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Energy Access Review

Exploring the energy-water nexus

The term 'nexus' has become somewhat of a buzz word in sustainable development conversations and it is often preceded by any combination of the words 'energy', 'water' and 'food'. The Sustainable Development Goals and their respective targets reveal that there is good reason for this focus: realization of all these goals is dependent, to some extent, on at least one of the nexus components. For instance, Goal 1 seeks to end poverty in all its forms everywhere – to do this, sustainable economic growth is needed and it is enabled by energy and water availability among other factors; Goal 2 is to end hunger and Goals 3 is to ensure healthy lives – goals that are, in some way, wholly dependent on availability of food, water and energy. Other examples include Goal 6 that looks to ensure access to water and sanitation for all, Goal 7 that pertains to ensuring access to affordable, reliable, sustainable and modern energy for all and Goal 12 that promotes sustainable consumption and production. While, indeed, the realization of the Sustainable Development Agenda is highly dependent on the energy-water-food nexus, it is the interdependence of the three components that is most striking. A lot of literature exists on their symbiosis and this article focuses on the need to develop policies and interventions that seek areas of synergy within the *energy-water nexus*, using Kenya's development agenda, Vision 2030 as a case.

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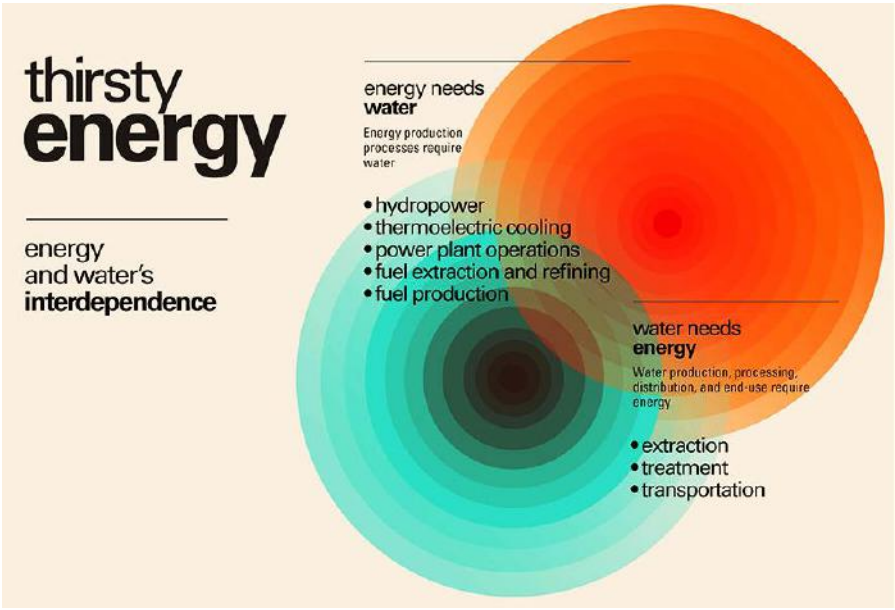
Figure 1: Energy and Water Interdependence ***Source:*** **World Bank, 2013**



