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# Energy Access Review

INSIDE THIS ISSUE



## *From 9/10 to 9/10: Estimating the cost of attaining grid-based universal electrification in Sub Saharan Africa*

Nine out of ten rural homes in the United States were without electricity in the mid-1930s. President Roosevelt signed into law the Rural Electrification Act in May 1936 which set in motion actions that led to, among other things, the rapid spread of the grid network in rural United States[1]. By 1953 it is reported that more than nine out of ten rural homes had electricity – a transition from nine out of ten, to nine out of ten in less than 20 years. We have argued in a past publication that a key factor that distinguishes the context between the United States then, and Sub Saharan Africa (SSA) now, is the measure of wealth as estimated by the GDP per capita. GDP per capita stood at about seven times the current GDP per capita of a country like Kenya (when adjusted for present day dollars). There are several discussions on whether SSA should advance a similar or different model in view of the existing technological options, economic constraints and sparsely distributed demand points. This is not the topic of discussion today. Today we attempt to estimate the cost of attaining universal electrification (95% +) in Africa based on the Roosevelt model. In any case, grid-based electrification is the most desirable form of electrification now as it was then. As one farmer in Tennessee in the 1930s put it, "the greatest thing on earth is to have the love of God in your heart, and the next greatest thing is to have electricity in your house."[2]

**Figure 1: Staff of the US Rural Electrification Administration (REA) in the 1930s (Photo credits: NRECA)**

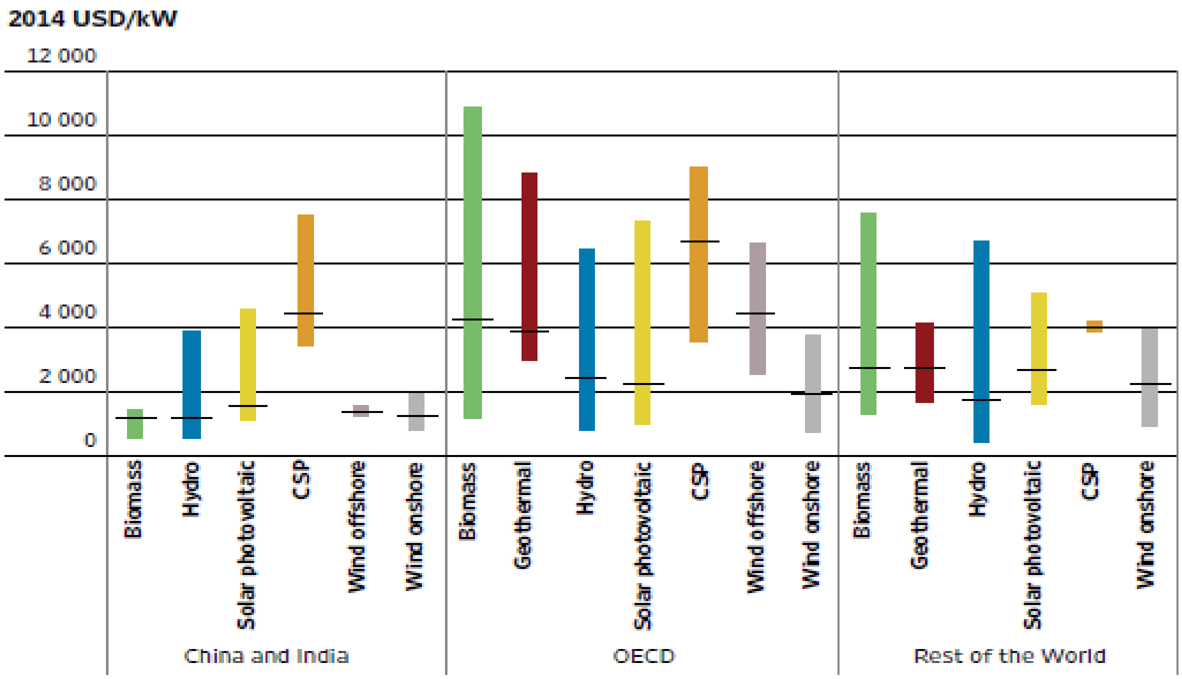
"The greatest thing on earth is to have the love of God in your heart, and the next greatest thing is to have electricity in your house."

