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Cover Page Footnote

Juris Doctor Candidate, Notre Dame Law School, 2020; Bachelor of Arts in Government, Georgetown University, 2013. I would like to thank Professor Bruce Huber for his guidance on the writing process. I would also like to thank my family for their ongoing support and the staff of the Notre Dame Journal of International & Comparative Law for their sincere and helpful edits.

IT'S TIME TO TURN ON THE LIGHTS: THE NECESSARY STEPS FOR THE RURAL ELECTRIFICATION OF SUB-SAHARAN AFRICA

JOHN MORRIS*

INTRODUCTION

For a vast majority of the Earth's population (roughly six billion people), the darkness that follows each day is lifted by the flip of a light switch. This light is, to a large extent, taken for granted. For the 1.2 billion others who remain off-grid, however, sunsets bring a darkness from which there is little respite until the following morning.[1] Of that 1.2 billion people, 650 million are Africans living in remote, rural areas of the continent. There is much work to be done to ensure that sufficient electricity reaches these areas in the coming decades.[2]

Globally, for over one hundred years, there have been proposals on how to address the problem of rural electrification. Solutions in the United States, for instance, have been coming from the federal government for decades. In a 1926

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[1] Gabriel Davies, *Building the Grid of the Future, Today,* BROOKINGS: AFRICA IN FOCUS (Oct. 10, 2017), https://www.brookings.edu/blog/africa-in-focus/2017/10/10/building-the-grid-of-the-future-today/.

[2] *Id.*

congressional research report, multiple challenges were identified by Congress as to why the electrification of the rural parts of America had lagged behind the urban areas:

> Widespread rural electrification has been held back to date by the financial obstacles to profitable distribution of power in the farming areas . . . Chief among the financial obstacles are the farmer's small cash income, coupled with the large unit investment required in distribution systems to serve only a few farms per mile of line.[3]

Less than a decade later, President Franklin Roosevelt addressed this issue by establishing the Rural Electrification Administration (REA).[4] In the first five years of the REA's existence, it provided more than $227 million in government subsidized loans[5] to connect rural farmers through "laying distribution lines, wiring homes, and even building local diesel generation plants."[6]

For the most part, rural electrification has been achieved in the First World due to the proliferation of administrative agencies similar to the REA. However, in areas of the Third World, such as sub-Saharan Africa, the goal of rural electrification is far from realized and will go unachieved for the foreseeable future without a confluence of investment, support, and regulation. In fact, many of the same hurdles that rural America faced in the early half of the twentieth century mirror what rural Africa must now overcome. The continued growth of renewable energy infrastructure in the region has made widespread rural electrification an attainable goal in recent years, and the prevalence of wind, solar, and geothermal options (all to a differing degree) signal hope for the region as a whole. Nevertheless, there is much work left to be done. The impediments to rural electrification in sub-Saharan Africa can begin to be mitigated with three aforementioned tools: investment, support, and regulation.

This note will address those three factors, which need to coalesce to form a solution to the problem of access to electricity. Investment, from both the public and private sectors, will be crucial not only for the proliferation of electrification but also for the initial growth of solutions to energy access, such as mini-grids. Second, support from governments and non-governmental organizations will also be crucial for the continued success of projects across the region, and it will be partially on private associations of developers to do some of the legwork in this regard. Specifically, these organizations need to partner with individual companies or broader associations and refrain from hindering progress because of a vested interest in the continuing dominance of the national, often government-owned, utility grid. Finally, regulatory frameworks will need to be enacted, both domestically and internationally. One of the primary barriers to investment and support is the complicated, redundant, and often non-existent regulatory framework set up for the renewable energy space and the power sector in general. Given the vast disparity in resources between the First and

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[3] *Id.*
[4] *Id.*
[5] *Id.* This figure equates to $3.6 billion in 2017 dollars.
[6] *Id.*

Third Worlds, collaboration between governments in sub-Saharan Africa (or "regional integration") must occur if humans are to enhance their everyday lives with power.

This note will begin by analyzing the evolution of the power supply in the First World, highlighting the long development processes that the West had to undergo to reach the current state of affairs that it now enjoys, in regards to power generation. An understanding of this non-linear growth and the various sources through which the First World generates power is integral to understanding the process of electrifying the sub-Saharan African continent and how it will not happen overnight. A discussion of different types of renewable energy will follow, outlining certain diverse characteristics of wind, solar, and geothermal energy, including the basic science behind each source's generation. This note will then detail the recent progress made in the electrification of sub-Saharan Africa, looking at Tanzania and Kenya, and specifically at how the proposed solutions in this paper have, in part, begun to be enacted. The current need for renewable energy in Africa will be discussed and the current state of government involvement in electrification projects will be analyzed. An analysis of the various factors needed to implement a successful electrification strategy—mini-grids, private company associations, government sponsorship, and various forms of investment—will also be addressed. Finally, this paper will conclude with a proposed solution marrying investment, governmental (and non-governmental) support, and regulatory frameworks—all of which are necessary. This solution shows that without public and private collaboration, both domestically and across sovereign borders, there is little hope for electrification of rural, sub-Saharan Africa in the near or immediate future. This paper provides a roadmap that organizations can look to when embarking upon the endeavor of bringing energy to the 600 million-plus people that have no way to turn on the lights when the sun has gone down.

I. A HISTORY OF POWER GENERATION IN THE FIRST WORLD

The history of power generation in the West features a slow, non-linear evolution of inventions and power sources that spans multiple centuries. The first demonstration of electric conduction, performed by Englishman Stephen Gray, led to the invention of glass friction generators in Germany in 1740. This event is often the starting point for many accounts of power generation.[7] This invention led to many more experiments that would shape the evolution of power generation across Europe and North America: the inventions of the battery in 1800 by Alessandro Volta, the first effective "arc lamp" by Humphry Davy in 1808, and the demonstration of the relationship between electricity and magnetism by Hans Christian Oersted in 1820.[8] Perhaps the "most pivotal

[7] Abby Harvey, Aaron Larson & Sonal Patel, *History of Power: The Evolution of the Electric Generation Industry*, POWER MAG. (Oct. 1, 2017), https://www.powermag.com/history-of-power-the-evolution-of-the-electric-generation-industry/. Benjamin Franklin was said to have been inspired by the glass friction generators, which led to his own experimentation with electricity in the eighteenth century.