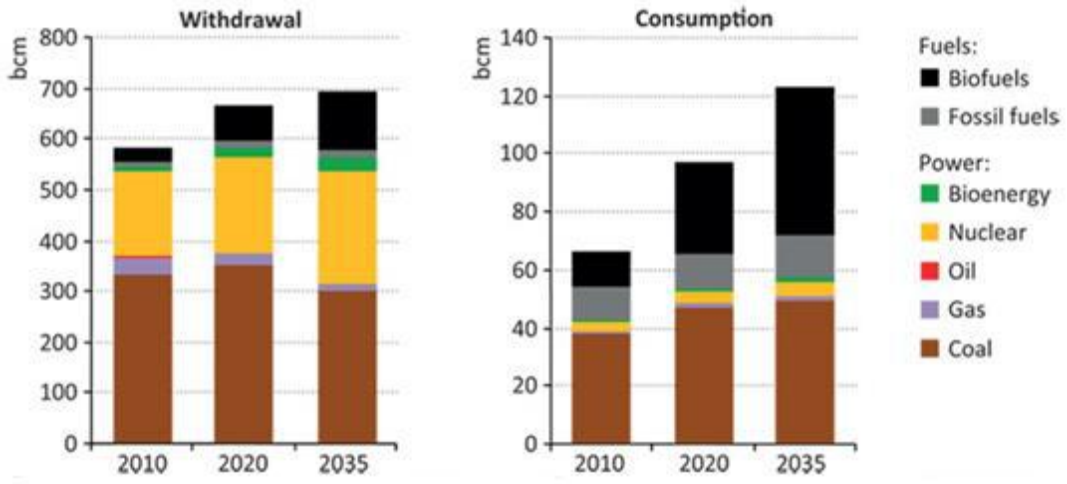
"700% growth in electricity generation is expected in Africa between 2012 and 2050 translating to a 500% increase in water usage by the power sector. (World Bank, 2013)"

Some energy-water nexus facts and statistics include:

- Globally, about 580 billion cubic meters of freshwater are withdrawn annually for energy production, accounting for about 15% of fresh water withdrawals – this number is only second to withdrawal needs for agriculture (IEA, 2012).
- Global energy consumption is predicted to increase by 35%[1] between 2010- 2035.
- Consequently, water withdrawal for the energy sector is expected to increase by 20% between 2010 and 2035; water consumption by the sector (where water is not returned directly to the environment) is expected to increase by 85% by 2035[2] (See *Figure 2).*
- Globally, approximately 2.5 billion people have unreliable or no access to electricity while about 2.8 billion live in high water stress areas (World Bank, 2013[3]).
- 700% growth in electricity generation is projected for Africa (2012 – 2050) leading to a 500% increase in water usage by the power sector[4].
- Inter-annual water variability (measure in variation of water supply from year to year) is expected to increase posing a risk to the energy sector. The extent of variability is summarized in *Figure 3*.

In a world that is increasingly concerned about water risks, (including increasing water temperatures, decreasing freshwater availability, climate change, water quality and sea level rise), the energy sector faces significant risk: power plants shut down or decreased power generation; hydropower capacity reduction; regulation concerns on permits for water extraction and power plant location; financial losses and; social and political instability.

Figure 2: Global water use for energy production by fuel and power generation type

