United States International Trade Commission
Journal of International Commerce and Economics
June 2018

Low Electricity Supply in Sub-Saharan Africa: Causes, Implications, and Remedies

Jeremy E. J. Streatfeild

Abstract

Electricity supply is lower and costs are higher in sub-Saharan Africa (SSA) than in any other world region. While several SSA countries have sought to address this issue through cross-border trade and investment in domestic infrastructure, these efforts have been greatly impeded by the high degree of systems losses—the difference between out and sales of electricity—as well as by electricity tariffs that are too low to recover utilities' costs. This paper assesses the extent and economic significance of low levels of electricity supply in SSA, gives a regional overview of electricity generation levels, and discusses SSA countries' efforts to engage in electricity trade in order to improve regional economies of scale.

Suggested citation: Streatfeild, Jeremy. "Low Electricity Supply in SSA: Causes, Implications, and Potential Remedies." *Journal of International Commerce and Economics*, June 2018. http://www.usitc.gov/journals.

 Please direct all correspondence to Jeremy Streatfeild, Office of Industries, U.S. International Trade Commission, 500 E Street, SW, Washington, DC 20436, or by email to jstreatf@gmail.com.

Introduction

Sub-Saharan Africa (SSA) has a lower supply of electricity than any other region in the world, as shown by satellite images depicting the region's relative lack of nighttime lights (image 1). Several studies have quantified this lack of electricity. For example, almost one billion people currently live without electricity, worldwide, of which approximately 600 million reside in SSA.[1] Surveys of households in 22 SSA countries show that just one-third of the population uses electricity. Income levels and geographic location seem to be key determinants of electricity use, as electricity consumers tend to be urban and comparatively better off.[2]

Image 1. Satellite imagery of Earth at night

Source. Compiled by the Suomi National Polar-Orbiting Partnership satellite with data from the NASA Earth Observatory (https://commons.wikimedia.org/wiki/File:The_earth_at_night.jpg).

The World Bank states that low levels of electricity supply have harmed the region's economy.[3] Three-quarters of SSA firms experience power outages, reportedly losing an average of 8.3 percent of their annual sales as a result. Due to the unreliability of electricity supply across the region, half of SSA firms own a backup generator.[4] Generators typically supply one-quarter of these firms' total electricity, despite an operating cost that can be up to 10 times higher than that of on-grid electricity supplied by a utility.[5] The World Bank estimates it may take up to $60 billion in annual investments to address this rising electricity demand and aging infrastructure.

[1] By comparison, SSA accounts for about 16 percent of the global population but more than 60 percent of the world's population without electricity. Author's calculations from WDI (EG.ELC.ACCS.ZS and SP.POP.TOTL).
[2] Kojima et al., "Who Uses Electricity in Sub-Saharan Africa?" August 2016.
[3] PPIAF, *Linking Up: Public-Private Partnerships*, 2017.
[4] World Bank, "Infrastructure"(accessed May 14, 2018)
[5] *Economist*, "Electricity in Africa," September 2014.

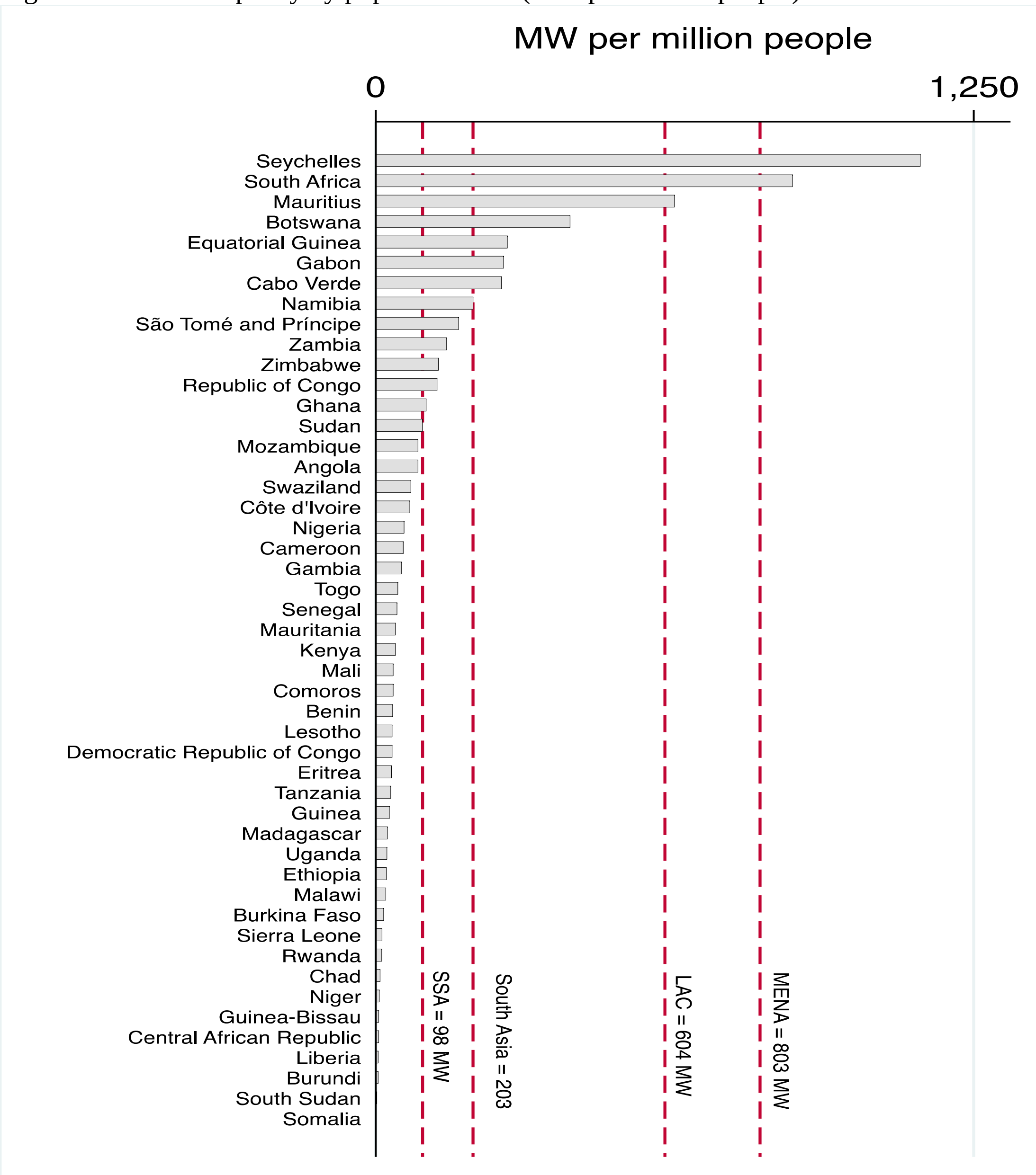
This paper outlines the steps SSA governments have taken to increase domestic electricity supply, either through new public and private investments in generation or, to a lesser extent, through cross-border imports of electricity. The paper then addresses the institutional factors dampen private investment incentives. Electricity prices (or tariffs)—while high by global standards—are below production costs in all but two SSA countries. As a result, utilities remain unreliable guarantors of private investment, thereby perpetuating the electricity shortage. Although many countries encounter political opposition to higher tariffs,[6] analysts argue that regulators need to raise tariffs so that utilities can collect enough revenue to cover their costs. This would help to attract new investment while offsetting financial losses in the system due to theft or waste.

