Electricity and education: The benefits, barriers, and recommendations for achieving the electrification of primary and secondary schools

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Executive Summary

Even though large-scale electricity networks have existed for more than a century, and hundreds of millions of people have received reliable and affordable access to electricity over the past few decades, many primary and secondary schools have no electricity whatsoever.

The first part of this report describes the current status of electrification and schools. As it reveals, some of the specific numbers are dreadful. About 90 percent of children in Sub-Saharan Africa go to primary schools that lack electricity, 27 percent of village schools in India lack electricity access, and fewer than half of Peruvian schools are electrified. Collectively, 188 million children attend schools not connected to any type of electricity supply—a number of people greater than the populations of Nigeria, Bangladesh, Russia or Japan. Put another way, almost one child out of every three goes to a school that lacks electricity and thus electric lights, refrigerators, fans, computers, and printers.

The second part of the report discusses the educational benefits of school electrification. Lighting can enable classes to be taught early in the morning or late at night. Electricity enables the use of modern mass media tools in the classroom such as the internet and televisions. Electrified schools have better staff retention, outperform non-electrified schools on key educational indicators, and can in some cases enable broader social and economic development of communities.

The third part of the report identifies a series of interconnected challenges to electrifying these schools. Some barriers are technical and economic, such as the high upfront cost of a grid connection or the expense of purchasing renewable energy technologies. Others are social or political, such as lack of energy access at households interfering with school attendance or studying or urban bias and classism in educational projects and partnerships.

The fourth part of the report presents recommendations for overcoming these barriers. It shows how high upfront costs can be mitigated and overcome by tapping into financing streams and distributing risk through public private partnerships (PPPs). Technical problems can be countered by stable policy frameworks with strong standards and certification schemes. Electrification efforts can be coupled with household and cooking programs and community capacity building and training efforts.

In sum, the report shows that primary and secondary schools can provide students with the light, heat, comfort, and modern tools of teaching they deserve if planners, investors, and policymakers make a determined, coordinated effort at promoting electricity for education.

1. Introduction

Visitors arriving at the international airport in Conakry, the capital city of Guinea, are greeted by an unexpected sight: literally hundreds of children studying under the parking lot streetlights, ignoring the cacophonous din of jet engine exhausts, honking taxis, and rumbling buses as they write in notebooks or read textbooks.[1] Children gather in publicly illuminated areas to study and complete their homework because they have electricity neither at home nor at their school. In South Africa, each year almost 80,000 young children unintentionally ingest kerosene (spilled from lamps) to the point where they need to be admitted to the hospital and, even with treatment, more than half (60 percent) develop chemically induced pneumonia.[2] In Uganda, it is common for children to study in bed with a candle on the edge of their headboards, inducing fires and thousands of burn-related accidents, some of which lead to death or lifelong disfigurement.[3]

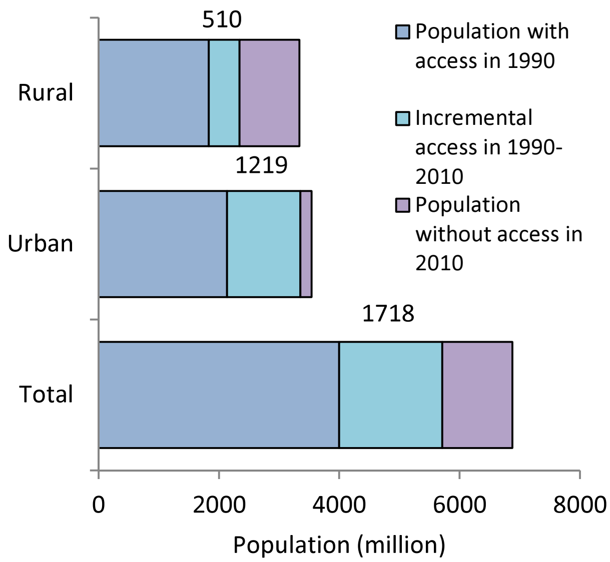
Despite the obvious connection between electricity and educational achievement, however, the troubling scenes in Guinea, South Africa, and Uganda are repeated in thousands and thousands of parking lots, hospitals, and homes across the developing world. As one expert laments, in the educational community, "we focus largely on pedagogy and little on access to energy."[4] Such an absence of focus is detrimental because, as another study put it, "education is also widely recognized as one of the most essential components for poverty reduction."[5] Lack of electricity at primary and secondary schools therefore creates considerable obstacles towards escaping poverty, and correlates with many factors that contribute directly towards it.

This report assesses the direct link between electricity and education. Based on the most recently available survey data from the World Bank and United Nations Educational, Scientific and Cultural Organization (UNESCO), the report first describes the current state of electrification of schools. According to the this data, roughly four out of every five primary and secondary schools in African countries surveyed lacked access to electricity, along with almost three-quarters of village schools in India. Based on a systematic review of the peer-reviewed and policy literature concerning electricity and education, the report then assesses the educational benefits of electrification of primary and secondary schools, including lighting and access to information and communications technologies (ICT) as well improvements in staff retention and student completion and graduation rates. The final two main parts of the report, drawn from energy policy, development studies, and innovations in financing and public private partnerships literature, discuss the challenges facing school electrification, such as lack of financing and technical problems with equipment, along with the solutions and incentives with the potential to overcome them, such as PPPs.

2. Electrification and Schools: Current Status

The international community has made significant progress on electrification over the past few decades. The expansion of national electricity grids—the "traditional" method of expanding access to energy services—involves adding more power plants and electric utilities and expanding high-voltage transmission lines into rural areas. Canadian energy professor Hisham Zerriff argues that grid electrification "is still the model favored worldwide by utilities and often, implicitly or explicitly, by regulators and policymakers as well."[6] Rural electrification programs have focused on connecting villages incrementally to the existing grid, typically reaching towns and settlements in order of the least expensive.[7] In the past two decades, Figure 1 depicts that more than 1.7 *billion* people have been added to national electricity networks worldwide.[8] As energy expert Douglas F. Barnes has concluded, "Well-planned, carefully targeted, and effectively implemented rural electrification programs provide enormous benefits to rural people."[9]

Figure 1: Incremental increases in grid electricity access, 1990-2010

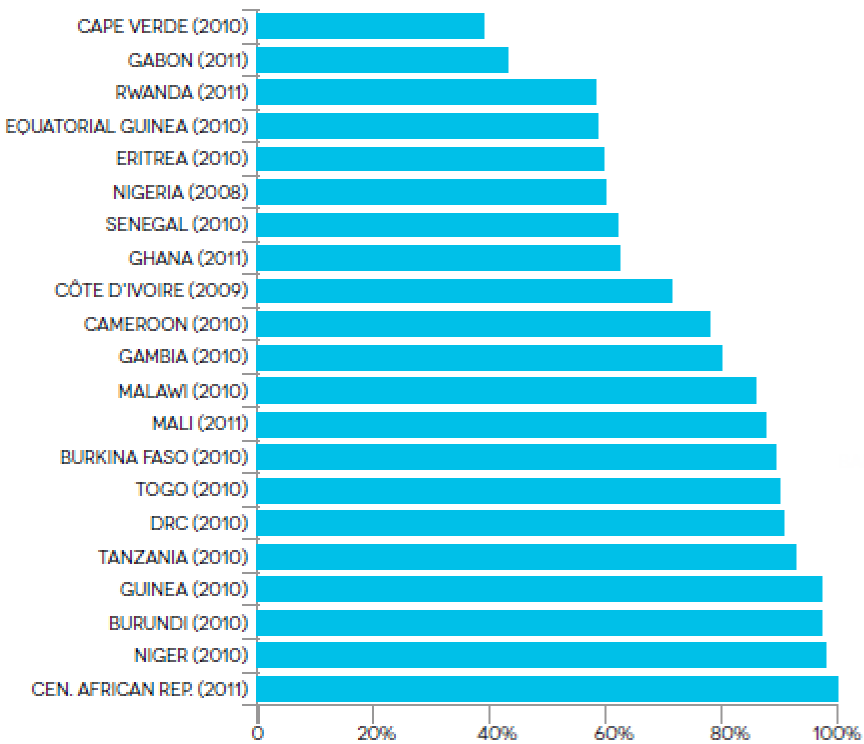


Source: World Bank and International Energy Agency. Sustainable Energy for All: Global Tracking Framework (Washington, DC: World Bank, 2013).

However, despite this progress, efforts to electrify schools have lagged behind, and left millions of children in the dark. A 2008 survey undertaken in 11 countries of 7,600 schools spread across Latin America, Asia and North Africa noted that in general village schools lack electricity.[10] According to that survey's results only 27% of village schools in India had electricity compared to 76% of schools in towns and cities. Only about half of the rural schools surveyed have enough toilets for girls, and fewer than 4% had a telephone. In Peru, fewer than half of rural schools are equipped with electricity, a library, or toilets for boys and girls. In Sri Lanka, roughly one in five schools lacked access to electricity.