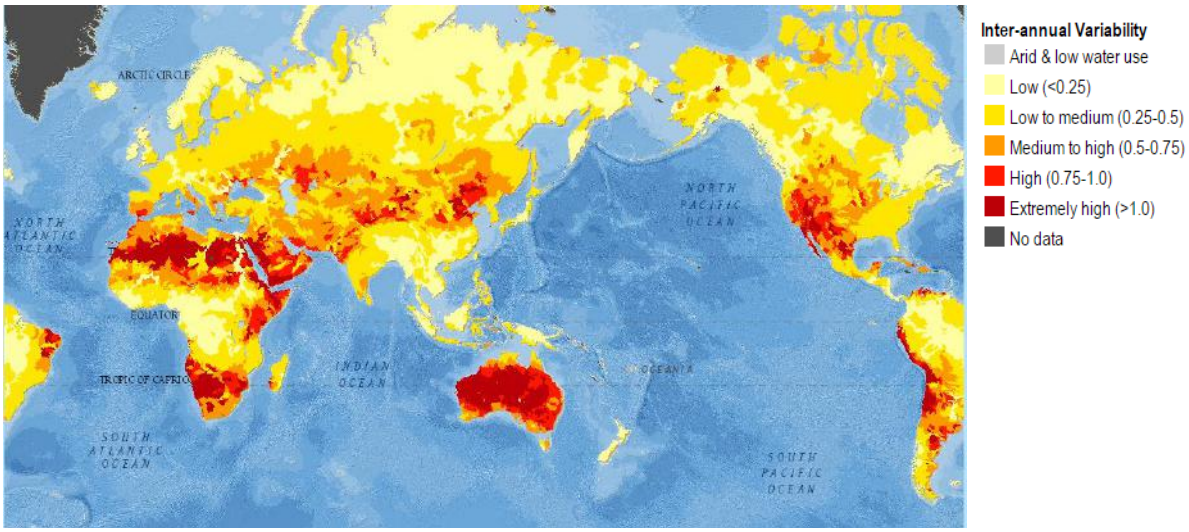


Source: World Energy Outlook, 2012

The CDP Global Water Report (2013) found that 82% of energy companies and 73% of power utility companies indicated that water was a substantive risk to their business operations while 59% of energy

1 World Bank, Aug 2013, Thirsty Energy: Securing Energy in a Water-Constrained World, http://www.worldbank.org/en/topic/sustainabledevelopment/brief/water-energy-nexus#Infographics
2 Ibid
3 World Bank, 2013, Thirsty Energy Infographics, http://www.worldbank.org/content/dam/Worldbank/Feature%20Story/SDN/Water/Water-Thirsty-Energy-Infographic-FULL-Vertical-900.jpg
4 Ibid

Figure 3: Global Inter-Annual Water Variability Source: Water Resources Institute, 2016



companies and 67% of power utility companies admitted having experienced water related business impacts in the past five years. At a more focused level, the Millennial Drought of Australia forced three coal power plants to reduce power production to conserve municipal water supplies for urban water supply while the Snowy Hydropower System's[5] water levels were at 8% of their installed capacity[6]. The drought also led to a higher demand for power, e.g. for indoor cooling. These combined drought impacts led to increased electricity prices[7] with prices almost doubling in Southern Australia. More recently, the California drought led to the States hydro-power systems functioning at about a third of its installed capacity[8] while water scarcity in South Africa has forced all new power plants to shift from application of water-cooled systems to the costlier and less efficient dry cooling systems (World Bank, 2014)[9].

It is within these concerns that energy planning and production can no longer be done without considering current and future water constraints and the risks posed by extreme events. Various states and organizations have come to this realization and are applying a variety of solutions to tackle this energy-water challenge. One such solution is diversification of energy generation, moving away from coal and natural gas to clean energy: wind and solar power generation is to a great extent water independent. Among places applying this approach is the UAE (home to the proposed world's largest solar powered water desalination plant) and California (has focused on large solar power installations as part of its drought resilience initiatives).

Another approach has been to optimize the functioning of the energy and water sectors through integrated planning at national government level. An example is offered by the

5 The system is among the world's most complex integrated water and hydro-electric power schemes comprising of sixteen major dams, seven major power stations (two underground), a pumping station, 145kms of inter-connected trans-mountain tunnels and 80kms of aqueducts. The system is responsible for about 32% of all renewable energy that is available to the eastern mainland grid of Australia.

6 World Bank, 2013, Thirsty Energy: Securing Energy in a Water-Constrained World, http://www.worldbank.org/en/topic/sustainabledevelopment/brief/water-energy-nexus#Infographics

7 Van Dijk A. I. J. M. et al., 2013, The Millennium Drought in southeast Australia (2001–2009): Natural and human causes and implications for water resources, ecosystems, economy, and society.

8 Gleick P. H., 2016, Impacts of California's Drought: Hydro-electricity generation, Pacific Institute, Oakland, California.

9 World Bank, 2014, 4 Ways Water Shortages Are Harming Energy Production, http://blogs.worldbank.org/water/4-ways-water-shortages-are-harming-energy-production

Kingdom of Morocco, a country considered a net importer of energy and with an annual rainfall of about 346mm (World Bank Data[10]). The country has institutionalized the water-energy-food nexus so that all policies under the nexus are managed under one ministry – Ministry of Energy, Mines, Water and Environment. Additionally, the government, in 2011, merged the national water and electricity utilities under one single entity, the Office National de l'Electricité et de l'Eau Potable (ONEE). It is under this set up that the government has gone on to i) promote drip irrigation and solar PV water pumping to promote efficiency in irrigation and water pumping, ii) promote less water intensive power generation technologies for water conservation, focusing on solar power, and iii) promote recycling of urban water with plans for more than 30 new water treatment stations[11]. This ministerial and utility integration is seen as an avenue for policymakers to identify crucial interactions, conflicting demands and potential synergies between the water, energy and food sectors and develop solutions that may serve both as adaptation and mitigation measures.