- A Tennessee Farmer, 1930 -

[1] United States Federal Government (1936), Rural Electrification Act, May 20 1936, Washington DC.
[2] Lindop E., and Goldstein M., (2010) America in the 1930s, Twenty-First Century Books, Minneapolis, USA

This following estimation is not a rigorous academic exercise but rather a logical back-of-the-envelope calculation that approximates the cost of connecting and supplying power to a single household in Kenya using data from Kenya Power (Annual report 2014), together with generation cost averages from the International Renewable Energy Agency (IRENA) and other sources cited here.

**Figure 2: Typical ranges and weighted averages for the total installed costs of utility scale renewable power generation technologies by region (Source: IRENA, 2014)**




Ghana[3], Zambia[4] and Uganda[5] have all set targets for attaining universal electrification by Year-2020, Year-2030 and Year-2040 respectively. A host of other SSA countries have also set similar targets. It is important to get a feel of how much such an undertaking would cost especially in the context of other recurrent and developmental expenses, and relative to the national budgets. Using Kenya as a case, we estimate the total cost of providing electricity to an average household inclusive of power generation and distribution capital expenses and make extrapolations for other countries in the region. The Kenya Power report provides actual data in terms of installed capacity (disaggregated by technology), the number of customers being served (disaggregated by household versus non-household users) and the amount of electricity sold to each customer segment.

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[3] Energy Commission (2006), Strategic National Energy Plan 2006 – 2020,
[4] Ministry of Mines, Energy and Water Development (2013), Expression of interest to participate in SREP, Republic of Zambia, Lusaka
[5] Ministry of Energy and Mineral Development (2012), Rural Electrification Study and Plan, Government of Uganda, Kampala

We find that households – which constitute 90% of the client base - consumed only 26% of the total electricity sold by Kenya Power in 2014. Based on this we estimate that slightly less than 500MW out of the total installed capacity then can be seen as being dedicated to households and that the average cost of generating power for one household under a national utility network is about US$ 342. Interestingly, but unrelated to this discussion, it appears that only an additional 1000MW will be sufficient to meet the needs of all the unconnected households in Kenya. A comprehensive geo-spatial study on national electricity planning in Kenya led by Parshall and a team from the Earth Institute (Columbia University) in 2009 estimates that it will cost an average of US$ 1900 to connect one household to the grid. Combining the cost of generation and distribution we estimate that it will take about US$ 2,242 (KES 231,036) to electrify an average household in Kenya. Using extrapolations from the 2009 national census, Kenya would have about 10 million households in 2014 of which 34% are connected to the grid leaving about 6.6 million household unconnected. Based on the electrification cost above, we estimate that it will cost at least US$ 15 billion to attain grid-based universal electrification in Kenya. We use the term "at least" because this estimation does not include the cost of transmission. For Ghana, Rwanda, Tanzania, Uganda and Zambia we estimate this to be about US$ 4.9B, US$ 4.9B, US$ 16.8, US$ 14 B and US$ 4.9 B respectively as shown in figure 3 below. These are significant investments relative to the total annual government spending in each of these countries and ranges from 42% of the national budget in Ghana to as high as 256% in Uganda.

