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Innovation and Renewable Electrification in Kenya

INNOVATION AND RENEWABLE ELECTRIFICATION IN KENYA (IREK)

A desk assessment on the overviews of current solar and wind energy projects in Kenya

Note:

The review is largely from unpublished and non-technical sources, such as news articles and project report, retrieved online. The major objective of the review is to get a feel of what is happening around solar and wind energy in Kenya.

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Contents

1. Overviews on current status quo of solar energy projects in Kenya

1.1. The Kenyan solar energy sector overviews, key facts and figures

- Kenya has abundant solar energy resources. Its daily average solar insolation is estimated to beabout 4-6 kilowatt hours per squaremeter, which isconsidered one of the best for solar electric energy production in sub-Saharan Africa[1]. Depending on the conversion efficiency of solar modules, 10-14% of this energy can be converted to electric power[2]. However, there are regional and seasonal differences in the solar resources of the country. Seasonally, for instance, Nairobi experiences high level of solar isolation from December to February while sun radiation decreases between June and September[3].
- Utilising solar resources in Kenya started in the 1870s, following government's use of solar photovoltaic (PV) systems to operate broadcast installations (masts) in remote areas[4],[5]. In the 1980s, international donors and NGOs began to play a key role in the development of solar energy sector in Kenya to provide electric power to social services, such as school lighting, water pumping and vaccine refrigeration[6]. However, donor support had gradually phased-out over the years; and since the 1990s the sector has been driven by the private sector. In the early years of PV development in Kenya, solar systems were relatively larger, complicated and expensive. Most of them failed because of lack of capability for appropriate installations and maintenance[7]. Despite this significant success was achieved in the commercial diffusion of battery-based solar home systems, driven by a desire for TV viewingof the rural community[8].

[1]http://www.erc.go.ke/index.php?option=com_fsf&view=faq&catid=2&Itemid=649
[2] https://energypedia.info/wiki/Kenya_Energy_Situation
[3]https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCEQFjAA&url=http%3A%2F%2Fwww.africansolardesigns.com%2Fasddocumentation%2FNet-MeteringReport%2520Kenya.pdf&ei=-iCeVcKrI7CQ7Abz5KHoCg&usg=AFQjCNF5y_dZBx_cB31-9DmkUIwZeuP7Cg&sig2=WlQsT_EDTHfOeMA3w3gE4w
[4]file:///C:/Users/ATigabu/Downloads/Working%20paper%20Solar%20PV%20East%20Africa%20(1).pdf
[5]http://www.fnu.zmaw.de/fileadmin/fnu-files/staff/ondraczek/110816_PVSEC_Paper_Janosch_Ondraczek_final.pdf
[6] http://kerea.org/wp-content/uploads/2012/12/111216_The-Sun-Rises-in-the-East-of-Africa_Working-Paper-2_Final.pdf
[7]https://www.lightingafrica.org/where-we-work/kenya/
[8]http://www.fnu.zmaw.de/fileadmin/fnu-files/staff/ondraczek/110816_PVSEC_Paper_Janosch_Ondraczek_final.pdf

- Today a vibrant private sector exists, particularly in the small-scale PV market[9]. It is estimated that over 320,000 rural households (4.4% of rural people in Kenya) have solar home systems as of 2010[10]. Annually, it is estimated that 25,000-30,000 PV systems are sold in the market[11], [12],[13]. This means that as of 2015, assuming that each household has at least only one PV system, over 445, 000 to 470,000 PV systems have been installed in Kenya. Other reports put this figure even higher, considering the introduction of low-cost solar lanterns recently. Statistics indicate that solar PV lantern sales have reached to about 1,000,000 units in 2014[14]. The total installed solar power capacity is estimated at 16MWp as of 2012 in which the vast majority is contributed by solar home systems installed at individual homes[15]. Figures from the Energy Regularity commission (ERC) of Kenya show that the total installed capacity is likely to be over 20MWp as of January 2015. This is projected to grow at 15% annually[16]. PV systems commercially distributed to rural areas of Kenya typically consist of 14 to 20Wp, wiring, rechargeable battery, sometimes a charge controller system, lighting systems, and connections to small appliances (such as a radio, television, or mobile phone charging units)[17].
- The spectacular market growth of solar home systems in Kenya is due to strong marketing efforts of the private sector with little (and often times no) support from the government[18]. However, since 2005, the Government has shown increasing interest for solar energy by providing boarding schools and health facilities in remote areas access to electricity through PV panels. From 3000 institutions in remote areas, about 450 have been equipped with solar PV systems, 220 schools are electrified with stand-alone solar PV with a total capacity of 574.22 KWp at an estimated cost of 6.16 million Euros. Additional 10 million euros have

[9] file:///C:/Users/ATigabu/Downloads/Working%20paper%20Solar%20PV%20East%20Africa%20(1).pdf
[10] https://www.researchgate.net/publication/254450502_Renewables_in_the_energy_transition_-_Evidence_on_solar_home_systems_and_lighting_fuel_choice_in_Kenya?ev=prf_pub
[11] http://www.roedl.de/de-DE/de/medien/publikationen/fachaufsaetze/erneuerbare-energie/Documents/Kenya-article.pdf
[12] file:///C:/Users/ATigabu/Downloads/snv_kenya_solar_fact_sheet.pdf
[13] https://energypedia.info/wiki/Kenya_Energy_Situation
[14] http://kerea.org/voluntary-accreditation-of-solar-pv-businesses-in-kenya-2/
[15] http://www.internationalenergyworkshop.org/docs/IEW%202013_2E3paperOndraczek.pdf
[16] http://www.trust.org/item/20150123092221-7nuus
[17] https://www.researchgate.net/publication/254450502_Renewables_in_the_energy_transition_-_Evidence_on_solar_home_systems_and_lighting_fuel_choice_in_Kenya?ev=prf_pub
[18] file:///E:/solar_kenya_gray_litrature/ATPS_Research_Paper_No_28_Urama_Ozor_Kirumba_Review_of_Kenya_Policy_Environment_on_Solar_PV.pdf

also been granted by Spain for electrification of selected public institutions through solar solutions.[19] There is also a plan to provide solar electricity for another 400 institutions[20],[21].

