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Energy Access Review

A case for reticulated water supply mini-grids

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That diarrheal diseases are a leading cause of death in Kenya should be a great concern. Even more concerning is that these diseases are responsible for about three times the number of premature deaths in Kenya, compared to similar countries ranked according to social-demographic indicators (SDI) (see Table 1). Not only is the scale astounding, but the fact that these diseases are primarily caused by limited access to safe water in adequate quantities – which is a constitutional right – should draw all attention to this problem. Like electricity supply, reticulated water systems have been traditionally developed in the densely populated urban and peri-urban areas while isolated systems such as boreholes, wells and water pans would commonly serve sparsely populated regions. In this review, we first discuss the common transmission pathways of diarrheal diseases and propose 'bringing water to communities' in sparsely populated areas through reticulated water supply mini-grids. This approach is not prescribed as the ultimate solution but presented as one of the many possible options. We choose to highlight this as an option because it is one with unique possibilities but has often been overlooked in the water access narrative.

Table 1: Diarrhea as a cause of premature death for countries within the same SDI (Low-middle SDI). Age-standardized rate per 100,000, 2016

Comparison group mean	Kenya	Cambodia	Cameroon	Cape Verde	Ghana	Iraq	Laos	Morocco	Myanmar
1,936.6	5,968.9	396.7	2,204.8	260.1	768.5	271.5	772.9	356.0	551.4

Source: Institute for Health Metrics and Evaluation

Every person has a right to "clean and safe water in adequate quantities" under Kenya's constitution. Data, however, shows that a significant proportion of Kenyans, especially in rural areas, do not have access to clean and safe water. About 50% of the rural population has attained at least basic levels of drinking water services according to the Joint Monitoring Program (JMP) progress report for 2017. That leaves 10% with limited access to water, 11% sourcing water from unimproved sources and 29% relying on surface water sources such as rivers, dams and lakes among others. To make a case for reticulated water supply systems, we explore the need and urgency to prioritize safely managed water services for all and present basic economic considerations to demonstrate viability. The JMP defines safely managed water supply as the availability of drinking water from an improved water source which is located within premises, available when needed and free of faecal and priority chemicals contamination.

> "About 50% of [Kenya's] rural population has attained at least the basic level of drinking water services"

Wide literature exists on the relationship between water access (or lack of) and transmission of water related diseases. Figure 1 below summarizes four transmission routes adopted from David Bradley's (1974) classification of water-related diseases. Worth noting is the relationship between water access and diarrheal diseases, which are seen to be the leading cause of death in Kenya (see Figure 2). Infectious diarrheas are observed under the water-borne and water-washed transmission categories and include cholera, salmonellosis, shigellosis, amoebiasis, and other protozoal and viral intestinal infections.

As per the Bradley classification (Figure 1), provision of clean and safe water helps prevent water borne diseases while provision of water in adequate quantities helps deal with water washed diseases. Additionally, as seen in Figure 3 and Table 2, the place for hygiene and good sanitation cannot be understated.