**US$ 2,242**

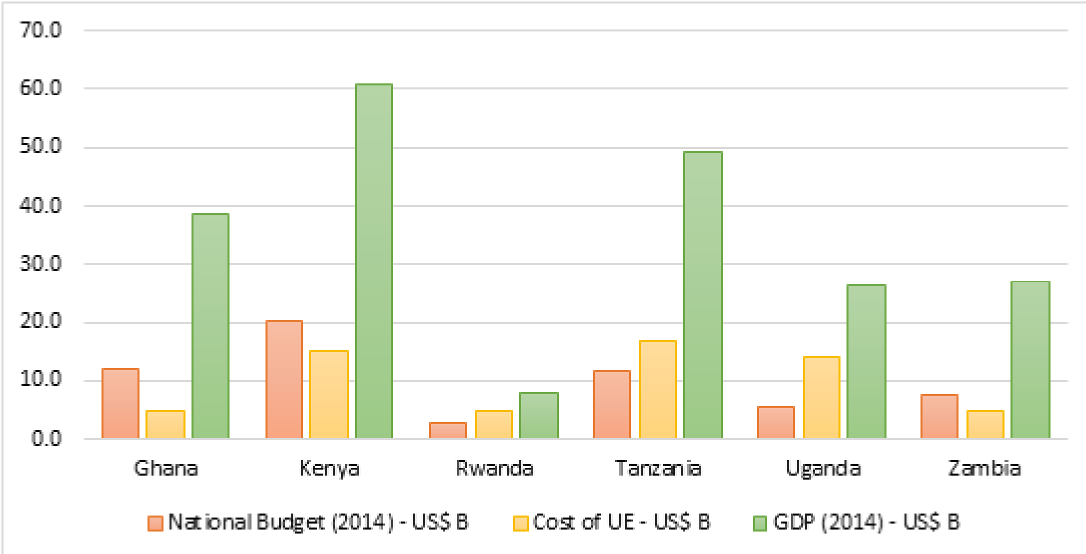
**Estimated national average cost of electrifying a single household in Kenya (grid – based electrification)**

**Figure 3: Estimated costs of attaining grid-based universal electrification (UE) in US$ billions**

| # | Country | National Budget (2014) - US$ B | Cost of UE - US$ B | GDP (2014) - US$ B | % of the 2014 National Budget |
|---|---|---|---|---|---|
| **1** | Ghana | 11.8 | 4.9 | 38.6 | 42% |
| **2** | Kenya | 20.3 | 15.0 | 60.9 | 74% |
| **3** | Rwanda | 2.6 | 4.9 | 7.89 | 190% |
| **4** | Tanzania | 11.6 | 16.8 | 49.18 | 145% |
| **5** | Uganda | 5.5 | 14.0 | 26.3 | 256% |
| **6** | Zambia | 7.4 | 4.9 | 27.1 | 67% |

***Data sources used in this compilation***: NBST (2014), Basic demographic and socio-economic statistical tables, National Bureau of Statistics – Tanzania, Dar es Salaam; WB (2014), Country Profiles – GDP, World Bank online database, Washington; AfDB (2015), Renewable energy in Africa – Tanzania Country Profile, African Development Bank, Abidjan; Kenya Power (2014) Annual Financial Reports, Kenya Power, Nairobi; UBS (2014), National population and housing census, Republic of Uganda, Kampala; NISR (2014), Fourth population and housing census of Rwanda, National Institute of Statistics of Rwanda, Kigali; CSO (2012) Zambia 2010 housing and population censure volume 11, Central Statistical Office, Lusaka, GSS (2013), 2010 population and housing census – National Analytical report, Ghana Statistical Service, Accra; 2014 Budget statements for Ghana, Kenya, Rwanda, Tanzania, Uganda and Zambia.

**Figure 4: Comparing cost of universal electrification (UE) with national budgets and GDP (in US$ Billions)**




The cost of attaining universal electrification across countries will depend first on the agreed working definition of electrification. Electrification means different things to different people and varies from only grid-based connections to definitions that consider non-grid based electrification, for example, access to solar based lighting applications. Other factors include the number of households without electricity, type of generation technology and energy source, geospatial spread of human settlements (affecting transmission and distribution costs) and development approaches (private versus public versus public-private partnerships).

From these estimates we can conclude that: (i) Justifying a hasty increase in generation capacity based on low electrification rates needs a reconsideration because households consume only a small portion of the total electricity produced by the utilities. For example, it is inaccurate to estimate that county X that has 1000 MW generation capacity and only a 25% electrification rate, needs 4000MW to attain universal (100%) electrification. The relationship is not linear; (ii) Public finance will always be inadequate towards attaining universal electrification and conducive spaces for private sector investments need to be created; (iii) At the household level, distribution costs per household are almost always significantly higher than generation costs. A lot of focus is however placed on increasing megawatt generation capacity than connecting households and; (iv) With rapid economic growth being experienced across the continent, we expect the fastest growth in electricity demand to be in urban areas – both from industrial applications and the expanding middle class households. This creates, in addition to the focus on rural electrification, a critical need for the refurbishment of the urban electricity distribution infrastructure.