[8] *Id.*

contribution to modern power systems" was the invention of the electric motor by Michael Faraday and Joseph Henry in 1820, and their follow-up experiment, which "documented that an electric current can be produced in a wire moving near a magnet," establishing the principle of the generator.[9]

Over the remainder of the nineteenth century, European and American inventors expanded upon the concept of a generator until Thomas Edison established a central generating station in lower Manhattan in September of 1882.[10] This was the first implementation of a full-scale central power station, and Edison employed a system of conductors to distribute electricity to end-users around the city.[11]

While all of these advancements were occurring, coal power generation was also becoming entrenched as a primary source of power on either side of the Atlantic, a phenomenon rooted in surging power demand and the flourishing mining sector.[12] Natural gas, which provides the majority of installed capacity and generation in the United States, did not grow nearly as rapidly as coal.[13] Innovations to natural gas infrastructure in the late nineteenth and early twentieth centuries, spearheaded by American inventor Charles Curtis and Dr. Sanford Moss of the General Electric Company, boosted the prevalence and importance of natural gas technology. Furthermore, innovations in aircraft technology, as well as engineering and manufacturing advancements due to both World Wars, led to gas power technology gaining new prominence.[14] Inventions throughout the middle part of the twentieth century ensured that natural gas power became the backbone for much of the power generation in the United States.[15]

An oft-overlooked part of energy generation's growth and distribution was the role that today's "renewable sources" played in the preceding centuries. The beginning of what is now thought of as modern renewable energy began in the late 1800s in the form of hydropower. In fact, hydropower was the first power source to become a "commercial electricity generation source" in 1880, and only two years later, the world's first central direct-current (or DC) hydroelectric station supplied power to a paper mill in Appleton, Wisconsin.[16] Four years after that, there were between forty and fifty hydroelectric plants in the United States and Canada, and two years after that, "roughly 200 electric companies relied on hydropower for at least some of their electricity generation."[17] Internationally,

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[9] *Id.*
[10] *Id.*
[11] *Id.* In reality, most of the distribution was delivered to the "high-profile" business district.
[12] *Id.*
[13] *Id.*
[14] *Id.*
[15] *Id.* During this time, specifically the 1940s and 1950s, nuclear power also gained favor. Inventors of the time, such as Enrico Fermi, Otto Hahn, and Fritz Strassman, discovered the power of nuclear fission and paired their discoveries with the work of Albert Einstein to advance scientific understanding of atomic principles. Such work was integral to the advancement of nuclear power and reactors. In the context of this paper, however, nuclear energy need not be discussed.
[16] *Id.*
[17] *Id.* In 1889, the first alternate-current (or AC) hydroelectric plant came online in Oregon City, Oregon.

the Swiss were at the forefront of "pumped storage," and the first such plant opened in Switzerland in 1909.[18]

During this boom in hydropower usage, inventors also worked to harness wind power to drive commercially-viable production.[19] Wind power never quite spread like other forms of power generation; however, in places like the American Midwest, where the turbines were used to power irrigation pumps, it found success.[20] In the latter part of the twentieth century, as the United States began to both incentivize and require companies to use renewable energy sources, wind power saw an uptick in interest.[21]

Finally, compared to the "other commercially available renewable energy sources, solar power is in its infancy."[22] Despite the discovery of the photovoltaic (PV) effect in 1839 by the French scientist Edmond Becquerel, the first solar cell was not created until 1882,[23] and was not commercially produced until the 1950s.[24] During subsequent decades, solar power increased its viability, both for commercial and residential use, when grid-connected options were not available. Notwithstanding, by 2016, still only 0.9% of U.S. electricity was generated by solar power at "utility-scale facilities."[25] That number is somewhat deceiving, however, as 0.9% actually represents a near doubling of the previous record year.[26]

This background information shows that the power generation in the Western world took centuries to develop. Whether it was the proliferation of gas or coal-powered generation or the renewable energy sources being championed today, the process of establishing efficient sources of power was iterative and meandered often during the nineteenth and twentieth centuries. For sub-Saharan Africa, an area which accounts for nearly fourteen percent of the world's population yet only commands four percent of global energy investment, an increase in the amount of renewable energy is likely needed to reach the region's young and growing population.[27]

II. RENEWABLE ENERGY BROADLY

To understand what the proper solutions should be to electrify the African continent, one must have a rudimentary understanding of renewable energy.

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[18] *Id.*

[19] *Id.* For instance, in 1888, an Ohio an inventor, Charles Brush, constructed a wind turbine sixty feet tall on his property to generate electricity. The turbine was fifty-six feet in diameter, had 144 blades, and was connected to batteries in the basement of his home.

[20] *Id.*

[21] *Id.* Because of the 1970's oil crisis, wind power was the target of much research and development. Additionally, President Jimmy Carter signed the Public Utility Regulatory Policies Act of 1978, requiring companies to buy a certain amount of electricity from renewable energy sources, which included wind.

[22] *Id.*

[23] *Id.* American inventor Charles Fritts was the first to create a solar cell.

[24] *Id.*

[25] *Id.*

[26] *Id.*

[27] *Energy Access Outlook 2017: From Poverty to Prosperity*, INT'L ENERGY AGENCY, 77 (2017), https://www.iea.org/publications/freepublications/publication/WEO2017SpecialReport_EnergyAccess Outlook.pdf [hereinafter IEA REPORT].

Renewable energy is "energy from sources that are naturally replenishing but flow-limited."[28] While renewable energy sources are virtually inexhaustible, they are limited in the amount of energy that is available at any given time.[29]

A. *CURRENT TYPES OF RENEWABLE ENERGY*

1. *Solar*

The collection of solar energy has been occurring for close to two hundred years.[30] While there are many different technologies that can be employed to collect and to convert solar radiation into useful energy, this note will focus primarily on solar photovoltaic devices. These solar devices are commonly referred to as solar cells, and they are able to convert sunlight directly into electricity.[31] When these PV cells are arranged into various panels and arrangements, they can produce a significant amount of electricity.

There are two central benefits to using solar energy. First, unlike energy derived from fossil fuels, it does not produce air pollutants and carbon dioxide. Second, systems employing solar energy have minimum effects on the environment.[32] There are, however, detractors from the solar energy space, who state that there are limitations to the science. One limitation is that the amount of sunlight that arrives at the earth's surface is inconsistent; the amount of sunlight varies based on factors such as location, time, season, and overall weather conditions.[33] Furthermore, another limitation is that the amount of sunlight actually reaching the earth's surface is "relatively small, so a large surface area is necessary to absorb or collect" an amount of energy that could be considered useful.[34]

2. *Wind*

While the phenomenon of wind creation may be simple (uneven heating of the earth's surface by the sun creates wind), harnessing wind to generate electricity can be difficult.[35] For starters, simply erecting complex wind turbines is not always an effective or efficient way to attempt to corral wind power. Effective sites for wind turbines include the tops of smooth, rounded hills, open plains and water, and mountain gaps that funnel and intensify wind.[36] Even after ideal placement, however, varying wind speeds throughout an area may lead to an inefficient control of power. Furthermore, even though wind is an "emissions-

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[28] *Renewable Energy Explained*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/energyexplained/?page=renewable_home (last visited Nov. 18, 2018).

[29] *Id.*

[30] *Id.* In the 1830s, John Herschel, a British astronomer used a solar oven for cooking purposes during an expedition to Africa.

[31] *Id.* Small PV cells can power watches and other small, everyday electronic devices.

[32] *Id.*

[33] *Id.*

[34] *Id.*

[35] *Wind Explained: Where Wind Power is Harnessed*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/energyexplained/index.php?page=wind_where (last visited Nov. 18, 2018).