Supply of Electricity in SSA

SSA's total installed electric power capacity is 100 gigawatts,[7] or 98 MW per million people,[8] far lower than in any other world region (see figure 1).[9] By comparison, India has approximately 300 MW of installed capacity per million people, Latin America and the Caribbean have an average of 604 MW per million people, and the Middle East and North Africa have an average of 803 MW per million people.[10]

[6] Some countries try to lessen the energy cost burden for their manufacturing sectors by lowering tariffs, but this is likely to result in or increase utilities' financial losses. but this places extra financial stress on their utilities, which in most cases are already losing money. For an example of electricity tariff protests in Nigeria see Nwokoro, "Three groups protest electricity tariff hike," December 2017; in South Africa, see Rustomjee "South Africa's municipal electricity tariffs are hurting the economy," May 2018; in Ghana see Kaledzi, "Ghanaians protest rising fuel and electricity tariffs," January 2016; and in Sudan see Dabanga, "Electricity tariff hike 'a deathblow to Sudanese industry,'" January 2014.
[7] One gigawatt (GW) is equal to 1,000 megawatts (MW).
[8] A few countries, including Seychelles, South Africa, and Mauritius, have capacity levels above that of the Latin America and Caribbean region average (604 MW per million people), but these are exceptions.
[9] Installed capacity is the full-load sustained output of a generation plant. The above estimate may actually overstate SSA's installed capacity, as a Deloitte report calculates that poor maintenance and infrastructure quality has kept one-quarter of SSA's full-load capacity offline—lowering the level to about 75 MW per million people. Scott et al., *Sub-Saharan Africa Power Outlook*, 2016, 4.
[10] PPIAF, *Linking Up: Public-Private Partnerships*, 2017.

Figure 1. Installed capacity by population size (MW per million people).



`

Source: Trimble et al., "Financial Viability of Electricity Sectors," 2015, 85–86. LAC refers to Latin America and Caribbean and MENA refers to the Middle East and North America.

The fuel mix used to generate electricity in SSA is relatively inexpensive. Worldwide, coal, hydropower, and natural gas power plants offer some of the cheapest electricity production,[11] and such plants largely comprise SSA's installed capacity: coal accounts for 49 percent of production, large hydropower for 20 percent, and natural gas for 16 percent.[12] However, due to a lack of infrastructure maintenance, poor management, and systems planning, among other factors, generation costs in SSA are higher than in any other world region.

Not only is utility-supplied electricity more expensive in SSA, but it is in short supply. In response to this shortage, the Kenya Tea Development Agency, for example, built its own 23 MW hydropower plant to reduce its reliance on the utility's undependable electricity supply.[13] However, firms in the region more typically rely on generators to fill the gap.[14] Rates of generator use are particularly high for firms in South Sudan, Liberia, Chad, the Republic of the Congo, and Nigeria; firms in these countries use backup generators to supply at least 40 percent of their electricity needs, even though doing so, as noted earlier, can increase their electricity expenditures per kilowatt-hour (kWh) up to 10-fold.[15] By contrast, backup generator use is comparatively low in several SSA countries with low GDP per capita, suggesting that high generator prices may limit demand in those markets.[16]

Impediments to infrastructure investment

In most SSA countries, regulators set electricity tariffs artificially low, and as a result, utilities cannot price electricity to cover production costs.[17] Because of these low tariffs, utilities often do not have the money to invest in the construction of new power infrastructure, including generation facilities that use lower-cost energy sources. Further, utilities that are unable to cover costs lack funds to attract or repay investors. In a PwC survey of utility managers in SSA, two-thirds of respondents cited the lack of a cost-recovery tariff as a major hindrance to attracting investment in new generation and transmission projects, and 83 percent of respondents indicated

[11] Oil and diesel (with 8 percent of production), renewables excluding large hydropower (5 percent), and nuclear (2 percent) account for the balance of the region's generation mix. Roche, *True Cost of Electricity*, 2017 5; Stacy and Taylor, *The Levelized Cost of Electricity*, 2015, 44.

