Who's got the power? The electrification of Africa

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1. Introduction

Reasonable access to grid electricity is one of the most important, if not the most important, tipping points for economic development in Africa. About 30% of people in Sub-Saharan Africa have access to grid electricity, the lowest of any major region in the world. Per head, Sub-Saharan Africans consume only one fifth the grid electricity of the global average. People who do not have it must rely on expensive diesel generators, kerosene lamps, candles or firewood. This complicates progress beyond basic levels of health care and education. Moreover, without electricity one cannot use electric appliances, which are the foundation of both large and small scale modern industry. Because of low levels of electrification, many things are made by hand in Africa, such as furniture, which in other places are made by machines. The extensive use of firewood as an alternative source of energy incurs great environmental costs, such as deforestation and soil erosion.

There are also important social consequences of lacking electricity access. Many Africans, often women and children, have to spend time sourcing firewood. This is one of the reasons why people living in cities tend to be more productive: urban access rates to grid electricity is, on average, five times higher than in rural areas. Therefore, expanding electricity production and broadening access to grid electricity is of enormous importance. As long as it is done safely and in the interests of communities and not just for large scale industry, it empowers citizens and improves living standards. It enables private individuals to better participate in government and society and it allows for the expansion of other important infrastructure services (e.g. the internet).

This chapter aims to explain how and where electricity has been produced and distributed in Africa and how this links to current development challenges and solutions. From the time most African countries became independent (about 1960) the electricity industry has been

primarily government owned and dominated. This chapter will show that the progress of the sector has been a significant feature and consequence of the evolution of stable and responsive government structures.

The chapter has the following structure. Section 2 explains what is meant by electrification and electricity access, explains the key concepts necessary to understand the process of electrification, and gives some examples of how they have worked in practice in the African context. Section 3 reviews the problems of coordination of electricity generation and distribution. Sections 4 and 5 discuss the colonial and post-independence historical development of electricity production and access in Africa. Section 6 discusses some of the causes of intra-regional differences in electricity consumption within Africa. Section 7 explains current development challenges, including who funds and manages power plants and utilities today. It also addresses the potential impact on electricity access of new technologies such as solar and wind energy. Section 8 discusses the conclusions of the chapter.

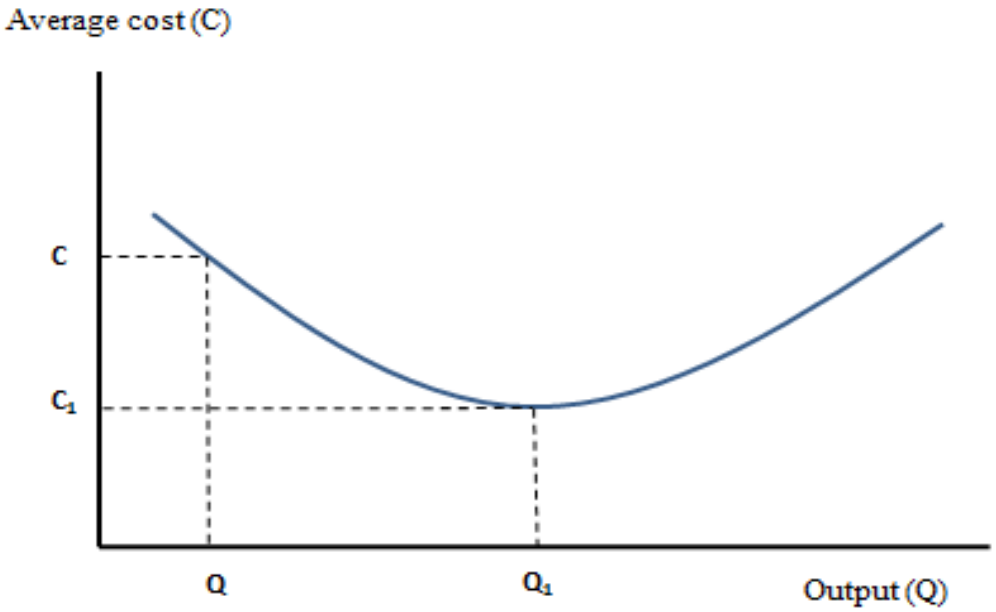
A view of low voltage electricity poles, the ‘distribution network’ connecting houses to the electricity grid.

2. Electrification and 'economies of scale'

Electrification can be briefly defined as *the expansion of the use of electricity by consumers (e.g. households, schools, firms, offices etc.) in a specific area*. Electrification usually involves increasing access of consumers to an electricity grid, with energy being centrally produced and then distributed to many metered connection points. However, individuals, households or businesses can also generate their own electricity using a generator or solar panel. A common measure of *electricity access* that scholars, development agencies and governments use is the *percentage of households that have an electricity grid connection, and consume a minimum level of electricity*. It is possible, however, to have electrification without an increase in household access to electricity. This occurs if electricity production is developed (and often funded) by one or more industrial companies, which have exclusive use of most of that electricity. As we will see further below, industrial production and use of electricity has often come before household use of electricity in the electrification process of African countries.