- Despite this growth, Kenya Renewable Energy association (KEREA) laments that "market spoilage due to poor quality of products as well as design, installation and maintenance services has significantly hindered market growth. According to the 2009 census, of the 6.7 million households not connected to the grid, only 1.6% (142,000 households) have a solar PV system; this in a country where the solar PV market started in the mid 80's"[22]. Indeed, a 'field inspection and testing study' by KEREA (2009) has shown that out of 76 randomly selected PV systems installed by technicians, 64% were found to have some technical installation problems, clearly showing that the technical capacity of some of the technicians is low[23]. In response to this, KEREA has recently started a voluntary accreditation framework for solar PV businesses in Kenya to increase stove installation quality and consumer confidence on solar businesses[24].
- The University of Nairobi has a product quality testing laboratory for off-grid lighting products.[25] Two universities train PV technicians, and as a result about 300 technicians enter into the Solar PV sector every year[26].
- There are over 40 solar PV distributing private companies. These include big companies, such as Solarnet, BP Solar, Chloride Exide, Sollatek Electronics, Solagen and Electric Link. Most of these companies are located in Nairobi. Most solar accessories are imported mainly from China, the United Kingdom and the US. The exception is storage batteries, which are locally manufactured[27]. In 2009, there were three lead acid battery manufacturers, including eight private companies that manufacture solar lamps[28]. There are a large number of solar technicians (estimated to be over 2000 in 2009), who sometimes directly participate in the marketing of solar PV technologies as resellers.

[19] http://www.sv.uio.no/iss/english/research/projects/solar-transitions/announcements/Kenya-Henry_Gichungi.pdf
[20] http://www.erc.go.ke/index.php?option=com_fsf&view=faq&catid=2&Itemid=649
[21] http://www.pv-magazine.com/news/details/beitrag/special-report-africa--kenya_100013508/#axzz3eiH9glXA
[22] http://kerea.org/voluntary-accreditation-of-solar-pv-businesses-in-kenya-2/
[23] http://kerea.org/voluntary-accreditation-of-solar-pv-businesses-in-kenya-2/
[24] a voluntary accreditation framework for solar PV businesses in Kenya
[25] https://www.lightingafrica.org/where-we-work/kenya/
[26] http://trinomics.eu/wp-content/uploads/2015/05/Market-study-to-strenghten-economic.pdf
[27] file:///C:/Users/ATigabu/Downloads/saia_sop_25_disenyana_20090218_en.pdf
[28] http://kerea.org/wp-content/uploads/2012/12/111216_The-Sun-Rises-in-the-East-of-Africa_Working-Paper-2_Final.pdf

- In 2011, a new solar panel factory has been launched in Naivasha at a cost of $2.7 million. The factory is owned by Ubbink East Africa. The factory produces 100 solar panels per day, with capacities ranging from 13 watts to 125 watts. Its major targets are rural households. The installation of the factory was financially supported by Dutch Government through the Private Sector Investing Programme (PSI)[29].
- A solar assembly line named 'fosera assembly line' has also been opened in 2009[30].The Assembly line has employed about 100 people who produce about 70,000 PV units per year[31].
- Despite the tremendous market growth of pico-solar and SHSs in Kenya, the diffusion of large-scale solar plants is extremely limited due to high capital investment requirements and limited awareness of potential investors and the governmenton the opportunities and risks of investing in solar energy[32].

1.2. Overviews on current solar projects

- The major solar PV projects in Kenya can be classified into five categories. The first category is the smallest pico-applications, such as solar lanterns and small mobile-phone chargers. The second can be solar home systems (SHS) installed in private households for lighting and communication purposes. The third group can be stand-alone institutional PV systems, which are installed in public settings, such as schools and health care systems. The fourth category is mini-grids often installed at village level, which may also include hybrid systems with solar PV component. The last category is large-scale or utility-scale often grid-connected plants[33]. In this classification, the difference between pico-applications and solar home systems is only the power output, i.e. Pico systems will produce less than 10wp whereas SHSs produce 10-100 Wp[34]. More broadly we may classify solar PV applications as off-grid, mini-grid and large-scale on grid. In this case off-grid represents pico-applications, solar home systems, stand-alone institutional PV systems and mini-grids.
- Solar PV systems have also been used beyond powering LED light sources, charging mobile phones, and powering TV and radios. For example, there are a number of projects that use

[29]http://www.fosera.com/company/assembly-network/kenya-naivasha.html
[30]http://www.fosera.com/company/assembly-network/kenya-naivasha.html
[31]http://www.fosera.com/company/assembly-network/kenya-naivasha.html
[32]http://www.ieakenya.or.ke/publications/doc_download/284-energy-in-kenya
[33]file:///C:/Users/ATigabu/Downloads/Working%20paper%20Solar%20PV%20East%20Africa%20(8).pdf
[34]file:///C:/Users/ATigabu/Downloads/Working%20paper%20Solar%20PV%20East%20Africa%20(8).pdf

solar PV generated electric power to irrigate small-scale farms in Kenya. Examples are given below.

- Holgojo farm is located in Garissa County where the climate is arid. Solar PV systems are used to run motors that pump out water from nearby Tana River. The system is operational since end of 2014. The system has given indications that solar PV systems are reliable sources of electric power that can be used to irrigate small-scale farms compared to diesel-operated water pumps[35].
- Ongata-Rongai farm is located in Nairobi. The farm's climatic condition is semi-arid. It has a solar-powered irrigation system, which has 2.5Kw PV generator with Lorentz tracking system. The PV pumping system is built at the cost of 8,250 Euros. Similar to Holgojo farm, this PV-powered irrigation system has demonstrated that solar power is more reliable and cheaper than grid-connected or diesel powered water pumping systems. The farm was able to achieve 50% saving of electricity bill by using solar energy[36].

- Telecommunication and tourism solar PV sectors are also emerging. As of 2008, it is estimated thatthe telecom and tourism sectorshave installed a total of 100KWp, and 50 KWp, respectively[37].
- An estimated 140 000 units of solar water heaters are also in use in Kenya. This is a fast-growing solar energy sector in Kenya. By 2020, the demand for solar heating is projected to grow to 400,000 units (representing an annual growth of 10%). The major users of solar water heaters are public institutions, such as hospitals and schools, and commercial centres, such as hotels and wealthy households in cities[38].
- In the following, an exploratory review of current solar PV projects in each of the five categories is provided. This assessment is not exhaustive. It needs to be seen as providing an overview of what is currently happening in Kenya.