The Case of Kenya and her Vision 2030

Kenya Vision 2030 is the country's development blueprint for the period 2008-2030 that aims to "transform Kenya into a newly industrializing, middle-income country providing a high quality life to all its citizens by the year 2030". The Vision identifies energy as one of its key foundations, recognizing that proposed projects will lead to increased energy demand. Given that Kenya's energy costs are higher than those of her competitors, she needs to generate more energy at a lower cost to increase efficiency in energy consumption. This very specific foundational goal has led to an overhaul of the energy sector with institutional reforms and targeted and well planned interventions. For instance, the Rural Electrification Authority has targets and deadlines on school and health facilities electrification. Also, *Table 1* and *Table 2* summarize the country's power generation capacity targets for 2016 and 2031. These numbers, indeed, tell a beautiful story: through this road map, the cost of generation, in US cents, is projected to reduce from 11.30 to 7.41 by 2016. Commercial / industrial tariff will, consequently, reduce from 14.14 to 9.00 and domestic tariff from cents 19.78 to 10.45. This a step in the right direction towards Vision 2030. However, a few considerations arise.

Table 1: 40-Month 5000+MW Strategy: New Capacity Additions (MW) ***LNG - Liquefied Natural Gas**

Energy Source		Months							Total
		6	12	18	24	30	36	40	
Hydro	MW	24		--	--	--	--	--	**24**
Thermal		87	163	--	--	--	--	--	**250**
Geothermal		90	176	190	50	205	150	785	**1,646**
Wind		--	--	20	60	300	250	--	**630**
Coal		--	--	--	--	960	--	960	**1,920**
LNG		--	--	--	700	350	--	--	**1,050**
Co-generation		--	--	18	--	--	--	--	**18**
Total		**201**	**339**	**228**	**810**	**1,815**	**400**	**1,745**	
Cumulative Additions		**--**	**201**	**540**	**768**	**1,578**	**3,393**	**3,793**	**5,538**

10 World Bank Data, http://data.worldbank.org/indicator/AG.LND.PRCP.MM

11 Diani A., 2015, How Morocco deals with Water-Energy-Food-Climate Nexus: Facts & Outlook https://www.linkedin.com/pulse/how-morocco-deal-water-energy-food-energy-nexus-facts-adil-diani

Going by the projections, 50.9% of the planned capacity under the 40 Month 5000+ strategy and 58.1% of the 2031 power projections is water intensive (highlighted additions). Coal, responsible for most water withdrawal and consumption per *Figure 2* is a main player in planned power generation.

Table 2: Power Capacity in Kenya (MW) Data
Source: Nuclear Electricity Project Committee, 2012

Energy Source	Installed capacity (2012)	Projected Capacity (2031)
Hydro	763.3	1,039
Thermal	527.5	--
Geothermal	198	5,530
Wind	5.45	2036
Isolated grid	14.6	--
Co-generation	26	--
Coal	--	2,720
Natural Gas	--	2,340
Medium Speed Diesel (MSD)	--	1,955
Nuclear	--	4,000
Import	--	2,000
Total	**1,529**	**21,620**

To paint a picture of Kenya's water scarcity[12], the freshwater endowment per capita per year is about 526m^3 which places Kenya in the bottom eight percent countries globally on water availability: compared to Uganda and Tanzania at over 2,000m^3 each. Over 80% of Kenya's area is arid or semi-arid and only Western Kenya and the Central Highlands have abundant water resources. Further complicating the scarcity concern is that about 54% of Kenya's water resources are shared with neighboring countries limiting their exploitability (e.g. Nile Basin water politics). Kenya is further disadvantaged by high inter-annual and intra-annual variability (as can be seen in *Figure 3)* whose effects of drought and floods will only increase with climate change. The country's low water storage capacity, at 103m^3 per capita (compare to South Africa at 687m^3 or North America at 5961m^3), makes Kenya highly vulnerable to hydrological variability.