## *Floating Solar PV Technology – Should Africa pay attention?*

Floating solar PV is an innovative technology in which standard PV panels are installed on large water bodies such as water reservoirs, remediation and tailing ponds, dams, irrigation canals, and quarry lakes. This system can be particularly useful for large companies that are involved in energy and water intensive activities, who are limited by the amount of land or water that they have available. Wineries, dairy farms, mining companies, waste water treatment plants, irrigation and water agencies are all good examples of industries around the world in which floating solar PV technology is applicable. The world's first floating solar PV system was installed in 2007 at the water ponds of a Napa Valley winery by American company SPG Solar, which has since been acquired by Sun Edison. Since then, companies from Australia, India, Japan, Korea, the US, and most recently Brazil have all announced floating solar PV projects.

Of floating solar PV projects that are already completed, the largest is a 2.3 MW project in Hyogo, Japan installed by French company *Ciel et Terre* International. The electricity generated at this pond comprises of 10% of total global installed floating solar PV capacity, and is sufficient enough to supply 820 households with power[4]. The Hyogo project is just one of several floating solar PV projects in Japan, a country that is increasingly embracing solar PV technology after the Fukushima disaster and the closing of its nuclear plants. Floating solar panels offer several advantages because they:

- Are at least 11% more efficient than conventional panels[5].

**Figure 5: 850kW floating PV project in Hyogo prefecture in southern Japan (Photo credits: Asia and Japan Watch, 2015)**

[4] Asia and Japan Watch (2015) *Biggest floating solar power plant built in Hyogo*. Retrieved from http://ajw.asahi.com/article/business/AJ201505260067

[5] Choi, Y.K. (2014) A Study on Power Generation Analysis of Floating PV System Considering Environmental Impact. *International Journal of Software Engineering and Its Applications,* 8(1), 75-84. Retrieved from http://www.sersc.org/journals/IJSEIA/vol8_no1_2014/7.pdf

The enhanced efficiency is due to the naturally occurring cooling effects of the water body.

- Are easier to clean due to their proximity to water and often have built in sprinkler systems.
- Reduce water evaporation. Developer SPG solar claim that solar panels can reduce evaporation by up to 70%[6] while others have this figure much lower at 33%[7].
- Do not require land purchase or usage thus lowering the cost significantly in some cases. This has the potential of increasing the economic viability of these systems.
- Can be integrated with hydro power plants that have reservoirs.

One important factor to consider is whether the $/w cost of floating solar PV is cheaper than that of ground mounted PV. In 2014, Mark Bennett, a farmer in Berkshire, England had a 200 KW *Ciel et Terre* floating solar system installed on a 3 acre man-made lake. He paid £250,000 for his 200 kW system [8], or £1.25 per watt. This compares favorably to the current standard solar installation price of £2.50 to £3.00 per watt in the UK.[9] While the installation costs of other floating solar PV projects are not known, Mark Bennett's story exemplifies that floating solar PV can be cheaper to install than standard solar PV. Some major contributors to the lower cost of the floating solar PV system are the short installation period as well as the straight forward method of assembling the panels. In the case of Mark Bennett, "it took only a week to install the 800-panel system, and they needed no tools or heavy equipment. You just clip the platform's plastic units together, attach the solar and float them out onto the water. In terms of installation speed per kW, it's seven times faster than a rooftop installation."[10]

Whether this technology applies within the context of SSA should be answered in view of the (i) lost opportunity costs of recreational and livelihood purposes, such as fishing, which would be displaced as a result of a floating PV system, (ii) increased efficiency versus the total costs, (iii) long term ecological impacts. Already a lot has been achieved through ground mounted and roof-top systems. This is bound to grow further if enabling policy such as electricity banking and net metering are enacted. Perhaps the best way to look at this option is not as a competing option but a potential complementary to the conventional systems.