1.2.1. Pico-Solar-Home-Systems (1-10 Wp)

[35] https://energypedia.info/wiki/File:Case_Study_Kenya_-_Holgajo_Farm.pdf
[36] https://energypedia.info/images/3/32/Case_Study_Kenya-_Ongata_Rongai.pdf
[37]https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCEQFjAA&url=http%3A%2F%2Fwww.africansolardesigns.com%2Fasddocumentation%2FNet-MeteringReport%2520Kenya.pdf&ei=-iCeVcKrI7CQ7Abz5KHoCg&usg=AFQjCNF5y_dZBx_cB31-9DmkUIwZeuP7Cg&sig2=WlQsT_EDTHfOeMA3w3gE4w
[38]file:///C:/Users/ATigabu/Downloads/saia_sop_25_disenyana_20090218_en.pdf

- Pico-Solar-Home-Systems are often used for light generation (solar lamps) and phone charging. These are mostly over the counter products in Kenya and are often bought by individual costumers[39].
- A well-known platform in pico solar systems distribution is a joint IFC/World Bank program named 'Lighting Africa' that markets pico solar systems in sub-Saharan Africa. Lighting Africa is a component of the Global Lighting and Energy Access Partnership (Global LEAP) that aims to 'catalyse the development of markets for affordable, modern off-grid lighting products in Africa'. The project's website [https://www.lightingafrica.org/about-us/] states that the program has 'enabled more than 35 million people in Africa to access clean, affordable and safer lighting'. Lighting Africa aims to increase access to solar lights to 250 million people by 2030[40].
- Over 70% pico-solar home systems manufacturers are based in China. It is estimated that over 90% pico-solar home systems distributed in Africa are made in China[41].
- A study by M-KOPA Solar and InterMedia (2014) has stated that 'Kenya has emerged as a hot spot for off-grid solar, with 14% of the population [out of 300 households] surveyed using solar as their primary lighting and charging source'[42]. The market for solar lanterns in Kenya is growing at 200% every year. Currently (07/2015), it is estimated that 700,000 lanterns are in use in Kenya[43]. These are mostly a result of market-based distributions. According to Lighting Africa, there are 21 distributors/importers, and over 1500 SMEs that sell solar lanterns in Kenya. There are currently 29 quality-verified solar lighting products, from 17 manufacturers on sale[44].While primarily private sector driven, the sector has some key actors, such as micro-finance institutes and quality control agencies (such as the University of Nairobi) and some international donors[45]. Kenyan microfinance institutions (MFIs) often finance off-grid lighting products, which meet Lighting Global Quality Standards[46].
- Cursory desk reviews seem to suggest that a large number of companies are involved in the Pico-Solar-Home-Systems marketing in Kenya. Mapping all of these companies is not easy as

[39] file:///C:/Users/ATigabu/Downloads/Working%20paper%20Solar%20PV%20East%20Africa%20(8).pdf
[40] file:///C:/Users/ATigabu/Downloads/5_Market-Brief-Report-ElectronicREV-1.pdf
[41] file:///C:/Users/ATigabu/Downloads/5_Market-Brief-Report-ElectronicREV-1.pdf
[42] http://www.m-kopa.com/press-release/kenya-emerges-as-solar-pv-hot-spot/
[43] https://www.lightingafrica.org/where-we-work/kenya/
[44] https://www.lightingafrica.org/where-we-work/kenya/
[45] file:///C:/Users/ATigabu/Downloads/Working%20paper%20Solar%20PV%20East%20Africa%20(2).pdf
[46] https://www.lightingafrica.org/where-we-work/kenya/

many of them are not online. For overviews, Table 1 provides some examples of Pico-Solar-Home-Systems distributors in Kenya.

Table 1: some examples of current Pico-Solar-Home-Systems projects in Kenya

Name of the project	Brief description	Key actors	Reference
Visionary Empowerment Programme (VEP)	A local NGO in Thika that run a successful micro-credit for over 7000 women. It offers credit for women wishing to buy solar lanterns.		file:///E:/snv_kenya_solar_fact_sheet.pdf
Sunny Money	Sunny Money is a non-profit social enterprise thatpromotes solar lanterns commercially in remote rural areas of Kenya. It is supported by SolarAid, which was founded in 2008. SolarAid reinvests its profits to disseminating pico-solar systems in rural areas, to meet its objectives of eradicating kerosene lamp from Africa by 2020. Sunny Money'steam travels in remote areas with the purpose of creating awareness about solar lanterns. Sunny Money has achieved a successful diffusion of solar lanterns. As of 2013, the monthly sales have averaged over 13,000, registering 2500% increase to that of the monthly sales at 2011.		http://sunnymoney.org/assets/Uploads/PDFs/Kenya-report-2014-1.pdf http://wdi.umich.edu/research/bop/projects/field-based-projects/Child%20Impact%20Case%20Study%204%20-%20Access%20to%20Clean%20Lighting%20-%20SunnyMoney.pdf

SNV, ENDEV and GIZ solar pico project	The project seeks to increase access to and use of modern lightning for households at the base of pyramid (BOP) by utilising solar power. The objective of this project is establishing and strengthening sustainable and commercially viable supply model for quality pico PV (1-10V) in Kenya.	SNV, ENDEV, GIZ, Barefoot Power, Smart Solar (K) Ltd	file:///E:/snv_kenya_solar_fact_sheet.pdf
Mibawa Supplies Limited	Mibawa Supplies Limited sells the IndiGo product from Azuri Technologies with pay-as-you-go payment system. As of July 2015, Mibawa Supplies Limited has sold 7000 units and works to achieve a monthly sales target of 500 models.	GVEP provides advisory and monitory capacity support; ESME grant ('ESME is an initiative that aims to support Energy SME Development in sub-Saharan Africa to foster local private entrepreneurship and invest in the provision of energy services in remote, un-served or under-served regions'.	http://www.mibawa.co.ke/
Over the counter Commercialisation	There are a number of companies that import and distribute pico-systems in Kenya. An example is Go-solar Systems Ltd. The company		http://erc.go.ke/images/docs/COMPANIES%20DEALI

and wholesale distribution of pico portable lighting systems	has installed solar systems over 200 Health facilities, schools, police stations, district and divisional headquarters in Arid and semi-Arid(ASAL) Regions of Kenya. Some of the major companies involved in solar lantern marketing and whole sell distribution are listed below: 1. One Acre Fund (Nairobi) 2. Raj Ushanga (Nairobi) 3. D. Light Kenya Limited (Nairobi) 4. Barefoot Power (Africa) Limited(Nairobi) 5. Apple Logistics Limited (Nairobi) 6. Sun Transfer Kenya Investment Limited(Nairobi) 7. S3C Kenya Limited(Nairobi) 8. Total Kenya Limited(Nairobi) 9. Thrive Energy Technologies (EA) Limited(Nairobi) 10. Krystalline Salt Limited(Nairobi) 11. Kingfisher Consultants Limited(Nairobi) 12. Cook n' Lite Limited(Nairobi) 13. Mibawa Suppliers Limited(Nairobi) 14. Orb Energy Limited(Nairobi) 15. Light UP (East African) Foundation(Nairobi) 16. Solataa Limited(Nairobi)		NG%20IN%20CONSUMER%20DEVICES.pdf