[12] As a result of droughts, some utilities in SSA have turned to more costly emergency power sources for significant shares of their electricity. For example, in Tanzania, a 2010 drought forced the national utility to invest in expensive diesel generators to provide 100 MW during a period marked by particularly high diesel prices. Reliance on these generators ultimately accounted for one-half of the utility's total costs. Wolfram and Gertler, "Is the Regulator Compact Broken in Sub-Saharan Africa?" 2016.

[13] Nyambura-Mwaura, "Kenya's Biggest Tea Producer to Generate Own Power," 2009.

[14] In the early 2000s, Sierra Leone used diesel generators to supply 100 percent of its electricity needs at a cost of 1 percent of its GDP, while Rwanda used generators to supply 48 percent of its electricity needs at a cost of 2 percent of GDP and Uganda used them to supply 42 percent of its needs at a cost of 3 percent of GDP. Eberhard et al., *Africa's Power Infrastructure*, 2011, 11.

[15] CDC, *What Are the Links between Power, Economic Growth, and Job Creation?* 2016,16. Private generators produce electricity at an estimated cost of $0.35 per kWh, which is as much as 10 times the cost of grid electricity. *Economist*, "Electricity in Africa," 2014.

[16] World Bank, "Infrastructure" (accessed May 14, 2018); and World Development Indicators, 2017.

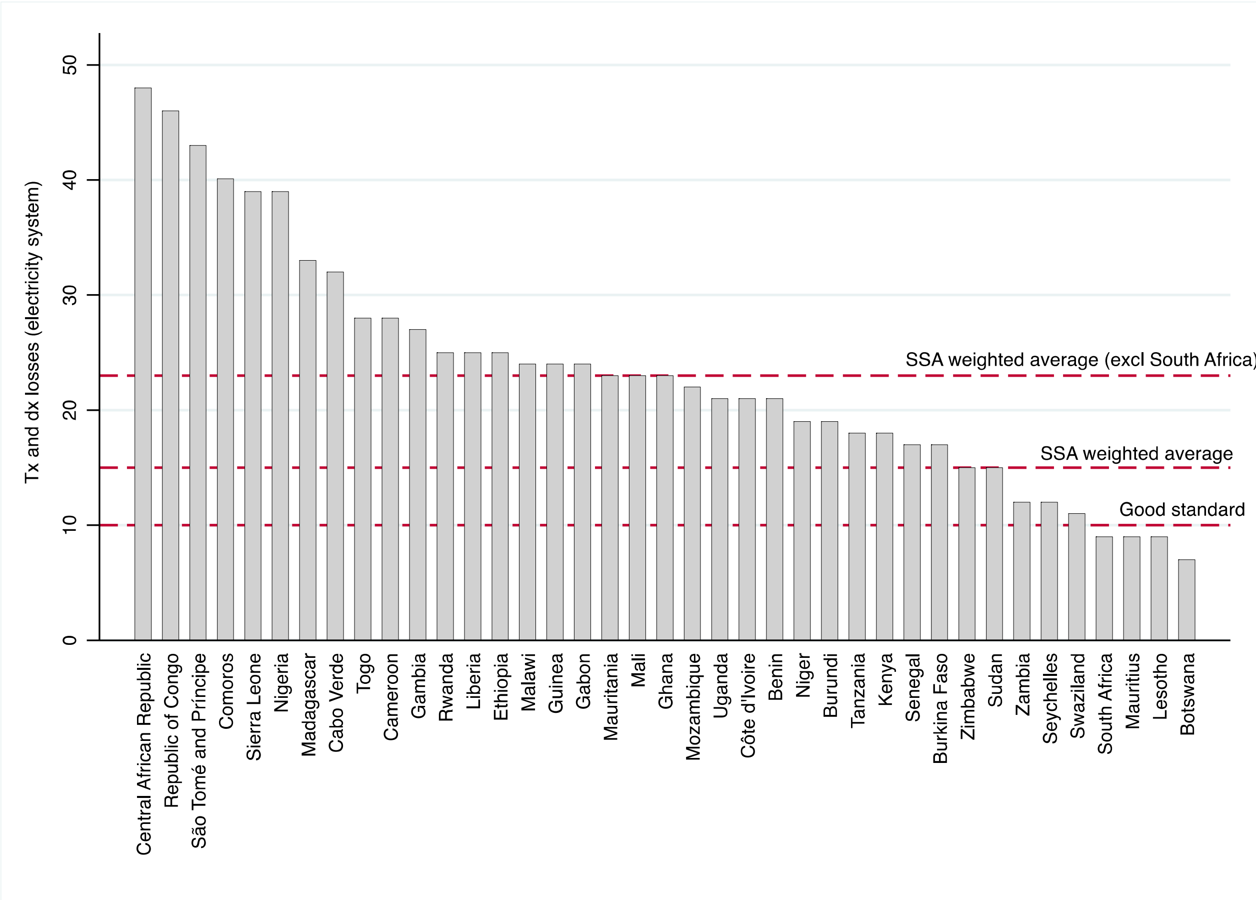
[17] Regulators may set low tariffs because electricity reforms may encounter a consumer backlash; politicians approve such reforms only if they improve electoral support. Besant-Jones, "Reforming Power Markets in Developing Countries," 2006, 6, 16. Perhaps as a result of these political concerns, just two countries—Seychelles and Uganda—have rates that are high enough to cover utilities' costs.

that instituting cost-reflective tariffs would have a high positive impact on electricity supply and reliability.[18]

Systems losses—the difference between output and sales of electricity—are another notable impediment to efforts to meet electricity demand in SSA. Some system losses arise from institutional constraints (or non-technical losses), whereby consumers steal electricity or utilities fail to bill consumers for consumption; others, from technical losses that can arise from electricity dissipating physically along the network.[19] Only four SSA utilities manage to contain their losses to a "good standard," which the World Bank defines as 10 percent or less (figure 2, appendix A). By contrast, eight SSA countries have losses of 30 percent or more—this means that for every 100 kWh the utility generates, it collects no revenue on 30 kWh. High systems losses in the region impair utilities' ability to repay infrastructure loans or fund maintenance needs, thereby making it more difficult to meet demand.[20] It may be no coincidence that the four SSA countries with the highest level of installed capacity per million people also rank among the five SSA countries with the lowest amounts of systems losses.