Figure 1: Classification of water-related diseases

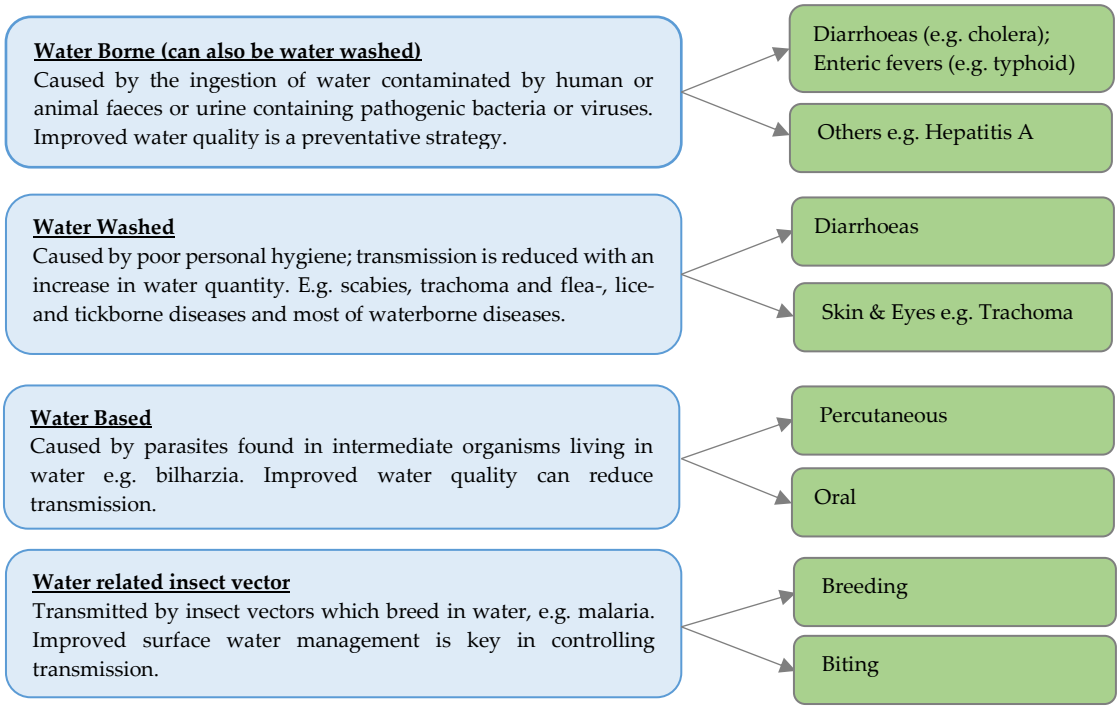


Figure 2: Leading causes of deaths in Kenya

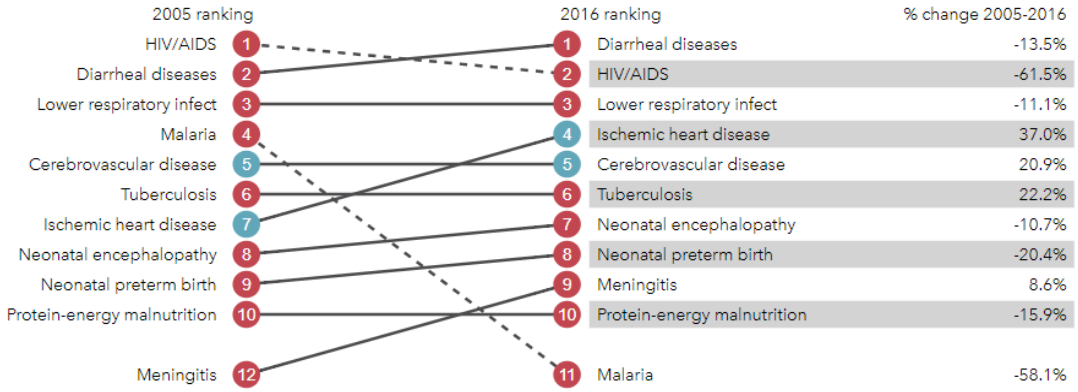
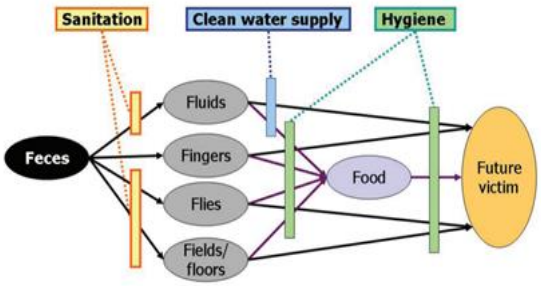


Figure 3: Routes of fecal disease transmission and protective barriers (The F-Diagram)



Source: Wagner and Lanoix 1959, World Bank Group 2013

Figure 3 represents the different avenues through which fecal contamination is transmitted to a potential victim of diarrheal disease. Once again, it is worth noting the number of transmission routes whose barrier is proper hygiene. As hygiene is closely linked to maintaining cleanliness, (hygiene may be defined as the degree to which people keep themselves or their environment clean[1]; conditions or practices as of cleanliness conducive to health[2]), water access, especially in adequate quantities, is key to exercising proper hygiene.

Table 2: Effect of interventions on reduction in diarrhea[3]

Intervention	Reduction in diarrhea (approx. %)
Water quality	15
Water quantity	20
Hygiene	33
Sanitation	35

Given that diarrhea is the leading cause of death in Kenya, and occurrence of diarrheal disease is directly linked to access to water, it may be concluded that water access should be prioritized as a public health concern for Kenya. The fight against malaria demonstrates the benefits that can be accrued from prioritizing a target issue as a public health concern. Through concerted efforts including use of insecticide-treated mosquito nets (ITNs) and indoor residual spraying (IRS) funded by different entities such as the Global Fund and the Bill and Melinda Gates Foundation, malaria has fallen from fourth in 2005 to eleventh in 2016 as a leading cause of death in Kenya. In contrast, diarrheal diseases were the second and are currently the leading cause of death as seen in Figure 2.