More recently in 2013, the World Bank and International Energy Agency compiled data on the electrification of African schools and noted that in at least twenty countries shown in Figure 2, half or more public primary schools lacked access to electricity.[11] Collectively, this suggests that 90 million primary school students in sub-Saharan Africa, 94 million students in South Asia, and 4 million students in Latin America regularly attend schools without electricity.[12] When aggregated, roughly 90 percent of children in Sub-Saharan Africa go to primary schools that lack electricity,[13] and despite South Africa priding itself on having the highest figures for grid electricity across the continent, some 3,544 schools are still without power, 2,401 have no water on site, and 510 are "mud schools," schools in which the buildings are literally made of mud.[14] Electrifying these schools would require improvements in the building structures.

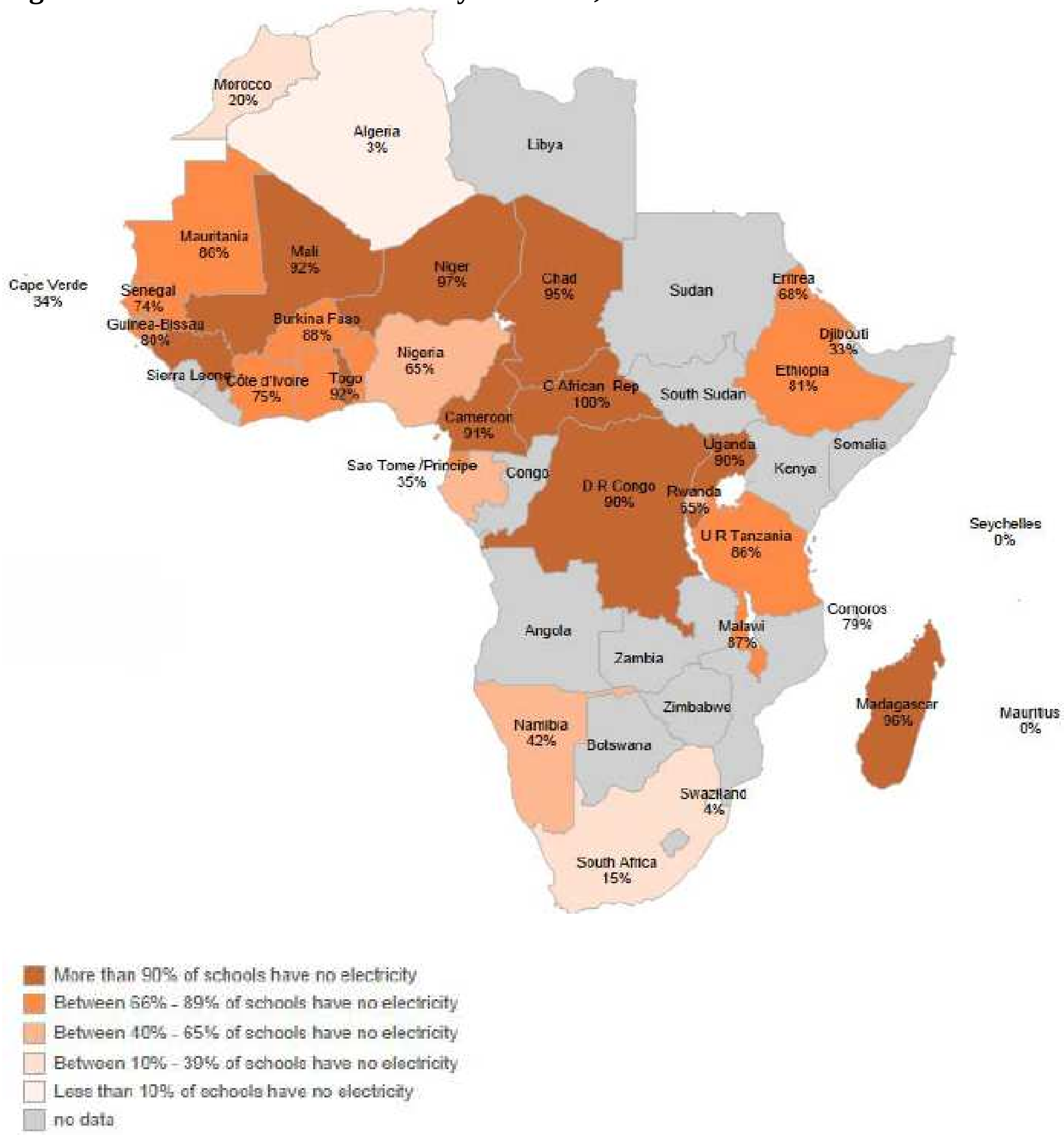
Figure 2: Public Primary Schools Without Access to Electricity in Africa



Source: World Bank and International Energy Agency. Sustainable Energy for All: Global Tracking Framework (Washington, DC: World Bank, 2013).

Most recently, 2014 data compiled by UNESCO from 46 countries in sub-Saharan Africa showed that "the vast majority of schools report having no electricity in nearly all countries." In more than half of all countries surveyed, 4 in 5 primary schools have no electricity.[15] Figure 3 breaks down the results by country for those for which data was available.

Figure 3: Schools without Electricity in Africa, 2014

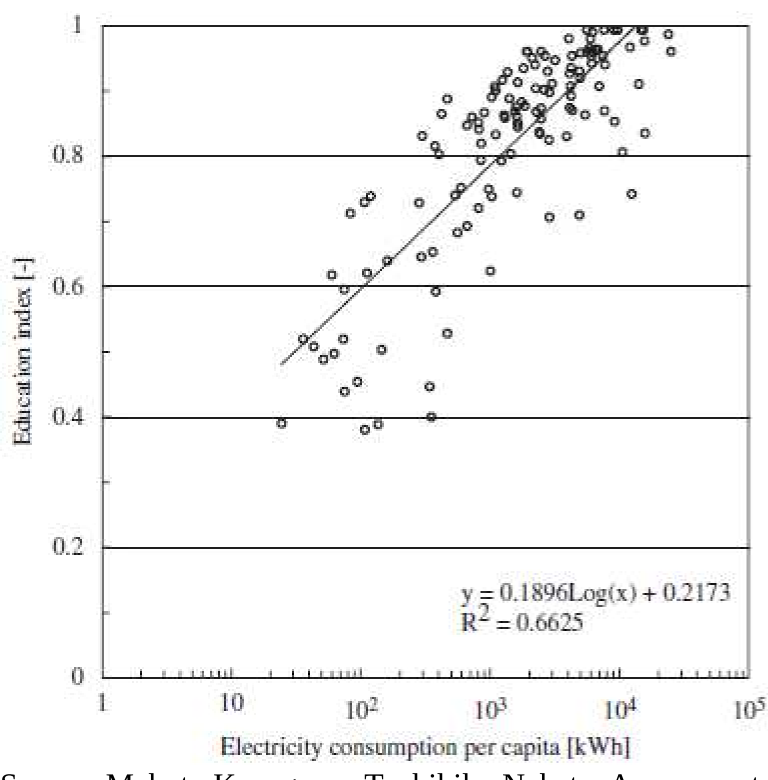


Source: UNESCO Institute for Statistics, A view inside schools in Africa: Regional education survey (Paris: UNESCO, May 2014).

3. Educational Benefits of Electricity Access

The lack of electricity at schools is unfortunate, because of the multiple services it can provide in the classroom. Lighting can enable classes to be taught early in the morning or late at night. Electricity access facilitates the introduction of ICTs into the classroom such as computers and televisions. Electrified schools can enable principals to recruit and retain better qualified teachers, and have been correlated with improvements on both test scores and graduation rates. As one study states, electricity "allows the access of lower-income people to lighting, communication, as well as a variety of educational delivery opportunities … A major impact [of electrification] has been reducing illiteracy and improving the quality of education."[16] Figure 4 shows a strong correlation (above 66%) with electricity consumption per capita and higher scores on the education index—a proxy for the mean years of schooling a student receives—across 120 countries.[17] The inverse is also true: schools without electricity tend to perform more poorly than electrified counterparts. As one study noted, "extremely poor infrastructure has an effect on teachers, as well as pupils."[18]

Figure 4: Relationship between Electricity Consumption and Education in 210 countries



Source: Makoto Kanagawa, Toshihiko Nakata, Assessment of access to electricity and the socio-economic impacts in rural areas of developing countries, Energy Policy 36 (2008) 2016–2029

Electricity access, then, can play a significant role in improving learning outcomes at schools.[19] This part of the report discusses at least five positive benefits related to the electrification of schools: (1) lighting and extended studying hours, (2) facilitation of ICT in the classroom, (3) enhanced staff retention and teacher training, (4) better school performance based on attendance, completion rates, and test scores, and (5) co-benefits such as improved sanitation and health, gender empowerment, and community resilience.