Joining the various dots draws a clear need for strategic planning to address water-energy challenges in Kenya. The dots: energy needs water; water needs energy; Kenya has an aggressive water-intensive plan to develop her energy sector; but Kenya is water scarce which will get worse with climate change. Further, the energy sector will be competing for this scarce resource from other factors. For instance, Kenya is facing increasing demand for urban water supplies in addition to the need to realize the human right to water by 2030 for its increasing population: Kenya has a population growth rate of 2.6% (2014) - compared to global average of 1.2% - and a steady urban population growth rate of 4.3% (2006 – 2014) compared to a declining global rate (2.3 (2006) – 2.1 (2014)). Additionally, Vision 2030 seeks to more than double the amount of land under irrigation, build resort cities in either arid, semi-arid or downstream locations and promote manufacturing among other water-intensive development

> "54% of Kenya's water resources are shared with neighboring countries."

12 Data from: World Bank, 2011, Towards a Strategic Analysis of Water Resources Investments in Kenya, http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/08/12/000445729_20130812115925/Rendered/PDF/801440ESW0P1180Box0379800B00PUBLIC0.pdf

interventions. While there is nothing wrong with the proposed developments, The Vision's plan to deal with the increasing demand for high quality water, which it recognizes, might be cause for alarm to some. The plan aims to "conserve water sources and start new ways of harvesting and using rain water and groundwater". The flagship projects under water and sanitation are, perhaps, a clear indication of what is meant by that statement. The projects include construction of multiple, varied-size multi-purpose dams, construction of the Rahole Canal to transfer water from Tana River to Garissa, rehabilitation and expansion of urban water supply systems among others. While these plans contribute to increased water storage (increase resilience to hydrological variability) and water access for all, they also pose challenges (such as risk of Tana River drying downstream) and do not address volumetric water scarcity concerns in Kenya. As such, Kenya needs to adapt and invest in technologies that ensure efficient use of water, a finite resource.

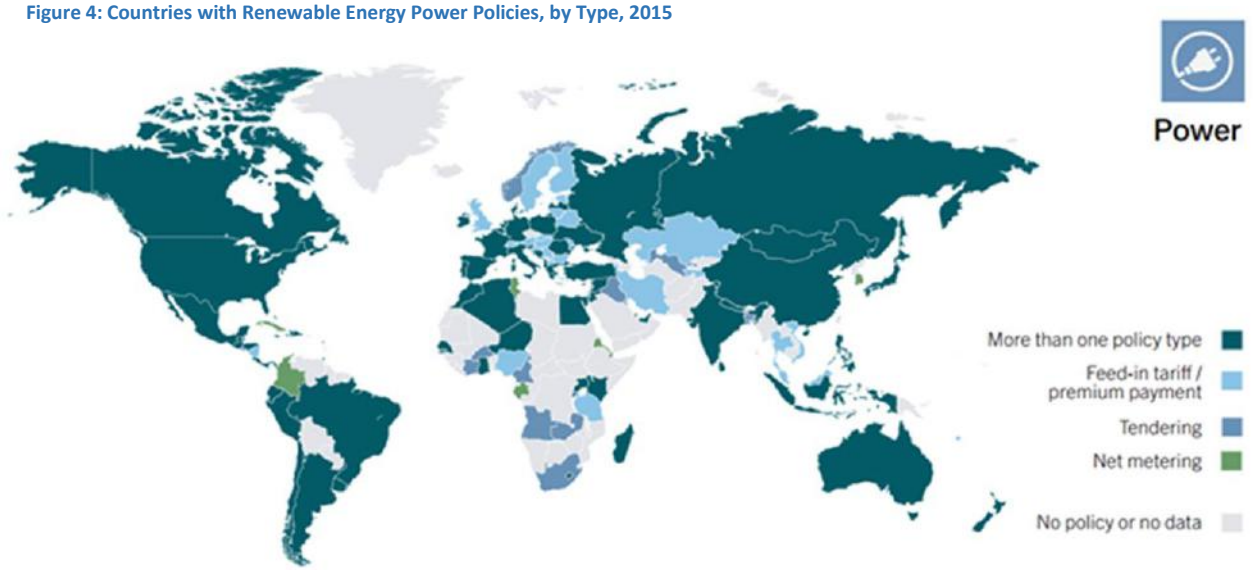
There is a running joke that the waters of the Thames are used seven times before they drain into the ocean, and the seventh time is to flush the Olympic Park toilets. The Olympic Park toilets and watering the Park's lawns is not a joke though – the Old Ford Recycling Plant treats 'black water' for use in the park. These are, perhaps, the technologies that should be considered to ensure sustainable development of Kenya's water-energy nexus. For instance, planning for recycling of urban sewerage for use in cooling thermal and nuclear plants and reclamation of the same water for irrigation. A variety of climate models predict increased hydrological variability for East Africa with higher frequency of extreme events. Planning for sustainability and resilience as energy projects along other Vision 2030 initiatives are implemented is thus of paramount importance.