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1.2.2. Solar home systems (SHS) (10-100 Wp)

- Solar home systems (SHS) are often bought by private households and installed to provide electricity for lighting and powering TV and radios. In Kenya, SHSs are mostly marketed over the counter. There are a number of players, making the sector highly competitive.
- The solar home systems market in Kenya is believed to have been primarily driven by the private sector, particularly since the 1990s. While international donors have been active in solar home systems diffusion, the role of the Government has been comparatively limited. Among the international donors and development organizations, the World Bank and GTZ were key actors[47]. In 2013, SHSs market constituted for over 80% of the total solar PV market volume[48]. Eight off-grid solar stations or kiosk lighting and mobile-phone charging stations were built in recent years[49]. These stations also called "WE!Hubs", will provide community members 'access to environmentally friendly lighting, charging for computers and clean drinking water' [50]. Table 2 provides some examples of current SHS projects, including kiosk lighting and mobile-phone charging stations, in Kenya.
- The SHS industry is constrained by theft of installed PV systems, fragmented policy and regulatory frameworksand limited purchasing power and poor access to alternative financing schemes[51].

[47]file:///C:/Users/ATigabu/Downloads/Working%20paper%20Solar%20PV%20East%20Africa%20(2).pdf
[48]file:///C:/Users/ATigabu/Downloads/UNEP%20RISOE_Prospects%20for%20Investment%20Solar%20Power_WEB.pdf
[49]http://www.renewableenergyworld.com/articles/print/volume-17/issue-5/solar-energy/electrifying-keyna-how-one-african-country-is-approaching-renewable-energy-development.html
[50]http://www.globalnature.org/solar-kenya
[51]http://brage.bibsys.no/xmlui/bitstream/handle/11250/219722/Torrie_2014.pdf?sequence=1

Table 2: Some examples of current solar home systems projects in Kenya

Name of the project	Brief description	Key actors	Reference
M-KOPA Solar	M-KOPA Solar is a company that specialises in the "pay-as-you-go" energy services for off-grid customers. It has provided energy access to 200,000 homes across East Africa (Kenya, Uganda and Tanzania). This off-grid solar company started in Kenya in 2012. M-KOPA's mission is to make high quality energy affordable to everyone		http://solar.m-kopa.com/about/company-overview/
Solar Energy for Rural Kenya	'This is Water-Energy Hubs for Kenya (WE!Hubs) project implemented by Germany-based company OSRAM supported by Global Nature Fund and the European Union. It was implemented thorough the grant in the framework of the ACP-EU Energy Facility. The WE!Hubs provided lamps, batteries and charging stations for mobile phones. The Hubs were also equipped with a water purification system to allow the supply of clean water.' The project was implemented form July 2011 to December 2014.	'Siemens Stiftung, which was committed to social entrepreneurship and the provision of basic water and energy services. OSRAM accompanied the project as a technology partner in a supportive and advisory capacity. The technical implementation of the project lied in the hands of two Kenyan companies, Thames Electricals Ltd. and	https://www.globalnature.org/bausteine.net/f/8106/P133784_Osram_Projekthandbuch_ES.PDF?fd=0 https://energypedia.info/wiki/Off-grid_project_in_Kenya_by_OSRAM

	'A central objective of the project was to provide clean and environmentally friendly generated electrical energy and drinking water to people in areas with an insufficient infrastructure'. Since 2008, three water and solar energy stations, also called OSRAM Energy hubs (O-Hubs), were installed to serve rural communities in Suba district, Kenya. These O-Hubs were equipped with battery charging station, charge controllers connected to PV panels, a mobile phone charging station, water purification and sterilisation unit with rain water collection system and a sales room. Therese latter were upgraded to WE!Hubs.	its subsidiary Light for Life Ltd. GNF will be coordinating the venture'.	

1.2.3. Stand-alone institutional PV systems (50-500 Wp)

- Stand-alone institutional PV systems are installed in public institutions, such as public health centres and schools. These are often bought under Government procurement procedures.
- In Kenya, stand-alone PV systems had a long history, dating back to the 1980s. The installation of stand-alone institutional PV systems was highly supported by international donors in the early days. These types of PV systems were installed mainly in schools and heath care centres. The institutional PV system market was dominant in the 1980s until it was overtaken by solar home systems in the 1990s[52]. A recent trend with regard to these types of PV systems in Kenya is Government's derive to expand electricity access to remote rural public institutions through solar solutions[53]. Indeed, as of December 2014, over '744 public places in isolated areas, from health centres to schools, have been hooked up to off-grid solar power'[54].
- Although there is a recent interest and plan by the Government to install institutional PV systems in public institutions located in remote areas, we could not trace a source online on such current projects.

1.2.4. Mini-grids (e.g. hybrid PV-diesel or Wind) (5 kW-1 MWp)

- Mini-grids are often installed for village electrification purposes.***However, there are also stand-alone units that can fit to this category based on the level of power output (i.e. 5 kW-1 MWp).These projects are also included in Table 3.***
- In Kenya, the emergence of mini-grids has been a relatively recent phenomenon. The Government through its Rural Electrification Master Plan (2008) encourages existing diesel-based power generators to install additional PV systems. This sector has been a key focus of international support. A typical example was the World Bank's Scaling-Up Renewable Energy Program (SREP) that funded upgrading of existing 12 mini-grids to hybrid diesel-PV systems with additional power generation of 3 MWp[55]. Currently, there are six solar hybrid mini-grids.These are Mandera (300Kw solar), Hola (60KW solar), Habaswein (60KW solar),Elwak

[52]http://www.fnu.zmaw.de/fileadmin/fnu-files/staff/ondraczek/110816_PVSEC_Paper_Janosch_Ondraczek_final.pdf
[53]file:///C:/Users/ATigabu/Downloads/Working%20paper%20Solar%20PV%20East%20Africa%20(2).pdf
[54]http://www.renewableenergyworld.com/articles/print/volume-17/issue-5/solar-energy/electrifying-keyna-how-one-african-country-is-approaching-renewable-energy-development.html
[55]file:///C:/Users/ATigabu/Downloads/Working%20paper%20Solar%20PV%20East%20Africa%20(2).pdf

(50KW solar) and Merti(13KWp solar)[56]. There are also grid connected mini-grid (according to the level of their power output) systems in Kenya[57]. Two of these were installed by German companies[58]. These aresolar plants installed at Strathmore University, SOS village in Mombasa and the UNEP office in Nairobi. These three projects are primarily aimed at familiarizing PV to grid operators in Kenya[59].