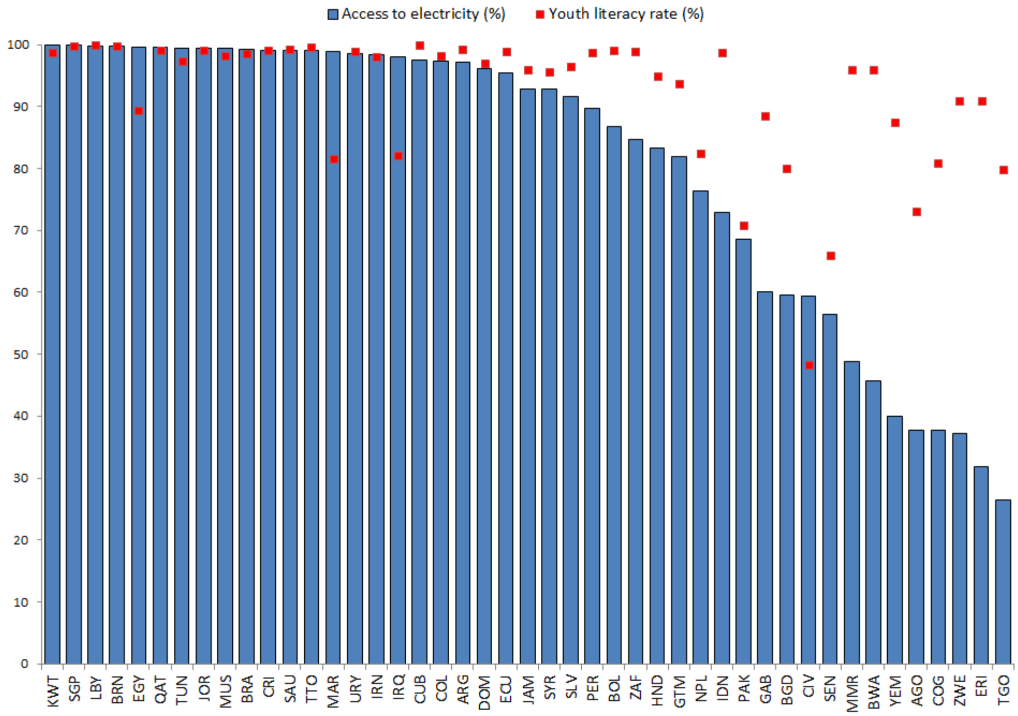
3.1 Lighting and extended studying hours

Perhaps the simplest benefit from electrification is the provision of lighting which enables longer studying (or classroom hours) at schools. In Argentina, for instance, classes at un-electrified schools could not start until mid-morning when it was bright enough inside the classroom to read. The provision of electricity enabled teaching to extend into the early morning and after dark, and also prompted students living onsite to remain on campus after hours.[20] In Nepal, interviews with local schoolteachers and students revealed that "educational attainment is greater because electricity allows for more time for reading and homework."[21] In Kenya, lighting has enabled existing teachers to provide extra teaching early in the day and late at night to make up for material not adequately covered during normal hours, due to a shortfall of staff. [22]

Moreover, the quality of light from electricity—often compact fluorescent lamps (CFLs) or light emitting diodes (LEDs)—is much better and more efficient than traditional source such as kerosene lamps, candles, or wood. After 50,000 hours of use, kerosene lamps cost $1,251 to operate, while incandescent lamps cost $175, CFLs cost $75, and LEDs cost $20 to operate.[23] Access to modern lighting technologies can yield substantial benefits. For example, a study conducted for the Millennium Villages Project in Malawi indicated that when households, hospitals, or schools switched from kerosene lamps to solar lamps, their annual expenditures on lighting dropped by almost $50 per building, excluding the cost of the lantern (about $30).[24] The majority of households had an average payback of less than a year for these lamps.

In short, electricity facilitates both improved quantity and quality of studying—making it possible in more parts of the day, and providing higher quality of light happens.[25] This may explain why provision of electricity seems to have a positive impact on the literacy of youths. Drawn from data in 45 developing countries, Figure 5 indicates that youth literacy rates tend to be lower in countries with electrification rates below 80%.

Figure 5: Electrification rate (% of population) and Youth literacy rate (% people age 15-24) for 45 developing countries, 2012



Source: World Bank 2014. "Data". Available at http://data.worldbank.org/, updated December 3, 2014. Note: To enhance the robustness of the chart with as many data points as possible, when 2012 information for a country was not available the author included 2011 or 2013 data. The term "Developing country" includes middle income, lower middle income, and least developed countries. All countries are shown for which both datasets were available.

3.2 Facilitation of ICT

Electricity at schools facilitates the use of a bundle of ICT technologies including not only telephones (mobile or not) and televisions but also computers and the internet, audio tapes, projectors and slide projectors, printers and copy machines, digital cameras, and radios. As UNESCO has reported, the provision of ICT can produce a profound impact for schools:

> *ICT can improve student achievement, improve access to schooling, increase efficiencies and reduce costs, enhance students' ability to learn and promote their lifelong learning, and prepare them for a globally competitive workforce. As the power and capability of computers have increased, as they have become interconnected in a worldwide web of information and resources, as they provide a conduit for participation and interaction with other people.*[26]

In Argentina, for example, electricity has enabled teachers to integrate radios into the classroom, keeping students informed about current events, and playing music to accompany celebrations and social events. Recording devices have been utilized to improve phonetics among students improving their mother tongue or those trying to learn new languages such as English. Televisions and video players permitted classes to watch educational films.[27] In rural Kenya, electricity has yielded the ability to conduct experiments in a science laboratory and improved the efficiency of processing information through computers and photocopying machines. Schools have also begun to offer expanded vocational classes in engineering, welding, metal works, and carpentry, all made easier with electric appliances and tools.[28]

Perhaps the most transformative impact ICT can have on schooling, however, is through the internet and connections to the worldwide web. It is the internet, some studies suggest, that serves as one of the best tools for exposing students to a broad set of information and experiences that can become central to their education, socialization, and future employment.[29] Internet provision has been statistically correlated with higher rates of school completion, higher rates of literacy, trade openness, and even income.[30] This makes the internet one of the key tools in bridging a "digital divide" between rich and poor as it integrates students into a global culture and can also mobilize civic participation and deliberative democracy.[31]

3.3 Enhanced staff retention and teacher training

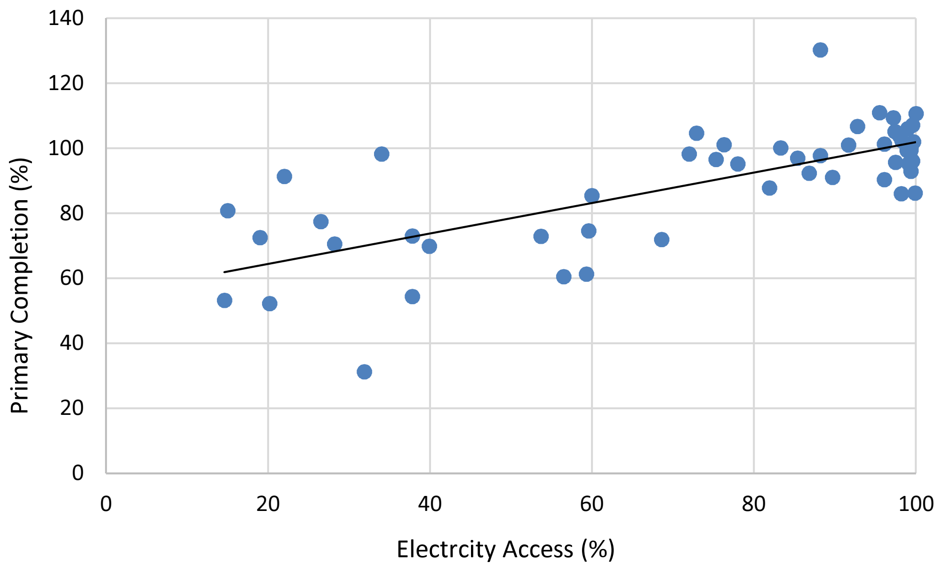
Electricity not only attracts students and enhances their learning experience; it can also enhance staff retention and lead to better teacher training. As UNESCO put it succinctly, "Teachers are understandably reluctant to work in deprived areas, which lack basic facilities such as electricity, good housing and health care."[32] Electricity, in addition to providing lights and computers, can also improve facilities with fans and other amenities that make them more comfortable.[33] One survey of schools electrified with solar PV panels in Argentina found that almost two-thirds (63%) of staff and faculty surveyed said they had been able to improve the quality of their work thanks to the better working conditions and teaching aids electricity offered.[34]

Electrified schools also provide teachers with better training, new skills and techniques for improved practices in the classroom. In both Sub-Saharan Africa and South America, electrification enabled teachers to become familiar with computers that they then used to engage in professional societies, conduct e-learning, better manage student marks and parental reports, search for educational content, and plan lessons.[35]

3.4 Better school performance

In aggregate, the benefits from electricity-based lighting, ICT, and improved teaching lead to better outcomes in school performance—less truancy and absenteeism, higher enrollments rates, higher graduation and completion rates, and the achievement of higher test scores. Figure 6 charts data related to electrification and primary school completion rates for 56 countries and shows a clear correlation between electricity access and students graduating.