[18] PwC, *A New Africa Energy World*, 2015.
[19] Trimble et al., "Financial Viability of Electricity Sectors," 2015, 3–4.
[20] Kojima, Bacon, and Trimble, "Political Economy of Power Sector Subsidies," 2014; Streatfeild, "Does This Road Go On Forever?" 2017.

Figure 2. Transmission (tx) and distribution (dx) losses and international benchmarks (as % of generation).

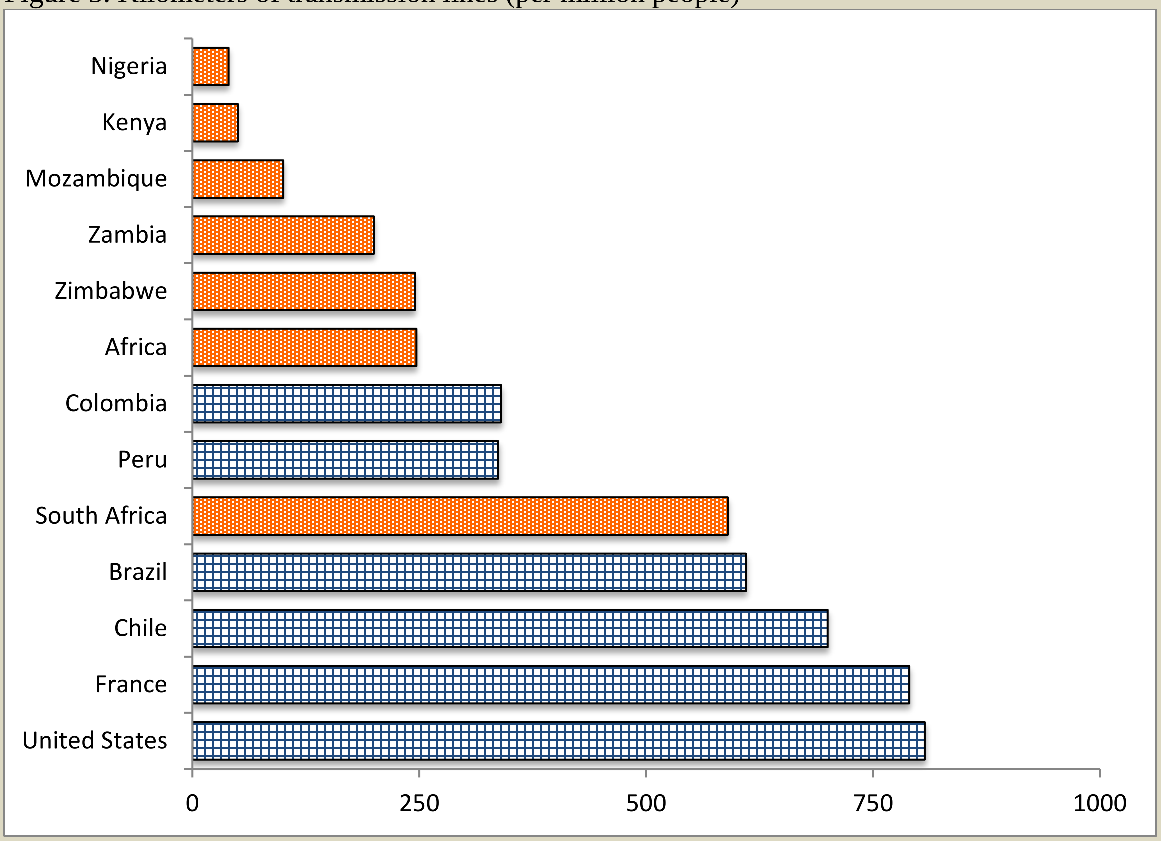


Source. Trimble et al., "Financial Viability of Electricity Sectors," 2015, 45

Box 1. Condition of Transmission Infrastructure in Sub-Saharan Africa (SSA)

The quality and extent of transmission networks are important components of any power system's ability to deliver electricity efficiently to its customers, and such infrastructure is largely deficient in SSA. Voltage levels are mostly inadequate: only 9 of 38 SSA countries in a World Bank study had transmission lines with voltages above 100 kilovolts (kV).[21] Coverage is also sparse—figure 3 shows that Africa has 247 km of transmission lines per million people, while Peru has 339 km, Brazil has 610 km, and the United States has 807 km. Further, utilities across SSA face difficulties in financing the expansion of their transmission networks outside of urban centers.[22] In fact, there has been no private investment in SSAs transmission networks, and foreign donors remain leading sources of investment in transmission (totaling $1.2 billion in 2015).[23]

Figure 3. Kilometers of transmission lines (per million people)



PPIAF, *Linking Up: Public-Private Partnerships*, 2017, xvii.

[21] Higher-voltage lines reduce resistance and losses when transmitting electricity from generation to consumer. Warkentin, *Electric Power Industry*, 1998, 18.
[22] Hosier et al., *Rural Electrification Concessions in Africa*, 2017.
[23] PPIAF, *Linking Up: Public-Private Partnerships*, 2017.