[36] *Id.*

free source of energy," wind turbines can negatively affect the environment.[37] Most contemporary wind turbines are very large machines, and some can cause harm to the surrounding wildlife and vegetation.[38]

Although some believe that wind energy is becoming more cost-effective, a tale of cost efficiency does not tell the whole story. Between 1980 and 2015, wind energy received $30 billion in federal subsidies and grants, all while supplying the U.S. with only 4.4% of its electricity in 2014.[39] Despite the supposed decrease in capital-intensive nature of wind energy infrastructure construction, the technology itself does not generate enough power to justify its expanded use quite yet.

3. *Geothermal*

Geothermal energy comes from the heat within the earth itself, and it is a renewable energy source because heat is continuously produced.[40] There are three main types of geothermal energy systems: direct use and district heating systems, electricity generation power plants, and geothermal heat pumps.[41]

Direct use and district heating systems use hot water from reservoirs or springs that are close to the earth's surface; in certain instances, the direct use is employed by piping the hot water directly into buildings for heat.[42]

Geothermal electricity generation requires water or steam at very high temperatures, ranging from 300 degrees to 700 degrees Fahrenheit; these power plants are thus often built near where the geothermal reservoirs are located.[43] Surprisingly, the United States leads the world in the amount of electricity generated by geothermal energy, with its geothermal plants producing about 16 billion kWh in 2017 (a figure that equates to 0.4% of the total "utility-scale electricity generation").[44]

Finally, geothermal heat pumps "use the constant temperatures near the surface of the earth"[45] to both heat and cool buildings, depending on the time of year. Similar to the direct use of geothermal energy, heat pumps transfer heat from the ground or water into buildings.

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[37] *Id.*

[38] *Id.* Some of the detrimental effects in the past have included fires caused by the turbines, leaking lubrication fluids, sound pollution, animal death, and the mining of minerals and other materials to build the turbines.

[39] Randy Simmons, *What's the True Cost of Wind Power?*, NEWSWEEK (Apr. 11, 2015), https://www.newsweek.com/whats-true-cost-wind-power-321480.

[40] *Geothermal Explained: What is Geothermal Energy?*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/energyexplained/index.php?page=geothermal_home (last visited Jan. 10, 2018). The slow decay of radioactive particles within the earth's core (which is a process that occurs in all rocks) is what produces geothermal energy.

[41] *Geothermal Explained: Use of Geothermal Energy*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/energyexplained/index.php?page=geothermal_use (last visited Jan. 10, 2018).

[42] *Id.*

[43] *Id.*

[44] *Id.*

[45] *Id.*

B. *CURRENT USE OF RENEWABLE ENERGY IN THE UNITED STATES*

Up until the middle of the nineteenth century, the primary source of the nation's energy needs, for uses such as light, heating, and cooking, was wood.[46] In the late 1800s, the primary source of energy became fossil fuels: coal, petroleum, and natural gas; this paradigm remains entrenched in modern America. While certain renewable energy sources were employed in the U.S. before the 1990s, such as hydropower[47] and solid biomass,[48] the energy supply in the last two decades has come from additional renewable sources, such as biofuel, solar, and wind technologies.[49] In 2010, for instance, electricity generation in the United States was derived from a variety of sources.[50]

In 2017, renewable energy provided roughly 11 quadrillion Btu (or British thermal units, the basic unit of measure for energy), which was equal to 11% of the total energy consumption of the United States.[51] About 57% of the country's renewable energy consumption was by the electric power industry, and roughly 17% of electricity generation in the United States was from renewable energy sources.[52]

III. THE CURRENT STATE OF ELECTRIFICATION IN SUB-SAHARAN AFRICA

The current state of electrification throughout the eastern portion of the African continent presents an interesting case study into the diverse regulatory requirements across the region. Certain countries have initiated task forces or commissions to deal with the issue of electrification while others have not.[53] At this point in time, each country is in a different state of electrification. For the purposes of this note, the primary focus will be on the nations of Tanzania and Kenya.

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[46] *Renewable Energy Explained*, *supra* note 28.

[47] *Hydropower Explained*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/energyexplained/index.php?page=hydropower_home (last visited Nov. 18, 2018). Hydropower is the energy that resides in moving water, and to understand hydropower, one must understand the three steps of the water cycle. First, solar energy heats water on the surface of rivers, lakes, and oceans, and this causes water to evaporate. Then, water vapor condenses into clouds and falls as precipitation. Finally, that precipitation collects in streams and in rivers, which empty in oceans and lakes where the cycles begins again. The amount of precipitation in a given area determines the amount of water available to produce hydropower. Hydroelectric power is produced from moving water, and thus hydroelectric power generally comes from power plants that are located on or near a water source.

[48] *Biomass Explained*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/energyexplained/index.php?page=biomass_home (last visited Nov. 18, 2018). Biomass is organic material that comes from plants and animals, and it is also a source of renewable energy. In short, biomass contains stored energy from the sun, and when biomass is burned, it releases heat as an energy source.

[49] *Id.*

[50] Simmons, *supra* note 39. The breakdown of electricity generation in the U.S. in 2010 consisted of: 20% generated from nuclear power, 45% from coal, 25% from natural gas, 2% from wind power, a nominal amount from solar power, and 8% spread across "other" forms of electricity generation.

[51] *Renewable Energy Explained*, *supra* note 28.

[52] *Id.*

[53] JOHN KIDENDA, INT'L ENERGY AGENCY'S WORLD ENERGY OUTLOOK: MINI-GRIDS ON THE TRAJECTORY OF RURAL ELECTRIFICATION IN AFRICA: AN AMDA POSITION PAPER 8 (2011). The Nigerian Electricity Regulatory Commission (NERC) is such a body.

A. *SUB-SAHARAN AFRICA BROADLY*

Sub-Saharan Africa is a culturally and economically diverse region that is ripe for rapid economic expansion. Certain countries, such as Tanzania, Rwanda, and Ethiopia, have economic growth rates of greater than five percent, while other countries have little to no growth forecasted for their economies in the coming years.[54] Due to these slower-growth economies, the forecasted economic growth across the entire region was around 2.6% in 2017.[55] Related to population growth, between the years of 2017 and 2032, an estimated 300 million Africans in the region will reach employment age, with two-thirds of that population located in rural areas.[56] As previously stated, while sub-Saharan Africa comprises roughly fourteen percent of the world's population, it commands only four percent of the energy infrastructure funding.[57] Additionally, the region is home to a forty-eight percent share of the global population without access to electricity.[58] Such a disparity keeps productivity low in the region, which remains primarily agricultural in nature. With only a small increase in access to electricity, the economic output of the region could skyrocket.