[56]https://www.giz.de/fachexpertise/downloads/2013-en-gichungi-pep-workshop-pv-kenia.pdf
[57]http://www.fnu.zmaw.de/fileadmin/fnu-files/staff/ondraczek/110816_PVSEC_Paper_Janosch_Ondraczek_final.pdf
[58]http://www.pv-magazine.com/news/details/beitrag/special-report-africa--kenya_100013508/#axzz3eiH9glXA
[59]http://www.internationalenergyworkshop.org/docs/IEW%202013_2E3paperOndraczek.pdf

Table 3: Current Mini-grid projects in Kenya

Name of the project	Brief description of the project	Key actors/partners	Reference
Solar Hybrid plant at Lodwar	Solar component of Lodwar was introduced in April 2012 while the diesel part was installed in 1976, making the mini-grid a PV (solar) - diesel hybrid station. The solar project was launched in 2012 at a total cost of US $ 412,000. Introduction of solar power to the station has reduced fuel cost by US $ 17,000 per month. There is a plan to expand solar generated power by 250KW.		http://www.solarwirtschaft.de/fileadmin/media/pdf/IV_2_MoEP_Kenya_Mbithi_Presentation_-_Intersolar_Munich.pdf
Off-grid solar power project in Kitonyoni, Kenya	The plant is a 13.5 KW photovoltaic solar panel. This is able to produce enough energy for more than 3,000 people who are currently benefiting from the establishment through powering schools as well as providing support to over 40 businesses dependent on electrical power.The major objective of this project was improving the Kitonyoni community in creating for themselves a sustainable economic digital village.The project was launched in 2013. The funding and development of the project is from a project by the University of Southampton and Imperial College, London. The project is sponsored by the Research Councils UK and Department of International Development, United Kingdom.	University of Southampton, Imperial College, London, The project Research Council, UK and Department of International Development, United Kingdom	http://producthealth.com/grid-solar-power-project-kitonyoni-kenya/

Powerhive East Africa Ltd micro-grid project	Powerhive East Africa Ltd operated its pilot solar micro-grids for two years in Kisii, Kenya. The pilot project served about 1500 people. Powerhive East Africa Ltd has planned to expand its project to addressing over 200,000 homes. It 'currently operates 4 micro-grids in Kenya with a total generation capacity of 80kW, and will build an additional 100 sites in Kenya - serving 100,000 residential and small business customers'		http://cio.co.ke/news/top-stories/powerhive's-kenya's-first-private-utility-to-sell-electricity http://africa-energy-forum.com/partner/powerhive http://globenewswire.com/news-release/2015/04/28/729555/10131310/en/Powerhive-Inc-First-Solar-Backed-Off-Grid-Innovator-to-Capitalize-on-Kenya-Experience.html
SteamaCo's solar microgrid project	SteamaCo's solar micro-grid project is an innovative mini solar power station providing electricity for villages to run small businesses, as well as power TVs, radios and lights. The project utilises an 'innovative cloud-based remote metering' system in which connected households will pay prepaid power fee through MPESA. The project has been recognised through the Asheden Award, receiving a total of $60,000. Each solar micro-grid costs about $15,000 to $20,000. SteamaCo runs about 23 power and water micro-grids in East Africa and Nepal.		http://www.reuters.com/article/2015/04/16/us-kenya-energy-solar-idUSKBN0N70TK20150416 http://www.ashden.org/winners/SteamaCo15

Kitonyoni solar power plant	Kitonyoni solar power plantis an off-grid rural market village in MakueniCountylaunched in 2012.The major objective of the project was providing cheap electricity to a tea farm (cost reductions to up to 30%).It is owned by a local cooperative. It provides service to about 300 people.	The energy for Development (E4D) Villagers; Local contractors; local co-operatives (who maintain installed PVs)	http://www.energyfordevelopment.net/current-projects/kitonyoni/
Solar Project at Changoi Tea Farm	This project is owned by Williamson Tea. It provides 1MWp solar power to the tea processing factory. The major objective of the project is to establish an economically sustainable approach where the community contributes to the project.		http://www.solarcentury.com/uk/case-studies/williamson-tea/
Isiolo county Solar Power plant	A new solar plant, which is expected to begin production of electric power by January 2016. The project is expected to start in 2016. The major objective of this project is delivering reliable and predictable power to the national grid at a fixed price for a minimum of two decades	Isiolo county government	http://abdas.org/?sn=kenya-deepens-solar-energy-potentials-with-new-plant
Changoi Tea Farm solar project	1 MWp PV plant installed at Williamson Tea's Changoi farm in Bomet County. The project was launched in 2014. The solar system will cut Williamson Tea's energy costs by around 30%, supplying clean electricity during the daytime to	Installed by the British solar energy company Solarcentury	http://www.pv-magazine.com/news/details/beitrag/solarcentury-installs-pv-plant-in-kenya_100015167/#ixzz3eWz3J1O

	meet most of the tea processing factory's energy demand.		3
Kericho County Solar plant project	'1-MW solar power plant in Kericho County, eastern Kenya, launched in 2013 at cost of KES17 Billion. The largest solar power facility in East Africa. It will be used to provide energy to a tea processing industry of the Kenya Tea Development Agency. This will cut the daily electricity costs and the amount of diesel used by 30%.'	Kericho county government, Bluetechs UK Group Ltd., East African Solar	http://pesatimes.co.tz/news/energy-mining/largest-solar-plant-in-ea-to-be-opened-in-kenya/Kenya/ http://constructionreviewonline.com/2014/08/40mw-solar-plant-set-kenya-alten/
Red Lands Roses solar project	Red Lands Roses in Ruiru, 27km east of Nairobi, has recently launched the implementation of a solar power project. It aims to produce 30kW.		http://africanfarming.net/crops/horticulture/kenya-flower-farms-turn-to-solar-power
Uhuru Flowers solar project, Nanyuki county	This is a '72 kilowatt plant for Uhuru Flowers based in Laikipia County in Kenya, reducing power cost by 80%. This plant has been the first to be connected to the national grid. However, it is not earning money since theKenyan law requires that payment is only for those feeding the national grid with a minimum of 0.5MW to 40MW of solar power'. The solar power farm was developed by Azimuth Power Ltd (Kenya) at a cost of Ksh15 million ($177,000)		http://pesatimes.co.tz/news/energy-mining/largest-solar-plant-in-ea-to-be-opened-in-kenya/Kenya/ http://www.hortfreshjournal.com/articles/uhuruflowersfolarproject.pdf
Nanyuki flower farm solar project,	'The farm installed a 60-kilowatt solar power system in a bid to trim operation cost and reduce carbon emission whenever		http://www.businessdailyafrica.com/Corporate-News/Tambuzi-