The implications of low electricity supply

The unavailability of reliable electricity supply in SSA reportedly undermines the region's economic performance. Electricity reliability (as defined by countries' "Quality of Electricity Supply" score) is closely and positively correlated with GDP per capita, and electricity reliability in many SSA countries is relatively low.[24]

Managers of manufacturing firms in SSA are more likely than managers in other world regions to highlight electricity shortages as their biggest production constraint. Dinh et al. estimate that power outages are associated with an average loss of 5 percent of firm sales across SSA.[25] The extent of lost sales varies across the region: lost sales rates are particularly high in the Central African Republic, Ghana, and Nigeria, while Eritrea, Liberia, and Rwanda have some of the lowest loss rates among countries at their income level. Similarly, the World Bank Enterprise Survey reports that exporting firms in SSA countries that experience electrical outages lose 7.5 percent of their annual sales due to these outages.[26]

Country- and firm-specific examples also illustrate the impact of unreliable electricity supply in the region. For example, Malawi's electricity supply is subject to outages and rising tariffs as hydroelectric plants see their output diminish in the dry season, negatively impacting the country's manufacturing sector.[27] British American Tobacco left Malawi in 2000, due in part to electricity supply factors, and the country's frequent power outages forced uranium mines to use their own diesel generators at a significantly higher cost.[28] In another example, a consortium of investors withdrew from Namibia in 2017, citing concerns with the security of electricity supplies in the country.[29]

Electricity trade

In an effort to address electricity shortages by increasing supply, many SSA countries have engaged in cross-border trade through power pools, as well as through public and private investment. This section focuses on the former, while a subsequent paper will address the latter. Power pools are trading arrangements involving two or more interconnected electricity systems that seek to integrate and maximize their performance in generating and transmitting power.[30]

---

[24] Individual countries' "Quality of Electricity Supply" scores reflect responses to the question, "In your country, how reliable is the electricity supply (lack of interruptions and lack of voltage fluctuations)? [1 = extremely unreliable; 7 = extremely reliable]." World Economic Forum, "Competitiveness Rankings," (accessed May 14, 2018).
[25] Dinh et al., "The Binding Constraints on the Growth of Firms," 2012, 13–16.
[26] World Bank Group, "Enterprise Surveys: Data; Benin (2016); Infrastructure" [accessed May 14, 2018].
[27] Vidal, "The Day the Lights Went Out," December 13, 2017.
[28] MCA—Malawi, "Draft—Final Analysis of Constraints," 2010, 35.
[29] Carter, "Investors Baulk at Putting Up Local Factories," October 2017. Not all investors are dissuaded by a low supply of electricity. In 2015, Uganda's Kiira Motors Corporation, a firm is owned by the Ugandan government and Makerere University, unveiled an ambitious plan to produce 7,000 hybrid cars even as domestic concerns were raised about high manufacturing costs due to low supplies of electricity. Nakkazi, "Uganda Pushes Ahead with 'Risky' Car Plans," 2015.
[30] Deloitte, *The Roadmap to a Fully Integrated and Operational EAPP*, 2015.

Due to the small size of power markets in individual SSA countries,[31] pooling resources can mitigate market and supply risks while taking advantage of economies of scale.[32] Governments seek to pool power into regional grids in order to lower infrastructure needs and operating costs.[33] The African Development Bank estimates that if fully integrated, regional power trade could lower Africa's annual electricity costs by an estimated $2 billion.[34] Further, regional power trade could encourage large-scale investments in SSA (particularly in hydropower) by lowering operating costs of such projects.[35]

There are currently four power pools that together comprise about 15 percent of total installed capacity in SSA. The Southern African Power Pool (SAPP) is the largest of these power pools, followed by the West African Power Pool (WAPP), the Eastern Africa Power Pool (EAPP), and the Central Africa Power Pool (CAPP).[36] Table 2 also shows that power pools in southern and western Africa have comprised a sizable amount of electricity consumption in southern and western Africa.

Table 2. Power traded by power pool (for most recent year available)

Process	SAPP (2010)	EAPP (2008)	WAPP (2010)	CAPP (2009)
Consumption (GWh)	260,081	124,017	47,073	15,238
Imports (GWh)	19,565	513	3,247	38
Exports (GWh)	15,301	931	3,278	915

Source: ICA, *Regional Power Status in African Power Pools*, 2011 (most recent data available).

Outlook

SSA's high electricity costs and low supply place an undue burden on the region's firms. However, SSA countries are unlikely to address this issue in the near future. While instituting cost-recovery tariffs that fully cover operation and investment needs could encourage investment in new generation capacity and promote power trade among SSA countries, some SSA countries are moving in the opposite direction by setting lower tariffs in an effort to benefit their

[31] For example, Eberhard et al. indicates that 11 SSA countries have a market size of less than 100 MW, while 33 countries have a market size under 500 MW. Eberhard et al., *Africa's Power Infrastructure*, 2011, 24. By comparison, India's total installed capacity is 334.4 GW and U.S. installed capacity is approximately 1,074.3 GW. CEA, "All India Installed Capacity (in MW) of Power Stations," 2018; EIA, "U.S. Economy and Electricity Demand Growth," 2018. http://www.cea.nic.in/reports/monthly/installedcapacity/2018/installed_capacity-01.pdf.
[32] Deloitte, *The Roadmap to a Fully Integrated and Operational EAPP*, 2015, 10.
[33] World Bank, *Building Regional Power Pools: A Toolkit*, n.d. http://siteresources.worldbank.org/EXTENERGY2/Resources/toolkit_book_final.pdf?resourceurlname=toolkit_book_final.pdf.
[34] AfDB, "The High Cost of Electricity Generation in Africa," 2013.
[35] Eberhard et al., *Africa's Power Infrastructure*, 2011. According to Eberhard et al., the development and operation of large-scale hydropower systems would be particularly beneficial, as the operation of these facilities would cost approximately 50 percent less than diesel systems, could yield 20 or 30 percent returns on investment, and would reduce carbon emissions. Large hydropower producers like the Democratic Republic of the Congo, Ethiopia, and Guinea could consolidate their dominant positions in the region by exporting hydropower to as many as 16 smaller countries. By importing up to half of their energy from these larger SSA markets, the smaller hydropower producers would save $0.01 to $0.07 per kWh in the process.
[36] Kambanda, "Power Trade in Africa," 2013.

manufacturing sectors. A move towards more trade through power pools and the reduction of systems losses could also help to increase supply, but these initiatives may also require politically unpopular tariff increases and tariff-collection efforts.