[6] SPG Solar (2011) *Solar Power System- Overview and SPG Solar Statement of Qualifications*. Retrieved from https://www.usbr.gov/lc/region/programs/crbstudy/1_Evaporation_Reduction_via_Floatovoltaics_Systems.pdf

[7] Agrawal, P., Sahu, Y., Shahabuddin, M. (2014) *Floating Solar Photovoltaic System: An Emerging Technology.* Retrieved from http://www.slideshare.net/MdShahabuddin4/1-paper-on-floating-solar-photovoltaic-system-an-emerging-technology

[8] The Guardian (2014). *First Floating Solar Firm Built in UK.* Retrieved from: http://www.theguardian.com/environment/2014/sep/29/first-floating-solar-farm-built-in-uk

[9] The Eco Experts (2015). *How Much Do Solar Panels Cost In The UK?* Retrieved from: http://www.theecoexperts.co.uk/how-much-do-solar-panels-cost-uk#SolarCost

[10] Dauncey, G. (2015) *Floating Solar- A Crazy Big Idea?* Retrieved From: http://www.bcsea.org/floating-solar-crazy-big-idea

## *Third Quarter 2015 Energy Access News Highlights*

- **TANESCO starts power generation using natural gas -** Tanzania Electric Supply Company (TANESCO) in September switched on Ubungo power gas plants to allow generation of electricity by using natural gas that is being transported from Madimba in Mtwara Region. The Ubungo gas plants will at the initial stage contribute 90MW to the national grid and expected to reduce power shortages in the country. The Minister for Energy and Minerals, Mr. George Simbachawene, said that using natural gas to produce electricity is a permanent solution to power problems in the country, as it guarantees sufficient supply of electricity throughout the year.
- **AfDB loans US$145 million for Kenya-Tanzania power transmission line-** The African Development Bank (AfDB) has approved a US$ 145 million loan for the construction of a 510 km power transmission line running through Kenya and Tanzania. The two countries will use the loan to support their efforts in constructing the 400 kV line and several substations along the way and allowing them to trade in power. The Japan International Cooperation Agency (JICA) also announced that it will co-fund the project, which is expected to improve regional power connectivity across the East African nations.
- **SEFA awarded "Power Transaction of the Year" for Jumeme Rural Energy Supply Project in Tanzania-** the Sustainable Energy Fund for Africa (SEFA) was awarded "Power Transaction of the Year" by the East African Power Industry for its role in financing the development of an independent solar hybrid mini-grid project in rural Tanzania. The prize was received at East African Power Industry awards gala on August 27 during its annual convention which gathered about 1,200 industry leaders and professionals in Nairobi, Kenya. SEFA approved a preparation grant for joint venture Jumeme - Rural Power Supply Ltd (JRPS) to develop a mini-grid project using predominately solar energy to expand rural electrification in the north-western part of the country.

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- **Kenya Power signs geothermal, hydropower deals for 76 MW–** Kenya Power, Kenya's sole electricity distributor, signed two power purchase agreements for 76 megawatts of geothermal energy and hydropower. The utility will buy 70 megawatts from Akiira Geothermal Ltd., a project developer, and Marine Power Generation Ltd., its development partner. The distributor will also purchase 6 megawatts from Kleen Energy, a local hydropower producer.

- **Africa's first grid-linked biogas plant starts running in Kenya -** Tropical Power Kenya has started producing power at Africa's first biogas plant connected to the national grid. The company expects to sell the electricity for 10 cents per kilowatt hour to Kenya Power. The 2.2-megawatt plant will be fed 50,000 metric tons of plant waste a year sourced from VegPro Group, East Africa's biggest exporter of vegetables to the U.K. The plant was built at a cost of US$ 7.5 million using anaerobic digesters supplied by U.S.-based General Electric Co.
- **Kenya signs nuclear power deal with China–** Kenya has signed a deal with China as part of plans to have a nuclear power station by 2025, the Kenya Nuclear Electricity Board (KNEB) revealed. Kenya plans to set up its first nuclear power plant with a capacity of 1000 MW by 2025 with ambitions to boost that to 4000 MW by 2033, and to make nuclear electricity "a key component of the country's energy" production. KNEB revealed that the memorandum of understanding will enable Kenya to obtain expertise from China by way of training and skills development, technical support in areas such as site selection for Kenya's nuclear power plants and feasibility studies.