Laikipia County	power supply is interfered with and have to turn to standby diesel-run generators.' The project saves 10,000 kilowatts per month in energy bills		flower-farm-eyes-cheaper-power-costs-solar-energy/-/539550/2145706/-/u1stvyz/-/index.html
Carport solar system at Garden city Mall, Nairobi	As of 18 September 2014, Solarcentury (a UK solar firm) and Garden city Mall, Nairobi have signed a deal. "Solarcentury is to design and construct Africa's largest carport on the uppermost storey car park at Garden city mall, which is part of the new 32-acre integrated residential retail park. The clean solar electricity generated by the 858kWp system will be used by the retail tenants. The solar installation will be financed under NVI Energy's Solar4Africa, a 12 year financed solution that enables Garden city to harness the power of renewable energy therefore overcoming many of the barriers that frequently beset commercial solar projects. As well as providing shade, the 3,300 solar panels on the car port will generate 1256MWh per year and cut down carbon emissions by around 745 tonnes per year."	Solarcentury (a UK solar firm)	http://www.solarcentury.com/uk/media-centre/largest-carport-in-africa http://www.businessgreen.com/bg/news/2370985/solarcentury-brings-africas-largest-solar-carport-to-kenya
SOS Children's	"The 60kW plant with over 300 modules is the third largest	Centrosolar (German	http://www.solarserver.com/solar-

village-Mombasa solar power plant	photovoltaic system in East Africa. The project dates back to the Renewable Energies Export Initiative of the German Federal Ministry for Economics and Technology. The PV plant generates electricity for the operator's own needs, feeds surplus into the public power grid. The installation was done by Asantys Systems [a German solar company] together with African Solar Design Ltd [a local company]. The plant supplies some of the power required by the SOS Children's Village and makes the 130 children living in the village a bit more independent. It also supplies some of the electricity to the nearby schools where over 500 students from the area are taught. The solar plant is the first plant in Kenya not only to generate electricity for the operator's own needs but also to feed its surplus into the public power grid. The so called net metering ensures that the electricity meter in the children's village counts backwards whenever the system feeds power into the grid, thus reducing energy costs". The project was launched in 2011 and was funded by the German Ministry of Economics and Technology.The Deutsche GesellschaftfürInternationaleZusammenarbeit (GIZ) was a key	photovoltaic company), which delivered the 312 photovoltaic modules needed for the 60 kilowatt ; Asantys Systems (a German company involved in the planning); SMA Solar Technology AG(a German company provided the inverters); local partner African Solar Designs (ASD) Ltd. (involved in the planning and design); SOS Children's Village; Renewable Energies Export Initiative of the German Federal Ministry for Economics and Technology (BMWi); German Ministry of	magazine/solar-news/archive-2011/kw24/centrosolar-supplies-pv-modules-for-sos-childrens-village-in-kenya-60-kw-plant-third-largest-photovoltaic-system-in-east-africa-goes-online.html http://www.pv-magazine.com/news/details/beitrag/kenyas-first-net-metered-pv-project-completed_100003367/#axzz3eiH9glXA https://www.giz.de/fachexpertise/downloads/giz2011-en-sos-children-villages-solar-project-factsheet.pdf

	partner in implementing this project. The project is widely considered as 'a lighthouse for solar development in Kenya' as it has been an exemplary project showing the possibility of implementing solar projects that can contribute to the national power grid.	Economics and Technology, the Deutsche GesellschaftfürInternationaleZusammenarbeit (GIZ)	
UNEP Nairobi solar project	The solar systems installed on the roofs of the UNEP offices in Nairobi produce 500 kW. During weekends and public holidays, there is a potential for feeding excess electricity into the national grid.'The main aim [of the project] was to create a building that would be capable of being energy neutral that means it would be able to generate as much energy as the occupants and facility operations consume'		http://www.greeningtheblue.org/sites/default/files/2011CNeutral_UN_final_0.pdf
Solar plant project at Merti	'This was the first solar grid tie generation plant in off-grid areas, which was commissioned on 25th August 2011.The rated capacity for the grid solar plant is 10kW. The production to date has achieved an average of 6.82 sunshine hours per day compared to the annual average for the country of 5.6hours. The solar plant estimates to produce a maximum output of 24,893 kWh annually, save on fuel and maintenance costs by		http://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/Renewable%20Energy%20in%20Off-Grid%20Areas%20of%20Kenya%20-%20SREP%20Learning%20Worksho

	Ksh 1,135,172 annually and avoid CO_2 emissions by 22,248kg.'		p_March%202012.pdf
Strathmore University solar power plant	PV solar power plants producing over 600 kilowatts, which consists of 2,400 solar panels and 30 inverters. The project was financed through secured green funds at concessionary rates from the Co-operative Bank of Kenya. The main objective of the project is cutting down the cost of electricity power of Strathmore University. The project has been able to save the university close to KES 1.8 million every month in terms of electricity bills	Strathmore University; Co-operative Bank of Kenya;	http://allafrica.com/stories/201407230320.html

1.2.5. Large-scale, grid-connected PV systems (1-50 MWp)

- Large-scale grid-connected PV systems in Kenya are often installed by independent power producers (IPPs), power utilities, foreign investors and the Government often with funding from international lenders.
- Currently, there is an enthusiasm both from the Kenyan Government and the private sector for large-scale grid connected PV systems due in part to falling solar PV prices and the rise of electric power price in the country[60]. The Government has put in place FiT policy (0.20 USD/kWh if a fixed amount of generation is agreed, and 0.10 USD/kWh if a fixed amount is not negotiated). There are over 25 FiT-approved solar PV projects currently underway with total installed capacity of 750 MW. Most of them are under the feasibility stage while a few have moved further to implementation (e.g. 20 MW plant installed in Nairobi by Strathmore University)[61].The revision of Kenya's FiT policy in 2012 had induced increased private investment interest in the renewable energy sector. In 2014 alone, the Government had received applications for 112 projects across all renewable energy types[62].
- The Government hopes that about 50MW and 200MW of power would be generated from (primarily form large-scale) PV by 2020 and 2030, respectively[63]. A Guardian news article (2014) shows that Kenya was set to generate half of its electricity form solar by 2017. It states that Kenya has selected nine sites for large-scale solar PV system installation at the cost of $1.2bn (£73m). As of 2014, the first planning and project design stages have been finalised and installation of solar PVs was to start immediately[64],[65]. Furthermore, the news states, over $500 million had been invested on solar projects in the country so far. If successfully implemented, the solar projects will rank Kenya third in terms of its solar power installed capacity[66]. However, this news has been disputed as 'farfetched' and baseless by other reports[67]. A news article from Renewable Energy Network also stated that '[i]n