Electricity access is important for social and economic development for a number of reasons, but the most important is that the cost of energy is normally far higher for people who are not connected to an electricity grid. This is mostly because there are significant 'economies of scale' in the production of energy, including electricity. 'Economies of scale' mean that the average costs of one unit of output (e.g. one kWh of electricity) decline if the scale of production increases. Figure 1 offers a graphical representation, where C is defined as the average costs per unit of output, and Q represents total output. The average costs decline if the *fixed costs* of production - investments costs that have to be made before one can even start producing a single unit of output – are spread over more units of output. Diseconomies of scale also exist. As shown in Figure 1, these may emerge after reaching a certain point (Q_1), for instance if one approaches the capacity limits of one power plant and will need to build another power plant to further increase production. Compared to the small scale production of households, large companies usually also enjoy access to cheaper fuel costs which they can buy in bulk. This means that they have lower *variable costs* in production. Variable costs are costs that are directly and positively related to the amount of production.

Figure 1: A graphical representation of economies of scale



In other words, once the electricity plant is running, the marginal cost of a unit of electricity is always cheaper to produce in a large power plant, which is then distributed over a grid, than by a small home generator. Without grid access you need to purchase a generator (fixed cost), find and buy kerosene, diesel, candles or firewood, and you have to invest time in bringing all this together (all variable costs). Indeed, there are great efficiency gains by coordinating all these activities at a central level, but the way it is coordinated can differ a lot: electricity can be provided by a private company, it can be provided by a state-led organization or it can be done by the cooperative effort of a large group of households who pool resources to buy or produce electricity.

There is another dimension to 'scale economies' which is related to the distribution of electricity to end users: the more households, firms, shops or offices demand electricity from the grid, the cheaper it will be, on average, to build the grid, since the costs of this infrastructure can be spread among more participants. This creates opportunities to lower the tariffs that people have to pay to get connected.

Finally, the way electricity is generated also impacts the cost structure of production and the ongoing risks to production. Hydroelectric plants are very expensive and complex to build, often taking five years or even longer, but because an ongoing water flow powers the generators there are hardly any fuel costs. Because of *high fixed costs, but very low variable costs* such plants normally provide cheaper electricity in the long run than other sources. However, electricity generated from hydroelectric plants is dependent on water flow, which can be affected by periodic droughts. Oil, gas or diesel powered plants are cheaper but are subject to fuel costs which vary according to the local and global market for oil and gas, which can be unstable. The fuel efficiency of the plant also depends on the size and design of the plant. In particular the smaller, mobile or temporary thermal units that many governments order because they have emergency needs tend to have inefficient and expensive fuel consumption, that is, they have *lower fixed costs, but much higher variable costs*.

3. The challenges of finance and coordination

One major reason that there is so little electricity and electricity access in Africa is the problem of coordination. Power plants are expensive, take a long time to build (often more than four years) and require considerable organizational capacity to arrange for the financing, as well as the technical operations and maintenance of both the plants and the transmission and distribution networks. Today, the construction of a power plant requires a series of contracts between various parties. This includes a long term (often 10 to 20 years) power purchase agreement (PPA) which determines who will buy the energy, and a fuel supply agreement, which secures the fuel (if necessary) for the power plant. In order for a power plant to get the necessary debt financing from a bank, its PPA needs to be 'bankable', or signed with a creditworthy counterparty, like a large industrial company or a well-funded government or utility. Such investments are usually supported by collecting tariffs from customers or a credit support letter from the government.

However, governments and utility companies are not always creditworthy enough to get financing for a large power plant. African governments are also often reluctant to raise tariffs when fuel costs rise, because most utility customers (e.g. wealthier urban residents, businesses) represent politically powerful groups. This means that tariffs end up being subsidized by state-owned utility companies, so that the difference between the energy price

paid by people connected to the grid and people who are not can be even larger than the difference in the cost of production. It also means that these state-owned companies are financially unsustainable and unable to raise funds required to expand and maintain their production capacity and infrastructure. But even African governments that are resource rich (e.g. major oil exporters) and can thus afford the construction of sufficient power plants from direct state budgets have often lacked that organizational capacity and long-term outlook.

To understand the complexity of developing a well-functioning national electricity sector, it is also important to consider that coordination is required between three fundamental parts: generation (plants producing electricity), transmission (high voltage lines which send electric currents from the plant to medium and low voltage networks) and distribution (typically the function of the electricity utility, which runs low and medium voltage power lines into communities and connects homes and businesses). There are typically one or more transmission grids which connect the three parts of the system and allow energy generated to be distributed over a large area. All these three parts need investment and maintenance. Generation 'comes first' because if there is not enough energy generated, homes and businesses connected to the grid will suffer from blackouts. However, if a transmission line is not maintained it may lose a lot of its current and if transmission lines are not extended, large parts of the country cannot get connected. Likewise distribution networks need investment to reduce technical losses of electricity, and need attention to metering and billing, to reduce so called 'commercial losses' from fraud, incorrect billing, and non-payment of bills.

