (37 percent) and also the region's population growth (44 percent) (United Nations 2017). This means that, on an aggregated basis, there was little progress to improve the energy demand situation in the region. The evolution of energy demand is far from being



**Figure 1.** Comparison of Eastern Africa's energy consumption per capita, 2015.

Source: UN 2015 Energy Balances, World Bank.

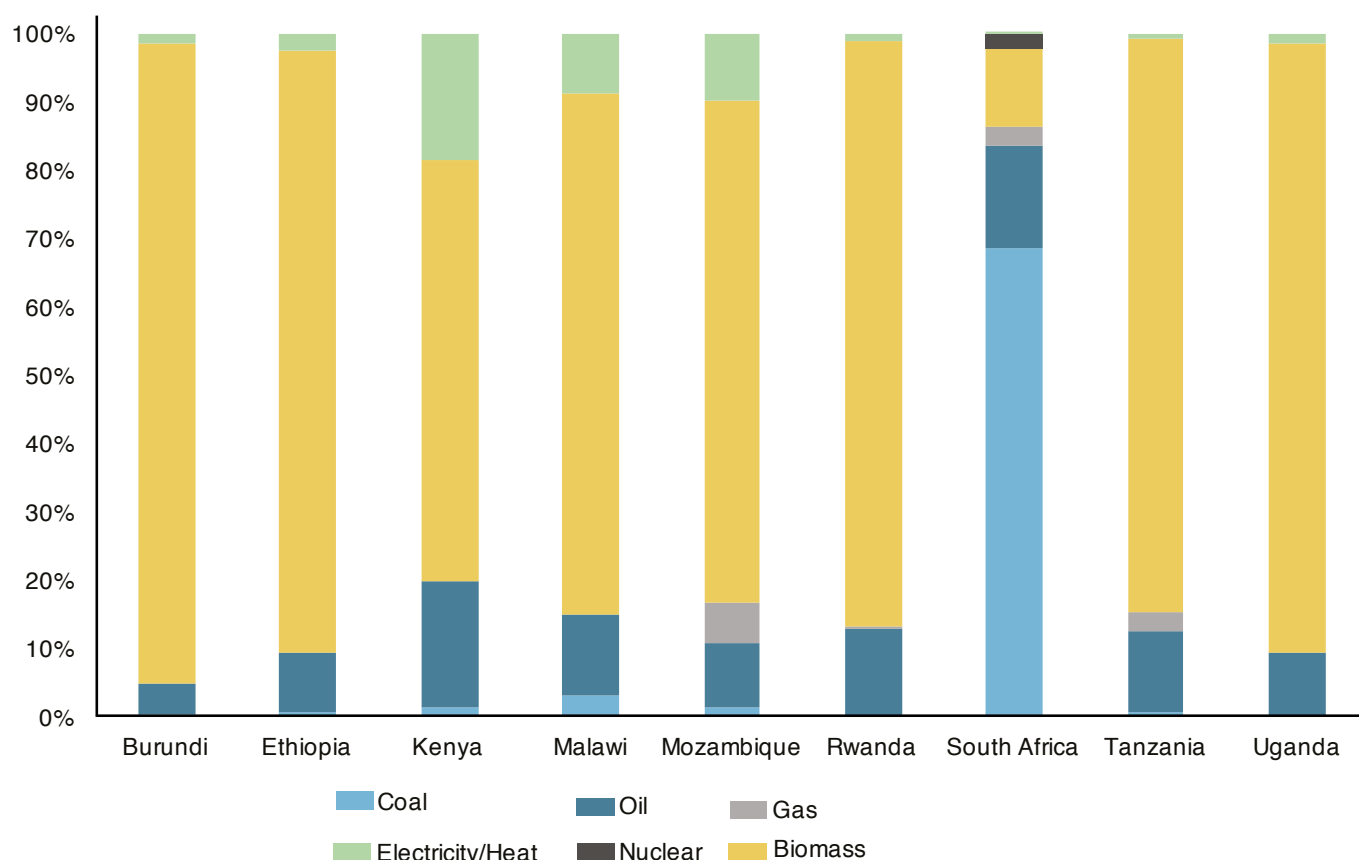
## Eastern Africa's Energy Profile

uniform: while Kenya's demand increased by 134 percent, Burundi's and Malawi's increased by only 13 and 20 percent respectively. Both countries have among the lowest gross national income (GNI) globally, while Kenya has joined South Africa as a middle-income country.

In general, the African continent relies heavily on traditional biomass as a fuel source for primary energy demand. The picture in Eastern Africa is no different (Figure 2). Excluding South Africa, 81 percent of Eastern Africa's primary energy needs were met by traditional biomass in 2015 (United Nations 2017). Traditional biomass consists of fuelwood, charcoal, tree leaves, animal dung and agricultural residues burnt for residential use. It

has a very low efficiency and can cause diseases, notably respiratory issues. Modern biomass offers a more effective technical utilization of biomass resources. South Africa only uses 11 percent of biomass, about half of which is used by households. The transformation and industrial sectors account for the rest of its biomass demand.

Coal comprises almost 70 percent of the primary energy demand in South Africa, and 39 percent of all the energy used in Eastern Africa. The bulk of it is used in the power sector. The rest is used almost equally in industrial and 'others' sectors (including the residential sector). Coal use is limited in other countries. In Mozambique and Malawi, it constitutes up to 1 and 3 percent of their



**Figure 2.** Primary energy demand by country and by source, 2015.

Source: UN 2015 Energy Balances.

primary energy demand, respectively, notably in the industrial sector. This is despite existing coal resources, particularly in Mozambique.

Oil products constitute between 8 and 16 percent of total energy demand among all countries in Eastern Africa. They are mostly used in two sectors: transport and power generation, the latter use costly compared to other alternatives. The industrial sector accounts for 9 percent of all oil consumption. Liquefied petroleum gas (LPG) is seen as a way to improve access to clean cooking among the population, but its use is not widespread. The use of oil products is likely to increase in the future due to the development of oil resources in Uganda and Kenya. A planned refinery in Uganda will supply surrounding countries.

There are only two nuclear power plants in South Africa (Koeberg 1 and 2), representing a capacity of 1.83 gigawatt (GW). The first reactor began operating in 1984, representing 2 percent of South Africa's primary energy demand. Previous electricity plans have considered additional nuclear capacity of 9.6 GW, while the latest integrated energy plan, published in 2016, considers expanding capacity to between 26 and 45 GW by 2050 (South Africa Department of Energy 2016). However, it does acknowledge the increasing difficulties of building and financing nuclear since 2011.

Only Mozambique, Tanzania and South Africa use natural gas; it represents 6 percent, 3 percent and 3 percent of their respective energy mixes. The power generation sector in Mozambique and Tanzania uses natural gas, while South Africa's Sasol uses it for gas-to-liquid (GTL) purposes.

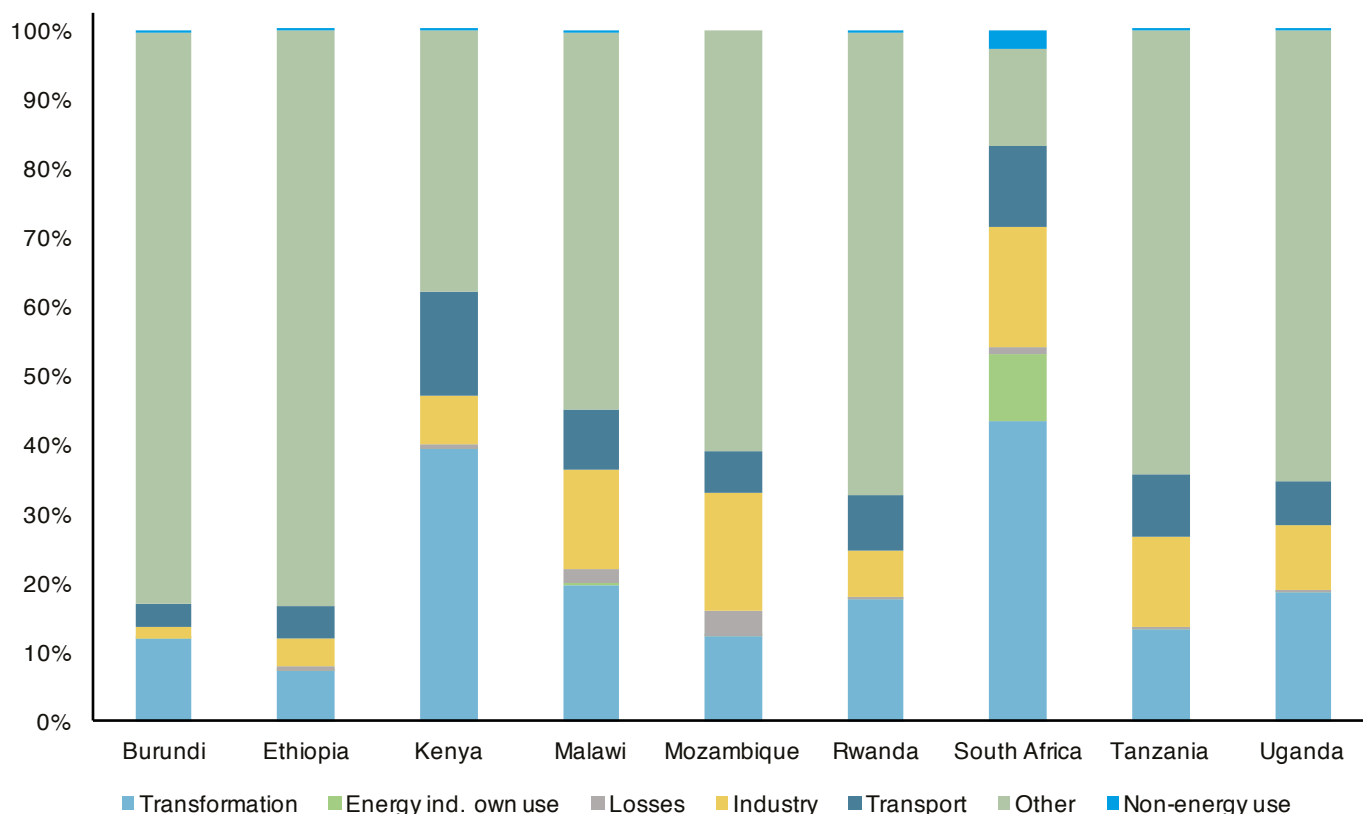
Large portions of the population have no access to electricity or modes of clean cooking and heating (IEA 2017). The largely rural residential sector

(cooking and heating) accounts for, on average, 65 percent of total consumption in Eastern Africa, except South Africa. This demand is met by biomass. Residential demand represents the bulk of the 'other' sector (green bars in Figure 3) which also includes agriculture, commerce and other small nonindustrial users. More than 40 percent of South Africa's energy demand comes from the power generation sector (transformation). By contrast, the industrial sector represents 2 percent of total energy demand in Burundi and 17 percent in Mozambique. The high share of industrial demand in Mozambique is due to facilities such as the Mozal aluminum factory. There is a lot of mining and quarrying in the region (e.g., in South Africa, Malawi and Tanzania), and agricultural activities (tea plantations and agro-processing). Unfortunately, the U.N. does not separate their data on industrial demand into specific industries, making it difficult to track industrial developments.