This article proposes **'bringing water to communities'** through reticulated networks. The argument is that water access at the household level allows: 1) access to higher volumes of water (this is contrasted to the amounts that may be used if a family has to collect water in '*mitungis*') and 2) for centralized water quality control (mitigate risk of water contamination between point of water collection and point of use). As discussed above, addressing the quality and quantity of water to communities will have a direct impact in combating the impact of diarrheal diseases in Kenya.

The obvious question to this proposition, however, is on its economic viability. We argue that it is more economical, in the longer term, to equip high yielding water sources and distribute water to households in multiple villages / communities as is feasible through reticulated networks than to develop standalone water sources for each individual community. A 2004 WHO study[4], for instance, estimated the economic value of various interventions in water and sanitation access. Table 3 below summarizes the estimated economic gains for Africa for two scenarios: 1) realizing the MDGs water targets (halving the proportion of people who do not have access to improved water sources by 2015), and 2) access for all to a regulated piped water supply and sewage connection (including sewers) in their houses. While the data presents the combined benefits for piped water and sewerage, the difference in gains from the two approaches demonstrates that reticulation yields the greatest benefits.

[1] Definition of Hygiene by the Cambridge Dictionary
[2] Definition of Hygiene by the Merriam Webster Dictionary
[3] Loughborough University, 2017, Mobile Note 60: Water – quality or quantity? https://wedc-knowledge.lboro.ac.uk/resources/e/mn/060-Water-quality-or-quantity.pdf

[4] World Health Organization, 2004, Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level

Table 3: Benefits of WASH access

Benefit	Attaining MDG Water Targets	Attaining Piped Access for all
Productive days gained due to less diarrheal illness (million days)	75	1,153
Days of school attendance gained due to less diarrheal illness ('000 days)	16,473	253,890
Healthy baby/infant days gained due to less diarrheal illness (million days)	96	1,486
Value of productive days gained due to less diarrheal illness (US$ M)	21	327
Annual value of time savings (US$ M),	1,820	39,798
Value of avoided deaths per capita (US$ M)	326	4,855

To further illustrate the economic viability of reticulated water networks for rural areas, two scenarios of intervention are considered. Scenario 1 involves installation of water systems at each target location as is often the practice with rural water access in Kenya. Assuming the use of a stand-alone solar powered borehole, current market prices for installation and equipping are estimated at KES 2,000,000. If a target locality (e.g. sublocation) has 5 settlements/villages, the cost of water supply through stand-alone communal waterpoints would be KES 10 million. In contrast, scenario 2 involves equipping a suitable water source with a solar powered pumping system and distributing water to target areas (assumption of 5 villages as in scenario 1). Table 4 provides rough back of the envelop estimates for laying the piping network assuming 50km of bulk distribution from source to the 5 target communities (DN 50), 20km of bulk distribution within communities (DN 25) and 10km of piping into households (DN 19). The total cost of such a system is estimated at about KES 36 million.

Table 4: Estimated cost of piped water supply for HH water access[5]

Item Description (Pipes - HDPE, PN 16)	Distance (KM)	Rate (KES) /Meter	Total (KES)
Equipping water source with solar pumping system	-	-	2,000,000
DN 50 Nominal bore 50mm	50	450	22,500,000
DN 25 Nominal bore 50mm	20	400	8,000,000
DN 19 Nominal bore 50mm	10	350	3,500,000
Total			**36,000,000**

While capex costs for scenario 2 are higher than scenario 1, the economic gains of this approach are hinged on the economic gains of piped water access as presented earlier: 1) Health sector benefit due to avoided illness; (2) Reduced patient expenses due to avoided illness; (3) Value of deaths avoided; (4) Value of time savings due to access to water; (5) Value of productive days gained of those with avoided illness; (6) Value of days of school attendance gained of those with avoided illness; (7) Value of child days gained of those with avoided illness. As seen in Table 3, the economic benefits of ensuring piped water access for households yields extensive benefits for communities[6]. If Kenya is to realize these economic benefits and ensure the human right to clean and safe water in adequate quantities for all her citizens, then targeted and deliberate interventions are needed.

[5] Rates used are estimations from a water utility for the provision, laying and jointing of high density polyethylee (HDPE) PN16 pipes including excavation and backfilling of trenches to depth not exceeding 1.5m. It includes preparation of trench surfaces; upholding sides of the excavation, disposal of excess excavated material and removal of dead services.