Figure 6: Electrification rate (% of population) and primary school completion rate, total (%) for 56 developing countries, 2012



Source: World Bank 2014. "Data". Available at http://data.worldbank.org/, updated December 3, 2014. Note: To enhance the robustness of the chart with as many data points as possible, when 2012 information for a country was not available the author included 2011 or 2013 data. The term "Developing country" includes middle income, lower middle income, and least developed countries. All countries are shown for which both datasets were available.

A variety of real-world examples likely explain the reasons for this improved performance. In Argentina, staff reported that truancy diminished significantly after the installation of electrical lighting at schools.[36] In Sudan and Tanzania, the introduction of solar electricity at schools allowed a jump in completion rates at primary and secondary schools from less than 50 percent to close to 100 percent.[37] In Kenya, recently electrified schools show a substantial jump on student scores for national examinations.[38] In the Philippines, before six public schools were installed with solar PV systems, classes were cancelled during rainy weather due to lack of light, and teachers and students would have to travel 45 minutes by boat to get to the closest city where they could print their own papers. After electrification, as one commentator put it, "absenteeism went down, I guess because students got more excited to go to school."[39] Researchers from the University of California Irvine and Iowa State University also argue that "Schools providing basic facilities—in particular schools providing electricity—are found to perform much better in the production of achievement growth … Minimal basic facilities, and in particular, the provision of electricity, matter more than class-size and teacher training programs."[40]

3.5 Enablement of community co-benefits

In many cases, school electrification produces multiplier effects such as improved community sanitation or health, gender empowerment, and even reduced migration and strengthened resilience. For instance, electricity can enable schools to not only provide lighting and power ICT devices, it can also energize water purification systems, emergency radio or disaster warning alarms, space heating in the winter, and refrigeration of both food and vaccines. A hybrid wind-solar thermal-solar-PV energy system deployed on a school can provide a multitude of community services.[41] It can pump, purify, and treat drinking water, prepare and preserve food and medical supplies, and circulate air to maintain a comfortable indoor climate. Similarly, in Brazil, the Luz no Saber Program electrified 3,000 rural schools with grid and solar PV systems that then used their electricity to furnish potable water to communities through irrigation and pumping systems.[42]

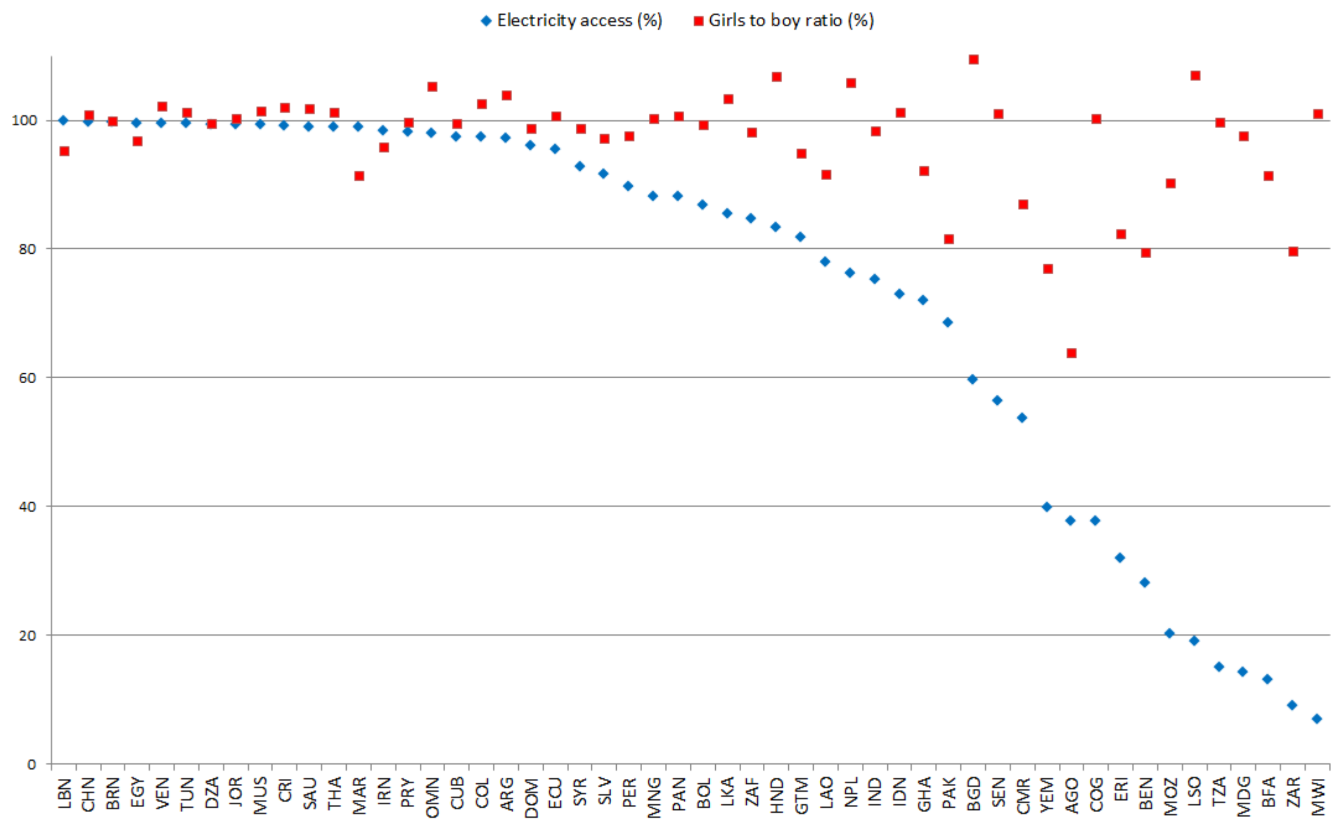
The provision of these modern energy services can create a positive, transformative impact on community health. In Kenya, before electrification schools would tend to seldom clean their toilets due to lack of water, and water-borne diseases such as skin infections, typhoid, and cholera were common, leading to "rampant absenteeism" of students and teachers. As one Deputy Principal explained, electrification changed all of this:

> *Before we got power, water was an even bigger problem. We had no piped water and students would spend 2–3 hours daily in the evenings hauling water with ropes and buckets from deep boreholes while others walked far way in search of water. Hygiene was very poor at the school. Obviously our first priority when we got power was water pumping and lighting. The 2–3 hours previously dedicated to gathering water are now dedicated to evening study, with better lighting and huge cost savings in kerosene bills when we switched from hurricane lamps to electricity.*[43]

One study of the Asia-Pacific also noted that educational awareness raising programs about epidemics and hygiene were enhanced through the modern tools of mass media, such as radios and televisions, which require electricity.[44] Similarly, a global review of electrification efforts and health found that access to ICT increased awareness of health issues, leading to changed behavior which improved health outcomes and reduced fertility.[45]

In certain situations, school electrification can promote gender equity. In Mali, electrification has increased levels of girls' school attendance, improved performance, and drastically improved boy-to-girl ratios. Electrified schools and villages have been documented to have lower drop-out rates, higher test scores, and higher proportions of girls entering secondary education.[46] In Nepal, girl student enrollment increased by 23.3% across a sample of villages that had received electricity at schools.[47] In Bhutan, rural electrification has been shown to contribute to 0.65 years of additional schooling for girls and 0.41 additional years for boys.[48] Figure 7 plots data for 52 countries and shows that a considerable number of countries with lower electricity access have lower girl-to-boy ratios in primary and secondary schools.

Figure 7: Electrification rate (% of population) and Ratio of girls to boys in primary and secondary education (%) for 52 developing countries, 2012



Source: World Bank 2014. "Data". Available at http://data.worldbank.org/, updated December 3, 2014. Note: To enhance the robustness of the chart with as many data points as possible, when 2012 information for a country was not available the author included 2011 or 2013 data. The term "Developing country" includes middle income, lower middle income, and least developed countries. All countries are shown for which both datasets were available.

Electrification of schools can directly or indirectly strengthen community resilience in other ways. In rural areas of Colombia, the electrification of schools has been shown to reduce rural-urban migration and convince many youths to remain in their communities.[49] In Nepal, rural electrification of schools has increased student enrollment "dramatically" and convinced many parents to keep their children in the village rather than sending them, as they had, to urban areas.[50] It has also strengthened community adaptive capacity by raising incomes, diversifying economic opportunities, and reducing migration.[51] As one study concludes, "village electrification not only upgraded the education system for students, but also has profound impact in regard to raised literacy, awareness, self-confidence, independence, and increased income-generation opportunities among illiterate populations."[52]

4. The Educational Challenges of Electricity Access

With so many benefits to the electrification of schools—encompassing extended studying, access to computers and mass media, better staff retention and school performance, and community co-benefits such as health and gender empowerment—Why do so many remain without power? This section of the report discusses at list four interrelated barriers that offer a likely explanation: (1) high up-front costs and difficulty in procuring financing, (2) technical problems with equipment including low reliability, vandalism, and theft, (3) lack of household access to modern energy services, and (4) classism and urban bias in education partnerships.