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- **AfDB approves US$ 121 million for electricity expansion to rural households in Uganda** - The African Development Bank (AfDB) Group Board approved a US$ 121 million loan and grant to help Uganda's government improve access to electricity for rural households, businesses and public institutions to ultimately improve the livelihoods, economic opportunities and access to social services in rural communities. The Bank Group allocated a US$ 100 million loan and an additional €10.205 million grant mobilized by the AfDB from the Sustainable Energy for All (SE4All) window of the EU-Africa Infrastructure Trust Fund (EU-AITF).
- **UpEnergy closes investment deal now raising US$ 1 million more in debt –** UpEnergy, a Uganda-based clean-energy startup, has closed a new debt investment deal with Global Hearthworks Foundation. The new debt investment is aimed at boosting UpEnergy's distribution channel by allowing it establish partnerships and drive sub-regional presence. UpEnergy had previously secured an equity investment deal of over $1 million and launched a campaign on VC4Africa to raise $1 million more in debt. Established in 2011, UpEnergy provides clean energy products such as improved cookstoves to underserved communities in Africa. The company has served about 400,000 Ugandans with clean energy technologies.

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- **Rwanda leases 22 small hydroelectric plants to private consortium-** Rwanda's Ministry of Infrastructure government announced that it had leased 22 small hydropower projects located in the northern and western provinces to private investors to spur the country's hydroelectric energy program. According to energy experts at the ministry, the plants would add about 24.6 MW of hydroelectric energy to the national grid. The listed facilities, three of which have a capacity that's yet to be determined, include: 200-kW Agatobwe; Nyamyotsi I and II, each 100 kW; 9-MW Kimbili Rukarara V; 2.2-MW Rugezi; 200-kW Mutobo; Base I and II; and Ngororero.
- **African Development Bank seeks to spur US$ 55 Billion for energy-** African Development Bank President Akinwumi Adesina, who took over in September, said he's aiming to eliminate Africa's energy deficit by 2025 by mobilizing $55 billion of investment. It is termed the "New Deal for Energy in Africa". AfDB also plans to significantly raise its support for energy projects and urges its partners to also scale up efforts. The proposal also called for African countries to increase financing for the development of the energy industry.
- **Actis exits its energy interests in Africa-** Actis, an investment firm, has sold its stake in a power generating firm with interests in Cameroon, Tanzania, Cote d'Ivoire, Kenya and South Africa. Actis confirmed completing the sale and full transfer of its stake held in Globeleq Africa to a firm jointly owned by Norfund, the Norwegian investment fund for developing countries and CDC Group ("CDC"), the UK government's development finance institution. Actis, who were exclusively advised by Goldman Sachs said it held an indirect majority stake of over Sh36.7 billion invested in the past seven years through Globeleq Africa that saw Globeleq's electricity generating capacity doubling to 1,234MW.
- **African Renewable Energy Fund reaches US$ 200 million investment target-** The African Renewable Energy Fund (AREF) has reached its final investment target, with US $200 million of committed capital to support small to medium scale projects on the continent. The final close came with funding from the European Investment Bank (EIB) and the Global Energy Efficiency and Renewable Energy Fund (GEEREF), among other investors, joining the African Development Bank (AfDB) as the fund's lead sponsor. Climate finance instruments such as Sustainable Energy for Africa (SEFA) and the Global Environment Facility (GEF) have also invested in AREF, which held its first close of US$ 100 million in March last year.

## *In the Next Issues of Energy Access Review*

- Nantennas, airborne wind turbines and other emerging energy access technologies to watch
- A look at the System Average Interruption Duration Index (SAIDA) and correlations between quality of power and economic growth in Africa.
- Regular updates on energy access from Tanzania, Kenya, Uganda and the Africa region

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