[6] This approach may be critiqued as not suitable for pastoralist communities in Kenya's marginalized areas due to their nomadic lifestyle. However, it is increasingly observed that these communities are transitioning to a settled lifestyle where young men herd the animals during the dry seasons while women, children and the elderly remain in permanent settlements. These are the settlements to be targeted.

Rural Water Access – Insights from Paraguay

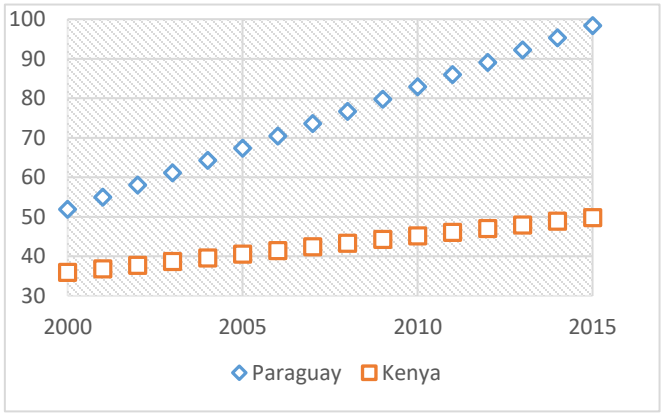
In 2007, Kenya recognized "Sustainable access to safe water and basic sanitation [as] a human right" under the key principles of the 2007 – 2015 National Water Services Strategy. In the same year, Paraguay also recognized access to water and sanitation as a human right noting that "Every natural person has a right to access a minimum quantity of drinking water per day that is sufficient for the satisfaction of their basic needs"[7]. This was notable progress by both countries considering that it was not until 2010 that the United Nations declared access to water a basic human right. Data, however, shows significant disparity between the two countries in realizing this basic human right.

Figure 5 contrasts the changes in rural water access rates for Paraguay against Kenya for the years 2000 – 2015. According to World Bank Data, 98% of Paraguay's rural population had access to at least basic drinking water services in 2015 compared to 52% with similar access levels in 2000. This may be contrasted to Kenya's 50% in 2015 and 36% in 2000.

> "98% of Paraguay's rural population had access to at least basic drinking water services in 2015 compared to 52% with similar access levels in 2000."

What did Paraguay do differently and what lessons exist for Kenya? This article highlights some key actions taken by Paraguay over the years that have

Figure 5: Rural Access to Basic Drinking Water Services



resulted in these high water access levels in rural areas.

The National Environmental Health Service, SENASA (*Servicio Nacional de Sanamiento Ambiental*), is the organization mandated with delivery of water and sanitation services to rural areas of Paraguay (areas with less than 10,000 inhabitants). The agency was created in 1972 and despite a sector reorganization in 2000, it has always been placed within the department of health. This institutional set-up ensures that access to water and sanitation is treated as a public health concern and in so doing, demonstrates that institutional arrangements have an impact on water accessibility.

SENASA works through *Juntas de Saneamiento (Juntas)* to provide potable water to rural areas. *Juntas* are community-based water service providers which rely on community volunteers. The *Juntas* are responsible for ensuring water accessibility for small communities through setting water tariffs and improving piped water infrastructure.

[7] Law on Water Resources, Law 3239 of 10 July 2007, available at http://www.waterlex.org/waterlex-legal-database/index.php?r=legalDocument/customView&id=149.

Below are some key attributes of the *Juntas* Model[8,9,10]:

- SENASA provides seed money to establish the Juntas. This includes planning, promoting and installing systems for water and sanitation services. This is structured as a subsidy scheme, where depending on the number of potential connections, the Agency subsidizes 40% - 82% of the investment costs for a new community water scheme and offers concessional loans for the remaining amount.
- Following construction of systems, SENASA transfers them to the *Junta* - a board elected by all water users – who become responsible for the schemes operations and management. This includes tariff setting and collections to pay back the government loan. SENASA provides technical and financial support to the boards.
- Financing from International corporations' resources has been key in enabling the model. The government's approach has been to apply external grants and loans to subsidize the developments. This *Juntas* model was first piloted in 1977 under a World Bank supported projected. It is estimated that about 90% of SENASA's investments are made possible by loans and grants from international donors.
- The success in realizing water connections observed after the 2000's may be attributed to very deliberate focus on water and sanitation services by the government. The early 2010's saw an increased investment of about US$ 80 million per year in 2006 – 2013 to water and sanitation compared to US$ 10 million for 2003-2005. The bulk of these investments was targeted at rural areas with SENASA executing about 67% of the total amount.