In 2013, the number of people without access to electricity in the region failed to increase for the first time. In fact, that same number has steadily declined, led the by efforts of a handful of nations.[59] Additionally, since 2012, the pace of electrification has almost tripled when compared to the rate of electrification found in the region between 2000 and 2012.[60] Despite this success, "590 million people—roughly 57% of the population—remain without access in sub-Saharan Africa, making it the largest concentration of people in the world without electricity access as efforts have often struggled to keep pace with population growth."[61] More than eighty percent of the population that lives without access to power does so in rural areas, where the electrification rate is less than twenty-five percent (as compared to seventy-one percent in urban areas).[62]

While national grid expansion is, and will remain, the primary mode through which access to electricity will spread in the region, it is important to note that renewable energy access is increasing and it will likely continue to do so: "[b]etween 2012 and 2015, around 18 million people gained access from renewable-based power every year."[63] This figure is a drastic change from the

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[54] IEA REPORT, *supra* note 27, at 76.
[55] *Id.*
[56] *Id.*
[57] *Id.*
[58] ANTONIO CASTELLANO ET AL., MCKINSEY & COMPANY, *BRIGHTER AFRICA: THE GROWTH POTENTIAL OF THE SUB-SAHARAN ELECTRICITY SECTOR* 6 (MCKINSEY & COMPANY, 2015) [hereinafter MCKINSEY REPORT].
[59] IEA REPORT, *supra* note 27, at 80. These nations include Cote d'Ivoire, Ethiopia, Ghana, Kenya, Sudan, and Tanzania.
[60] *Id.*
[61] *Id.*
[62] *Id.*
[63] *Id.*

three million people that gained access to electricity from renewables each year between 2000 and 2012.[64]

Decentralized systems, including mini-grids, are a major catalyst of this phenomenon. While these systems may only comprise a small share of the increased access, they have proven to be particularly effective in reaching parts of the region that have yet to be powered by the main grid. Thus, these systems have become a conduit through which this underserved population is being electrified. In the past decade, both the countries of Tanzania and Kenya have been on the forefront of this movement, with both nations becoming experiments in how decentralized power systems can bring electricity to massive rural populations.

B. *Tanzania*

The country of Tanzania currently has about 109 mini-grids, serving more than 180,000 people.[65] These mini-grids account for 157.7 megawatts (MW) of installed capacity spread across a variety of energy sources that include hydro, biomass, hybrid, fossil fuel, and solar.[66] According to the country's own estimates, roughly half of the rural population may be served in a more cost-effective manner by decentralized power options rather than by an expansion of the centralized grid.[67]

In order to encourage low-cost investment in the mini-grid space, Tanzania adopted a new regulatory framework in 2008 that caused the number of mini-grids to double.[68] The primary mechanism used to do this was called a feed-in tariff, and it favored biomass and hydro development with low generation cost.[69] Just a few years later in 2015, a revision to the policy encouraged the development of solar and wind power sources. In 2017, the country's Energy and Water Utilities Regulatory Authority (EWURA) approved a third update to the framework.[70]

This new framework included several improvements that created "an enabling regulatory environment."[71] Electrification groups believe that while these are important improvements, there are "limitations on the grid integration framework creating ambiguity in implementation," and there is a lack of clarity on grid expansion planning that poses a risk to potential investors in the space.[72]

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[64] *Id.*
[65] KIDENDA, *supra* note 53, at 898.
[66] *Id.*
[67] *Id.*
[68] *Id.*
[69] *Id.*
[70] *Id.*
[71] *Id.* at 9. These improvements included allowing mini-grids at multiple locations to acquire a single license (above one megawatt) or registration for mini-grids using the same technology (below one megawatt), exempting mini-grids below 100 kilowatts from tariff regulation, defining eligible customers that need not have their tariffs reviewed by EWURA, allowing grid-connected mini-grids to operate in "islanded" mode when power supply is not available from the main grid, and providing some clarity and credibility on the calculation of the limited compensation for distribution assets when the main grid connects to a previously isolated mini-grid.
[72] *Id.* at 10.

C. *KENYA*

The current installed capacity in Kenya is roughly 2,400 MW and that capacity is predominantly derived from geothermal and large hydro sources.[73] What makes Kenya slightly different from Tanzania and other countries in the region, such as Nigeria, is the "robust private sector participation in power generation" that already exists.[74] Increased investment in the space, however, is hampered by the lack of regulatory frameworks to boost transmission and distribution.[75] Additionally, Kenya Power, which is the country's national utility, has collaborated with the Rural Electrification Agency (REA) to increase rural electrification for over a decade.[76] The collaboration has taken the form of the Last Mile Connectivity Project, which, funded by the World Bank, provides a subsidy to the national utility for each household connected to the main grid of Kenya.[77]

The 2015 National Energy Policy and Bill, which was meant to "bring clarity on key issues," such as the specific procedures surrounding the interconnection of mini-grids and the main grid, has stalled, engendering a hamstrung regulatory environment.[78] While there are certain regulations currently in place,[79] the lack of a fleshed-out mini-grid policy has slowed the momentum of the industry, as many would-be developers are awaiting regulatory clarity before beginning development.[80] The new bill is expected to reduce the regulatory burden for developers by providing guidelines for mini-grid development and clarifying the broader national electrification strategy.[81]

IV. ANALYSIS

To put forth viable solutions that will solve the problem of energy access across the African continent, there are many terms to define, myths to dispel, and nuances to understand. This section will address some of these important factors and entities that will be vital if the process of electrification in sub-Saharan Africa is to be successful.

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[73] *Id.*

[74] *Id.*

[75] *Id.*

[76] *Id.* Kenya Power and REA have clear objectives for what they hope the distribution system can look like in the country. This vision includes "building a stronger and more flexible grid" by incorporating redundancies, reducing losses, and adding smart technologies to the process of electrification. The two groups are also looking to enhance off-grid access by "hybridizing 19 off-grid diesel-powered stations and adding 43 greenfield solar mini-grids."

[77] *Id.*

[78] *Id.*

[79] *Id.* Current regulation does provide guidance on the requirements for mini-grid registration based on the size of the generation; that is, installations that are smaller than three megawatts are required to apply for a permit, while larger installations require a full license.

[80] KIDENDA, *supra* note 53, at 10.

[81] *Id.*

A. *THE MINI-GRID: ITS IMPORTANCE TO THE CONTINUED SCALING OF SOLAR POWER*

The mini-grid is arguably the most important factor in the solution to a lack of electrification in rural areas of sub-Saharan Africa. They do, however, still carry certain connotations that are potentially negative. Three primary biases are that mini-grids are endorsements of fossil fuels, endorsements for centralized generation, and that they are "going away."[82] These biases, however, have no basis in reality. While fossil fuels can be used to keep a mini-grid running when other forms of power, such as solar and wind, are unavailable, that does not have to be the case, and the enhancement of storage mechanisms reduces the need for fossil fuels in this context. Additionally, as technology in the energy sector continues to evolve, the grid will become even more integral to solutions, not less—they are not "going" anywhere.[83]

Moreover, there are many positive aspects of mini-grids that make them the "biggest, cheapest batteries" available.[84] Grids are about storage, not generation, and the costs to go "off-grid" will remain extremely high, even as batteries continue to get cheaper.[85] As a leading mini-grid manufacturer and power company, PowerGen Renewable Energy wrote about the future of African electrification: "Grids are networks, and well-managed networks drive resource utilization efficiency."[86] In that vein, it is very difficult for mini-grid companies to deliver cost-effective electricity without a grid. In the coming decades, as demand for power in the emerging markets of the world skyrockets, even great strides in energy efficiency will not eliminate the need for a grid.[87] In fact, installing large-scale renewables will continue to require a "large, smart, robust grid."[88] The need for large-scale renewables also belies another common misconception: as the Third World sees the United States and other countries across Europe employ solar energy in a seemingly cheap, yet effective manner, some assume that solar can be scaled down to be distributed.[89] This is wrong for two reasons. First, solar may be susceptible to being "scaled-down," but the storage of solar energy is not.[90] Second, the sole reason that solar has "worked" in the United States and across Europe is due to the "big, free battery" that feeds into the grid, not to mention the billions of dollars in subsidies.[91]

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[82] *The Future of Power in Africa: How Africa Can Lead the Next Generation of Global Power Infrastructure*, POWERGEN RENEWABLE ENERGY, 5 (2016) [hereinafter "*The Future of Power in Africa*"].