To overcome coordination problems, in many African countries all three parts of the sector, generation, transmission and distribution, are run together by the same government controlled entity, and this is called a 'bundled' sector. In some cases the parts have been split out and are either run independently from each other, or one or more parts have been privatised and are owned by different parties. This is called an 'unbundled' sector. It is also possible to have a 'bundled' sector which has been privatised in its entirety, such as was done in Cameroon in 2001, though this is quite unusual.

In sum, there are various causes of low and insecure access to electricity in Africa. Lack of production capacity and a growing demand for electricity are part of these, but coordination failures can also be a reason for regular black-outs. Power outages raise the costs of

production for businesses and complicate domestic work. It is now time to look a bit deeper into the historical development of the electricity sector.

4. Electricity production during the colonial era, c. 1890-1960

Electricity was first generated in Sub-Saharan Africa for a grid in the late nineteenth century and the early decades of the twentieth century. Table 1 presents some landmarks in the colonial history of African electrification, showing the early transmission of electricity technology to a number of African countries. Kate Showers has written a number of survey articles describing the beginning of electricity across Africa. She has noted that developments in technology to produce and distribute electricity came to Africa not long after they were developed in Europe and North America. She also notes, however, that in Europe and North America small thermal plants were quickly replaced by large facilities which could produce electricity much cheaper because of economies of scale, whereas in most parts of Africa, access rates spread at a much slower pace and that small, comparatively expensive plants continue to be used until today.

Table 1: Early efforts to produce and distribute electricity for a sample of African countries

Ethiopia	The first diesel generator was reportedly a gift from the German government to the Emperor in the 1890s
Ghana	The Gold Coast railway introduced the first electricity supply for public use in 1914
Nigeria	The Public Works Department was already supplying electricity to government buildings in Lagos by 1896
Sierra Leone	The colonial government installed a diesel generator in Freetown in 1928
South Africa	The first African city with electric street lights was Kimberly in 1882
Tanzania	Dar es Salaam had street lights before 1900
Zambia	A thermal station was in use by 1906

Source: K. Showers, 'Electrifying Africa: An environmental history with policy implications', Geografiska Annaler: Series B, Human Geography, 93:3 (2011), 196-197.

By the end of the colonial period in Africa, there was hardly any electricity access outside of the major cities and even in cities there was very limited household access. This is confirmed

by a 1964 United Nations (UN) comprehensive report of the state of electrification of Africa (for more information about this see suggested readings at the end of this chapter). Colonial governments had concentrated their efforts on installing small generation facilities for colonial settler communities, and limited urban areas such as government quarters. Only in a few places did they invest in larger power facilities, especially responding to demands of large mines or industrial plants. Sometimes these were thermal stations fuelled by wood, coal or diesel, sometimes these were hydroelectric stations. Commercial enterprises during the colonial period also sometimes installed facilities for their own use, and in some situations sold the electricity generated privately to other users. Although electricity access was limited this does not mean that the facilities which were developed during the colonial period were unimportant. Many colonial facilities remained the foundation for electricity infrastructure for many decades after independence and in some places are still important sources of electricity today (even though they were insufficient to meet rising demand).

The UN report suggests that colonial governments up to the 1960s, or even the UN itself, did not see widespread household use of electricity for most Africans as practical or affordable. With very few exceptions (Nigeria possibly being one) colonial governments were only confident about the potential of large multinational industrial companies to pay for electricity. It was well known at the time that Africa's rivers had potential for hydroelectric power which required huge investments, but once undertaken, could provide relatively cheap energy in large quantities. In the late colonial era, many colonial governments thus conducted studies into, and developed plans for, the construction of large hydroelectric plants for industrial purposes.

Countries with great hydroelectric potential (Congo, Zimbabwe) or other abundant sources of fuel such as coal or oil (Nigeria, South Africa) had a clear advantage in the development of their electricity sector. In most cases colonial African governments would sign a long term contract with a major European or American company (often more than 10 years) to buy power at a fixed pre-determined price, which is called an 'off-take' arrangement. The contract with a long term client gave banks and other financing institutions the confidence to offer credit needed for the construction project. Under these arrangements, a number of large scale hydroelectric plants for large industrial projects took off. One example is the hydroelectric plant Edea, in Cameroon, which was built in 1953 in order to supply energy to a large aluminium smelter (now called Alucam, see photo below). In Mozambique the

Portuguese colonial government finished building the large Cahora Bassa dam in 1974, after contracting out almost the entire amount of energy produced on long-term contracts to South Africa, who planned to use the electricity for industry. Likewise, the Kariba dam was built to supply large copper companies in the 1950s by the quasi-colonial regime of the Central African Federation (now Zambia, Zimbabwe and Malawi). The Owen Falls dam, in Uganda, was built in the 1950s with copper and other mineral processing in mind.