A Peek into the REN21, Renewable 2016, Global Status Report

Table 3: Summary of Key numbers

1	GW	Solar PV capacity achieved by South Africa
5	%	Employment increase in the renewable energy sector in 2015
52	Number	Countries with net metering or similar regulations
77	%	Contribution of solar and wind to the total additional installed capacity in 2015
147	GW	Renewable power capacity added in 2015
150	GW	The total installed power generating capacity of Africa
173	Number	Countries with renewable energy targets
2015	Year	Paris agreement signed
3,940	TWh	Electric energy generated from hydropower plants in 2015
39,600	MW_{th}	Total global installed capacity of solar water heating collectors in 2015
530,000	Number	Pico-solar lighting products sold under Lighting Global
1,370,000	Number	Off-grid solar products sold in Sub-Saharan Africa in 2015
4,494,681	Number	Installed clean cook stoves in Ethiopia, the highest in Africa
44,000,000	Number	Off-grid pico solar products sold globally by mid-2015
160,000,000	US$	Capital raised by PAYG off-grid renewable energy companies in 2015
276,000,000	US$	Capital raised by off-grid renewable energy companies in 2015

Figure 4: Countries with Renewable Energy Power Policies, by Type, 2015



Second Quarter 2016 Energy Access News Highlights

- **Villagers spared eviction as Tanzania halts US$ 500 million energy project to save wildlife -** More than 1,500 people have been spared eviction to make way for an energy plant after the Tanzanian government halted the project citing concern for wildlife in a nearby sanctuary. The bioelectricity plant was to be built in Saadani National Park in northern Tanzania and would have siphoned huge amounts of water from a major river, River Wami, affecting the elephants, hippos and giraffes that roam the 1,100 square km sanctuary. Construction of the US$ 569 million plant, which was to produce ethanol from locally grown sugar and generate enough power for 100,000 rural households, would also have forced the eviction of thousands of smallholder farmers who work lands surrounding the park.
- **Tanzania looks for alternative funding for rural electrification** - Galvanised by America's move to withhold US$ 472 million from the Millennium Challenge Account last year, the Tanzanian government is seeking to overhaul the existing energy legal and regulatory framework to attract investments in alternative sources of energy. The board of the Millennium Challenge Corporation deferred a vote over Tanzania's eligibility to the funds meant for electrification. It is suspected that this was because of the impasse in Zanzibar and the arrests under the cyber-crime law during last year's October national elections. The suspended US$ 472 million grant was meant mainly to fund electrification projects through the country's rural electrification agency, Rural Energy Agency.
- **Tanzania plans to invest US$ 1.9 billion annually in energy projects by 2025 –** Prime Minister, Kassim Majaliwa said Tanzania plans to invest US$ 1.9 billion each year by 2025 in energy projects in a bid to end power shortages and boost industrial growth. The aim is to boost power generation capacity to 10,000 megawatts from around 1,500MW at present, using natural gas and coal and reducing its dependence on hydro power sources.