With the alarmingly high usage of biomass by households, it will take a long time for modern fuels to displace its current usage. The International Energy Agency's (IEA) World Energy Outlook predicts that population growth in sub-Saharan Africa (SSA) will offset the pollution reduction achieved by shifting away from biomass and other polluting household fuels (IEA 2017). Penetration of modern and cleaner fuels such as LPG is an obvious way of moving up the energy ladder, but high costs, access to modern appliances, and problems in the supply chain such as a lack of LPG import terminals, pipelines and paved roads make it difficult for households to switch. Clean cookstoves are an affordable and practical solution: they use biomass efficiently and curb indoor pollution, but their deployment has been slow (Oxfam 2017). Their slow deployment is partly due to more policy attention being focused on electrification than clean cooking.



## Eastern Africa's Energy Profile



**Figure 3.** Sectoral demand by country, 2015.

Source: UN 2015 Energy Balances.

### A power mix dominated by hydro and coal

Total gross electricity consumption in Eastern Africa amounted to 302 terawatt hours (TWh) in 2015, less than Italy's consumption. Of that total, South Africa consumes 250 TWh, leaving 52 TWh to the eight remaining countries (United Nations 2017). To put things in perspective, in 2015 these eight countries, with a total population of 309 million, consumed less electricity than Greece did with its population of less than 11 million. The share of the industrial sector in the final power consumption (manufacturing, construction and non-fuel

industry) of Burundi, Ethiopia, Malawi, Rwanda and Tanzania is lower than 50 percent and stands below 2.9 TWh in each country. Only South Africa and Mozambique have an industrial consumption above 10 TWh, with South Africa's industrial consumption more diversified. In Mozambique, industrial demand accounts for 80 percent of total power consumption (United Nations 2017). Industry is not the only indicator and driver of economic development: Ethiopia, Kenya and Tanzania also have a relatively high level of consumption in the commercial and public services.

Currently, the power mix of Eastern Africa, excluding South Africa, consists of high amounts



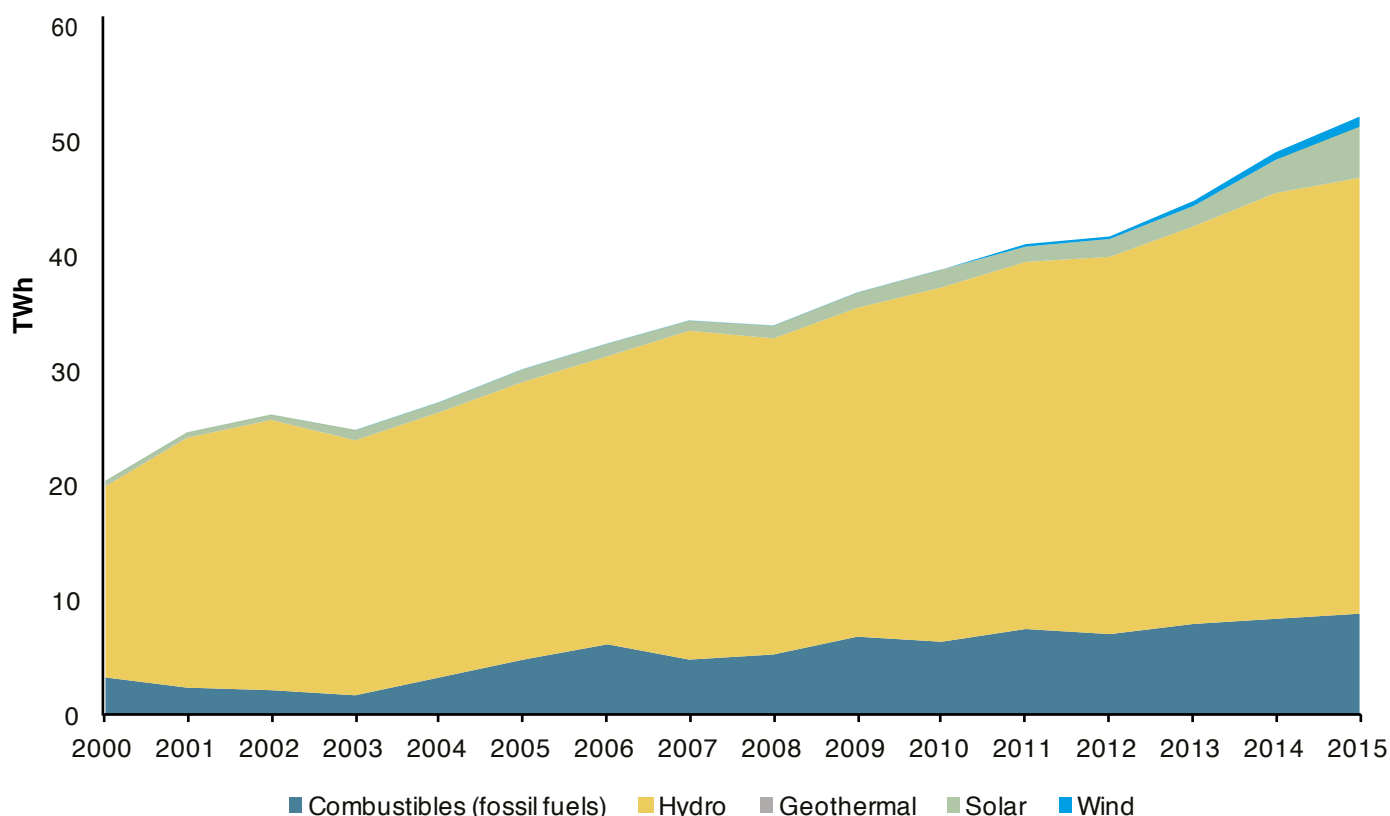
of hydropower as shown in Figure 4. Combustible fuels are increasingly being used. They include natural gas from domestic gas fields such as Songo-Songo and Mnazi Bay in Tanzania, and Pande and Temane in Mozambique, and are also generated from oil products (at times imported) which tend to be costly and more polluting. Geothermal is mostly present in Kenya. Solar and wind are rarely used, despite being significant resources (2.2 and 3.1 TWh respectively). In South Africa, coal was the major source of electricity generation in 2015, accounting for 92 percent of the power mix (IEA 2017).

The high dependency on hydropower presents two problems: large hydro projects have a significant environmental impact and sometimes lead to the

resettlement of the population. Secondly, it makes the power system vulnerable to droughts which can rapidly reduce the amount of electricity available. In 2015, Tanzania suffered from severe droughts, leading to the closure of some of its hydro facilities and reducing its hydro generating capacity from 561 megawatts (MW) to 110 MW (Reuters 2015). This pushed Tanzania to use more fossil fuels, notably gas. Nevertheless, given the hydro potential in the region, many countries are developing hydro projects either individually or multilaterally.

### A wealth of energy resources

The region contains a variety of energy resources, with sizable oil and gas reserves only discovered in the past 15 years, and significant coal resources.



**Figure 4.** Power mix by source in Eastern Africa (excluding South Africa).

Source: KAPSARC, UN Energy Statistics Database.

## Eastern Africa's Energy Profile

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Recent studies have enabled countries in this region to better understand their renewable potential (Africa-EU RECP 2017).

Eastern Africa's largest energy development over the past decade has unarguably been the discovery of large gas and oil resources. Around 188 trillion cubic feet (Tcf) of proved and probable reserves are located in Mozambique and Tanzania. South Africa has an estimated 390 Tcf of technically recoverable shale gas according to the EIA. The Petroleum Agency of South Africa estimates the recoverable resource at 30 Tcf, with between 20 to 30 Tcf of coal-bed methane (South Africa Oil and Gas Alliance 2017). Other gas resources exist in Kenya (Lamu, Anza and offshore), Rwanda (1.9 Tcf in Lake Kivu), and Ethiopia. According to the latest official statistics from the IEA, in 2015 total production was 6.8 billion cubic metres (bcm), all of which was consumed in the region (IEA Natural Gas Information 2017). There are plans to develop these gas resources for liquefied natural gas (LNG) exports and domestic use. Meanwhile, both Uganda and Kenya have discovered significant recoverable oil reserves: 1,092 million barrels in Uganda and 800 million barrels in Kenya. Uganda aims to start production from the Lake Albert discoveries by 2020 and to build a 30,000 barrels per day (bbl/d) refinery to meet its own needs as well as its neighbors'. Currently only Kenya, South Africa and Tanzania have refineries.

Eastern Africa is also a large coal producer thanks to South Africa which holds an estimated 9,893 million tonnes of proven coal reserves and produced around 251 million tonnes in 2016, part of which was exported (BP 2017). About 80 percent of South Africa's coal demand originates from the power sector (United Nations 2017). Mozambique holds an estimated 20 billion tonnes of coal, most of which is

good quality hard coking (metallurgical) coal, largely located in the Tete province, while Tanzania holds 1.9 billion tonnes. There are a few coal-to-power projects in both countries.

The region also has significant renewable potential (see Table 1). All countries plan to use renewables to increase power capacity, improve electricity access and expand rural electrification (Table 1, Appendix 1). There has been a lot of focus on improving data collection and conducting a more thorough assessment of the various energies' potential. Depending on the country, renewable energy expansion is supported by feed-in tariffs, or bidding rounds (such as in South Africa). Hydropower already represents the bulk of renewable electricity output (42 TWh or 81 percent of renewable energy output as of 2015). Hydro plants range from very large projects (several hundreds of MW to several GW), such as those in Mozambique and Ethiopia, down to pico-hydro plants (< 5 kW). The region also has significant solar potential, notably in South Africa. Some countries have started to exploit for grid-connected as well as off-grid solutions. Several countries have good wind locations. South Africa and Ethiopia have made great strides in utilizing these. Kenya, Ethiopia and, to a lesser extent, Tanzania, Rwanda and Uganda also have geothermal potential.

There are also significant biomass resources, but their use has to be carefully monitored. In some countries such as Burundi, the massive use of firewood in residential and industrial applications creates deforestation. Projects could use resources such as residues and waste from dedicated plantations, and residual bagasse from the sugarcane crushing process for use in cogeneration plants, as well as municipal waste. There is interest in developing biomass power, biomass co-firing and biogas which could help reduce deforestation.

**Table 1.** Assessment of renewable energies' resources in Eastern Africa.

	Hydro	Solar	Wind	Geothermal
<b>Burundi</b>	1700 MW (300 MW economically viable)	4-5 kWh/m <sup>2</sup> /day	4-6 m/s – maybe potential in some sites	18 MW on 6 sites
<b>Ethiopia</b>	45 GW	4-6 kWh/m <sup>2</sup> /day	>7 m/s 1350 GW potential	est. <10 GW
<b>Kenya</b>	1500 MW (1310 MW from projects > 30 MW)	4-6 kWh/m <sup>2</sup> /day Photovoltaic potential 23 TWh	9 m/s in the North > 1 GW potential	10 GW
<b>Malawi</b>	2 GW	6 kWh/m <sup>2</sup>	3-10 m/s	4 GW
<b>Mozambique</b>	12-19 GW (1446 sites representing 19 GW)	5-6 kWh/m <sup>2</sup> /day 2.7 GW (599 MW of grid connected potential)	4.5 GW (230 MW high potential)	None reported
<b>Rwanda</b>	300 MW (333 sites)	4-5.4 kWh/m <sup>2</sup> /day 66.8 TWh potential	Limited	170-340 MW
<b>South Africa</b>	247 MW small-scale hydro	4.5-6.5 kWh/m <sup>2</sup> /day Targets: 40 GW of Solar PV and 30 GW of CSP by 2050	3.4 GW contracted by 2022 37.4 GW potential by 2050	None reported
<b>Tanzania</b>	4 GW potential 16 projects (3 GW) identified to start by 2031	4-7 kWh/m <sup>2</sup> /day Grid-tied solar PV potential: 800 MW	>8.9 m/s in Kititimo and Makambako	650 MW (50 sites)
<b>Uganda</b>	Potential estimated between 2 and 4.5 GW. 783 MW currently implemented. Other large-scale sites with a potential 1.5 GW identified. 59 mini sites with a potential of 210 MW.	5-6.8 kWh/m <sup>2</sup> /day	Insufficient	450 MW potential

Source: Africa EU RECP 2017; Think Geoenergy 2010; Ministry of Energy and Mining (Burundi) 2012; Derbew 2013; Malawi Ministry of Energy presentation at JICA International Center 2013.