The building of these large dams had significant environmental and social consequences. They often required the physical relocation of thousands of people and disrupted the living environment for many more people. In some cases dams were build making use of forced or indentured labour, working under dangerous conditions. There have been a number of works describing the building of these dams and some of their consequences, by scholars including Julian Tischler (the Kariba dam) and Allen and Barbara Isaacman (Cahora Bassa dam).

View of the aluminium smelter Alucam from the Edea hydroelectric plant, Cameroon.

5. Growth and stagnation during the post-independence era

After independence, many African governments with hydroelectric potential continued to look for industrial off-takers to help develop their energy resources. Cameroon, for example, continued to expand and build more power plants primarily to support aluminium smelting. The newly independent government of Ghana likewise contracted with an international company to build an aluminium smelter, Valco, to develop a large hydroelectric plant at Akosombo. Another major example is the Inga Falls project 1 and 2, planned during the colonial period but commissioned by the Democratic Republic of Congo government in 1972 and 1982 respectively. Enormous dams were built in the Lower Congo river to supply electricity for the copper sector and other mining activities. However, these projects were never cost efficient, one of the problems being that the envisaged consumers (the mines in Katanga, Southeastern Congo) were located more than a thousand miles away from the production site (near Kinshasa, Western Congo).

Although generally the independent governments made a greater effort to electrify households than the colonial governments, progress remained slow, so that fifty years after independence most African households still lack access to electricity, even in places where there is significant electricity being produced. The main problem is that industrial consumers have nearly always been granted priority over households, partly because of their strategic position and partly because they often helped co-finance power plants. In some places the cheap rates of electricity and long term contracts for ore smelters have reduced the availability, and thus raised the price, of electricity for households. When droughts occurred (for example in West Africa in 1972-74), industrial consumers were served first, while households suffered from increased load shedding, with all its social and economic consequences.

Nevertheless, in most places access rates did increase over time, despite growing demand for electricity by households and business (partly driven by rapid population growth). One of the main reasons was the rapid rate of urbanisation across Africa. As cities grew, it became feasible to expand grid access making use of scale economies. This also meant that industrial users had to start competing with households for scarcely available energy. Yet, the better bargaining position of large industrial firms and their legal expertise (use of penalties in

contracts for non-compliance) usually meant that industry maintained its preferential position vis-à-vis individual households.

Hence, for example, in Cameroon the aluminium smelter still consumes about 25% of the country's electricity, in spite of the fact that there is barely enough supply to meet the growing demand of the general public. The smelter also pays the local utility much less per unit of electricity than other users. In Mozambique too, very few households profit from the energy generated by the Cahora Bassa dam. According to the International Energy Agency only 20% of Mozambique's households had electricity access in 2011.

Taking into account all of the structural challenges and constraints of the power sector described here, the slow electrification of African countries after 1960 can be explained, firstly, by the diseconomies of scale of distributing electricity to a largely rural population scattered across vast hinterlands and, secondly, by the poor organizational capacity of African governments (some African states have collapsed all together). But the third constraint, the complications of arranging funding for the sector, has also continued to play a role.

The most significant single entity in the development of the global power sector after the Second World War was the World Bank, or as one of its predecessor entities was initially known, the International Bank for Reconstruction and Development. It was and is important in helping to plan and fund power projects all over the world, and particularly in post-independence Africa. The World Bank helped finance strategic plans, rural electrification programs and power plants. In order to understand the history of the African electrification, it is important to understand how changing power financing trends over time interacted with World Bank policies and global capital market developments. We may distinguish four phases.

In the first phase, during the 1950s and 1960s, the World Bank started to support a few African governments developing their energy sector. Despite there being a dire need, most countries did not start trying to connect the rural population until decades later. However, in a few countries, among them Cote d'Ivoire, the government did see the inclusion of the rural areas as a priority and consequently started electrification programs to extend access right after independence. Close to half of the people in Cote d'Ivoire was recorded as having a connection by 1980.

The second phase started with the oil crisis of the early 1970s. Those governments with rich oil resources like Nigeria found themselves with extraordinary resources to plan much more ambitious power sector expansion, but these projects took some time to plan and execute, generally until the 1980s. Countries without oil were forced by high fuel prices to look for alternatives, in particular hydroelectric capacity. Around the same time, a series of droughts forced governments with hydroelectric plants to look for alternative thermal power generation which could be relied upon during times of drought. Many governments could not pay back their power sector loans to the World Bank and other funding bodies.

The third phase started with the implementation of structural adjustment programs (SAPs) from the mid to late 1980s, when most African countries had become heavily indebted, and funding for the sector slowed. Government budgets were cut under the influence of the International Monetary Fund (IMF). A few countries with programmes which had been planned from the late 1970s continued, such as the ambitious Nigerian programme. However, although three billion US$ was invested in new generation capacity in Nigeria, poor organizational capacity jeopardized proper maintenance of existing capacity, so that the program had a disappointing net impact on the sector.