[60] http://www.pv-magazine.com/news/details/beitrag/special-report-africa--kenya_100013508/#axzz3eiH9glXA
[61] http://cleantechnica.com/2014/03/10/750-mw-fit-approved-solar-pv-projects-pipeline-kenya/
[62] http://cleantechnica.com/2014/03/10/750-mw-fit-approved-solar-pv-projects-pipeline-kenya/
[63] file:///C:/Users/ATigabu/Downloads/Working%20paper%20Solar%20PV%20East%20Africa%20(2).pdf
[64] http://www.pv-magazine.com/news/details/beitrag/solar-could-power-half-of-kenya-by-2016--according-to-experts_100013986/#axzz3eWqGfxzE
[65] http://constructionreviewonline.com/2014/08/40mw-solar-plant-set-kenya-alten/
[66] http://www.theguardian.com/environment/2014/jan/17/kenya-solar-power-plants
[67] http://www.pv-tech.org/news/regulators_and_analysts_dismiss_solar_reports_on_kenya_moratorium_and_50_en

contrast to Kenya's booming wind power sector, Kenya's solar policy has been beset with confusion. In January [2014], the Guardian reported that the country planned to source half of its energy from solar by 2016 through a plan to invest $1.2 billion jointly with private firms to install nine major solar power plants across the country. The Government has announced no such plans'.[68] The network news also states that Kenyan government's preference of wind over solar is abundantly clear. Large-scale solar does not feature significantly in the energy development prospectus. According to Renewable Energy Network the major barrier for slow development of large-scale solar projects is insufficient subsidy. It states '[d]espite the fact that feed in tariffs have been in place for a few years nothing significant has really happened...the tariffs for sale are not sufficient to facilitate any major uptake[69].' Land ownerships rights, Kenya's tax regime and high cost of wind turbine installations have also been cited as major impending factors[70,71].

- Major current large-scale projects are summarised in Table 4.

[68]http://www.renewableenergyworld.com/articles/print/volume-17/issue-5/solar-energy/electrifying-keyna-how-one-african-country-is-approaching-renewable-energy-development.html
[69]http://www.renewableenergyworld.com/articles/print/volume-17/issue-5/solar-energy/electrifying-keyna-how-one-african-country-is-approaching-renewable-energy-development.html
[70]http://www.pv-tech.org/news/kenya_in_line_for_40mw_utility_pv_power_plant
[71]http://elearning.jkuat.ac.ke/journals/ojs/index.php/jscp/article/viewFile/1135/937

Table 4: current large-scale, grid-connected PV systems

Name of the project	Brief description	Key actors	Reference
Samburu Solar PV project	This project was launched in 2013 at the cost of $71 million in Samburu county. It was planned to be installed over two years and is expected to be finalised in 2016. The solar park will have 160,000 PV modules covering 104 ha of land. It shall produce 40MWp. It is being developed by Stimaken SAS. Once completed, the project will provide access to electricity for over 20,000 people and save 2,420 metric tonnes of $C0_2$ emissions per year.	StimakenSAS;Kenya Power Company Ltd; Minstry of Energy	http://acts-net.org/images/Pubs/Magazine/The_African_Technopolitan_Jan_2015_Issue.pdf
Kopere Solar Park, Kisumu	A concept note written in 2013 shows a proposed Kopere Solar Park in Kisumu area. It states that the project "is being developed by Subuiga International, a group of local entrepreneurs with a technical partnership with Martifer Solar". It aims to installing a 15 MW power plant. A letter (dated January 14, 2014) from AfDB shows that the project is funded. The project stared on 12th August 2013 at a total cost of US$ 11.6 million. "The objective of the Kopere Project is to create a privately financed Solar Farm in Kenya, which will generate 22.7 GWh per year of electricity from renewable sources. Based on a specific production of 1,591.7 kWh/kWp/year, the plant was designed with a capacity of 17,134 kWp to obtain 15,000 kW of power to be injected into the grid infrastructure"	AfDB; Subuiga International; Martifer Solar	https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/AfDB_Kenya_PCN_SREP_Set_Aside_15Aug2013_Public.pdf https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/working_documents/Approval_by_mail_Kopere_S

			olar_Park_AfDB_MPIS_approved_decision_notification.pdf
Witu Solar Project	Kenya Solar Energy Limited [KENSEN] intends to develop a renewable energy project of 40MW to be based at WITU in Lamu County. The project has not yet started construction as of July 2015. KENSEN is a Locally registered Private Company with the aim of contributing modern energy access in Kenya through solar	KENSEN	http://www.kensen.co.ke/projects.html
Solar Plant in Kesses, UasinGishu County Kenya	This is a solar power plant expected to be erected in Kesses with power production capacity of 40MW. The total cost is estimated to beUS$10m. Expected to start in 2016 (currently (July 2015) feasibility studies have been finalised, and the construction has not yet started).	Alten Kenya Solarfarms; Moi University, Eldoret; UasinGishu County government	http://constructionreviewonline.com/2014/08/40mw-solar-plant-set-kenya-alten/
Garissa 50MW solar park	Kenya and China have signed an agreement to build 50MW solar park in Garissa. The park is expected to produce about 76,470 megawatt hours per year. The park will be constructed by the China Jiangxi Corp for International Economic and Technical Corporation Ltd (CJIC).The project is to be funded with a concessional loan from China Import-Export Bank with undisclosed amount. This is part of the US$ 5 billion investment project announced by	The Kenyan Government, China Import-Export Bank, and the Chinese Photovoltaic (PV) Manufacturer-Jinko	http://www.constructionkenya.com/2747/china-garissa-kenya-solar-plant/ http://emergingequity.org/2015/06/15/china-plans-major-solar-power-plant-in-