[83] *Id.*

[84] *Id.* at 6.

[85] *Id.* Average costs to go "off-grid" (for storage only, excluding generation costs) for average homes would still be prohibitively expensive in countries like the United States, Germany, and India. In the United States, it would cost over $40,000; in Germany, it would cost nearly $15,000; in India, it would cost between $3,000 and $4,000. Those monetary figures are based on an average use of 30kWh/day in the U.S., 10kWh/day in Germany, and 2.5kWh/day in India.

[86] *Id.*

[87] *Id.* at 7.

[88] *Id.*

[89] *Id.*

[90] *Id.*

[91] *Id.*

In conclusion, the mini-grid is more than just a distribution network; it is a storage mechanism, and for the continued scaling of solar energy in sub-Saharan Africa, the mini-grid will need to play a prominent role.

B. *ROLE OF PRIVATE COMPANY ASSOCIATIONS*

For power to reach the 600 million Africans that currently live without electrification, there must be a joint effort between the private and public sectors. The "private utilities [that are] developing small, renewable, localized power grids" lack the capacity to integrate with each other across the broader region.[92] Also, they lack the resources to lobby the various national governments in sub-Saharan Africa.[93] Aimed at a common goal—rural electrification—mini-grid developers have begun to form trade associations, like the Africa Mini-Grid Developers Association (AMDA).[94]

The goal of associations like AMDA is to "help achieve a long-term solution to electricity poverty in [s]ub-Saharan Africa."[95] Given that about 80% of the 600 million connections necessary to accomplish such a goal could come from private utilities, it is important for these private developers to cohesively lobby the public sector for access to the market and for a regulatory scheme that is fair and allows for Africans to receive power.[96] Associations like AMDA "promote cohesion within the sector and provide for a 'unified vision for the African continent for what future utilities look like and how [association members] can build them.'"[97]

The associations that are to aid the process of rural electrification will need to work with a wide variety of partners: policy makers, governmental authorities, regulators, the current national utilities operating the main grid, and various other constituencies from professionals to investors.[98]

The Africa Mini-Grid Developers Association has outlined principles that it believes "are critical for supporting the role of mini-grids as a key component in providing reliable, affordable and sustainable energy access and the achievement of Africa's energy goals."[99] These principles are either regulatory or financial in nature, and there are four of each, and they are an excellent framework for the type of standards and lobbying goals that similar associations should emulate.[100] If the private companies are to succeed in electrifying sub-Saharan Africa in the future, they will need associations with a similar structure to AMDA to collaborate with the various governmental and non-governmental stakeholders in the process.

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[92] KIDENDA, *supra* note 53, at 4.
[93] *Id.* at 14.
[94] *Id.*
[95] *In conversation…Africa Mini-grid Developers Association (AMDA)*, SOLAR MAG. (Oct. 11, 2017), https://solarmagazine.com/in-conversation-africa-mini-grid-developers-association-amda/.
[96] *Id.*
[97] *Id.*
[98] *Principles*, AFRICA MINI-GRID DEVELOPERS ASS'N, http://africamda.org/index.php/about/principles/ (last visited Nov. 20, 2018).
[99] *Id.*
[100] *Id.*

The regulatory principles are technical including: safety standards, grid integration frameworks, tariff frameworks, and permitting policies.[101] The financial principles include: subsidy parity, infrastructure financing, off-taker bankability, and hybrid energy systems.[102]

The technical and safety standards are necessary because it is of paramount importance that all members of the trade association make consumer safety their highest priority. When member developers engage with local and national government entities, it is important that not only the technical and safety standards are met but that they are "practical, cost-effective, and robust" while allowing for a smooth integration with the main grid in the future.[103]

With regard to the grid integration framework, it will be important that the trade association and government work together to ensure an attractive investment for private sector entities looking to put their money to work.[104] Specifically, the trade association should establish avenues in which the mini-grids being built now could later cooperate and coexist with the main grid once it reaches rural parts of Africa serviced by the mini-grid.[105]

The third regulatory principle that should be discussed by a trade organization is a tariff framework.[106] As new technologies, such as solar, smart metering, and storage, become commonplace throughout the world, power will increasingly be "viewed as a service, rather than a commodity."[107] Under the traditional model of tariffs, energy is not sold as a service, and the governments in Africa can ensure that they remain at the fore of the global energy system by constructively engaging with the process of transitioning from "commodity thinking" to "service thinking."[108] Related to the tariff framework principle, mini-grids offer additional value to consumers that warrants recognition in tariff and subsidy approval processes.[109] Given the goal of increasing overall societal welfare, mini-grid developers find these added value propositions also ensure that there are mechanisms reflecting "social value in commercial terms."[110] Finally, a transparent and equitable tariff model is required; this model must acknowledge that the majority of main grid tariffs contain a number of inherent subsidies that are not accounted for in a transparent manner.[111] Tariffs for these private mini-grids must account for all of the building and operating costs of

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[101] *Id.*

[102] *Id.*

[103] *Id.*

[104] *Id.*

[105] *Id.* AMDA suggests that these avenues include "allowing independently operated mini-grids to be efficiently and transparently connected to the main grid once it arrives in the area where the mini-grid operates." Additionally, "enabling the mini-grid to continue operating once the main grid arrives, by buying power from and/or selling to the main grid in such a way that enables the commercial viability of the mini-grid" would be another way to accomplish this goal. Finally, AMDA suggests that by allowing independently operating mini-grids to sell their grid infrastructure assets to a national utility in an acceptable and transparent manner when the main grid arrives would further allow for the co-existence between the main grid and the mini-grid.

[106] *Id.*

[107] *Id.*

[108] *Id.*

[109] *Id.* Mini-grids often provide enhanced value to consumers through "improved reliability, connection fee financing, appliance financing, and enhanced customer service," all of which are "value-add" propositions that may not be available even upon connection to the national grid.