The fourth phase was the reforms of the 1990s and 2000s. Because of the problems with debt accumulation and debt repayment, including the loans to the electricity sector, the World Bank encouraged reforms. At the same time, the World Bank and other development finance institutions (DFIs) started providing funds for rural electrification programs. The reforms involved the commercialisation of utilities, unbundling of the sector, and privatization. However, these reforms did not have much success in attracting private capital, as the investment in climate in Africa was still regarded as comparatively risky, and power sector deregulations in the US and Europe offered more attractive investment opportunities. There were exceptions, however. The electrification programs of Ghana and Cameroon, for instance, were highly successful. Since 2000, companies and organisations backed by the Chinese government are playing an increasing role in funding and building large scale infrastructure projects, including power generation. The website http://china.aiddata.org/ maintains a database of Chinese involvement in African infrastructure projects. In a few African countries, such as South Africa, commercial lenders have also become important for financing power projects.

6. Understanding intra-African differences in electricity consumption

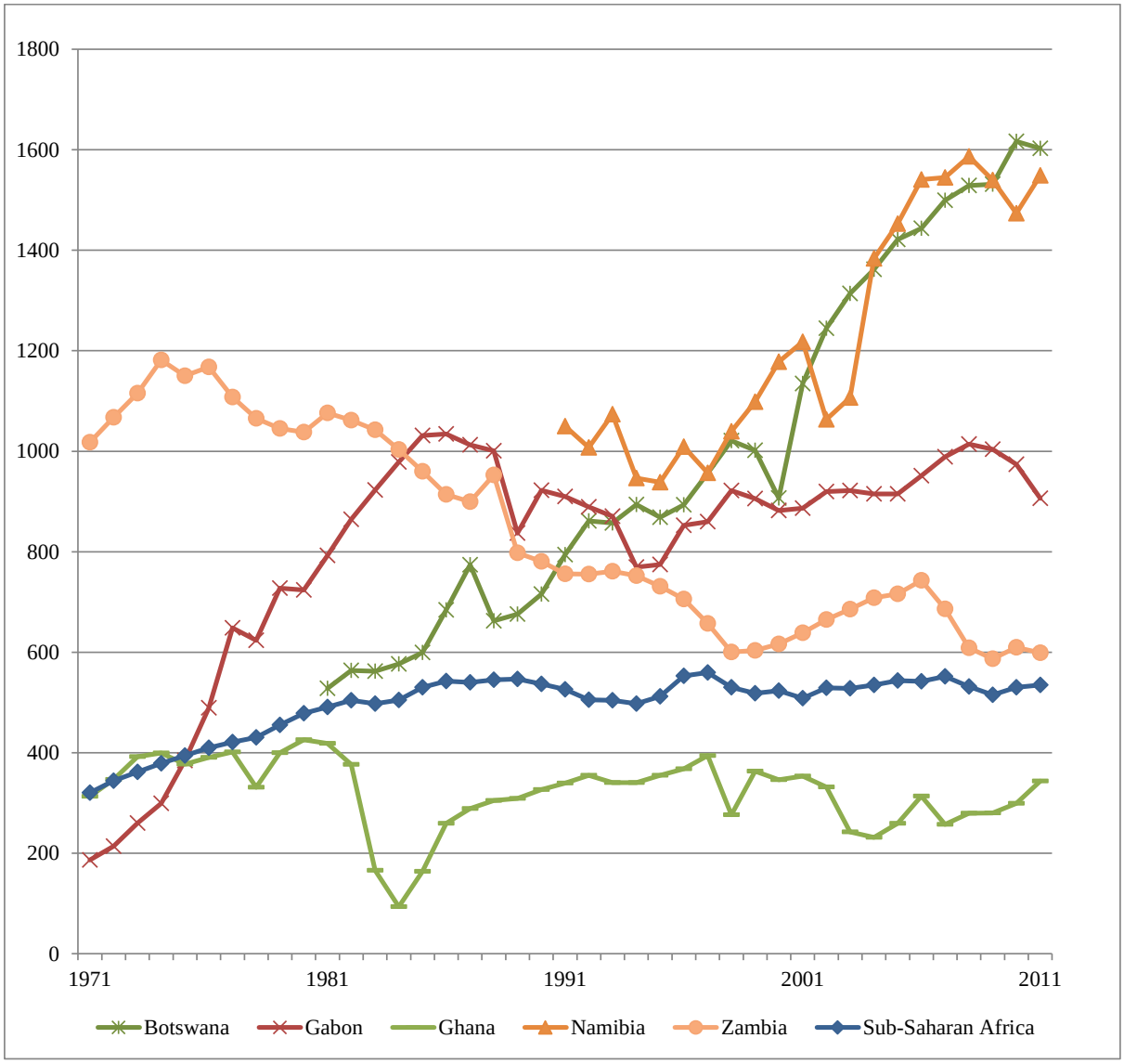
In the post-independence period, as in the colonial period, the countries where it was easiest to get low cost and large scale electricity generation were the same ones which either had hydroelectric potential or a large industrial client who could help to finance a power plant. A considerable number of countries in Africa, however, lacked commodity wealth, hydroelectric potential or a large dense population. But there are also exceptions to the rule. Some countries, such as Nigeria, had a large and relatively dense population, and so could support a large hydroelectric building program on a mixture of industrial, small commercial, and household demand, and Nigeria in the 1960s had a very ambitious program to expand its generation. Nigeria later funded even more expansion in the 1980s with the revenues from its oil wealth, though as noted above this generation capacity was not maintained and so the country still suffers from an acute shortage of electricity.