- **Kenya creates 17 new oil exploration blocks –** The Kenya Government has created 17 new oil blocks from the unused land that was returned by oil prospecting companies and raised the number of exploration blocks to 63. The Ministry of Energy in May gazetted the 63 oil blocks with their new coordinates and location in what annuls the previous blocks. Energy Secretary Charles Keter said in the gazette notice that 37 of the blocks are located in the Lamu basin, 7 in the Anza basin, 5 in the Mandera basin, and 14 in the Tertiary Rift Basin. The notice shows all the blocks defined by their longitudes and latitude, their sizes and block maps. This means that the country now has 17 new oil blocks that it can issue to prospective firms as it steps up its oil exploration initiatives.

- **Kenya Power signs 100MW power purchase deal with Kipeto –** In a move that will see Kenya's wind power increased from the current 787 megawatts (MW), Kenya Power and Kipeto Energy Limited have signed a 20-year power purchase deal which will see Kipeto deliver 100 MW of power to the country's power grid. The wind project will be put up at a cost of about US$ 320 million and will be funded by the US government's Overseas Private Investment Corporation (OPIC). Kenya Power Managing Director and CEO Ben Chumo says that the project will contribute to the government's initiative of providing 70 percent of households with electricity by 2017.
- **US$ 150 million wind power plant up for auction in land row –** The 38 turbines for the cancelled US$ 150 million wind farm in Kinangop are being auctioned after the developers failed to repay money borrowed for the project that ran into land compensation headwinds. Kinangop Wind Park (KWP) was put under receivership after pulling the plug on the 60.8 megawatt (MW) project in February due to depletion of funds on delays and hostilities from the local community in Kinangop, Nyandarua County. The receiver managers have now invited bids from interested buyers to purchase 38 wind turbine generators and accessories made by US conglomerate General Electric. Each turbine has a capacity of 1.6 MW.
- **Kenya Power set to lose say in arriving at grid electricity mix -** Kenya Power is set to lose the muscle to determine the electricity mix to be sold to consumers under a new plan to establish an independent player to decide which power plants are to be fed to the national grid. The Energy Regulatory Commission (ERC) said plans are afoot to set up a national load dispatch centre charged with scheduling feeding of electricity to homes and industries starting with the cheapest options such as hydro and geothermal. The Kenya Electricity Transmission Co. Ltd (KETRACO) will manage the load dispatch centre, the regulator said, and will ensure that plants generating cheaper power are dispatched to the grid first and other costly options brought on-stream as demand rises.

- **UETCL to build US$ 100 million power sub-stations -** A Chinese construction firm has embarked on the construction of four mega sub-stations at Luzira, Namanve, Mukono, and Iganga industrial parks. Mr. Mark Namungo, the senior power analyst at the Uganda Electricity Transmission Company Limited (UETCL), said the project is expected to cost US$ 100 million which was borrowed from the Chinese Exim Bank. The government has contracted CAMC to construct these substations. He revealed that 85 per cent of the money will be spent on the construction of the four mega power sub-stations whereas the 15 per cent will be used for resettlement.