4.1 Capital cost and limited financing

Perhaps the most obvious challenge is the fact that electrification of schools—through the grid, or through off-grid or micro-grid systems including renewable energy—is expensive. Schools may not be able to afford high initial connection fees. There can be long waiting times for connections and some rural schools may never be cost-effective to connect. Moreover, building centralized electricity grids is capital intensive. Such electrification efforts have connected hundreds of millions of people to the grid, but have also been expensive, with incremental transmission expansion costs ranging from $29 to $2,000 for every newly installed kW (see Table 1) serving new power plants.

Table 1: **Incremental Rural Grid Extension Costs in U.S. Dollars per kW of New Peak Load**

Region	Minimum Cost	Maximum Cost
Europe	290	846
North America	45	925
Central America	51	920
Caribbean	65	518
Asia	29	2,000

Source: Business Council for Sustainable Energy and the U.S. Agency for International Development, *Increasing Energy Access in Developing Countries: The Role of Distributed Generation* (Washington, DC: USAID, 2004).

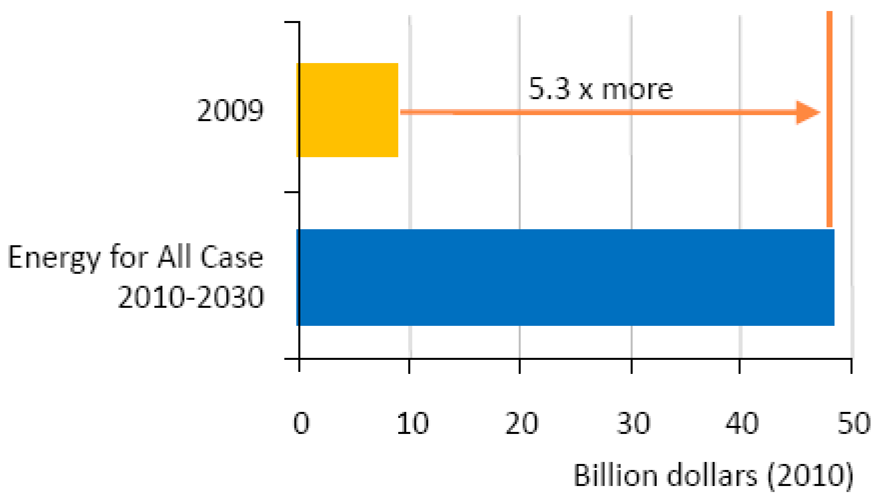
Thus, rural electrification programs in Chile, China, Honduras, Mexico, the Philippines, and Tunisia all depended on massive subsidies; they each funded their grid electrification efforts by using taxpayer dollars to finance 70 percent or more of total costs.[53] These heavily subsidized programs have occasionally “drained” the resources of state-owned electricity companies, with highly damaging effects on their overall performance and quality of service. The result is widespread brownouts and blackouts for all of their existing customers, and a reluctance of the power companies to reach out and provide electricity service to the poor.[54]

Even then, when electricity access is provided, many schools cannot afford to pay for it or maintain it. For instance, in South America, although electricity supplies only 10 percent or so of the total energy used in schools, it accounts for more than 50 percent of its total cost, leading one study to note that “it is a very expensive source of energy for the region.”[55] Some teachers and principals admit that they believe scarce school revenue can be spent on other things such as books or more teachers. In South Africa, two-thirds of school staff interviewed said they would have liked the money spent on electrification to be spent on other things such as accommodation for students or extra classrooms.[56] In

Papua New Guinea, one $13 million program called Solar Lighting for Rural Schools distributed almost 1,700 solar PV kits spread across 2,400 classrooms at 320 primary schools, but failed completely when neither teachers nor school boards could afford to invest in maintenance. Only a handful of units remained operational a mere five years after the program ended.[57]

The sheer cost of electrification means schools and other major actors need appropriate mechanisms to finance it. However, this financing is unlikely to materialize without significant changes. The most recent projections from the International Energy Agency (IEA) subtly, but clearly, underscore that many of the poor are not likely to receive electricity access soon. In projecting the future, the IEA estimated that almost 1 billion people will still be without electricity by 2030.[58] The IEA also estimated that about $1 trillion would be needed for universal access to energy and electricity between 2010 and 2030, an average of $50 billion per year. As of 2009-2010, however, only 3 percent of this needed investment has been committed. On a yearly basis, as Figure 8 shows, investments in financing electrification need to be ramped up by more than five *times.*

Figure 8: Needed Investment for Universal Electricity Access



Source: International Energy Agency 2012.

This financing barrier impedes electrification and plays out in many different countries around the world. In India, many state electricity boards and smaller energy companies have "significant financial problems," with many operating at a loss and unable to make a profit with electricity tariffs that do not enable full recovery of costs.[59] The World Bank has noted that India's regulatory framework "fails to adequately address utilities' long-term financial concerns."[60] Project developers consequently report difficulty finding credit and financing for renewable energy projects. As one report put it, "the non-availability of sufficient credit facilities and the difficulties in obtaining required finances for energy saving projects are strong deterrents to investments in energy efficiency in India."[61]

In Malaysia, financing for energy efficiency "remains a challenge due to limited successful cases" and costs of renewable energy technologies are still "considered high" and risky by financiers.[62] In Nepal, the United Nations Development Programme surveyed key lenders in the sector and noted that commercial banks and financial institutions are "generally not interested" in investing in energy.[63] In the Solomon Islands, the government has defaulted on previous loan interest payments, actions that make it difficult, even today, to secure financing for energy projects, given that investors see the Solomon Islands as high risk.[64] As one assessment warned, “commercial finance is difficult to obtain on affordable terms.”[65]

4.2 Technical problems and theft

Other challenges include resource constraints, technical problems, and theft. In terms of availability, renewable energy has diverse resource flows, which means that not all schools will be in areas that have sufficient wind, solar, hydro, or bioenergy potential. As the U.S. National Renewable Energy Laboratory puts it, “because renewable energy is regionally diverse, choosing the appropriate renewable energy system will be regionally and site dependent.”[66] In Sub-Saharan Africa, for instance, the technical feasibility of hybrid hydro-wind-PV systems for schools is limited to a small number of villages with optimal resource flows.[67] In India “much economically attractive wind and small hydropower potential remains untapped because of lack of adequate grid evacuation capacity and approach roads.”[68]

In terms of technical problems, these can arise both in the supply of energy and the reliability of energy-using devices such as lights or ICT equipment. One program in South Africa equipped 45 schools with solar PV systems only to find that the systems did not work as planned. More than 80 percent of school staff surveyed stated that the performance of solar energy was inferior to the grid due to problems with batteries, mounting of units to buildings, and quality of electricity delivered.[69] In Argentina, a rural school electrification program prompted complaints concerning flickering lights, poor illumination, and frequent burn-outs with the average fluorescent tube lasting only 9 months. Each school had to call for technical assistance at least *twice* and 29 % reported that their technical problems were never fully resolved.[70] An evaluation of Thailand’s renewable energy sector noted that “the absence of skilled manpower and spare parts” is a “prime” barrier, with capacity lacking particularly in wind, solar, and biomass energy.[71]

A third, perhaps more surreptitious barrier is theft and vandalism of electricity supply equipment. For example, in Papua New Guinea, solar units deployed to schools have been prone to unusually high rates of vandalism, sabotage, and theft. Under a *wantok* system rooted in tribal traditions, clans there share resources. Solar panels, which benefit a particular school, assault this system of *wantok*. Tribal communities have therefore smashed hundreds of solar panels or, worse, threatened their owners.[72] Similarly, in Argentina a Concessions Program for Solar Energy at Schools in Salta reported that “poorly mounted panels are subject to theft.”[73]

4.3 Lack of household energy access

School electrification programs provide access to schools, but rarely to households—meaning students’ and teachers’ homes remain without access (except in the cases in which teachers live in the schools). This results in two obvious drawbacks: they are unable to capture the educational benefits of household electrification, and do little to address the human health issues arising from dependence on solid fuels for cooking (except for schools that provide breakfasts and lunches for students and teachers).