Figure 2 below (and Appendix A at the end of the chapter) shows World Development Indicators data compiled by The World Bank on a few African countries on electricity consumption per capita. In this case, consumption is defined roughly as production which can be sold. Electricity is generally not produced unless it can be sold and in the post-1970 years demand tended to outweigh production. In 2011 (the most recent estimate), most Sub-Saharan African countries had a per capita electricity consumption of less than 400 kWh. The Sub-Saharan African regional aggregate, including South Africa, was less that 550 kWh per capita. To put this in global perspective, the United States in 2011 consumed 13,246 kWh per capita. OECD countries consumed 8,173 kWh and India 684 kWh per capita.

Figure 2 shows some leaders in African electricity production per capita currently including Botswana (which showed steady growth from early 1980s when data was first collected), Namibia (growth from early 1990s when data is first available), and Gabon (growth during 1970s, but no growth thereafter). Zambia had relatively high levels of consumption per capita in the early 1970s which has declined since then. These however are the exceptions, on which more research should be carried out in order to explain, and verify, the trends in more detail. It is clear from the Sub-Saharan Africa regional aggregate that most of the other countries, such as Ghana, have had consistently low use per capita over time. Since all of this data is done on a per capita basis, population size and growth relative to resources and other factors,

as opposed to the development of the power sector alone, are a strong determinate of each country's place in the chart.

Figure 2: Electric power consumption for a selection of countries (kWh per capita)



Source: World Bank, World Development Indicators (International Energy Agency (IEA Statistics © OECD/IEA, http://www.iea.org/stats/index.asp), Energy Statistics and Balances of Non-OECD. See http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC/countries?display=default, accessed 17.7.14) Note: Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants.

As already noted, total electricity consumption and production is an important indicator of electrification, but electricity access indicates the proportion of households that actually benefit from this electrification. Global sources of data about electricity access are scarce,

especially historically. Information on access is normally gathered from electricity utilities who know how many metered connection points they have, and then can estimate how many households they serve and the average size of the household. Information is also collected from household surveys and the census, where people are asked if they have a connection at home. Because of these various information sources, and because many people have illegal connections or share meters with many other families, it is very hard to get accurate estimates of electricity access, especially over time. Many surveys only started to include questions on electricity access during the 1990s, so it can be challenging to get long term historical data on electricity access from anyone other than the electricity utilities.

Regarding electricity *access*, The World Bank's World Development Indicators only have data for 2010-2011 from a minority of African countries. The International Energy Agency has the most commonly used current estimates of household electrification, showing that in 2011 just 32% of people in Africa (as measured by households) had access to an electricity grid. This compares to 75% in India, 95% in Latin America, 91% in the Middle East. Within Sub-Saharan Africa, there are also big differences in access rates. Mauritius and South Africa have the highest rates, of 99% and 85% respectively (the energy sector development of South Africa was exceptional in Sub-Saharan Africa, and is not examined in detail in this chapter). There is a group of West and Central African countries with relatively high rates of access of about 50-60%, and these include Nigeria, Ghana, Gabon, Cote d'Ivoire, Senegal, Cameroon. At the same time, there are some Eastern and Central African countries with very low access, including among others Zambia, Mozambique, Uganda and Kenya.

In addition to the development of large hydroelectric dams and oil wealth already discussed, there are many other reasons why some countries have more electricity production and greater levels of access than others. An overview of some of these reasons, with country examples, is provided in table 2 below. More research is still needed to find out how each of these factors has affected access rates of individual countries.

Table 2: Major reasons for differences in electricity access in Africa

Resource endowments	Whether the country has rivers and potential for hydroelectric plants, gas, oil or coal reserves, solar irradiance or wind resource or a port which makes it easier to import fuel. For example, during the 1980s Nigeria funded electricity generation investment from its oil revenues, though it failed to maintain the plants and many fell into disrepair.
Urbanisation and topography	It is easier and cheaper to connect new customers if they are concentrated in cities, or if the landscape makes transportation and network extension easy. Almost all African countries have seen higher rates of electricity access corresponding to growth in urbanisation.
Colonial policy and legacy	Some countries had more colonial settlers with access to a grid, or colonial governments had specific industrial or infrastructure needs which helped get generating plants built. For example, South Africa had an advanced electricity sector built for its settler population but there are very few other examples of this.
Utility, regulatory management	During certain periods some countries had better organised utilities and power plants, with high quality management, or very poor organisation.
Political stability	If a country has war or civil unrest it is unlikely to be able to extend network access and the existing grid is often destroyed. For example, countries such as Liberia, Sierra Leone, Democratic Republic of Congo and Rwanda made very limited grid investment during their periods of conflict.
Affordability	As countries and households have more income, governments have more stable fiscal and monetary policies, investment becomes more likely. For example, in Cote d'Ivoire electricity access and generation capacity received significant early investment because of its large population of farmers who could afford to pay for electricity.
Resources to attract industrial clients	If a country has mineral wealth such as bauxite, copper, etc, this made it more likely that an industrial client could support the building of a power plant, which in time may facilitate access for households. For example, Zambia and Zimbabwe (as the Central African Federation), Democratic Republic of Congo and Uganda all received investment in hydroelectric plants because of mining potential.
Government policy and donor attention on access	Some governments prioritized access early after independence, such as Cote d'Ivoire, while other government saw other infrastructure projects such as roads as more important priorities. Also some countries, such as Ghana, were able to attract and organise donor funding for rural electrification from the 1990s onwards.