A biogas plant is already operating in Naivasha (Kenya). The plant's anaerobic digester produces biogas, which is used to produce power (Engineering news 2017). Uganda and South Africa's sugar industries already use residues for heat/electricity production. A national biomass atlas is currently being prepared in South Africa to provide better information on biomass potential (Africa EU RECP 2017).

The abundance of energy resources presents a great opportunity to increase the electrification rates needed to spur economic growth. Until now, most governments in Eastern Africa have found it challenging to utilize many of these resources and turn them into productive investments to accelerate energy access. The next section will establish exactly where these challenges occur and will explore the potential of these resources in both the industrial and transportation sectors.

# Current Energy Challenges for Governments and the Society

## Energy and economic development

The Eastern African countries selected in this study made up about 40 percent of sub-Saharan Africa's real gross domestic product (GDP) in 2016 according to data from the World Bank (2017). South Africa accounts for 67 percent of Eastern Africa's GDP. Its impact on the region's energy picture is significant: its economy, energy demand, and electricity access dwarf the rest of Eastern Africa.

Except for Burundi and more recently South Africa, the growth of real GDP per capita in Eastern Africa since the beginning of the century has been momentous. Tanzania, Mozambique, Rwanda, and Ethiopia have seen significant annual growth in their GDP per capita, averaging between 4 and 6 percent

between 2000 and 2015. Growth in South Africa, Kenya, Malawi, and Uganda has averaged slightly less, at about 2 to 3 percent. Burundi's GDP per capita has seen a minimal growth rate of 1 percent per annum on average over the last 15 years.

Governments in Eastern Africa have focused their attention on economic development and encouraging investment from the private sector, to increase welfare and income per capita. Increasing economic development and improving social welfare is key to alleviating poverty and bringing stability to the region. The economic development goals for each country show a common aim: to reach middle-income status (see Appendix 1). According to the World Bank, a 'middle-income' economy is one that attains gross national income (GNI) of at least \$1,045 per capita per year. Figure 5 shows how each country's GNI

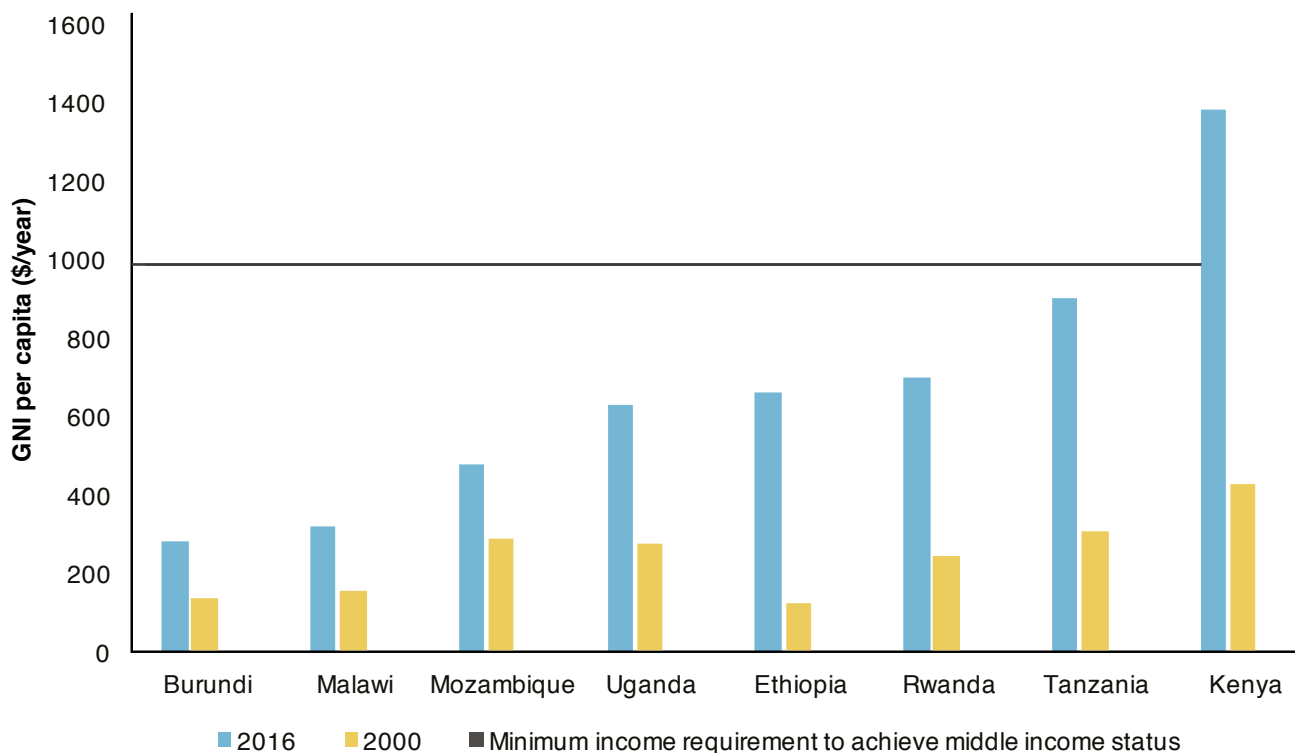


Figure 5. GNI per capita, World Bank Atlas method (nominal currency).

Source: KAPSARC, World Bank.

per capita compared to the World Bank's minimum requirement for middle-income economies. South Africa, which had a GNI of \$5,480/capita in 2016, and Kenya are the only countries so far that have attained middle-income status.

But the speed of economic development in Eastern Africa is tied to the development of the energy sector. Energy access is a pre-requisite for any country undergoing socio-economic development and is usually an instrument mentioned in the 'vision' plans to spur economic growth. To achieve the ambitious goal of transitioning from a low-income country to a middle-income one, all sectors of the economy must have access to affordable and reliable energy. Indeed, economic development and electricity consumption are closely linked. The Overseas Development Institute conducted a review of over 40 studies looking at this link. They found that energy use is either the cause or the facilitator of economic growth (CDC Group 2016). Around three-quarters of the studies surveyed showed a positive correlation between energy use and economic growth, while half show a positive and significant causal link between energy use and economic growth. Appendix 1 contains a further assessment of the 'vision' documents for each country and their strategies for overcoming their energy deficits. Some are more detailed than others and are often complemented by energy strategies, rural electrification plans, gas master plans or renewable development strategies which detail the targets more explicitly. Some goals may nevertheless be ambitious and may not be met within the specified time frame.

What is particularly striking for this group of countries is the importance of electrification. While developing the transport and industrial sectors is crucial, all countries have electrification targets.

The pace of growth of electricity infrastructure will depend on external funding, given the massive investments needed. The regulatory framework must be in place to encourage investment, to ensure ease of business for new entrants, a reasonable tariff structure and guaranteed payment collection methods. The power generating capacity needs to be increased, and the existing transmission and distribution lines that are causing many of the electricity shortages in the region need to be rehabilitated and expanded.

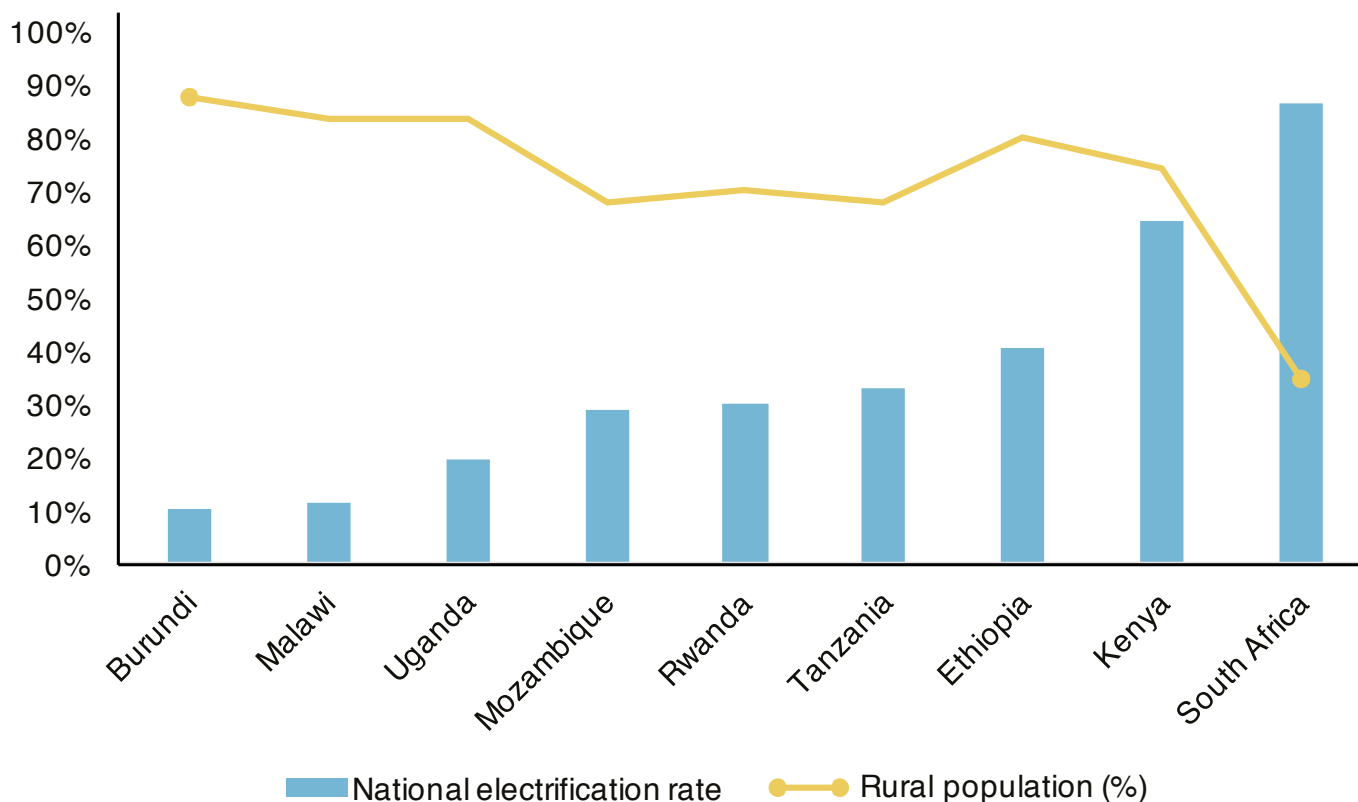
### **Low access to power supplies**

Electricity consumption per capita in the region averages to 512 kWh (125 kWh excluding South Africa). This is considered to be very low access. According to the IEA, as many as 233 million inhabitants do not have access to electricity in Eastern Africa (IEA 2017).