Multiple studies have confirmed the positive link between household access to electricity and various improved educational outcomes. In Zimbabwe, children in a household with access to solar energy spend more time doing homework compared to households without access.[74] In Bangladesh, duration of school attendance by children corresponds with the duration of household access to electricity.[75] In the Philippines, homes with access to electricity on average have children that attend school for two years longer than those from homes lacking it.[76] In Vietnam, another report concludes that "children from grid connected households tend to stay in school more than those from ones without grid electricity."[77] In India, students whose households are electrified are more likely to complete grade-appropriate tests successfully as compared to their counterparts whose households are not electrified;[78] electrified households also have higher literacy rates.[79] Another study of India found that household electrification increases school enrollment by about 6 percent for boys and 7.4 percent for girls; as the authors note, *household* electricity access, in conjunction with service reliability "is what matters in improving household welfare in rural India."[80]

Furthermore, lack of access to modern energy services at the home can negatively impact schooling and education. Numerous medical studies have documented a strong connection between the effects of indoor air pollution at home (from cookstoves) and acute respiratory infections in children, which is the principal cause of school absences in many countries. In Uganda, for example, one-third of school absences come from such infections, which commonly last 7 to 9 days each.[81] Moreover, many children, typically girls, are withdrawn from school to complete their chores, including cooking and fuelwood collection. One study in Malawi noted that literacy levels were lower in fuelwood stressed regions of the country, and it also found a strong correlation between the time children spend collecting fuel and reduced school attendance.[82] Consequently, by focusing on schools but not homes, school electrification programs are unable to capture the benefits of providing households with reliable access to both electricity and cleaner forms of cooking.

4.4 Urban bias and classism

This challenge revolves around an urban and class bias in electrification programs. Most electrification efforts focus first and foremost on urban customers, since cities have greater population density and also tend to be more central areas of economic, political, and cultural power. Then, when they do reach rural areas, they tend to have a class bias: wealthier homes or schools are electrified first, sometimes at the exclusion of poorer segments of society.

Evidence of an urban bias in both electrification programs and in education come from multiple places. In most countries, funding formulas for schools are based on student input and amount of institutional activities. In many cases this puts rural schools, which lack electricity, at a disadvantage in terms of lower levels of enrollment and inability to provide diverse extracurricular activities.[83] It is especially hard for rural schools with financing arrangements covering only civil works (buildings) and teacher salary; other costs such as maintenance, books, food and water, uniforms, and outreach programs must be funded from other sources.[84] Educational priorities can become so skewed towards urban centers that in some cases rural schools have had to rely on litigation—to file a lawsuit—to get funds allocated to them.[85]

Sometimes private sector investors are not willing to finance public projects without extensive feasibility studies, which can add to project cost—something easier for urban schools to afford. Private sector players often want projects implemented quickly, meaning they may not seek the participation of civil society and community groups which could slow projects down.[86] Sometimes firms may strategically manipulate the project selection process to hurt competitors. One study, for instance, found that firms often lowball offers in infrastructure projects to prevent new entrants from competing with them, in essence making bids a predatory instrument rather than one of enhanced competition.[87]

Urban bias and inequitable outcomes are not the only problem. Most electrification programs also have a hidden class dimension: they can serve to enhance existing inequalities in income. One survey in Bangladesh noted that electrification seemed to only enhance the attributes of existing family wealth, it did not significantly eliminate poverty.[88] A similar study of solar energy use in Kenya concluded that "the benefits of solar electrification are captured primarily by the rural middle class" and that solar units play only a "modest role in supporting economically productive and education-related activities."[89]

5. Recommendations for School Electrification Programs

Thankfully, the four challenges identified above are not insurmountable, and a series of reforms, solutions, and policy mechanisms exist to overcome them. These are (1) leveraging innovative financing streams and public private partnerships to fund electrification efforts, (2) ensuring technical reliability of grid connections and equipment through standards and certification, (3) bundling school programs with those that provide household access and/or cleaner cooking options, and (4) coupling school electrification with community training opportunities that can fight poverty and classism.

5.1 Leverage innovative financing streams and partnerships

To address the problem of capital expense and lack of financing, a variety of financing instruments and sources are available. As Figure 9 reveals, these span a gamut of options and include grants, loans, and subsidies provided by banks, multilateral organizations, and the private sector. [90] Venture capital funds usually support early stage technology or start-up companies, and would be relevant to back any electrification programs (perhaps using prototype or advanced technology) with high risks but also high rewards if they succeed. Private equity funds attract a broader range of technology development stages and can be directed at "growth capital" (enabling commercial rollout of technology) or equity stakes in more mature companies already operating projects. Infrastructure funds will work for mature, lower risk and longer-term investment opportunities, such as those spanning power plants or transmission grids. Institutional sources of investment such as pension funds or insurance companies have large pools of money to manage and may allocate capital in specialized funds for renewable energy or pro-poor lending. Grants, loans, and subsidies can also be given by a variety of public organizations (state or national governments) or private institutions (non-profit groups or charities).

Figure 9: Common Financing Instruments and Sources for Electrification and Energy Access

Source: International Energy Agency, *Energy for All: Financing Access for the Poor* (Paris: OECD, October, 2011).

Collaborations and programs involving governments as well as businesses, nonprofit organizations, banks, and community based cooperatives have blossomed in recent years as one way to raise this needed investment to achieve electrification. These mechanisms can successfully supplement and overcome government budgetary constraints for widening access to energy services, especially to schools, as they can allocate project-risks between the public and private sector.

One such innovative option is PPPs, an arrangement where national governments and other public sector entities (such as state governments, city councils, municipalities, and independent legal bodies) partner with actors outside the public sphere to implement energy and educational projects together.[91] Generally, PPPs have received support because of their ability to produce higher quality services at a lower cost than either public or private partners can do in isolation. Advantages include attracting private capital investment, increasing efficiency and effective use of resources, and improving budget certainty and the maximization of assets.[92]

Specifically in the realm of education, a whole range of PPP configurations are available to overcome constraints in capital and other resources. Services provided under a PPP can include construction, management, capacity development, and maintenance of infrastructure, as Figure 10 indicates. Sources of financing can also encompass bonds and public subsidies to donations, retained earnings, and long-term loans.[93]

Figure 10: Financing Arrangements and Contractual Configurations of Educational PPPs

a. Financing and Service Arrangements

Finance \ Provision	Private	Public
Private	• Private schools • Private universities • Home schooling • Tutoring	• User fees • Student loans
Public	• Vouchers • Contract schools • Charter schools • Contracting out	• Public schools • Public universities

b. Contractual configurations

What governments contract for	What governments buy
Management, professional, support services (input)	• School management (financial and human resources management) • Support services (meals and transportation) • Professional services (teacher training, curriculum design, textbook delivery, quality assurance, and supplemental services)
Operational services (process)	• The education of students, financial and human resources management, professional services, and building maintenance
Education services (outputs)	• Student places in private schools (by contracting with schools to enroll specific students)
Facility availability (inputs)	• Infrastructure and building maintenance • Infrastructure combined with services (operational or educational outputs)

Source: Harry Anthony Patrinos, Felipe Barrera-Osorio, Juliana Guáqueta, *The Role and Impact of Public-Private Partnerships in Education* (Washington, DC: The International Bank for Reconstruction and Development, 2009).

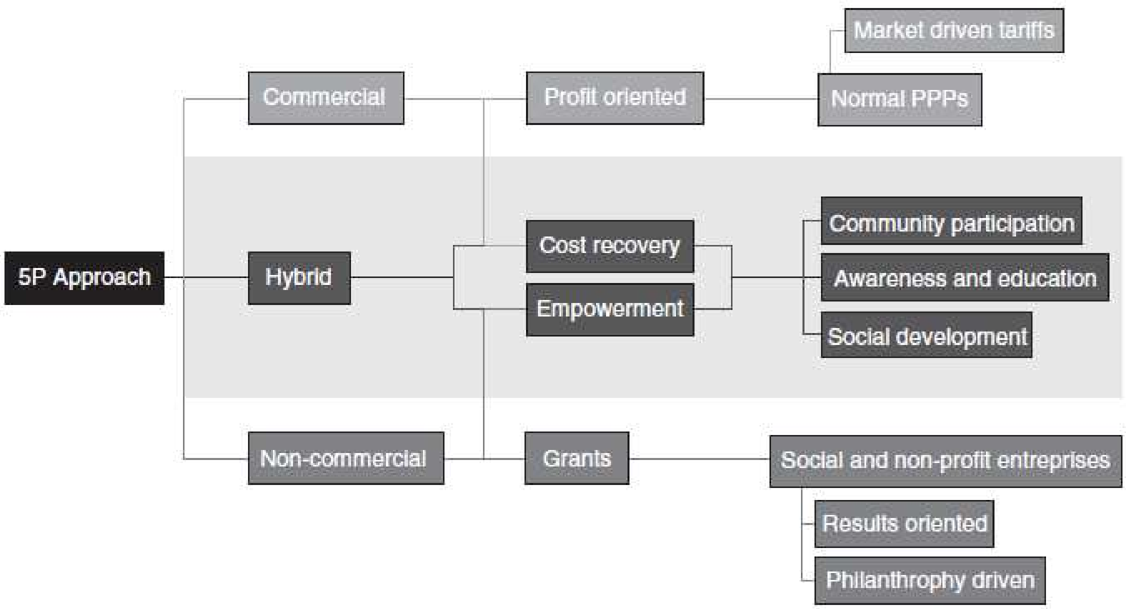
A number of school electrification programs have utilized differing forms of PPPs. In Argentina, the national government used concessions and build-operate-transfer PPPs to promote the solar electrification of schools in Neuquén and Salta. In South Africa, the national utility ESKOM designed electrical systems for rural schools but left the installation to private contractors and the management and maintenance to schools.[94] Such PPPs have been credited with three benefits. Private contractors in the business of selling and installing rural energy systems usually have the most knowledge or experience to provide needed services on a contractual basis. Educational institutions may be better equipped to manage programs and maintain systems rather than install them. And competitive procurements frequently result in lower costs.