[110] *Id.*

[111] *Id.*

mini-grids, while including a reasonable return.[112] Regardless, most national tariffs are facilitated by various types of subsidies, so if private developers are to provide energy access at similar prices, then tariffs need to be fair and "recognize the full cost of service provisions to ensure a level playing field" for all power access providers.[113]

Finally, most African governments have power project permitting rules that were originally constructed for large scale infrastructure projects.[114] These procedures are cumbersome and ineffective for the fast-paced construction and deployment of mini-grids. By constructing new permitting policies for mini-grid developers, governmental authorities would be able to ease the burden of construction on these projects without compromising the safety or compliance with many existing standards.[115] The two types of permitting that trade associations should focus on are programmatic permitting and tiered permitting. Programmatic permitting sets "standardized permitting requirements for projects that adhere to similar criteria."[116] Many countries throughout Africa have strong precedents for such a practice in their treatment of telecom towers.[117] Tiered permitting "aligns the permitting requirements with the size of the project."[118] Trade associations should lobby governments to increase the standard permitting requirements for projects between 100 kilowatt and 500 kilowatt projects, with the most intense permitting requirements designated for large-scale, customized projects.[119]

In addition to the important regulatory principles that trade associations like AMDA must lobby for and support, there are also financing principles that trade associations must strive to achieve for the further proliferation of mini-grid development and rural electrification.

The first of these financing principles is subsidy parity, and it is arguably the most important of the eight articulated principles. Many governments are currently in the midst of implementing national electrification plans that are supported by subsidies for connection fees and the myriad of other costs associated with grid expansions.[120] For the most part, the private mini-grid developers acknowledge these proposals. Yet, they also highlight that subsidy parity for mini-grid operators will be essential to the creation of an economic space in which a mini-grid utility sector can emerge in countries that impose uniform tariffs across the entirety of the power industry.[121]

The next financing principle that must be a focus of mini-grid developer trade associations is infrastructure financing. Like any sort of utility development project, mini-grids are capital intensive, long-term infrastructure

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[112] *Id.*
[113] *Id.*
[114] *Id.*
[115] *Id.*
[116] *Id.* As an example, all solar or hydro projects within a specific size range that also meet certain technical standards could be built throughout a particular region under the same programmatic permit.
[117] *Id.*
[118] *Id.* For example, a government may not have any, or have streamlined, permitting requirements for projects that utilize environmentally acceptable technologies and are smaller than a certain size (in terms of kilowatts).
[119] *Id.*
[120] *Id.*
[121] *Id.*

investments.[122] Over the coming years, it will be important for the industry to transition to a scale model from one that is simply "proof-of-concept."[123] In order to do this, appropriately-tailored project finance facilities will be necessary, and these funds must be sufficiently large to enable meaningful scale for the mini-grid space.[124] It will also be extremely important that these facilities have timing and return expectations that mirror the realities and needs of the asset class they are supporting.[125]

Because mini-grids do not have traditional power purchase agreements (PPAs) with a single, contracted off-taker, the sector must commit itself to developing a viable alternative.[126] A solar PPA is a financial agreement in which a solar developer arranges for the design, permitting, financing, and installation of a solar energy system (in this case, a mini-grid) on someone else's property (generally, the customer.)[127] The developer then sells the power generated from the system to the "host" at a fixed rate that is typically lower than a retail rate from a local utility.[128] The lower price offsets the customer's purchase of electricity from the main grid, while the developer receives not only the income from the electricity sales but also the tax credits generated from setting up the system.[129] The primary goal of trade associations like AMDA with regard to off-taker bankability is the development of "portfolios of uncontracted off-takers [that] can produce predictable, bankable cash flows."[130] Increasing the profitability and accuracy of revenue projections for investors is of the utmost importance if additional funds from investors are to be accessed.[131]

Finally, mini-grid developers are committed to employing hybrid sources of energy in the years between the status quo and complete electrification.[132] If consumers in sub-Saharan Africa are to receive power access, it must be done through hybrid sources; while "a green energy system and a low-carbon future" are certainly the goals of the entire mini-grid industry, the "intermittent nature of green energy sources" demands the employment of hybrid energy sources for the time-being and perhaps into the foreseeable future.[133]

C. *GOVERNMENT SPONSORSHIP*

Mini-grids have offered electricity to parts of the continent that would otherwise be without power. However, as the mini-grid associations that have begun to form in the region align the various private utilities, there must be

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122 *Id.*
123 *Id.*
124 *Id.*
125 *Id.* As the mini-grid sector matures, developers will recognize better ways to find funding. An important element of doing so will be creating more standardization of the asset class. This will allow investors from across the globe to realize the scope and realities of the projects in which they are investing.
126 *Id.*
127 *Solar Power Purchase Agreements: What is a Solar Power Purchase Agreement?*, SOLAR ENERGY INDUSTRIES ASS'N, (last visited Nov. 18, 2018), https://www.seia.org/research-resources/solar-power-purchase-agreements.
128 *Id.*
129 *Id.*
130 AFRICA MINI-GRID DEVELOPERS ASS'N, *supra* note 98, at 5.
131 *Id.*
132 *Id.*
133 *Id.*

ownership of the problem of electricity access by the governments of sub-Saharan Africa. To properly alleviate the problem in the coming months, years, and decades, governments must execute steps to bring to fruition the goal of electrifying their countries.

One particular example of a government taking a step in the right direction is the Last Mile Connectivity Project that began in February of 2015 in Kenya:

> The Last Mile Connectivity Project aims to support the Government's initiatives of ensuring increased electricity access to Kenyans. The existing distribution transformers shall be exploited to the maximum through extension of a low voltage network [*sic*] to reach households lying within transformers protections distance. In addition, a new distribution system will be installed to increase new customer connections.[134]

For fifteen years, the Kenyan government, along with the national utility, Kenya Power and Lighting Company (or KPLC), has conducted an extensive effort "to facilitate acceleration of customer connection," but the cost of connecting customers that fall within the purview of the project (for example, customers that are within 600 meters of distribution transformers) has proven to be expensive, and the longer the program has continued, the greater the material costs have been.[135] KPLC, which is in charge of power distribution within Kenya, has a total of roughly 35,000 distribution transformers spread throughout the nation.[136] Within the vicinity of these transformers, KPLC "has the potential to connect 472,000 households," a figure that equates to 1.2 million customers.[137] Furthermore, the Rural Electrification Authority, established by the government in 2006, has committed to connecting 17,000 public facilities between 2015 and 2020.[138]

This commitment on behalf of the Kenyan government and utility companies is a prime example of both the recognition and investment necessary to electrify sub-Saharan Africa. Projects like the Last Mile Connectivity Project are essential to expanding the grid in an accelerated, yet practical fashion. As more governmental and non-governmental sponsorship of programs like this occur, the more likely it will be that the mini-grids of Africa will be met in the near future by the national grid, a prospect that will ensure a higher level of power for Africans.

D. *International (and Locally-Sourced) Investment*

Providing energy access for all sub-Saharan Africans will require a significant increase in funding from a range of sources. These sources include

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[134] *Kenya – Last Mile Connectivity Project*, AFR. DEV. BANK GROUP, https://www.afdb.org/en/projects-and-operations/project-portfolio/p-ke-fa0-010/ (last visited on Jan. 20, 2019).

[135] *Id.*

[136] *Id.*

[137] *Id.* The estimated cost of connecting these households is estimated to be about $686 million (USD).