The rural population of Eastern Africa is very high: between 67 to 88 percent in each country (excluding South Africa). Figure 6 shows the relationship between electrification rates and rural population. With a lack of transmission and distribution infrastructure reaching rural dwellings, they have to resort to biomass to fulfill their energy needs. The lack of public and private investment makes the delivery of electricity to the majority of the inhabitants a challenging task. In addition, some of these countries (excluding Burundi and Rwanda) are vast and sparsely populated.

The distances across cities and rural areas have proved a barrier to investment in large conventional forms of energy production (UNEP 2017). The high on-grid distribution costs associated with

## Current Energy Challenges for Governments and the Society



**Figure 6.** Electrification rate and rural population by country (2016).

Source: IEA WEO 2017, World Bank.

connecting remote households in areas of low population density mean that few of these households will be able to afford grid connection. According to a World Bank study, the cost of the connection in all Eastern African countries except South Africa usually ranges from \$76 (Ethiopia) to \$197 (Tanzania, urban pre-paid); the cost in South Africa can be \$0 for some customers (World Bank 2016). Due to the country's economic power and past policies, 85 percent of South Africa's population has access to electricity. One solution to supply electricity to rural areas is to use off-grid generation or micro-grids. Though this is not a new technology, the rapid fall in upfront costs due to advancements in renewable technology, combined with energy-

efficient appliances and LED lighting, has made it an attractive investment and has increased its deployment (MIT Technology Review 2016). Kenya, Tanzania, Uganda, and Rwanda have high potential to expand in this area, given the support of public policy and private investment so far (IRENA 2015).

Limited electricity connectivity could be linked to many factors. Countries with the highest levels of poverty tend to have lower access to modern energy services (World Bank 2017). Low-income households are caught in a vicious circle whereby a lack of monetary resources prevents access to modern energy, and not having access to electricity creates fewer opportunities for income generation.

Figure 7 shows the progress of electrification rates from 2000 to 2014 where some countries lag more than others. In general, electricity access in Eastern Africa (except South Africa) remains lower than the current 35 percent average in continental sub-Saharan Africa. Access to electricity is important but not sufficient to alleviate poverty. Access to clean water, health services, good education and a communication network are also necessary factors (WEO 2002). Access to electricity also needs to trigger employment creation, in services, commercial activities or industries. To achieve 100 percent electrification, an aggressive policy needs to be implemented with the correct institutions and necessary framework. The current growth of

access to electricity in Africa is not keeping up with population growth. There is some progress, however, in Kenya, Malawi, Uganda and Rwanda. These countries have all seen an uptick in electricity access since 2012.

Ambitious targets for national electrification or rural electrification have not always been met (see Table 2). Some near-term targets seem challenging, such as having 70 percent access in Kenya by 2017 (from 36 percent in 2014) or having 70 percent access in Rwanda by 2018 (from 20 percent in 2014). Significant efforts are needed to improve electricity access. Beyond the need for finance from national and international institutions, the capacity

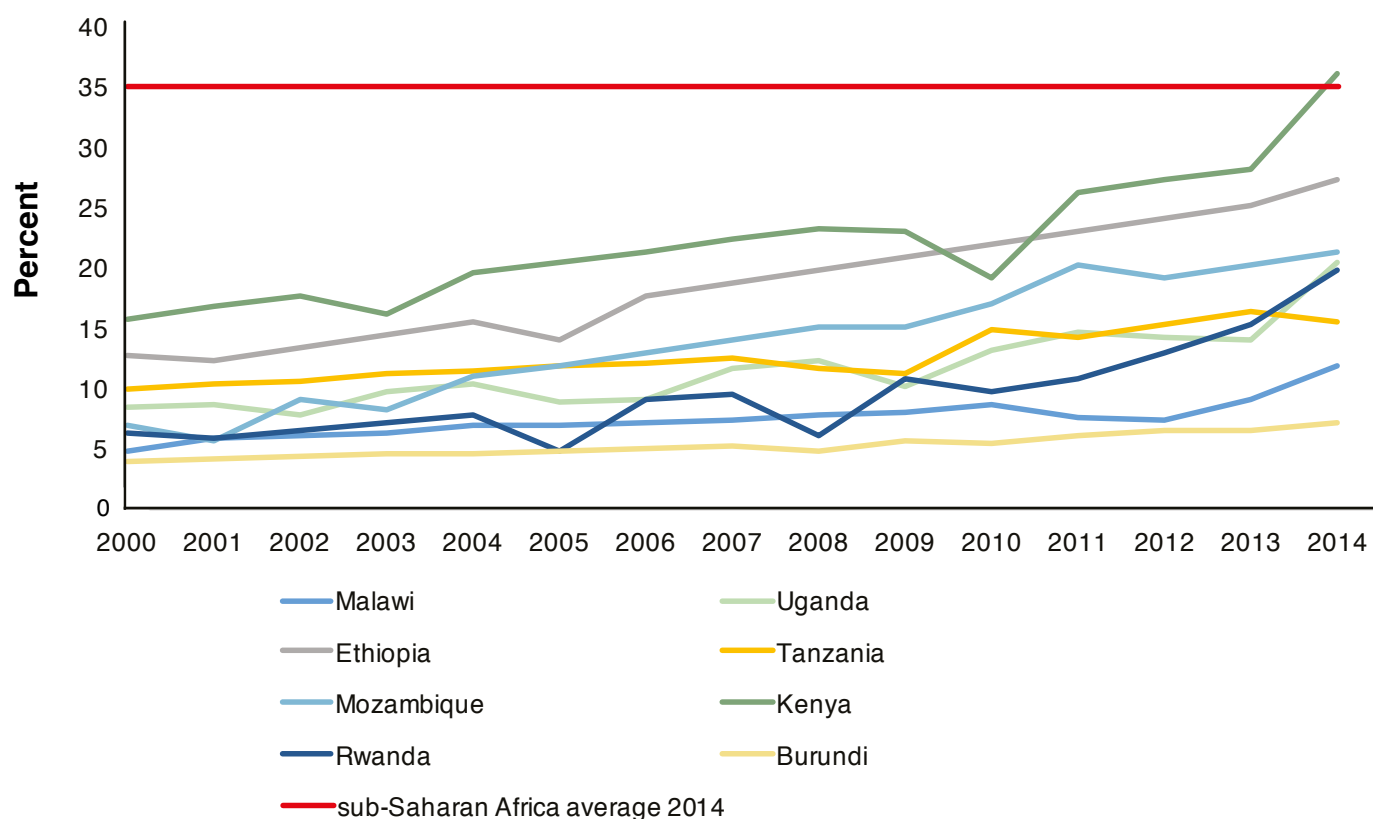


Figure 7. Eastern Africa electricity access by country as a percentage of the population, 2014 (excl. South Africa).

Source: KAPSARC, World Bank.



## Current Energy Challenges for Governments and the Society

**Table 2.** Electrification targets against achievements in selected countries.

	Previous targets	Achievement
<b>Ethiopia</b>	4 million connected by 2014/15. 70 percent coverage	2.31 million connected by 2014/15. 60 percent coverage
<b>Kenya</b>	20 percent of rural population by 2010	12 percent
<b>Tanzania</b>	30 percent in 2015	15.5 (2014), according to the WB, but IEA says 30 percent
<b>Uganda</b>	10 percent rural electrification by 2010	7 percent by 2013

Sources: [http://www.ethiopians.com/Ethiopia\\_GTP\\_2015.pdf](http://www.ethiopians.com/Ethiopia_GTP_2015.pdf); National Planning Commission (Ethiopia) 2016; Ouma (2013); <http://www.rea.or.ug/resources/strategy%20and%20plan%202013-2022.pdf>

to conduct these projects with local workforces or companies is sometimes insufficient; additional training may be needed. Once projects have been built, it is necessary to have a qualified workforce to operate them (National Planning Commission (Ethiopia) 2016). Kenya's Ministry of Energy blamed community interference, the failure to establish industrial parks, and droughts for hampering the achievement of the electrification targets. Land acquisition and compensation are also some of the biggest challenges to building infrastructure (Kebaso 2017).

A slow increase in power capacity, as well as high losses within the system, are one of the key factors resulting in low access to electricity supplies.

### Lagging development of power capacity

Total power capacity in the region amounted to just over 60 GW as of 2016, including 48 GW in South

Africa. Some of the current power infrastructure (at least 22 GW) was put in place during the colonial era (Eastern African countries, excluding Ethiopia, South Africa and Mozambique, gained their independence in the 1960s). Electricity infrastructure, specifically transmission and distribution, was tailored to serve extractive industries and commercial sites. For instance, the Cabora Bassa 2 GW hydropower plant in Mozambique was not intended to be used in Mozambique, but to satisfy South Africa's power needs. As of today, a large part of the electricity produced by this plant (1.3 GW) still goes to South Africa. Moreover, the current infrastructure is also aging and is not suited to handle the growth of the population and the expansion of industrial projects today.

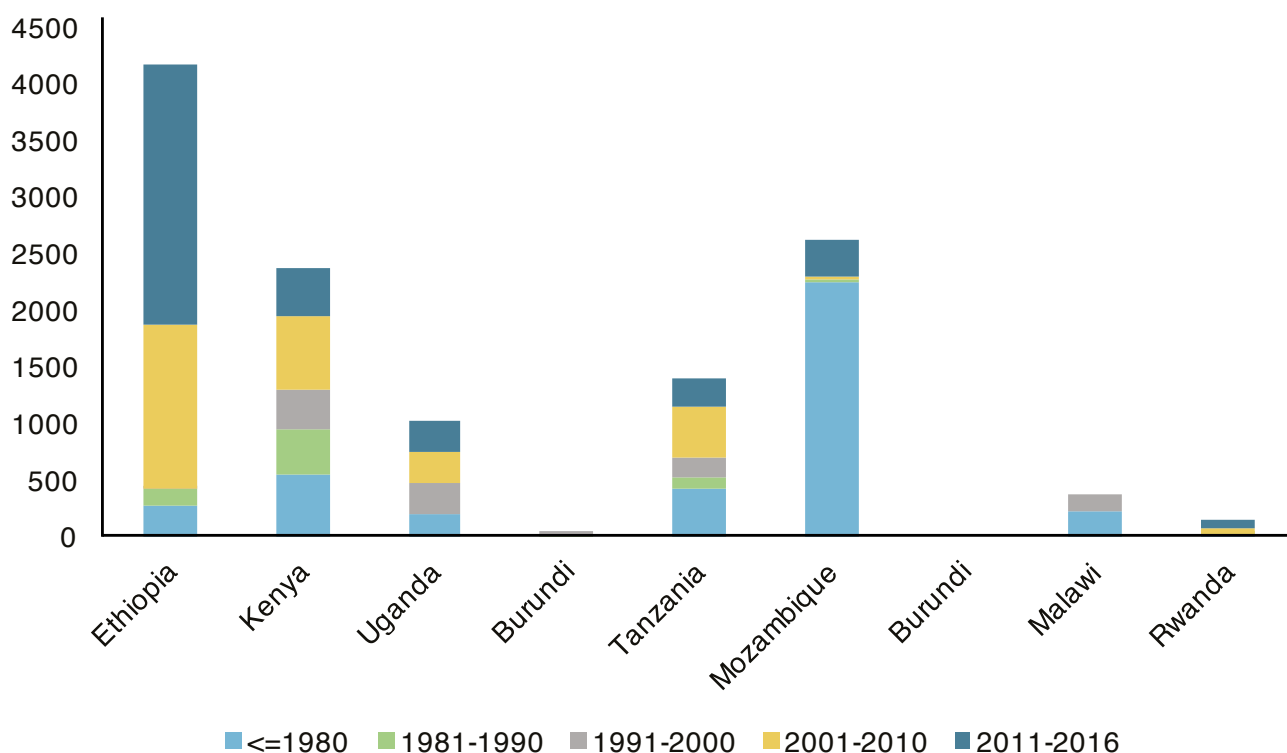
Providing good quality electricity at affordable prices constitutes a major challenge across sub-Saharan countries, and Eastern Africa is no exception. Most of these countries have been run by vertically

integrated state-owned electricity entities, where government allocated budgets constrained the development of electricity infrastructure. Weak institutional implementation capacity and a weak regulatory environment have also limited public and private participation in the electricity sector.