Bibliography

AfDB: Championing Inclusive Growth across Africa (blog). "The High Cost of Electricity Generation in Africa." African Development Bank, February 18, 2013. https://www.afdb.org/en/blogs/afdb-championing-inclusive-growth-across-africa/post/the-high-cost-of-electricity-generation-in-africa-11496/

Besant-Jones, John E. "Reforming Power Markets in Developing Countries: What Have We Learned?" World Bank. Energy and Mining Sector Discussion Paper 19, September 2006. http://documents.albankaldawli.org/curated/ar/483161468313819882/pdf/380170REPLACEMENT0Energy19.pdf.

Carter, Musa. "Investors Baulk at Putting Up Local Factories Due to Electricity Risks." *Namibia Economist*, October 25, 2017. https://economist.com.na/29927/headlines/investors-baulk-at-putting-up-local-factories-due-to-electricity-risks/.

CDC Group, *What Are the Links between Power, Economic Growth, and Job Creation?* 2016. http://www.cdcgroup.com/documents/evaluations/power%20economic%20growth%20and%20jobs.pdf.

Central Electricity Authority (CEA). "All India Installed Capacity (in MW) of Power Stations (Utilities)." January 1, 2018. http://www.cea.nic.in/reports/monthly/installedcapacity/2018/installed_capacity-01.pdf.

Dabanga. "Electricity Tariff Hike 'a Death Blow to Sudanese Industry." Dabangasudan.org, January 4, 2018. https://www.dabangasudan.org/en/all-news/article/electricity-tariff-hike-a-death-blow-to-sudanese-industry.

Deloitte. *The Roadmap to a Fully Integrated and Operational East African Power Pool*, 2015. https://www2.deloitte.com/content/dam/Deloitte/ke/Documents/energy-resources/ER_Power%20TL.pdf.

Dinh, Hinh T., Dimitris A. Mavridis, and Hoa B. Nguyen. "The Binding Constraint on the Growth of Firms in Developing Countries." In *Performance of Manufacturing Firms in Africa: An Empirical Analysis*, edited by Hinh T. Dinh and George R. G. Clarke, 87–135. Washington, DC: World Bank, 2012. DOI: 10.1596/978-0-8213-9632-2.

Eberhard, Anton, Orvika Rosnes, Maria Shkaratan, and Haakon Vennemo. *Africa's Power Infrastructure: Investment, Integration, Efficiency*. Washington, DC: World Bank, 2011. DOI: 10.1596/978-0-8213-8455-8.

Economist. "Electricity in Africa: Lighting a Dark Continent," September 27, 2014. https://www.economist.com/news/middle-east-and-africa/21620245-power-shortages-have-been-holding-africa-back-are-last-easing-lighting.

EIA. *See* U.S. Energy Information Administration (EIA).

Hosier, Richard, Morgan Bazilian, Tatia Lemondzhava, Kabir Malik, Mitsunori Motohashi, and David Vilar de Ferrenbach. *Rural Electrification Concessions in Africa: What Does Experience Tell Us?* World Bank, June 26, 2017. http://documents.worldbank.org/curated/en/347141498584160513/pdf/116898-WP-P018952-PUBLIC-Rural-Layout-fin-WEB.pdf.

Infrastructure Consortium for Africa (ICA). *Regional Power Status in African Power Pools: Report*, November 2011. https://www.icafrica.org/fileadmin/documents/Knowledge/Energy/ICA_RegionalPowerPools_Report.pdf.

Kaledzi, Isaac. "Ghanaians Protest Rising Fuel and Electricity Tariffs." DW, January 20, 2016. http://www.dw.com/en/ghanaians-protest-rising-fuel-and-electricity-tariffs/a-18994432.

Kambanda, Callixte. "Power Trade in Africa and the Role of Power Pools." *Industrialization and Trade Corner* (blog). African Development Bank, July 10, 2013. https://www.afdb.org/en/blogs/industrialisation-and-trade-corner/post/power-trade-in-africa-and-the-role-of-power-pools-12101/.

Kojima, Masami, Robert Bacon, and Chris Trimble. "Political Economy of Power Sector Subsidies: A Review with Reference to Sub-Saharan Africa." World Bank. Energy and Extractives Group. Paper no. 89547, July 2014. http://documents.worldbank.org/curated/en/860371467990087260/pdf/895470Replacem0sector0subsidies0030.pdf.

Kojima, Masami, Xin Zhou, Jace Jeesun Han, Joeri de Wit, Robert Bacon, and Chris Trimble. "Who Uses Electricity in Sub-Saharan Africa? Findings from Household Surveys." World Bank. Policy Research Working Paper 7789, August 2016. http://documents.worldbank.org/curated/en/967821470756082684/pdf/WPS7789.pdf.

Luhanga, Peter. "Electricity Tariff Hike Angers Cape Town Residents." News24, August 1, 2017. https://www.news24.com/SouthAfrica/News/electricity-tariff-hike-angers-cape-town-residents-20170801.

Millennium Challenge Account (MCA)—Malawi. "Draft— Final Analysis of Constraints on Economic Growth: The Republic of Malawi; The Millennium Challenge Account—Malawi." Constraints Analysis Study, 2010. https://assets.mcc.gov/content/uploads/2017/05/Malawi_CA_withCover.pdf.

Nakkazi, Esther. “Uganda Pushes Ahead with ‘Risky’ Car Plans.” SciDevNet, August 10, 2015. https://www.scidev.net/global/engineering/news/uganda-hybrid-cars-low-polluting-kiira.html.

Nwokoro, Silver. “Three groups protest against electricity tariff hike.” The Guardian Nigeria, December 13, 2017. https://guardian.ng/news/three-groups-protest-against-electricity-tariff-hike/.