[138] *Id.*

development banks, governments, "bilateral development assistance," and the private sector.[139]

International assistance has also grown in the past decade, as foreign nations, such as the United States and China, invest in the sub-Saharan region, primarily looking to support economic growth and sustainable power. "Power Africa" was a five-year plan launched by U.S. President Barack Obama in the summer of 2013, and the initiative aimed to support economic growth by "increasing access to reliable, affordable, and sustainable power in Africa."[140] The program was designed as "a multi-stakeholder partnership" among the governments of the United States and various African nations, as well as with the American and African private sectors.[141] The African Development Bank Group (or AfDB) has also been an integral part of the program, proving to be a key partner in designing the initiative and implementing the many tasks necessary to achieve its goals. The AfDB, between 2013 and 2018, allocated over $3 billion in investment loans, reforms, advisory work, and commitment guarantees in the six "priority" countries.[142]

The United States is not the only foreign power that is investing in the African power sector; China, too, has been investing significantly in the African continent for over two decades. In 1996, direct investment by the Chinese into the African continent generally was only $56 million.[143] By 2005, that figure had jumped nearly thirty times to $1.5 billion, and six years later, total investment was $15 billion.[144] About sixty-five percent of that overall investment (or almost $10 billion), has been allocated to sub-Saharan Africa, of which a third goes directly to the energy sector.[145] Such international investment by global powers like the United States and China, will be an important piece in the electrification of rural Africa, as the funding mechanisms available from local investment groups is unlikely (to put it mildly) to meet the demand of the region. That is not to say that locally-sourced investment does not have a role to play in the electrification of sub-Saharan Africa, however. Rather, the significant capital needed to either expand the national grid or finance private entities that are looking to implement projects on a smaller level (such as mini-grids) will need to be sourced by more than just local investment or from investment by international financial institutions like the World Bank.

To realize widespread rural electrification across sub-Saharan Africa, all of the aforementioned factors must play a role.

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[139] IEA REPORT, *supra* note 27, at 1058. *See also* MCKINSEY REPORT, *supra* note 58, at 62. For instance, the United Nations' Sustainable Energy for all initiative has attracted more than $120 billion in commitments for the renewable energy sector in Africa.

[140] *Power Africa Initiative*, AFR. DEV. BANK GROUP, https://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/power-africa-initiative/energy-power/ (last visited on Jan. 20, 2019).

[141] *Id.* The African governments involved include Tanzania, Kenya, Ethiopia, Ghana, Nigeria, and Liberia.

[142] *Id.* The AfDB expected this $3 billion investment to leverage "at least four times more investment in the energy sector."

[143] MCKINSEY REPORT, *supra* note 58, at 9.

[144] *Id.*

[145] *Id.*

V. PROPOSAL

While great strides have been made in the past few decades on the issue of rural electrification, advancements in technology have now made an acceleration in electrification possible. Technology can bridge the vast differentiation in the necessary resources to bring electricity to the fourteen percent of the globe's population in Africa. By employing the aforementioned factors and collaborating across governments, industries, and regulatory schemes, the goal of electrifying sub-Saharan Africa by 2030, long thought to be impossible, may be realized.

Substantial investment, governmental and non-governmental support, and proper regulatory frameworks are the three avenues through which rural electrification will be achieved, but none, in a vacuum, will succeed in accomplishing this goal. Thus, it is important to analyze how each of the tools (mini-grids, private associations, governmental sponsorship, and investment) interfaces with those three prongs of this proposal.

Mini-grids have the potential to be the lifeblood of the rural electrification movement. While national utilities, such as KPLC, continue to build out the national grid, mini-grids offer deployment flexibility that is unique and swift, while still providing the end customer with the product of electricity. Additionally, many private mini-grid companies, such as PowerGen, offer an attractive proposition to the governments of the countries in which they operate. Most notably, when the national grid does reach the remote Tanzanian villages of Saranda or Murusagamba, the mini-grids built, installed, and operated by companies like PowerGen are able to be employed by the grid. Specifically, when the national grid reaches these remote villages, they can simply purchase the installed infrastructure and, with it, PowerGen's connections and clients. With mini-grid companies thinking ahead and building infrastructure that can essentially be "plugged in" to the grid upon its eventual arrival, mini-grids are an immediate force for change in the electrification initiative.

Furthermore, the "rapid and substantial" advancements in solar technologies in recent years have disproportionately benefitted mini-grids.[146] Companies in countries like Tanzania and Kenya, as mentioned above, have already invested substantially in mini-grids and are leaning into the technology. Although there has been more limited investment into the asset class in other sub-Saharan African nations, several countries, like Nigeria and Rwanda, are beginning to pass "significant regulatory reforms to lower barriers to mini-grid investment."[147]

A major, current obstacle for mini-grids is attracting and sustaining private investment in the assets. While cost recovery is a legitimate concern for many of these investors—as mini-grid construction, installation, and maintenance are all costly endeavors (both in terms of monetary and labor resources)—other concerns are overblown. Namely, many investors are worried about what happens to mini-grids when the national utility begins to "penetrate [their]

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[146] WORLD BANK GROUP, 17 AFRICA'S PULSE 49 (Apr. 2018), http://documents.worldbank.org/curated/en/292931523967410313/pdf/125329-REPLACEMENT-PUBLIC.pdf.

[147] *Id.*

service territory."[148] As discussed above, however, as companies construct mini-grids that will be compatible with the national grid once it arrives, not only is that fear quelled but there is an appropriate and lucrative exit opportunity for investors.

Relatedly, for such confidence in the mini-grid industry to exist and evolve, there must be coordination across the private sector. Still in its infancy, and with technology constantly evolving, it is vital to the further success of the sector that private entities collaborate. Perhaps there is no more important issue on which to lobby than the matter of governmental regulation.

Sub-Saharan Africa is a region of the world that could "benefit from using innovations in power sector regulation."[149] There is a need for improved sector regulation and management to increase economic efficiency. Yet, there is also a need for frameworks that would spur public confidence and outside investment. Without writing new, as well as strengthening existing, policies related to the industry, it "will be impossible to raise sufficient capital and attract new customers."[150] International experts and authorities, such as the World Bank, believe that more transparency is needed into the national utility companies.[151] These reforms will likely be difficult and not without opposition, but without efforts in this arena, investment programs will not fund the electrification of the region.

That is the place for trade associations like AMDA. Instead of working in isolation, and against competitors, mini-grid companies across sub-Saharan Africa need to collaborate in order to achieve common policy goals, such as lowering tariffs or subsidy parity. Rural electrification remains such a greenfield opportunity that failing to coordinate particular policy aims is almost a disincentive.