As Figure 8 shows, in the two decades after most countries in Eastern Africa achieved independence (1960-1980), the increase in new generation capacity has been slow. By contrast, since the year 2000 many countries have seen a significant increase in power plant capacities. Importantly, in the past 15 years there has been a higher participation of independent power producers

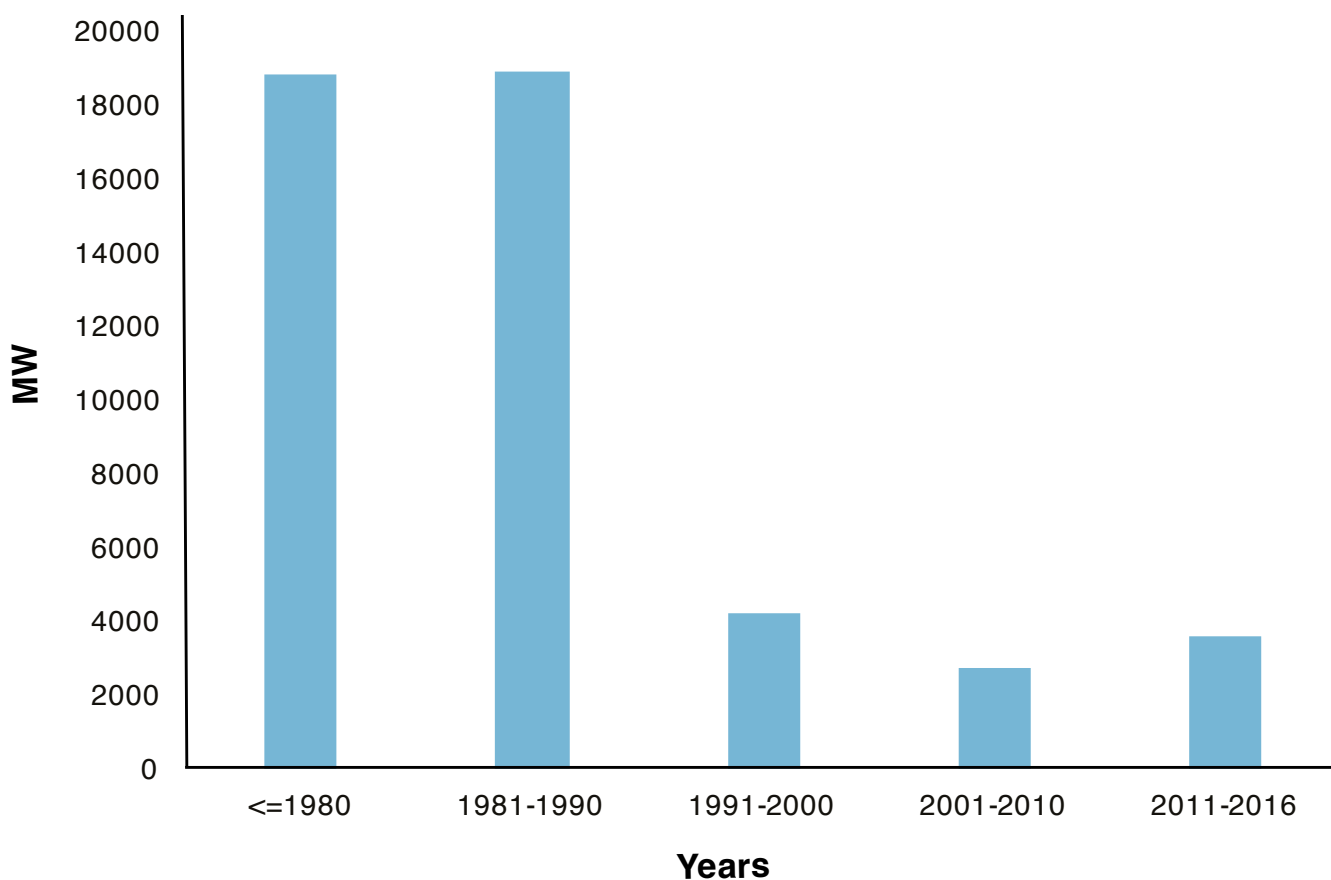
(IPPs). Between 2001 and 2010, as well as 2011 to 2016, almost 25 percent of the power projects that came online were commissioned by an IPP. Such investments were concentrated in Kenya, Rwanda, Tanzania, and Uganda, according to the IHS EDIN database.

As Figure 9 shows, South Africa has not seen a significant uptick in additional capacity compared to previous years. This underinvestment in new power generation and reliance on old power plants has led to blackouts and hampered its economy (WEF 2015). In 2017, however, the South African public electricity utility, Eskom, announced a daily excess capacity of 4,000 MW and is now exporting to



**Figure 8.** Power plant capacity build-out across Eastern Africa (excl. South Africa).

Source: IHS Markit EDIN.



**Figure 9.** Power plant capacity build-out in South Africa.

Source: IHS Markit EDIN.

neighboring countries. But experts suggest that this is the result of a drop in demand, and companies have started to take action by being more energy efficient to counter power shortages (Financial Times 2017).

### Quality and reliability of the power service

Even customers who have access to power are plagued by power outages as cash-strapped utilities struggle to maintain a steady, reliable supply because of a lack of investment in their aging infrastructure. The large distances between generation and consumption and a lack of

transmission line capacity present a major challenge for the electrification of new regions. Many of the regions within Eastern Africa suffer from running blackouts due to underinvestment in infrastructure and a lack of maintenance of existing assets such as distribution lines, transformers and conductors. As shown in Figures 8 and 9, many of the existing power plants built before the 1980s are aging, and may not be sufficient to meet today's growing needs, given the region's substantial population growth and increased industrialization. The network has expanded to meet electrification targets, but as the power capacity remains the same, the quality of supplies and the voltage have diminished for all connected consumers. In Kibera for instance, Kenya's largest slum, it is normal for blackouts

to sometimes last weeks. Kibera is connected to only five transformers, which roughly equates to one transformer for every 20,000 people. In greater Nairobi, the ratio is about one transformer per 1,000 people (Next City 2013).

Some countries did little to renovate and expand the generation, transmission and distribution lines to cope with the demand. In Malawi, for instance, “over 50 percent of the power generation plants have passed their expected lifespans and hence require frequent maintenance in order to improve on efficiency of the machines.” (Taulo, Gondwe and Sebitosi 2015) Besides the aging generation plants, the transmission and distribution networks fall into the same pattern. Aging transmission and distribution infrastructure causes high transmission and distribution losses and makes the power system highly vulnerable. The average age of the transmission infrastructure is around 30 years. The system also experiences termite attacks and rotting wood structures. Other problems include bushfires burning the wooden poles, and even vandalism on both wood and steel tower structures (Taulo,

Gondwe and Sebitosi 2015).

Table 3 shows the reported generation losses for each country in Eastern Africa. These can reach as high as 26 percent. They include technical and non-technical losses, such as theft and illegal connection of electricity. In some cases, thousands of kilometers of cable are robbed and sold as scrap in the black market. In South Africa, according to The Witness newspaper, Eskom loses R400 million (\$37.2 million) a year due to infrastructure vandalism (News24 2014).

Electricity theft and illegal connection have aggravated Eskom’s losses. In 2016 alone, Eskom’s non-technical losses amounted to R4.9 billion (\$370 million), while in 2015 the amount was R4.7 billion (\$368 million) (ESKOM 2016). Similar cases have hit state-owned electricity companies in Uganda, Mozambique and Kenya. As a result, several of the state-owned companies have started nationwide campaigns to raise awareness on the issue with its customers, as well as a widespread meter auditing and investigation that targets areas

**Table 3.** Electricity losses through quality of infrastructure and theft (2015).

Country	Gross generation (GWh)	Losses (GWh)	% of Losses
Burundi	166	NA	NA
Ethiopia	10,437	1,772	17
Kenya	9,515	1,642	17
Malawi	2,103	443	21
Mozambique	19,641	5,080	26
Rwanda	524	121	23
South Africa	249,655	19,895	8
Tanzania	6,295	1,120	18
Uganda	3,473	594	17

Sources: U.N. Statistics Database.

with high levels of energy and revenue losses (ESKOM 2016).

### Revenue collection, tariffs and investment

Contrary to what one might expect, residential electricity tariffs in some Eastern African countries can be high. According to a World Bank study, residential tariffs were above \$0.12/kWh as of 2014 in Kenya, Malawi (postpaid tariffs), Rwanda and Uganda (World Bank 2016). This means that residential power prices in some Eastern African countries are higher than the average residential tariffs in Latin America, Eastern Europe and East Asia. However, some Eastern African countries have very low tariffs, such as Ethiopia (as low as \$0.02/kWh) and Mozambique (\$0.03/kWh). Even high tariffs do not always allow companies to recover their costs, which vary depending on the

countries' generation mix, particularly when they have to use more expensive oil products.

Across the region, utilities are suffering from insufficient revenue collection, preventing them from recovering their costs and threatening their finances and future investments (Reuters 2014; Africa 2014). Table 4 highlights the difference between cash collected and the costs of supplying electricity. Uganda is the only country to have been able to cover the costs of supplying electricity, even though it also reported heavy losses due to electricity theft. All companies face serious challenges in making further investments, due to low revenues that do not cover all costs involved in electricity generation, transmission and distribution. This means that many countries cannot cover both operational costs and investment. It is likely – looking at the level of some commercial losses compared to capital expenditure and operational expenditure (OPEX) –

**Table 4.** Comparison of electricity supply cost versus cash collected, 2014 (US cents/kWh billed).

Country	Operating and capital expenditure	Cash collected	Commercial losses
Ethiopia	17	4	13
Uganda	16	17	0
Rwanda	43	23	20
Burundi	21	7	14
Kenya	22	15	7
Tanzania	17	14	3
Malawi	16	9	7
Mozambique	12	8	4
South Africa	11	6	5

Sources: World Bank Report 2016, Financial Viability of Electricity Sectors in Sub-Saharan Africa Quasi-Fiscal Deficits and Hidden Costs.

that some countries are not even covering OPEX, requiring different degrees of subsidization. Given that electricity tariffs are high in some Eastern African countries and that revenues are low, further tariff increases are likely to be difficult. In other countries, limited but frequent tariff increases may find wider acceptance, as long as electricity access is reliable. Governments' political agendas hamper the real tariffs that would safeguard companies' profitability and guarantee a good and reliable service. Since the companies are government owned, they cannot decide on the level of tariffs independently. As the revenues collected are so low, companies need support from governments to pay for the running costs and further investment.