One global review of using PPPs to promote renewable energy in rural areas noted that the following critical factors seem to be correlated with effective results:[95]

- If a country has little experience doing PPPs in the realm of energy, electricity, and/or education, it is suggested that the model be flexible so that it could be amended over time based on the results of monitoring and ongoing evaluations;
- The private sector firms provide, install, maintain and perhaps operate the power generation equipment, and the equipment is owned by the private company rather than the end-users at least for the first 10-15 years to allow the company to recover its investment and accumulate profit;
- The financing needs especially in the beginning should come from several sources: state budgets, the private investor as well as international loans or donations. The international donors usually offer technical advice along with the loan or the grant so countries can benefit from training and capacity building. Particularly at the start of the project, there needs to be cross-subsidies from the government so the end-users who cannot afford to pay for the service do not pay large bills, especially given that the population in the region has been accustomed to huge government subsidies on conventional fuels;
- The involvement of several ministries in the process is important. For instance involve the Ministry of Education with the schools in the area and the Ministry of Health with the health centers;
- The maintenance costs of the equipment can be covered through a minimum user fee or tariff but again should be subsidized by the government, particularly if the end-users cannot afford to pay;
- The service performance should be overseen and monitored at all stages and surveys and public hearings conducted to record community satisfaction or dissatisfaction with the service provided;
- Official monitoring and evaluation is important to ensure the project is running smoothly and efficiently. Usually, if an international agency has contributed to the budget of the project, it has its own monitoring mechanism which involves progress reports and sometimes visits from consultants to the project area for progress evaluation first-hand.

Additionally, a new type of PPP has emerged in recent years involving governments as well as private companies, banks, multilateral development banks, and nonprofit organizations (including NGOs) in expanding access to energy services.[96] A pro-poor public-private partnership model, usually indicated by the abbreviation "5P," has evolved to explicitly target the provision of services to poor communities, which are sometimes ignored by traditional PPPs since supplying the poor can involve substantial business risk. The 5P model views the poor not only as consumers that receive benefits, but also as partners in business ventures. It expands beyond the private sector to include partners from development banks, equipment manufacturers, rural energy service companies, philanthropic organizations, CBOs, cooperatives, and households themselves. Each of these groups plays a different role in the 5P: private sector participants can meet their corporate social responsibility obligations, utilities and energy companies can fulfill their obligation to deliver basic services, communities and members of civil society can expand access to basic services. Or, as the UNDP defines it, a 5P is one that "increases access of the poor to basic services by promoting inclusive partnerships between local government, business, community groups, NGOs, Faith Based Organizations and others."[97] As Figure 11 indicates, profit motivations are blended with social concerns and community empowerment.[98]

Figure 11: Hybrid Structure of Pro-Poor Public Private Partnerships (5Ps)



Source: Modified from Sovacool, BK. "Expanding Renewable Energy Access with Pro-Poor Public Private Partnerships in the Developing World," *Energy Strategy Reviews* 1(3) (March, 2013), pp. 181-192.

These partnerships and sources of financing, moreover, are not the only ones. One way to minimize transaction costs related to PPPs and technology procurement for rural schools is to bundle smaller projects together such that economies of scale are realized. Another is to tap into global carbon financing. During the 2010 Cancun Conference of the Parties, industrialized countries pledged to mobilize $100 billion per year by 2020 to address the needs of emerging economies in responding to climate change. At the center of this pledge is the Green Climate Fund (GCF), which has already raised $30 billion in "fast-track" financing as of 2012. If it reaches the $100 billion amount, the GCF will be equivalent to the cost of the entire four-year Marshall Plan to rebuild Europe after World War II.[99]

Three other types of legal innovations could also be harnessed to catalyze and scale up investment in school electrification: community interest companies (CICs), low-profit limited liability companies

(L3Cs), and for-benefit corporations (B Corporations). As Table 1 indicates, each has slightly different organizational objectives, customer relationships, and interaction with industry than traditional companies. They may each offer unique benefits of accelerating investments in community or school electrification.

Table 2: Key Distinguishing Features Between Traditional and Hybrid Corporate Financing Arrangements

	Organizational objectives	**Relationships with suppliers, employees, and customers**	**Interaction with market competitors and industry institutions**
Traditional firms	Addresses social and environmental issues only if the organization has the slack (e.g., resources, profit) and a strong business case	Cost factors are primary and relationships with suppliers, employees, and customers is functional and transactional	Activity is premised on creating markets for goods and services, appropriating and protecting competitive benefits, and altering industry standards for self-serving benefit
"Hybrid" firms such as B Corporations, Community Interest Companies, and Low-Profit Limited Liability Corporations	Addresses explicit social and environmental issues by design, independent of resources and profit	Social and environmental outcomes are primary and relationships with suppliers, employees, and customers is mutually beneficial	Activity is premised on creating markets for social objectives, competing successfully with traditional firms, and altering industry standards to serve the social and environmental contexts where companies operate

Source: Modified from Nardia Haigh, Andrew J. Hoffman, "Hybrid organizations: The next chapter of sustainable business," *Organizational Dynamics* (2012) 41, 126—134.

5.2 Ensure reliability through regulation and standardization

Many of the technical and even financial problems with rural electrification—both grid connections and equipment—can be offset by strong regulatory frameworks as well as national standards and certification systems. These have been shown to facilitate more reliable local manufacturing and maintenance activities, reduce costs, and improve quality of service.[100]

For instance, establishing a clear, stable and transparent legal framework appears to be an essential condition for attracting private capital in electrification. One survey of what capital market lenders look for when they select projects to invest in determined that they want national policy frameworks that are easy to understand, transparent in terms of eligibility and compliance, and stable in duration and statute.[101] One study even termed this having "loud, long, and legal" policies: loud in the sense that they offer clear price signals and encourage public involvement; long in that they are consistent and predictable; and legal in that they are backed by strong political support and have penalties for noncompliance.[102]

Stable legal and regulatory frameworks must come in tandem with standards for grid and off-grid technology. One survey of energy access programs in Asia concluded that programs that worked well tended to promote or harmonize rigorous technical standards to ensure renewable energy technologies work as expected. This underscores the reliability component of energy access, and it also serves as a meaningful form of consumer protection. As one expert commented in this study:

> *People will pay for energy services, just not for unreliability or unpredictability; they won't pay for electricity that is on when they don't need it or off when they do need it. Nor will they pay for electricity that has such erratic voltage fluctuations it fries appliances – that's what they don't want to pay for. But reliable, efficient service – yes, they want that.*[103]

Thus, successful programs strengthen technology—from design and installation to maintenance and replacement—in tandem with falling into clear and consistent policy environments.

A few examples from real-world energy access programs illustrate this point. In China, a Rural Energy Development Program distributing solar panels to rural areas focused on whole-cycle quality improvement for solar modules, chargers, batteries, and other equipment. It executed a "start-to-finish" quality process by establishing manufacturing standards and practices, facilitating access to product certification, and introducing a randomized testing regime which penalized companies at the production-line and retail stages for non-compliance with system performance requirements. It also culminated in the "Golden Sun" label to certify compliance with International Organization for Standardization (ISO) recommendations.[104] A Rural Energy Access Program in Mongolia established technical standards and procedures for testing the quality of solar and wind devices and mandated that only qualified systems could receive support under the program.[105] In Sri Lanka, a rural Energy Services Delivery project promoting off-grid and grid-connected microhydro units mandated that technologies meet national standards and technical compliance had to be verified by chartered engineers.[106]

5.3 Bundle household access into programs

To capture the benefits of providing modern energy access to households—improvement in educational outcomes and potential improvements to health—school electrification programs may want to have a household component or a cooking component. This component could simply provide affordable but healthy food for multiple meals (breakfast, lunch, and dinner) to significantly obviate the need for children to remain around cookstoves at home and their associated indoor pollution. Or, it could involve giving electricity, cleaner or improved cookstoves, or both to households, especially those where students live or the homes of teachers—likely areas where children can study.