7. Development challenges and opportunities

In Africa governments generally own power plants and utilities and so are limited to their own institutional capacity and affordability to get plants constructed and funded. However, even though very few electricity sectors were fully privatized in Africa, most countries have introduced some reform in order to bring in private sector investment and expertise, with mixed success. As with electricity access, Cote d'Ivoire was quite advanced in its power sector reform. The first privately funded independent power projects (IPPs) in Africa were there, CIPREL and AZITO in the 1990s. In addition, Cote d'Ivoire privatized its electricity utility in 1992, and it performance is very advanced compared to other African countries. There are just a handful of other privately owned utilities in Africa, and they mostly became private during the World Bank-driven reforms of the 1990s and early 2000s, such as Cameroon and Uganda.

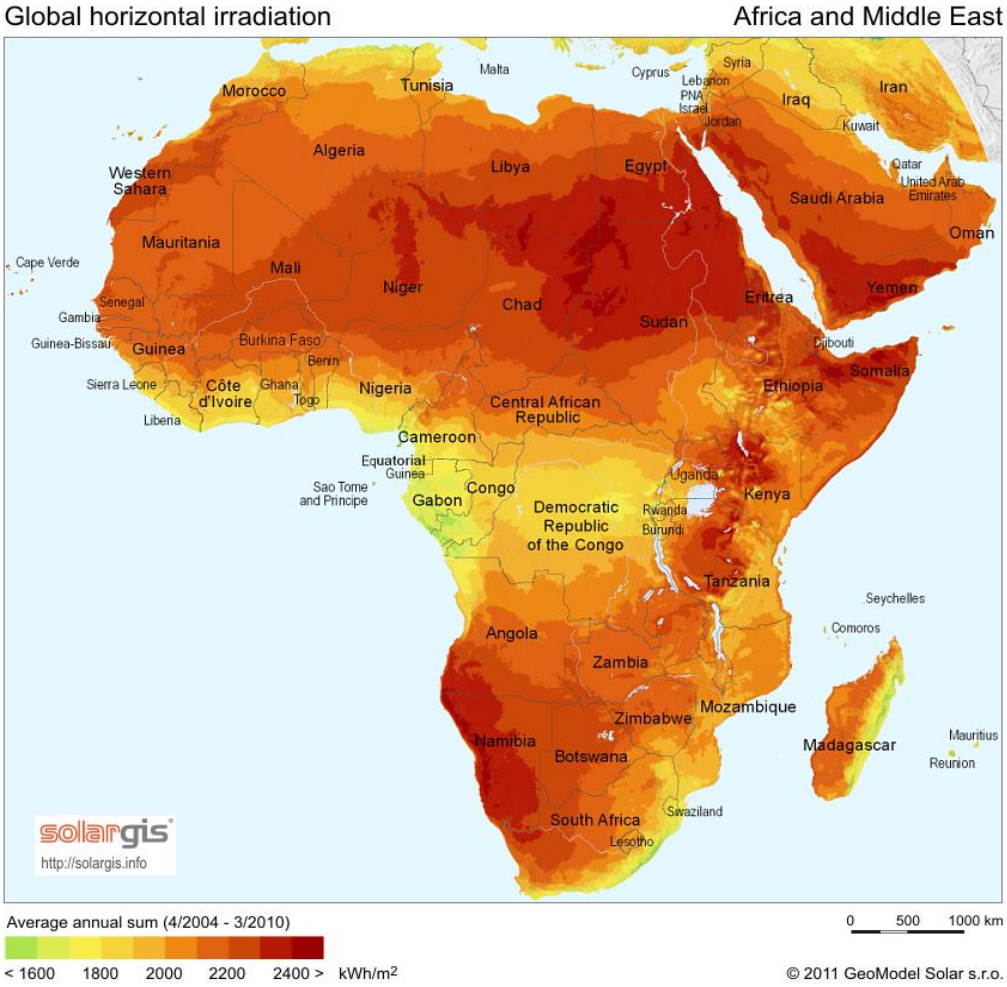
The frequent instability of African governments and their fiscal regimes in the post-independence era has complicated debt or equity financing for power plants. In the last two decades the World Bank developed two tools for governments and investors which are now important in alleviating these risks and attracting power sector investment in Africa. These are Partial Risk Guarantees (PRG) and Multilateral Investment Guarantee Agency (MIGA). They use the World Bank's relationship with governments to provide private debt and equity providers with guarantees that a state will uphold its part of the contract in a private project, ringfence funding to ensure that financing providers will be paid for a period of time if contracts are not honoured in good time, and provide political risk insurance. Many private projects use these instruments, often together, and they have been effective because they structure a way for the World Bank to intervene and mediate with governments when there seems to be a risk that the guarantee and insurance will be required.