While some elements of the tariffs are outside the utilities' control, many components can be optimized or improved with increased utility efficiency (The World Bank 2009). Billing and payment collections constitute the major challenge for all electricity companies. The notion that 'public services are for free' have deep roots in some countries. In South Africa, after decades of energy deprivation during apartheid, the African National Congress (ANC) decided to give 50 kWh/month for free to its citizens (Makonese, Kimemia and Annegarn 2006). However, citizens now use more than that while still not paying. This expectation of free electricity has started to burden Eskom with more than R3.6 billion (\$327 million) of unpaid electricity bills (Reuters 2014).

Another issue comes from how revenues are collected. Staff go from door to door to collect payments from households and have very little means of transportation and communication. The scale of illegal household connections constitutes another hurdle for the companies to overcome to collect the correct revenues.

Pre-paid meters (discussed later) have been a successful solution for utilities to recover some costs and for consumers to manage consumption. But non-technical issues are hampering profitability and the drive for electrification.

### **Transport sector growth faces hurdles**

While access to electricity is a priority for many governments, transport (and infrastructure development in general) is a significant challenge; one that goes beyond the energy sector. Africa's road infrastructure is underdeveloped. Under 20 percent of roads are currently paved, and many are in poor condition due to a lack of maintenance (AfDB 2011). For example, Kenya's road network covers around 161,000 km, but only 14,000 km is paved (Business Sweden in Nairobi 2017). Public and non-motorized transport (walking) are the most widely used modes of transport in Africa, notably in cities. Poor infrastructure is an obstacle in many Eastern African countries, except South Africa, and its negative economic implications include increasing the price of goods. For example, expenditure on transport in Kenya averages 45 percent of the total cost of goods, making commodities produced in the region uncompetitive (Business Sweden in Nairobi 2017). Similarly, the reduction of Malawi's high transport costs is one of the key objectives of its transport policy.

Transport represents about 10 percent of the region's total energy consumption, with South Africa accounting for almost 70 percent of this. Most of the energy used in transport is imported oil products (gasoline and diesel). South Africa uses some electricity and Mozambique uses tiny amounts of gas. The bulk of the consumption appears to be in road transport. Only South



## Current Energy Challenges for Governments and the Society

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Africa seems to have non-negligible consumption in aviation, waterways and railroads, but this may be due to poor statistics. All countries have airports. Addis Ababa is even a major aviation hub, being the fourth busiest African airport behind Johannesburg, Cape Town and Cairo. Aviation consumption is only 7 percent of South Africa's use (United Nations 2017).

Due to the growing share of the urban population coupled with the tremendous population increase, the size of many African cities is set to expand rapidly. According to the African Development Bank (AfdB), the continent's urban dwellers will increase from 40 percent in 2010 to 50 percent by 2030 and 65 percent by 2060 (AfDB 2011). Cairo, Kinshasa and Lagos were the only megacities in Africa in 2014 (above 10 million), but three more are expected to emerge by 2030: Dar es Salaam (Tanzania), Johannesburg (South Africa), and Luanda (Angola). Cities like Addis Ababa are expected to exceed 5 million by 2030.

Adequate expansion of the transport infrastructure is needed to avoid worsening heavy traffic situations that already exist in some major cities. There are plans to create or enhance public transport infrastructure in some cities, and in some cases to expand that regionally, such as connecting Burundi and Rwanda to the railway system in Uganda and Tanzania using electricity from the Rusumo Falls project (Ministry of Energy and Mining (Burundi) 2012). This is important as Burundi, Malawi, Uganda and Rwanda are landlocked and depend on transit through other countries to receive some goods. For example, neighboring landlocked countries utilize Kenya's road network as it is the transportation gateway for goods from Mombasa port. Another important development is the Lamu Port and South Sudan Ethiopia Transport (LAPSSSET) project. This will

result in an abundance of cross-sector opportunities in the construction of rail, roads, airport, housing and utility infrastructure.

Analyzing the energy strategies of Eastern African countries from the transport sector's perspective, a few items stand out:

Ethiopia and Tanzania consider the dependency on petroleum-driven vehicles a problematic issue. These countries aim to reduce the share of petroleum-dependent transportation (Ethiopia Ministry of Water and Energy 2012; Tanzania Ministry of Energy and Minerals 2015).

Ethiopia and Tanzania are prioritizing the development of mass transportation and establishing a system for electric trains, trams and buses for freight and passenger transport over long corridors and for mass urban transit.

The need to diversify their modes of transport. While continuing with the improvement of the road network, Malawi seeks to focus on rail and water transport infrastructure, including the Nsanje World Inland Port. Meanwhile, Uganda plans to have a substantial railway system with high-speed trains for passenger transport and cargo freights (Uganda National Planning Authority 2012). This will link Uganda to the sea through Mombasa, Dar-es-Salaam, Djibouti and Tanga ports.

Ensuring reliable supplies of petroleum. Rwanda, for example, envisages the extension of a refined products pipeline to Kigali (Ministry of Infrastructure 2017).

Diversification away from oil. Some countries such as Ethiopia, Kenya, Mozambique, and Tanzania are considering the use of compressed natural gas or electricity (Ministry of Energy and Petroleum (Kenya) 2015).



Encouraging fuel efficiency in transportation by, for example, promoting fuel-efficient vehicle fleets in Ethiopia, Kenya and Tanzania.

The number of registered vehicles in the region remains low (see Table 5). The United States, by contrast, has almost 850 vehicles per 1000 people. There is the potential for the number of vehicles to increase, notably for public transportation in the cities.

Very few detailed forecasts exist for fuel demand from transport for each country. South Africa’s Department of Energy has analyzed the potential evolution of fuel demand in the transport sector between 2015 and 2050 (South Africa DoE 2016). In South Africa, the dominant fuel for transportation is currently petrol (gasoline), capturing about 52 percent share in the transport sector. This is followed by diesel (36 percent), jet fuel (10 percent), and electricity (2 percent), mainly used in rail transport (South Africa DoE 2016). The Department

of Energy predicts that petrol and diesel vehicles will continue to capture the largest share of the transportation sector, but degrees of consumption will vary given efficiency gains in passenger vehicles and according to the different scenarios of the government’s environmental policies. Meanwhile, electric vehicles will account for about a one percent share in the private passenger fleet after 2040.

### Industrial sector potential with scaling up energy access

Many economies of the region continue to be largely agricultural and foresee this sector remaining a key contributor to their economies. Meanwhile, they also see industry playing a key role as economies transition toward middle-income status and have developed national industry policies which highlight the specific subsectors they wish to develop. Many subsectors are related to the agro-industry and mineral sectors, due to the important role of

**Table 5.** Number of registered vehicles.

Country	Number of registered vehicles	Year	Number of vehicles per 1000 inhabitants
Burundi	n/a	n/a	n/a
Ethiopia	478,244	2012-13	5
Kenya	2,011,972	2013	46
Malawi	437,416	2014	26
Mozambique	542,336	2013	20
Rwanda	107,411	2012	10
South Africa	9,909,923	2013	186
Tanzania	1,509,786	2014	29
Uganda	1,228,425	2013	34

Sources: <http://apps.who.int/gho/data/node.main.A995>, U.N. population.

## Current Energy Challenges for Governments and the Society

agriculture and the mineral resources present in the region. Natural gas discoveries have also opened up possibilities for GTL, fertilizer production and methanol (see Table 6). These developments create additional energy demand and, as such, industry needs are often considered in energy policy. For example, Rwanda's ambitious plans to grow various industrial sectors, seen in Table 7, will call for higher power capacity requirements to support these industrial activities.

Energy use in the industrial sector represents about 14 percent of the total consumption in the region.

South Africa represents an overwhelming 75 percent of the region's energy use in this sector, while the sector accounts for 17 percent of its total energy use. The share of energy use in the industrial sector within Eastern Africa varies between 2 percent (Burundi) and 18 percent (South Africa) — see Figure 3 for country details. In Eastern Africa, energy used in industry consists of electricity (32 percent), coal (29 percent), and biomass (23 percent), with little use of oil products (10 percent) and gas (5 percent). Taking out South Africa, the mix is largely dominated by biomass (57 percent) followed by electricity and oil (17 and 16 percent respectively) (United Nations

**Table 6.** Industrial sector priorities.

Country	Industrial sector priorities
<b>Burundi</b>	Nickel mines, tea production.
<b>Ethiopia</b>	Agro-processing industries, textile and garment, leather and leather products industries, sugar and related industry, chemical industries, pharmaceutical industries, metal and engineering industries.
<b>Kenya</b>	Agro-processing, textile and clothing, leather and leather products, iron and steel, machine tools and spares, agro-machinery and pharmaceuticals.
<b>Malawi</b>	Oilseeds products; sugarcane and sugarcane products; and manufacturing sector which includes subsectors like beverages, agro-processing, plastics and packaging, and assembly.
<b>Mozambique</b>	GTL, fertilizer.
<b>Rwanda</b>	Mining, special economic zones, tea factories and irrigation.
<b>South Africa</b>	Mining and quarrying, chemicals, iron and steel, non-ferrous metals, construction, non-metallic, minerals, pulp and paper, food and tobacco.
<b>Tanzania</b>	Fertilizer and chemicals industry, agro-processing (edible oil, cashew nuts, fruits, milk and dairy products), textile industry subsector, leather and leather goods industry, light industry manufacturing, and iron and steel industry.
<b>Uganda</b>	Phosphate industry in Tororo, limestone in Karamoja, iron ore industry in Muko, Kabale mining industry.

Sources: <http://www.ipdc.gov.et/index.php/en/investment-opportunitiesmm/priority-sectors>; Ministry of Energy and Mining (Burundi) 2012; Uganda National Planning Authority 2012  
[http://www.tzdpdpg.or.tz/fileadmin/\\_migrated/content\\_uploads/IIDS\\_Main\\_Report.pdf](http://www.tzdpdpg.or.tz/fileadmin/_migrated/content_uploads/IIDS_Main_Report.pdf)  
<http://www.moit.gov.mw/downloads/quick/National%20Industrial%20Policy.pdf>  
<http://www.industrialization.go.ke/index.php/projects/124-the-national-industrialization-policy>

**Table 7.** Electricity demand for industrial and large commercial users.

MW peak demand	2013	2018 (projected)
Cement	15.0	15.0
Steel	10.0	26.0
Industrial park		32.0
Large commercial		22.5
Mines		55.2
Irrigation	1.6	25.0
Tea		54.6
<b>Total MW</b>	<b>26.6</b>	<b>230.3</b>

Sources: SE4ALL Rwanda 2014, [http://www.se4all.org/sites/default/files/Rwanda\\_RAGA\\_EN\\_Released.pdf](http://www.se4all.org/sites/default/files/Rwanda_RAGA_EN_Released.pdf)

2017). U.N. statistics are often imprecise regarding which industrial subsectors consume energy, but sectors mentioned include non-metallic minerals, non-ferrous metals, food and tobacco, iron and steel, mining and quarrying.

A few themes stand out among the different energy strategies in the region:

- The need to improve the efficiency of machinery and processes.

- The need to provide adequate energy for industrial zones.

- The reliability, pricing, distribution and efficiency of energy supplies (power or oil products).

- Countries with identified gas resources have already developed some potential scenarios for industrialization including GTL, fertilizer, methanol, and dimethyl ether.