Nyambura-Mwaura, Helen. “Kenya’s Biggest Tea Producer to Generate Own Power.” Reuters, August 11, 2009. https://www.reuters.com/article/us-kenya-tea-energy/kenyas-biggest-tea-producer-to-generate-own-power-idUSTRE57A3ID20090811.

Public-Private Infrastructure Advisory Facility (PPIAF). *Linking Up: Public-Private Partnerships in Power Transmission in Africa*. World Bank, 2017. http://documents.worldbank.org/curated/en/794221496411403495/pdf/115521-WP-P152573-PUBLIC-June-6-SUPTAEnglishReportWeb.pdf.

PwC. *A New Africa Energy World: A More Positive Power Utilities Outlook.* PwC Africa Power and Utilities Sector Survey, July 2015. https://www.pwc.com/gx/en/utilities/publications/assets/pwc-africa-power-utilities-survey.pdf.

Roche, Maria Yetano (supported by Nnanna Ude and Ikenna Donald-Ofoegbu). *True Cost of Electricity: Comparison of Costs of Electricity Generation in Nigeria*. Heinrich Böll Stiftung, June 2017. https://ng.boell.org/sites/default/files/true_cost_of_power_technical_report_final.pdf.

Rustomjee, Zavareh. “South Africa's Municipal Electricity Tariffs are Hurting the Economy.” Mail & Guardian, 22 May 2018. https://mg.co.za/article/2018-05-22-south-africas-municipal-electricity-tariffs-are-hurting-the-economy.

Scott, De Buys, Christian Lindfeld, Alex Martin, Puleng Pitso, and Mark Engelbrecht. *KPMG Sub-Saharan Africa Power Outlook: 2016*. KPMG Africa Infrastructure, 2016. https://assets.kpmg.com/content/dam/kpmg/pdf/2016/05/kpmg-sub-saharan-africa-power-outlook.pdf.

Stacy, Thomas F., and George S. Taylor. “The Levelized Cost of Electricity from Existing Generation Resources.” Institute for Energy Research, 2015. https://www.instituteforenergyresearch.org/wp-content/uploads/2016/07/IER_LCOE_2016-2.pdf.

Streatfeild, Jeremy. "Does This Road Go on Forever? Modelling Sustainability of Infrastructure in Developing Countries." *Journal of Infrastructure Development*, October 2017. https://doi.org/10.1177/0974930617732240.

Trimble, Chris, Masami Kojima, Ines Perez Arroyo, and Farah Mohammadzadeh. "Financial Viability of Electricity Sectors in Sub-Saharan Africa: Quasi-Fiscal Deficits and Hidden Costs." World Bank. Policy Research Working Paper 7788, August 2016. http://documents.worldbank.org/curated/en/182071470748085038/pdf/WPS7788.pdf.

U.S. Energy Information Administration (EIA). "Existing Capacity by Energy Source, 2016 (Megawatts)," n.d. https://www.eia.gov/electricity/annual/html/epa_04_03.html.

U.S. Energy Information Administration (EIA). "U.S. Economy and Electricity Demand Growth are Linked, but Relationship is Changing," 2018. https://www.eia.gov/todayinenergy/detail.php?id=10491**.**

Vidal, John. "The Day the Lights Went Out: The Terrible Toll of Malawi's Power Cuts." *Guardian*, December 13, 2017. https://www.theguardian.com/global-development/2017/dec/13/malawi-power-cuts-national-blackouts-poor-hungry.

Warkentin, Denise. *Electric Power Industry: In Nontechnical Language*. Tulsa: PennWell, 1998

Wolfram, Catherine, and Paul Gertler. "Is the Regulatory Compact Broken in Sub-Saharan Africa?" *Energy Institute Blog*, September 12, 2016. https://energyathaas.wordpress.com/2016/09/12/is-the-regulatory-compact-broken-in-sub-saharan-africa/.

World Bank Group. "Enterprise Surveys: Data; Benin (2016); Infrastructure," https://www.enterprisesurveys.org/data/exploreeconomies/2016/benin#infrastructure--exporter-type. (accessed May 14, 2018).

World Bank. "Infrastructure." Enterprise Surveys. (accessed May 14,2018). https://www.enterprisesurveys.org/data/exploretopics/infrastructure.

World Bank. "World Development Indicators," databank.worldbank.org for EG.ELC.ACCS.ZS and SP.POP.TOTL. (accessed May 14, 2018).