One innovative way to promote both household and school access simultaneously is through community mini- or micro-grids. A mini-grid refers to a localized or isolated grouping of electricity generation, distribution, storage, and consumption within a confined geographic space.[107] While in some instances mini-grids can be interconnected to national electricity networks, in most cases they operate autonomously and at lower loads and voltages. Though definitions vary, mini-grids are often locally managed, they involve less than 10 MW of installed capacity, they serve small household loads, and they possess a radius of 50 kilometers or less. Micro-grids are even smaller and typically operate with less than 100 kW of capacity and at even lower voltage levels and possess a 3 to 8 kilometer radius.[108] Mini- and micro-grids can be powered by fossil fuels, such as diesel generators or fuel cells, or by renewable energy sources such as microhydro dams, solar PV plants, biomass combustion and wind turbines. When configured properly, such mini- and micro-grids can operate more cost effectively than centralized generation from a power grid.[109]

At least five countries in the Asia-Pacific—Nepal, Sri Lanka, Lao PDR, Mongolia, and Vietnam—have been experimenting with mini- and micro-grids for rural electrification over the past decade. Nepal's Rural Energy Development Programme, Sri Lanka's Energy Services Delivery Project, and the Rural Electrification Project in Lao PDR all entailed components tailoring grid, micro-grid, and off-grid solutions to local circumstances. The Sri Lankan project went so far as to specifically target different beneficiaries: solar units for rural households, microhydro units with micro-grids for villages that served households as well as schools, and grid-connected microhydro units for tea estate management companies and independent power producers. The Rural Energy Access Project in Mongolia, similarly, pursued a two-pronged strategy of isolated diesel and solar hybrids for some herders but micro-grids for others living near *soum* centers (in Mongolia, a *soum* is equivalent to a district or county).[110] Vietnam's Renewable Energy for Remote Island and Mountain Communes Project financed the construction of ten mini-hydropower facilities, with a capacity of less than 7.5 MW each, in several northern provinces. It built more than 100 kilometers of low-voltage micro-grid networks and electrified 50 villages and 5,000 households.[111]

Indeed, the IEA expects micro- and mini-grids to play an instrumental role in global electrification efforts over the next decade. The IEA's figures suggest that national grid extension is the most suitable option for almost all urban areas and but only about 30 percent of rural areas.[112] Therefore, roughly 70 percent of rural areas are assumed to be connected either with mini-grids (65 percent of this share) or with small, stand-alone off-grid solutions (the remaining 35 percent)—as Table 3 shows. Out of a total generation requirement of 838 TWh, 56 percent (or 470 TWh) will be provisioned via mini-grid and isolated off-grid technology.

Table 3: Generation Requirements for Universal Electricity Access by 2030, in TWh

	On-Grid	Mini-Grid	Isolated Off-Grid	Total
Africa	196	187	80	463
Developing Asia	173	206	88	468
Latin America	6	3	1	10
Developing Countries	379	3,993	171	949
World	380	400	172	952

Source: International Energy Agency, *World Energy Outlook 2012*. Paris: International Energy Agency.

Programs that do not focus on micro- or mini-grids can still promote electricity access and cooking access side-by-side. Though it did face a number of challenges, India's Village Energy Security Program is notable in this regard.[113] It focused simultaneously on expanding village access to electricity (including the electrification of some village schools) and cleaner sources of cooking. It promoted decentralized electricity supply from biomass gasifiers and vegetable oil diesel generators and sought to provide improved cookstoves and biogas units. It emphasized using energy for productive purposes (e.g., job creation), and established a dedicated tree plantation and management system as a feedstock for the village's energy production system. It, lastly, prompted participatory Village Energy Plans. Essentially, the program was intended to go beyond rural electrification to achieve "village energization" which would help reduce poverty, improve public health, reduce drudgery (particularly for rural women), raise agricultural productivity, create employment, generate incomes, and reduce migration.

5.4 Couple school electrification with community training

To overcome issues of classism and urban bias, school electrification efforts could be coupled with community training programs focused on skills development of income generation—essentially enabling them to learn for themselves how to raise standards of living. One promising path is to utilize apprenticeships alongside formal training procedures like classes or certificates. For instance, throughout Sub-Saharan Africa, traditional apprenticeships are how most youths are trained. In Senegal, young people were 40 times more likely to be trained through informal apprenticeships than through formal technical or vocational education.[114]

The necessity of community capacity building was confirmed by a University of Berkeley California study which noted that the best energy development programs directed resources not at particular technologies or projects, but to institutions and people themselves so that they, in turn, could distribute technology and implement projects in perpetuity.[115] Put another way, effective partnerships build local capacity so that a self-sustaining renewable energy market can function without external support or dependence on international actors. As one consultant with experience implementing renewable energy projects in dozens of countries commented, "energy services must always be paid for, at a fair cost … Once you give something away for free, you better be prepared to give it away for free forever."[116]

Successful energy access programs do have a good track record of coupling electrification with community training and capacity building. Grameen Shakti in Bangladesh offers a scholarship competition for the children of solar home system owners. It also sponsors technical degrees in engineering and related fields for employees that commit to staying with the organization long-term. Also, the organization has also done an excellent job linking its products and services to other local businesses, and integrating its technologies with other programs. As one example, it connects the use of biogas units in homes and shops with the livestock, poultry, agriculture, and fishery industries. Clients wishing to own their own biogas unit can also purchase livestock, and clients that do not wish to use the fertilizer created as a byproduct from biogas units can sell it to local farmers, aquaculturists, and poultry ranchers. Similar linkages have been made in the promotion of solar panels, mobile telephones, compact fluorescent light bulbs, and light emitting diode devices.[117] In Nepal, the UNDP's Renewable Energy Development Program successfully linked microhydro energy and the promotion of non-lighting uses of electricity including agro-processing, poultry farming, carpentry workshops, bakeries, ice making, lift irrigation, and water supply. [118]

The key lesson is that successful programs did not just supply energy or electricity, presuming people know how to use it; they instead teach them how to put that energy to productive use through classes, education, or apprenticeships. In essence, these projects succeeded because they promote the types of economic activities that go hand-in-hand with modern energy, enabling communities to form strong livelihood groups, to process agricultural commodities and crops, and to sustain small businesses and enterprises.[119]

6. Conclusion

Even though large-scale electricity networks have existed for more than a century, a troubling number of primary and secondary schools around the world lack access to them. Analysis of the data suggests that approximately nine out of every ten children in Sub-Saharan Africa go to primary schools without an electricity connection. Less than a third of village schools in India have electricity access, as do fewer than half of rural schools in Peru. In total about 188 million children attended primary schools that lack electricity access in 2013—a number so large, if it were a country, it would be the seventh largest in the world, between Pakistan and Nigeria. Given that about 660 million children are enrolled in primary school worldwide[120], this means almost one out of every three go to a school without electricity.

This dearth of electricity at institutions of learning leaves students literally in the dark, forcing them to study near kerosene lanterns, with poorly-lit candles, or under street or electric lights in urban areas. It also leaves teachers without many modern educational tools such as telephones, televisions, computers, projectors and slide projectors, printers and copy machines, digital cameras, and radios. Electrifying schools not only enables these labor saving and curriculum improving devices, it has also been shown to create more comfortable, successful schools that demonstrate better performance through attendance, graduation rates, and test scores. Some electrified schools have even seen benefits such as improved community sanitation, public health, and gender empowerment.

As Table 4 summates, some serious challenges exist to providing schools with the electricity they need to teach students and retain and train staff. High up-front costs and difficulty in procuring financing make it difficult for schools, especially rural schools, to afford investments in energy. Technical difficulties arise with procuring high-quality equipment and maintaining it. Programs that narrowly attempt to electrify schools but not homes still leaves teachers and students dependent on solid fuels or kerosene lamps and candles when they leave the school. Energy and education partnerships must fight against an urban and class bias.

Table 4: Barriers and Solutions to Accelerating School Electrification

Barrier to school electrification	Solution that overcomes this barrier
Capital cost, lack of financing	Innovative revenue schemes such as public private partnerships, bundling projects, carbon finance, community-interest companies, low-profit limited liability corporations, and for-benefit corporations
Technical problems, theft or destruction of equipment	Stable and consistent policy frameworks and technical standards and certification
Lack of household access, indoor air pollution arising from cooking practices	Bundling household access and modern cooking programs with school electrification efforts
Urban bias in electrification and education investments, inability to address poverty	Coupling electricity with community training and capacity building so that standards of living are raised and villages become more self-sufficient and autonomous

Source: Authors.

Table 4 also shows that each of these barriers has an assortment of solutions that can overcome it. High upfront costs can be mitigated and overcome by tapping into financing streams and distributing risk through public private partnerships. Technical problems can be countered by stable policy frameworks with strong technical standards and certification schemes. Lack of household access and urban bias can be reduced by coupling electrification efforts with household and cooking programs and community capacity building and training efforts. The lesson appears to be that though energy and electricity poverty of schools is acute, it is not inescapable. Plentiful options exist—for development practitioners, educational experts, planners, policymakers, investors, and energy companies—to ensure that primary and secondary schools provide students with the light, heat, comfort, and above all the ability to learn.

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