Nearly 2,500 *Juntas de Saneamiento* have been established in rural areas under this model[11]. An evaluation by the Inter-American Development Bank in 2014 reveals remarkable success among the *Juntas*. Evaluating 100 systems constructed with funding from the Bank between 2004 and 2008, the evaluation found 96% of the systems to provide services of acceptable quality. The water distribution networks were seen to be in good conditions and 88% of water users reported being satisfied with the service. While this model cannot be prescribed for other countries that are struggling to realize the human right to water, it demonstrates that innovation and a deliberate government focus on water services delivery can yield access for all within short timelines.

[8] Drees-Gross, F., et. al., 2005, Output-Based Aid in Water: Lessons in implementation from a Pilot in Paraguay. https://openknowledge.worldbank.org/bitstream/handle/10986/11043/343030rev0PY0water0OBApproaches07.pdf?sequence=1&isAllowed=y

[9] Inter-American Development Bank, 2016, Study in the Performance and Sustainability of Water and Sanitation Initiatives in Rural Areas.

[10] Fragano, F., Management Models for Small Towns: Community Water Board in Itagua, Paraguay. http://www.ehproject.org/PDF/Strategic_Papers/LACDEC/Paraguay.pdf

[11] Slawson, N., 2017, Rural Water Access: Why should countries follow Paraguay's lead? https://www.theguardian.com/global-development-professionals-network/2017/may/26/rural-water-access-paraguay-success-lessons

First Quarter 2018 Energy Access News Highlights

- **Kibo signs MOU with TANESCO on Mbeya Coal to Power Project** – Kibo Mining Plc announced in February that it had signed a Memorandum of Understanding with the Tanzania Electric Supply Company (TANESCO), for the Power Purchase Agreement (PPA) of the company's flagship 300 megawatts (MW) Mbeya Coal to Power Project. The MOU constitutes the precursor to the finalisation of the PPA with TANESCO which is expected to be concluded by quarter one of 2018, in accordance with the timeline previously agreed with TANESCO and the Ministry of Energy. Kibo chief executive stated that the firm hopes to complete funding arrangements for construction and commissioning of the coal plant during the second half of 2018, after which power generation can commence in 36 months. Kibo is working with SEPCO III of China for construction.

- **Unilever Tea to buy power from 600 kW solar plant–** Unilever Tea Kenya and CrossBoundary Energy signed a solar service agreement in March for the installation and operation of a 600-kilowatt power plant at the company's Kericho tea plantation. The plant is expected to start producing power in mid-2018 with Unilever to pay monthly power bills generated by CrossBoundary Energy who will finance and operate the plant for 15 years. The solar plant is the first commercial and industrial power purchase agreement for Unilever in Africa and is expected to deliver substantial savings on power costs and reduce its carbon emissions by over 10,000 tonnes over the plant's 30–year lifetime. CrossBoundary Energy has commissioned Solarcentury East Africa to design, procure, construct and commission the plant and partnered with SolarAfrica to act as a technical partner to manage project delivery and asset management.
- **M-Kopa to buy 500,000 solar panels locally in the next two years –** M-Kopa is planning to generate at least 6.6 megawatts (MW) of solar power in the next two years, through an addition of half a million photovoltaic panels it plans to source locally. The company's chairman says the half a million panels are up from the 100,000 panels it has distributed in the last two years. The panels are to be used in M-Kopa's larger home systems, which include TV, lights, radio and phone charging. The already installed solar panels are generating a total of 1.85 megawatts (MW) of off-grid power in homes across East Africa. Previously, M-Kopa imported its smaller 8 watts panels from outside the country.
- **Japan pumps US$ 90 million into Kenya's oldest geothermal plant –** Kenya is moving to rehabilitate its oldest geothermal power plant for increased generation of electricity after securing a US$ 90 million loan from Japan. Kenya's treasury officials in March signed the financing agreement with Japanese officials for the refurbishment of Olkaria I Units 1, 2 and 3 – Africa's

first geothermal plant built in 1981. The upgrade will expand the capacity of the ageing steam-powered plant from 45 MW to 50.7 MW upon completion in November 2021. The plant rehabilitation will involve change of steam turbines and installation of new electrical systems.