- **Uganda chooses Tanzania over Kenya for oil pipeline route -** Uganda is to route its oil exports through Tanzania after a report found the country was a cheaper and more secure option than its other east African neighbour Kenya. Uganda is to use Tanga, a seaport city about 200km north of Dar es Salaam, to export its crude oil, rather than Lamu in Kenya. The announcement was made April at the East African Community (EAC) summit held just outside Uganda's capital, Kampala. Uganda said a pipeline between Kabaale, in Hoima district, and Tanga, of about 1,400km, will be the most cost-effective route when Uganda begins exporting oil by 2020.
- **SN Power to buy SGBH's stake in Bujagali –** Norway's SN Power AS is to buy out SG Bujagali Holdings Ltd's (SGBH) partial interest in the 250 MW Bujagali project in Uganda in a move that SN Power hopes will help provide a platform for the company to develop additional hydropower projects in Sub-Saharan Africa. SN Power is owned by Statkraft, the Norwegian state-owned power firm, and Norfund, a Norwegian development financial institution. Bujagali was developed, financed and will continue to be operated by Bujagali Energy Limited (BEL), which was owned by affiliates of the Aga Khan Fund for Economic Development (AKFED), SGBH and the Ugandan Government. AKFED and the Government will retain their interests in the project. The Bujagali Hydropower Project is widely considered to be one of the most successful public private partnerships in the power sector in Sub-Saharan Africa and has been used as a model for subsequent projects in the region. It was commissioned in 2012.

- **EAC 2016/17 budgets prioritize infrastructure, energy sectors -** East African Community (EAC) member states have prioritized development expenditure as countries look to further strengthen the growth agenda of the regional economies. In the national budget estimates presented the regional bloc's biggest economy Kenya will be spending US$ 22.8 billion, Tanzania US$ 13.5 billion, and Uganda US$ 12 billion during the next financial year that starts on July 1. Rwanda plans to spend some US$ 2.49 billion in the fiscal year 2016/17. Kenya's energy sector got US$ 395 million. In Uganda, the works ministry was allocated US$ 1.1 billion, the biggest share of the country's 2016/17 fiscal year budget. It is followed by the education sector with US$ 808 million and the energy sector with US$ 718 million.
- **Rwanda inaugurates groundbreaking methane power project –** President Paul Kagame in May launched the Kivu-Watt Gas Power Plant located in the western district of Karongi. The Kivu-Watt Methane Gas plant, a project on Lake Kivu, effectively adds 25 megawatts (MW) to the national electricity grid, a boost in the country's efforts to increase its energy capacity. American energy firm Contour Global was given a 25-year concession to produce 100

megawatts from Lake Kivu, the world's only methane rich water body. The multimillion-dollar project, financed through a concessional loan by the African Development Bank, Emerging Africa Infrastructure Fund, Netherlands Development Finance Company and the Belgian Investment Company for Developing Countries, is the only gas water extraction power plant operating in the world.

- **Kagame, Kenyatta endorse new AfDB energy deal -** President Paul Kagame and his Kenyan counterpart Uhuru Kenyatta have endorsed the 'New Deal on Energy', a vehicle through which the African Development Bank (AfDB) will invest in delivering electricity for all Africans, by 2025. Both Kagame and Kenyatta were speaking on a live CNBC-Africa television debate that also featured AfDB president Dr. Akinwumi Adesina, in May, on the sidelines of the 51st AfDB Annual Meeting in Lusaka, Zambia.
- **US$ 7 million funding available for renewable energy entrepreneurs -** Emerging markets power project operator Access Power kicked off applications for the second Access Co-Development Facility (ACF), which offers renewable energy entrepreneurs the opportunity to walk away with US$ 7 million in funding. The Access Power competition, for which applications were open until May 20, aimed to find local power project developers with credible renewable energy projects in Africa who need access to funding, technical experience, and expertise to bring their plans to life. Following the competition's launch last year, the ACF increased its funding to US$ 7 million from US$ 5 million, with up to three successful projects to be selected by a panel of expert judges. Decisions will be made based on commercial, technical and environmental merits, the local regulatory environment, and capability of the project team.

In the Next Issues of Energy Access Review

- From off-grid to on-grid and back again: Why the on-grid and off-grid dichotomy may not hold in Africa
- Energy access issues in the cities of Africa
- Regular updates on energy access from Tanzania, Kenya, Uganda and the Africa region

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Contact us: Direct questions and comments to newsletter@eedadvisory.com.

Address: 6 Nas Court, Milimani Road, Nairobi |**Telephone**: +254 (20) 257 4927/ +254 (20) 237 6122
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