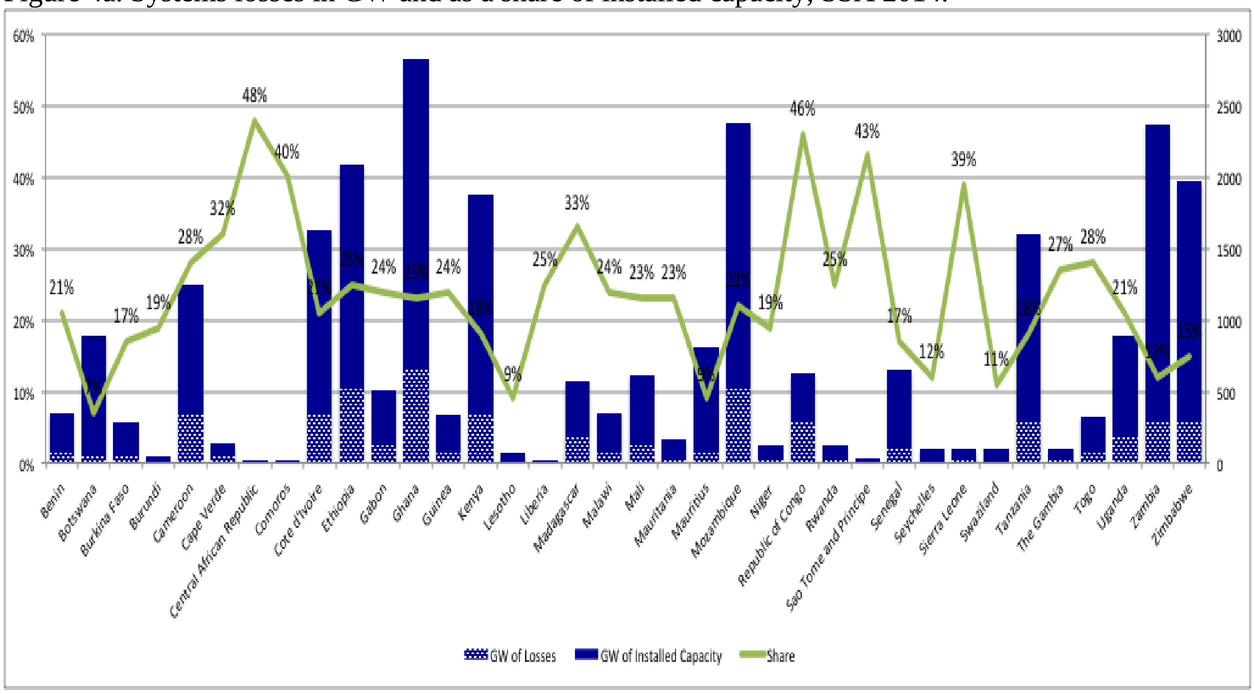
World Bank. *Building Regional Power Pools: A Toolkit*, (accessed May 14, 2018). http://siteresources.worldbank.org/EXTENERGY2/Resources/toolkit_book_final.pdf?resourceurlname=toolkit_book_final.pdf.

World Economic Forum. "Competitiveness Rankings," 2016. http://reports.weforum.org/global-competitiveness-report-2014-2015/rankings/.

Appendix A

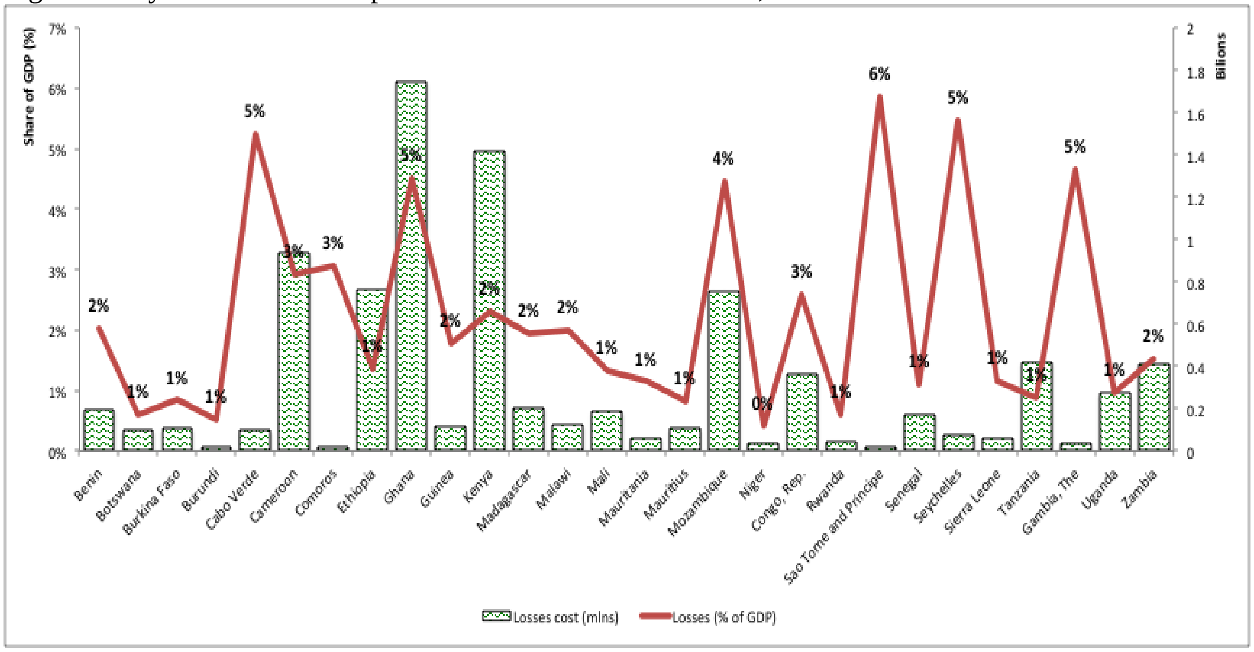
Figure 4a shows that, on average, about one-quarter of the electricity generated by SSA utilities (or about 25 GW) is lost either to technical or non-technical losses.[37] Although losses in South Africa are low in relatively terms (at about 4 GW of electricity annually compared to its total installed capacity of 47 GW), several other countries—including Ghana, Mozambique, and Zambia—lose at least 500 MW per year and these losses can have a large economic impact. For example, Nigeria's systems losses amount to 4 GW as well but that country's total installed capacity is 10.6 GW. in financial terms, $1.7 billion of Ghana's annual generation is foregone as a result of electricity losses (worth the equivalent of 5 percent of the country's GDP), because customers are not paying for that power (see figure 4b). The Gambia, São Tomé and Príncipe, and Cabo Verde also lose the equivalent of five percent of their GDP.

Figure 4a. Systems losses in GW and as a share of installed capacity, SSA 2014.



Source: Author's calculation from Trimble et al, Financial Viability of Electricity Sectors, 2016; World Bank, World Development Indicators; and Eberhard et al, Africa's Power Infrastructure, 2011.

Figure 4b. Systems losses in capital costs and as a share of GDP, SSA 2014.



Source: Author's calculation from Trimble et al, Financial Viability of Electricity Sectors, 2016; World Bank, World Development Indicators; and Eberhard et al, Africa's Power Infrastructure, 2011.