These associations, which would likely feature companies that operate across sovereign borders, would also be wise to consider regional integration of policy frameworks. Regional integration of resources, along with the promotion of renewable energy generation could prove to be a "game changer" in the coming decades.[152] Previous efforts to use policy aims across borders have been met with limited success, but there remains good reason to pursue them: "regional integration could save more than $40 billion in overall capital spending while greater adoption of renewables could lead to a twenty-seven percent reduction in CO2 emissions."[153] In sub-Saharan Africa specifically, over $50 billion in generation capital spending would be saved, while spending only an additional $9 billion for transmission infrastructure.[154]

For this dream of rural electrification to become a reality, however, these mini-grid associations will need governmental cooperation. The benefits of regional integration, even on the cost-saving aspect alone (not to mention the value of achieving the broader goal of electrification), should persuade

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[148] *Id.*
[149] *Id.*
[150] *Id.*
[151] *Id.*
[152] MCKINSEY REPORT, *supra* note 58, at 27.
[153] *Id.*
[154] *Id.*

governments to work together. To successfully achieve this, four requirements must be met: technical feasibility, financial feasibility, political acceptability, and regional stability.[155]

Technical feasibility refers to the need for sufficient power generation and transmission capacity. Such regional power integration "requires not only consistency in technical standards," (for example, cooperation and coordination between system operators), but also the development of transmission lines that cross borders.[156] Taking this one step further and relating it to the mini-grids that need to play a prominent role in broader electrification, mini-grid associations should also stipulate a set of standards that keep building specifications uniform across private entities. This practice would ensure that integration would be possible with each individual company's mini-grids but also with the broader, regional power distribution infrastructure.

Related to financial feasibility, the cost of power in the exporting country must be lower than the price of power in the importing country;[157] this could provide an obstacle to regions of sub-Saharan Africa in which mini-grid power generation is reliable and cheap compared to the product being distributed by the national utility. Nonetheless, a potential way to offset this cost could be governmental subsidies to customers that switch onto the national grid when it arrives. Furthermore, sufficient regulations should be enacted to encourage power trade, and exporters "should have assurances that they will be paid."[158]

Political acceptability and regional stability may provide the most difficult obstacles for regional integration across the sub-Saharan region. While it may be difficult to convince exporters that supplying their neighboring countries with power when electrification has not even been completed at home, generating incremental national revenue, as well as foreign exchange arbitrage, may be enough to convince power companies of the benefits. Additionally, the World Bank also highlights another, non-quantifiable benefit for countries with significant cross-border immigration: that is, if they improve the quality of life in neighboring nations through reliable electricity, there may be a reduction in immigration overall.[159]

Regional stability is the final hurdle for a large, cross-border integration project. Such an endeavor would require a long-term investment by multiple players. Requiring commitment of political leaders to a project that will outlast their terms in office could prove to be a difficult sell to many heads of state. This is of paramount importance, however, as sufficient economic and political stability in the region is necessary for such a project to succeed.[160]

In sum, governmental regulation and sponsorship will be critical on both a "country-level" and on a "regional-level," and while it may prove to be the largest impediment to success, without it, rural electrification will continue on its course of positive, yet slow and isolated, advancement.

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[155] *Id.* at 28.
[156] *Id.*
[157] *Id.*
[158] *Id.*
[159] *Id.*
[160] *Id.* at 28–29.

Finally, international and local investment will prove crucial to the success of electricity access. The "potential for renewable energy in sub-Saharan Africa is staggering," as solar alone could provide more than ten terawatts of new capacity to the region.[161] For the potential to be realized, however, there will need to be significant investment. While estimates vary widely, none are cheap. To achieve this goal, generation capital costs would have to increase by thirty-one percent, from $490 billion in 2040 to $643 billion.[162] Moreover, while the new solar and wind capacity would be favored over more traditional forms of energy generation, such as coal and gas, it would also be expected to replace hydro generation.[163] Should solar, wind, and geothermal generation triple its contribution in the coming decades to roughly thirty percent (compared to the current ten percent estimate based on "least cost"), then more than forty percent of this change would stem from a reduction in gas-fired generation while twenty-eight percent would come from less coal and fifteen percent from a reduction in hydro generation.[164]

There is a case to be made that this additional funding could come from private financing due to the demand for emerging market investment and a willingness to deploy capital in a "socially-conscious manner." Yet, an investment increase to nearly three quarters of a trillion dollars will require governmental backing and funding. With that in mind, continued investment by foreign governments, while potentially not attractive for geopolitical reasons, may be necessary for the simple quality of life of the citizens of these African nations. Furthermore, there is already significant investment on behalf of those governments, particularly toward the construction of roads and bridges. Redirecting these funds towards electrification projects would have a vast impact on the economies of these nations, affording the remote parts of the continent the opportunity to work and learn after the sun has gone down.

CONCLUSION

Over the past decade, sub-Saharan Africa has made great strides in the area of electricity access. The region remains critically underdeveloped in many ways. The region is particularly underdeveloped in the areas of energy access, installed capacity, or simply overall energy consumption.[165] These shortages cripple countries across the entire region, as each nation struggles to sustain even moderate GDP growth.

The next decade will be crucial in determining the future of electrification. As the world shrinks, there is more awareness, at least in the First World, of the problems of electricity access in countries like Kenya and Tanzania. Foreign

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[161] *Id.* at 29. Ten terawatts of energy, for reference, could power over 5.4 million households. *See Helpful Energy Comparisons, Anyone? A Guide to Measuring Energy*, CLIMATE CTR., https://www.climatecentral.org/blogs/helpful-energy-comparisons-anyone (last visited on Jan. 21, 2019).

[162] MCKINSEY REPORT, *supra* note 58, at 29. This would be due to the "higher overnight capital cost per installed kilowatt of solar and wind compared with other" (and often cheaper) domestic alternatives.

[163] *Id.*

[164] *Id.*

[165] *Id.* at 2.

powers, like the United States and China, have roles to play in the electrification of the region, but it is through an amalgamation of stakeholders already in sub-Saharan Africa that real change will occur.

Investment by the Africa Development Bank, the World Bank, and other international financial institutions with significant ties to the African continent will need to prioritize electricity access to reach the fourteen percent of the world's population without power that currently resides there. This investment, when combined with investments from private firms based in the region, will provide financing to private entities looking to solve this problem before the national utility reaches remote parts of the region, as well as to the public utilities. Further investment in mini-grids would be wise, both on an economic and social level.

To succeed, these investments and private entities will need to be met with governmental support. Programs like the Last Mile Connectivity Project are an excellent starting point. Governmental recognition of the problem will not solve the issue. Rather, governmental action, particularly in spearheading similar initiatives, will be what brings power to the remote parts of the continent.

Support does not just mean partnering with governments and public utilities, however. Supporting electricity access in sub-Saharan Africa will also require standardized regulatory frameworks, under which all private power generation companies can operate and thrive. To write and sustain such frameworks, not only does there need to be political stability in the nations of sub-Saharan Africa, but there also must be associations to lobby those governments. Individual entities are likely to meet little success. Private associations, like the African Mini-Grid Developers Association, therefore, are integral to both the standardization of frameworks and to the education of governments and public utilities. By working together to create a set of regulations that will govern the space, these private entities can show that they are not in competition with the national grid. Instead, they are the resources into which rural Africans can tap while the grid makes its way from the urban centers of Nairobi and Arusha to the outermost boundaries of Kenya and Tanzania.

In the struggle for electricity access, there are many parties and much uncertainty. A primary goal of these governments, private entities, and foreign investors, however, is the same: electricity access for all. By committing to renewable energy sources and collaborating across the public and private sectors, these stakeholders will be able to improve the quality of life of over ten percent of the world's population. They will give them the opportunity, when the sun goes down, to turn on the lights.