# Looking Forward: Where Are Countries' Energy Strategies Heading?

The energy strategies of the nine Eastern African countries are widely different. Some countries do not have a complete energy strategy – Burundi has not developed much besides their water and electricity law (Law No. I/014 2000). Others have a national energy strategy complemented by a series of legislative acts covering different sectors such as electricity, and petroleum. For example, Kenya's National Energy and Petroleum Policy are complemented by a number of bills and regulations on petroleum — such as the Petroleum (Exploration, Development and Production) Bill (2015) — as well as plans for the electricity sector (Last Mile Connectivity Project, Least Cost Power Development Plan). Electricity is a major part of Eastern African energy strategies, including transforming and unbundling the electricity sector to allow private players to participate. However, these energy strategies do not focus solely on the electricity sector. Countries endowed with oil and gas resources have developed plans on how to best use these resources to benefit their economies.

Tanzania, Mozambique and South Africa have natural gas master plans, which look at the power, industrial and transport sectors. Strategies for renewable developments are also a major part of the energy strategies.

## Improving access to electricity

As mentioned earlier, except for South Africa, improving access to electricity is crucial for all Eastern African countries. South Africa's recent National Energy Act (2008) focuses more on energy security issues, energy efficiency and investments in renewables. Rural electrification plans or legislative acts and funds are present in Ethiopia (Rural Electrification Fund), Kenya, Malawi, Rwanda, Tanzania (Rural Energy Agency) and Uganda. All countries have set electrification targets to meet by a specific year. These electrification targets are usually ambitious and not always reached. Table 8 compares the current electricity access rates for each country

**Table 8.** National electrification targets against current electricity access rates 2014 (in percent).

Country	Access rate (2014)	Objectives (year)
Burundi	7	25 (2025)
Ethiopia	27.2	90 (2020)
Kenya	36	100 (2020)
Malawi	11.9	30 (2020)
Mozambique	21.22	100 (2025)
Rwanda	19.8	70 (2018)
South Africa	86	100 (2025)
Tanzania	15.5	30 (2015), 50 (2025), 75 (2033)
Uganda	20.4	26 (2022) rural areas; 80 (2040)

Sources: The Energy Access Target Tracker database, [www.powerforall.org](http://www.powerforall.org); access rates from the WB; [https://www.afdb.org/fileadmin/uploads/afdb/Documents/Boards-Documents/Uganda-\\_AR-\\_Uganda\\_Rural\\_Electricity\\_Access\\_Project\\_-\\_09\\_2015.pdf](https://www.afdb.org/fileadmin/uploads/afdb/Documents/Boards-Documents/Uganda-_AR-_Uganda_Rural_Electricity_Access_Project_-_09_2015.pdf)

and the access rate objectives they aim to achieve by a certain date. These dates usually correspond with the timetables for their broader economic visions.

Rwanda's targets have been continuously revised up over time, until the last revision. Vision 2020 and the Economic Development and Poverty Reduction Strategy (EDPRS) of 2009-2012 planned to increase electricity access to 40 percent by 2025. The new cabinet, formed in October 2010, decided to accelerate this goal to 50 percent by 2017. This target was pushed up further to 70 percent by 2017 in the Leadership Forum of February 2012 and was finally revised in 2016 to 70 percent by 2018. There has been significant progress towards meeting this target: the share of the population with access to electricity increased from 4 percent in 2008 to 16 percent in 2012 and 24.5 percent as of mid-2016. However, reaching the target remains challenging. There was also a target to provide all schools, hospitals and public sector offices with access to electricity by 2017.

Giving electricity access to the poorest seems a daunting challenge. But there are examples of how new approaches can help overcome difficulties. One recent example is how the Kenya Power and Lighting Company (KPLC), with support from the World Bank, is working to increase legal connections in poor areas, including the Kibera slum. While the program struggled to take off in the initial period, with only 5,000 connections in 2014, they counted 150,000 a year later. KPLC changed its business process: instead of taking down illegal connections, it listened to community leaders and marketed the benefits of legal connections. It collaborated with the Kenya Informal Settlements Improvement Project (supported by the World Bank). The World Bank provided funding to KPLC

for each legal connection – reducing the cost of electricity, using the 'last mile' approach and ensuring electricity was available to households. Consequently, using power legally became less expensive for consumers than the illegal lines (World Bank 2015). In mid-2016, KPLC reported that 60 percent of Kibera was connected. The ability to increase electrification is not only dependent on financial and resource availability. Implementing innovative policies and a strategic framework can speed up this process.

### Adding new capacity

Many Eastern African countries have power capacity targets that are in line with their government's agendas and economic development goals. Tanzania, Ethiopia, Kenya, Uganda and South Africa have detailed the power mix they would like to attain by a specific date, as detailed in Table 9.

Many countries plan to use their existing resources to increase power capacity (see Appendix 1 for each country's plan and Table 1 for renewable energy potential). All countries are increasing their hydroelectric power capacity sizably, reflecting its lower variable cost compared to other fuels. This is despite its inherently high capital and environmental costs. The planned additions also include other renewables such as solar and wind. Some Eastern African countries plan to replicate the success of Kenya by utilizing geothermal energy from the Eastern African Rift. Geothermal capacity has contributed to the Kenyan energy mix since the 185 MW Olkaria plant was commissioned in 1981. This plant has since added three more units, boosting the capacity to 540 MW by 2014. South Africa has also committed to adding wind and solar under the Initial Resource Plan (IRP)

## Looking Forward: Where Are Countries' Energy Strategies Heading?

**Table 9.** Planned capacity additions announced by country (MW).

Country	Existing capacity (2016)	Goal	Hydro	Wind	Solar	Geothermal	Coal	Gas	Biomass and waste	Nuclear	Other
<b>Tanzania</b>	1,380	10,000 (by 2025)	1,529	200	100	200	2,900	3,968			
<b>Ethiopia</b>	4,166	17,208 (by 2020)	13,817	1,224	200	577		509	781		
<b>Kenya</b>	2,356	5,000 (2017)	799.52	25.67	0.2	624					760
<b>Uganda</b>	1,027	41,738 (by 2040)	4,500		5,000	1,500			1,700	24,000	4,300 (thermal capacity, did not specify coal/gas/oil)
<b>South Africa</b>	48,040	Additional 42,539 by 2030	2,609 (import)	8,400	9,400		6,250	6,280		9,600	

Source: Tanzania Ministry of Energy and Minerals: <http://www.gst.go.tz/images/TANZANIA%20ELECTRICITY%20SUPPLY%20INDUSTRY%20REFORM%20STRATEGY%20&%20ROADMAP.pdf>

Kenya Vision 2030: <http://www.vision2030.go.ke/493/progress-2016-march-energy-generation-distribution/>

Ethiopia GTP II 2015/16-2019/20

Uganda Vision 2040 <http://npa.ug/wp-content/themes/npatheme/documents/vision2040.pdf>

South Africa IRP 2011

Note: Addition of current capacity and new plant capacity may not add exactly to the goal since current capacity date is not aligned with the drafting of the policies.

2010-2030, finalized and approved in 2011. Thermal power from coal and natural gas remains to have a significant share in the future power mix. Two updates were made to the IRP in 2013 and 2016 by the Department of Energy for public comment. They called for an upward revision of renewables and gas in the energy mix by 2050 and delaying nuclear addition beyond 2030. These

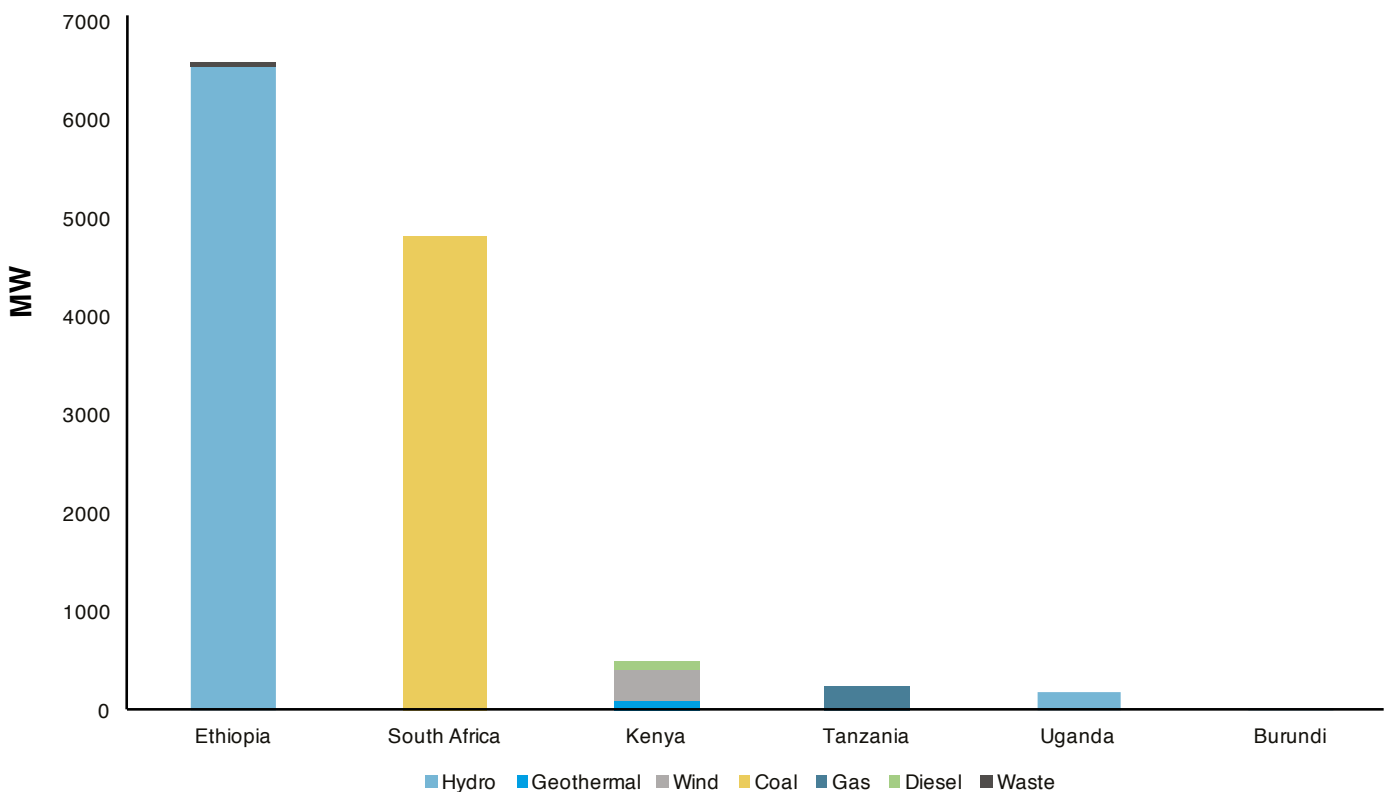
changes are still under review and have not yet received official approval from the Department of Energy (CSIR 2017; South Africa DoE 2016).

While these plans are ambitious and are a step in the right direction, it is important to analyze what is taking place on the ground currently in terms of increasing electricity access and meeting energy

demand growth goals. Figure 10 shows the electric power capacity currently under construction, indicating that the planned rollout of capacity additions are lagging compared to the timetables set for the targets.