- **Solar power firms to get US$ 75 million funding for plants –** The European Investment Bank will offer a US$ 75 million loan this year for construction of two solar power plants. The US$ 75 million (€60 million) credit line will go to Radiant Energy and Eldosol Energy. Both are owned by the same shareholders, Danish firm DI Frontier Markets, Selenkei Investment and Cedate Ltd and are located next to each other in Eldoret, Kenya. The two solar parks have a capacity of 40 MW each. The solar plants are expected to be connected to the national power grid and the electricity sold at US$ 0.12 per unit under Kenya's feed-in-tariff for solar power. Construction of the two solar farms is estimated at US$ 176 million (€140 million). The developers plan to raise the remaining US$ 101 million through other avenues, including equity.
- **ESMI Kenya enters into its third quarter –** ESMI Kenya pilot, an initiative jointly implemented by EED Advisory Ltd, Prayas (Energy Group) and World Resources Institute, has continued to provide a real-time, open-source database on supply interruption and voltage levels at over 50 locations in and around Nairobi into its third quarter of a year. An introductory blogpost was published on the WRI website reinforcing the need and usefulness of ESMI data. Quarterly summary analysis reports can be accessed on the ESMI Kenya website here.

- **Uganda off-grid power scheme gets US$ 11 million boost –** Uganda's off-grid power sector is to receive an US$ 11 million boost from the USA government initiative Power Africa. The funding will be distributed through the newly-launched Power Africa Uganda Electricity Supply Accelerator, which aims to grow Uganda's off-grid power capacity by 1000 MW and to support 1,000,000 new connections by 2020. The USA embassy in Uganda said the accelerator scheme builds on existing support for the country's Rural Electrification Agency and Electricity Regulatory Authority.

- **Solar power pay-as-you-go projects in Africa secure major funding –** The following three solar power pay-as-you-go companies secured additional funding in the first quarter of 2018: Off-Grid Electric, Azuri Technologies and Husk Power Systems. Off-Grid Electric, which serves about 150,000 people in Tanzania, Rwanda, Côte d'Ivoire, and recently expanded to Ghana, has secured US$ 55 million funding which will be focused on research and development and further expansion of its services on the continent. The Series

D funding was led by Helios Investment Partners, with support from GE Ventures.

Azuri Technologies launched a US$ 20 million off-balance-sheet debt financing program to provide working capital for its expansion in East Africa. Its first phase of US$ 4 million has already been completed with funding from the European Union's ElectriFI program and impact investment platform TRINE.

Shell and ENGIE are among investors to have pumped US$ 20 million into Husk Power Systems. Husk Power which operates mini-grid installations in emerging markets, has executed 75 projects in India, a total of 1.75 MW of generation capacity. More recently, Husk has moved into Tanzania and completed five sites totaling 0.2 MW.

- **US$ 1 billion renewable energy facility launched for sub-Saharan Africa –** The African Trade Insurance (ATI) and European Investment Bank (EIB) have launched a US$ 1 billion renewable energy facility for sub-Saharan Africa. A risk-sharing platform called the African Energy Guarantee Facility (AEGF) has been created to boost investment insurance availability by providing up to US$ 1 billion in reinsurance capacity for African sustainable energy projects. The aim of AEGF is to address the insurance gap which is tied to an annual US$ 20 billion shortfall in energy infrastructure investments. Products offered under the AEGF will include insurance against sovereign or sub-sovereign non-payment under a PPA, expropriation and breach of contract, currency inconvertibility, war, civil unrest and arbitration award default.
- **AfDB partners invest US$ 55 million in off-grid energy access fund** – The African Development Bank (AfDB) in January announced that its board in the previous month had approved a US$ 30 million (€ 25.2 million) investment in the Facility for Energy Inclusion Off-Grid Energy Access Fund (FEI OGEF). Additional investments of US$ 10 million, US$ 8.5 million and US$ 7.38 million (€ 6 million) are being provided by Calvert Impact Capital (CIC), the Global Environment Facility (GEF) and the Nordic Development Fund (NDF), respectively. The NDF will also provide a US$ 620,000 (€ 500,000) technical assistance grant. AfDB said these four first investments bring the fund closer to achieving its first close target in the first quarter of 2018. FEI OGEF is a US$ 100-million blended finance debt fund that will provide loans to off-grid energy companies. The fund, to be managed by Lion's Head Global Partners, will initially focus on East Africa, Cote d'Ivoire, Ghana and Nigeria.

In the Next Issues of Energy Access Review

- Traditional cooking solutions and the greenhouse gas burden
- Highlights from the Electricity Supply Monitoring Initiative (ESMI)
- Regular updates on energy access from Tanzania, Kenya, Uganda and the Africa region.

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