A modern African electricity substation.

As an alternative to privatization, a number of countries have instead chosen to offer management contracts of parts of their sector to international expert firms, with mixed success. In Zambia, for example, there is a large private company which supplies energy to mines, called Copperbelt Energy Corporation (CEC), but energy supply to households is mostly done by the government. Anton Eberhard of University of Cape Town and his co-authors have written a series of books describing the regulation, structure and state of the sector across Africa, which are available for free online (see suggested readings).

Although many parts of Africa, as shown in the irradiance map in Figure 3 below and in similar maps showing wind strength data, have strong potential for solar and wind energy, they have not yet been very significant sources of electricity in Africa.

Figure 3: Solar irradiance in Africa



Source: http://solargis.info/doc/_pics/freemaps/1000px/ghi/SolarGIS-Solar-map-Africa-and-Middle-East-en.png

In order for these renewable energies to be viable on a large scale (i.e. connected to a grid), their costs need to become lower than the costs of their primary substitute: diesel generators running on diesel oil. As solar and wind energy expand in the rest of the world the cost of turbines and solar panels have decreased. The technology becomes more mature and economies of scale have driven down prices. Wind became widely cost competitive in 2007, and solar is only just (2013-14) becoming cost-competitive against the price of diesel in some places in Africa, so we can expect it to increase further in places with high solar energy potential. Construction started on the first large-scale wind and solar farms in South Africa in 2012, which were some of the first in Sub-Saharan Africa. In both 2012 and 2013, there was over $10 billion of new investment in this 'clean' energy in the Middle East and Africa. Before 2012, investments had never exceeded $4.5 billion per year.

8. Conclusion

Electricity has come slowly to Africa and many Africans are still excluded from access or live in areas with insecure supplies. There are clear reasons for this lack of access. Four key trends should be noted from this chapter:

1. A limited colonial legacy: very little electricity generation or household access was achieved during the colonial period. In some countries with hydroelectric potential, some sizable assets were built in selected African countries to support industrial activity, but household demand remained largely neglected.

2. Industrial rather than domestic consumers have continued to be the main beneficiaries of efforts after independence: since independence, the early investments have been both a blessing and a curse, as they created capacity which would otherwise not have been built, but then industrial consumers got preference on capacity when households were eventually connected and demand rose.

3. Resource endowments, such as availability of gas, oil, coal or hydroelectric power potential have all been instrumental in determining how countries have developed their electricity supply. Solar and wind electricity potential are bound to play a major role in the future and offer new opportunities to enhance energy security.

4. Government institutional capacity has been crucial: electricity infrastructure has been and continues to be largely government owned and/or regulated. Regardless of a country's factor endowments, the organisation and ability of a government to implement and maintain investments has been a crucial factor in the development of its energy sector. Funding bodies like the World Bank have been important in providing both financing and institutional support for raising production capacity and extending electricity distribution networks.

Study questions

1. What was the colonial legacy of electricity in Africa?
2. What has been the role of the World Bank in the electrification of Africa?
3. What are the main reasons why Africa does not have sufficient electricity generation capacity for its needs?
4. Why are there such large difference in electricity access rates between various countries and regions within Africa?
5. What has been the development, social and environmental impact of Africa's hydroelectric dams?
6. Has private sector investment in the African electricity sector been a success? What about private management contracts?

Suggested readings

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Appendix A: Electricity consumption in a selection of African countries, 1971-2011 (kWh/capita)

	1971	1981	1991	2001	2011
Angola	92	64	63	97	248
Botswana		528	794	1,134	1,603
Cote d'Ivoire	94	184	146	187	212
Cameroon	147	192	188	161	256
Congo, Rep.	56	69	183	105	172
Eritrea				47	49
Gabon	186	792	910	887	907
Ghana	313	418	340	353	344
Mozambique	49	35	53	269	447
Namibia			1,050	1,218	1,549
Nigeria	28	51	89	75	149
Sudan	26	34	48	53	143
Senegal	75	106	103	124	187
Togo	64	67	84	100	
Tanzania	30	38	54	60	92
Congo, Dem. Rep.	162	136	124	96	105
Zambia	1,018	1,076	756	638	599
Zimbabwe	661	959	852	826	757
Sub-Saharan Africa	**320**	**491**	**526**	**508**	**535**

Source: World Bank, World Development Indicators (International Energy Agency (IEA Statistics © OECD/IEA, http://www.iea.org/stats/index.asp), Energy Statistics and Balances of Non-OECD. See http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC/countries?display=default, accessed 17.7.14)

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