Ethiopia and South Africa have started building large-scale power plants, which should significantly add to their power supply. The other countries have not been as active in building their planned capacity, which might result in them falling short of their targets. Ethiopia is currently expanding its hydroelectric capacity, notably with the construction of the Grand Ethiopian Renaissance Dam, which will house a 6,000 MW power plant, the largest in Africa.

South Africa has started construction on its 4,800 MW Kusile coal power plant, which will be the fourth largest coal power plant in the world. Uganda has one of the most ambitious power capacity addition plans, with a target of almost 42 GW by 2040, starting from a low base of just over 1 GW. As yet, only one hydropower plant (Isimba 183 MW) is under construction in Uganda. Tanzania may not reach its goal by 2025 due to financial disputes between Tanzania Electric Supply Company and one of Tanzania's IPPs, which may discourage future investment in the power sector (Reuters 2017). Implementing electrification plans hinge on investments from IPPs and financial support from international lenders. Governments and



**Figure 10.** Electric power capacity under construction in Eastern Africa 2017-2023.

Source: IHS Markit EDIN.



local regulators must have assurances in place to guarantee the implementation of policies and a sustainable return on investment.

### **Prepaid electricity: A solution for utilities' profitability**

Prepaid electricity has proven to be economically and technically the best solution to electricity billing and revenue collection and to counter unpaid bills. Similar to the coin gas meters in the United Kingdom before World War II, prepaid electricity allows customers to budget for their electricity use on a pay-as-you-go basis. This was made easier after the 1980s with the introduction of electronic pre-paid metering, making recharging easier and providing an instant reconnection. Prepaid metering also eliminates the high connection fees charged by utilities.

All state-owned electricity companies in Eastern Africa have set ambitious goals phasing in prepaid meters, and some, such as Ethiopia, have gone as far as planning to replace all existing postpaid meters and even shifting to smart meters (Capital 2012).

The Electricity Supply Corporation of Malawi pledged to replace all postpaid meters with prepaid ones by the end of 2016 (MBC 2016). Today, Electricidade de Moçambique claims to have about 1.2 million customers across the country (86 percent of its customers) covered by its prepaid metering system, CREDELEC (EDM 2017). Umeme, Uganda's largest energy distributor, wants its customers to use its new prepaid meters by 2018 (Daily Monitor 2014). KPLC ended its 2016 fiscal year with 2.3 million prepaid customers: 47 percent of its customer base (Standard Digital 2017).

Installing prepaid meters would potentially improve utility revenues by guaranteeing the flow of payment from consumers, increasing the ease of installation, and eliminating disconnection and connection costs and bad debts (Metering & Smart Energy International 1999). However, a migration toward prepaid metering systems implies a different business model than what utilities have traditionally been used to. This will change consumer behavior, how revenue collection is managed, and necessitate new IT procedures. But, most importantly, it gives the customer total control and responsibility for the way they use electricity.

# Conclusions

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**E**astern Africa is abundant in natural resources that have the potential to improve energy accessibility to its population and provide a pathway toward higher economic and social development. Eastern Africa's low energy access stems mainly from inefficient fiscal frameworks for energy resource extraction and the inability of national public entities to move forward with their plans. There is also a negative correlation between rural populations and access rates. Given the high rural population of these countries, except for South Africa, more policy attention has to be directed towards providing energy access to rural populations.

Access to electricity is at the forefront of energy access challenges. While governments of the nine countries studied have targets in place to increase electrification rates, various factors ranging from a lack of finance, inadequate tariff rates, insufficient payment collection methods and electricity theft have hindered the rollout of these plans. Policy attention aimed at revamping tariff structures is of the utmost importance, as most state utilities are operating at a commercial loss while IPPs need a proper business environment as well as holistic policy measures to enforce laws and regulations regarding payments. A happy medium needs to be struck between offering affordable electricity tariffs to consumers and profits for state utilities or IPPs, to generate a positive cycle of investment that results in the improvement and expansion of electricity networks. Providing prepaid electricity meters improves revenues for utilities and is a milestone in electricity provision to residential users. Eastern African governments are committed to the widespread installation of these meters in their respective countries.

Eastern Africa does have the potential to increase the use of modern renewables such as solar and

wind. As technology costs decline and off-grid solutions compliment on-grid expansions, the advantages of renewable energy in the region are apparent. Many countries in Eastern Africa have already taken major steps toward decentralized energy using renewable energy. The IEA is optimistic about the prospects of parts of the Eastern Africa region (the IEA's definition of Eastern Africa in the World Energy Outlook differs from this report but includes Burundi, Ethiopia, Kenya, Rwanda, and Uganda). It projects Eastern Africa to have one of the fastest growth in electrification levels in SSA, driven particularly by Kenya and Ethiopia as a result of government initiatives, private-public partnerships and international support (IEA 2017).

While increasing electricity access to residential households can benefit human welfare in the region, improvements in economic growth and development hinges on energy access for the industrial sector. Eastern African industrial development priorities range from agro-processing to mining and petrochemicals. Most of these industrial development options can lead to the expansion of the manufacturing base, increased employment, and increased investment and income generation throughout the value chain. Thus, Eastern African governments need to link industrial policies with energy access policies to spur economic growth and get the largest multiplier effect. The challenges in the transport sector lie with inadequate infrastructure. Some countries in Eastern Africa have plans to increase their modes of transport, including mass transportation. The growing population and urbanization rates call for development policies that would improve the quality of roads and expand infrastructure to meet the growing need.

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# Appendix 1

**Table 10.** Summary of vision goals and role of energy.

Country	National vision	Vision objective	Energy goal
<b>Tanzania</b>	Vision 2025	To become an industrialized, middle-income country. Increase income per capita to at least \$3000 by 2025.	<p>The draft National Energy Policy 2015</p> <ul style="list-style-type: none"> <li>• Increase the connectivity level to 30 percent in 2015, 50 percent in 2025, and 75 percent in 2033.</li> </ul> <p>Electricity supply industry reform strategy and roadmap 2014-2025.</p> <ul style="list-style-type: none"> <li>• Increase installed capacity of power generation to at least 10,000 MW.</li> <li>• Expand hydro and natural gas capacity.</li> <li>• Add coal, wind, solar and geothermal.</li> <li>• Expand transmission and distribution systems.</li> </ul>
<b>Mozambique</b>	Agenda 2025	To propel Mozambique into middle-income status by 2025.	<ul style="list-style-type: none"> <li>• 50 percent of the population connected to the grid by 2023.</li> <li>• Expansion of the national power grid.</li> <li>• Develop domestic use of natural gas.</li> <li>• Reduce consumption of firewood and liquid fuels (kerosene).</li> </ul>
<b>Ethiopia</b>	Vision 2025	Transitioning from a developing to a middle-income country by 2025. Using three medium-term Growth and Transformation Plans (GTP): GTP I, GTP II, GTP III.	<ul style="list-style-type: none"> <li>• GTP II aims to connect 7 million customers to electricity by 2020.</li> <li>• Expand hydropower projects and grid expansion.</li> <li>• GTP II (2016-2020) priority to increase power capacity to 17,347 MW from the current 2,421 MW.</li> <li>• Do not intend to build any fossil fuel based power plant. Mostly will come from geothermal, wind and solar.</li> </ul>
<b>Uganda</b>	Vision 2040	To become an upper-middle-class country by 2040. The goal is to reach per capita income of \$9,500. Decrease population living under the poverty line to 5 percent from 24.5 percent in 2010.	<ul style="list-style-type: none"> <li>• Increase electricity access to 80 percent of the population by 2040.</li> <li>• Increase capacity to 41,738 MW of capacity to drive industrialization via expansion of power capacity including hydro, geothermal, nuclear, solar, biomass, peat and thermal plants.</li> <li>• Develop oil and gas sector.</li> <li>• Encourage use of LPG. Build gas pipelines from neighboring countries to import LPG.</li> </ul>



Country	National vision	Vision objective	Energy goal
<b>Kenya</b>	Vision 2030	Middle-income industrialized country by 2030. Separated into medium-term plans. Currently in the second phase (2012-2017).	<ul style="list-style-type: none"> <li>• Raising electricity access to 70 percent by 2017 and universal access by 2020.</li> <li>• Increase capacity to 5,538 MW by the end of 2017, including a diesel plant, as well as hydro, geothermal, wind, coal and natural gas.</li> <li>• Construction of Ethiopia's power interconnectivity line to source cheaper hydropower.</li> <li>• Complete geothermal energy projects.</li> </ul>
<b>Malawi</b>	Vision 2020	Equal opportunities for all Malawians and to become a middle-income economy.	<ul style="list-style-type: none"> <li>• Reduce consumption of fuelwood in the long term.</li> <li>• Move to coal, biogas and solar.</li> </ul>
<b>Burundi</b>	Vision 2025	Increase GDP per capita to \$720, reduce the poverty rate by half, and achieve a higher standard of living.	<ul style="list-style-type: none"> <li>• Increase rural and urban electrification rate (25 percent by 2020).</li> <li>• Big focus on hydro.</li> <li>• Make 'wood-energy' more sustainable.</li> <li>• Promote solar, biogas, wind and ethanol.</li> </ul>
<b>Rwanda</b>	Vision 2020/Vision 2050	To reach upper middle-income by 2030 and high income by 2050.	<ul style="list-style-type: none"> <li>• Increase electricity access to 75 percent by 2020.</li> <li>• Reduce dependence on imported petroleum products.</li> <li>• Invest in hydropower.</li> <li>• Solar for rural areas.</li> <li>• Exploit peat and renewable methane gas while reducing the consumption of wood.</li> </ul>
<b>South Africa</b>	The Integrated Resource Plan 2010-2030	The official government plan that identifies the preferred generation mix required to meet expected demand growth by 2030.	<ul style="list-style-type: none"> <li>• Universal access by 2025.</li> <li>• Increase share of solar and wind, but thermal power such as coal and gas will retain its significant share.</li> </ul>

Source: KAPSARC.

# Notes

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## About the Team



### **Anne-Sophie Corbeau**

Anne-Sophie was formerly a research fellow at KAPSARC specializing in global gas markets. Before joining KAPSARC, she worked for the International Energy Agency and IHS CERA (now IHS Markit).



### **Rami Shabaneh**

Rami is a research associate at KAPSARC focusing on global gas and liquids markets. He has more than 10 years of research and industry experience in energy market analysis. He holds an M.S. in Sustainable Energy Development from the University of Calgary.



### **Fernando Tomas Nhantumbo**

Fernando was a visiting researcher at KAPSARC. During the last seven years, he has been working in the extractive industries in various areas, such as government relations, community development and local content.

## About the Project

**Project:** Eastern Africa Shared Gas Infrastructure Initiative

**Initiative:** Future of Natural Gas Markets

**Description:** In collaboration with Columbia's Center on Global Energy Policy and the Fondazione Eni Enrico Mattei (FEEM), this project investigates the potential demand for natural gas in the Eastern African region based on the development of resources in Mozambique and Tanzania, and potentially, Kenya. The countries analyzed include Mozambique, Tanzania, Kenya, Uganda, Malawi, Rwanda, Burundi, Ethiopia and South Africa. The project looks at the best ways to effectively develop gas use in these countries, first by using large anchor customers such as power plants and large industrials, but also investigating potential for more localized use of natural gas – as currently investigated by South Africa. It also looks at how the regulatory frameworks in the different regions could be improved to promote the development of regional natural gas demand. Moreover, it will examine how regional cooperation initiatives and the pace of development of LNG exports can influence such a development.



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