	China in Kenya. Ground-breaking ceremony will be held soon (the news is released on June 14, 2015). 'The whole project aims locally to: • support energy distribution • bring prosperity • help to tackle radicalization'.	Solar	kenya-linked-to-a-5-billion-investment-project/ http://www.ccs.org.za/wp-content/uploads/2015/06/CCS_Weekly_China_Briefing_19_June.pdf
40MW utility PV power plant project in northern Isiolo county	'Kenyan independent power producer, Greenmillenia Energy, is planning a 40MW utility PV power plant in the East African country. The plant, which is planned for Kenya's northern Isiolo county, would be the first solar project to qualify for Kenya's feed-in tariff. The plant was at a pre-finance stage of development and is expected to begin construction in the next one year (as of January 2015)'		http://www.pv-tech.org/news/kenya_in_line_for_40mw_utility_pv_power_plant http://www.constructionkenya.com/2747/china-garissa-kenya-solar-plant/
Nakuru 50MW solar power project (in plan as of 2013)	'Nakuru County government was in talks with a Chinese State corporation, Dongfang Electric International Corporation, for producing 50 megawatts of solar energy in 2013'. The total cost of the project is expected to be $100 million (Sh8.5 billion).		http://www.businessdailyafrica.com/Nakuru-eyes-50MW-solar-power-in-deal-with-Chinese/-/539546/1933018/-/x7idcbz/-/index.html


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Innovation and Renewable Electrification in Kenya

1.3. Overview on the enabling environment of solar energy in Kenya

- The Kenyan government has put in place a number of conducive policy and regulatory frameworks for the promotion of clean and renewable energy alternatives in general. This includes the Climate Change Action Plan, the Energy Policy draft[72], the Energy Act of 2006, the Updated Least Cost Energy Production Plan, the Power Purchase Agreement, Sessional Paper No. 4 of 2004 on Energy and the Feed-in-Tariff Policy[73]. With respect to solar PV in particular, there are a number of policies currently in place. These include the Sessional Paper No.4 of 2004, the Energy Act 2006, the Kenya Rural Electrification Master Plan[74], the Feed-in Tariff Policy, the Kenya vision 2030 and The Kenya National Climate Change Response Strategy.

i. The government has also put in place solar energy targets in its National Energy plan (2012). Accordingly, the installed PV capacity is expected to be 100 MWp by 2016, 200 MWp by 2022 and 500 MWp by 2030. There has also been a recent drive of electrifying rural public institutions through the government's Solar Energy Development project, which targets installing PV systems at 500 institutions. The national energy Policy targets that PV systems will be installed at 50% of rural institutionsby 2016, which do not have access to the national grid. The government has also set up Green Energy Fund Facility within the National Taskforce on Accelerated Development of Green Energy with the aim of lending entrepreneurs who wish to invest in renewable energy projects, including solar PV [75].

- The Ministry of Energy of Kenya had drafted a technology specific Feed in Tariff (FiT) policy in 2008 for power generated from Wind, Biomass, Small-Hydro, Geothermal and Biogas. The FiT was then revised in 2010 to include solar power and further revised in 2012 for amending tariffs. Currently the FiT scheme for Solar PV is 12US cents/kwh (grid connected), 20 US cents/kwh (for mini grids)[76]. Despite its presence for some time, there has not been

[72] The draft energy policy (dated February 24, 2014) can be found at: http://www.energy.go.ke/downloads/National%20Energy%20Policy%20-%20Final%20Draft.pdf
[73]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48396/5507-cmci-nairobi-workshop-summary.pdf
[74] The Rural Electrification Master Plans seems to focus on extending national grid to rural areas. In fact a solar study [http://kerea.org/wp-content/uploads/2012/12/111216_The-Sun-Rises-in-the-East-of-Africa_Working-Paper-2_Final.pdf] suggests that success of the rural electrification plan will kill solar sector in Kenya.
[75]file:///C:/Users/ATigabu/Downloads/UNEP%20RISOE_Prospects%20for%20Investment%20Solar%20Power_WEB.pdf
[76]http://www.erc.go.ke/erc/fitpolicy.pdf

any utility-scale solar project that has been built and benefited from the scheme[77]. The scheme is applicable for 20 years from the start of the project and for power generation capacity not more than 500kW[78]. There are concerns by some industry experts that the FiT rate is not sufficient to ensure a reasonable return and as such attract private investment[79].

- In addition to the FiT, there has been a recommendation for net-metering policy for large-scale grid connected solar in Kenya. A giz study in 2011 has stated that '[a] net metering policy would be a low cost and low risk way to introduce grid connected solar PV...It would allow residential, commercial and industrial consumers to invest in small renewable energy systems on a competitive, free-market based approach that would be administered by parastatals such as the ERC [Energy Regulatory Commission] and KPLC [Kenya Power and Lighting Company Ltd]. Such a policy would allow Kenya to continue its leadership of East Africa's commercial solar energy development'[80].
- Some 'unofficial' sources suggest that net-metering policy for solar PV systems was introduced in 2012 by the Kenyan government. *However, the author of this desk assessment was not able to confirm this claim*. The reviewer rather observed that tests of net-metering have been conducted on solar plantsinstalled at SOS Mombasa Children's home, Uhuru flowers Kenya and Strathmore University recently[81].
- Although it does not specifically point out solar energy, the Energy Act 2006 is also considered as one of the key policy frameworks that supports renewable energy in Kenya.
- Similarly,the Kenya National Climate Change Action Plan does not directly address solar energy in Kenya. However, the plan provides directions towards promoting renewable energy alternatives for rural electrification[82].

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[77]http://www.pv-tech.org/news/kenya_in_line_for_40mw_utility_pv_power_plant
[78]http://www.solarwirtschaft.de/fileadmin/media/pdf/IV_2_MoEP_Kenya_Mbithi_Presentation_-_Intersolar_Munich.pdf
[79]file:///C:/Users/ATigabu/Downloads/saia_sop_25_disenyana_20090218_en.pdf
[80]https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCEQFjAA&url=http%3A%2F%2Fwww.africansolardesigns.com%2Fasddocumentation%2FNet-MeteringReport%2520Kenya.pdf&ei=-iCeVcKrI7CQ7Abz5KHoCg&usg=AFQjCNF5y_dZBx_cB31-9DmkUIwZeuP7Cg&sig2=WlQsT_EDTHfOeMA3w3gE4w
[81]https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCEQFjAA&url=http%3A%2F%2Fwww.africansolardesigns.com%2Fasddocumentation%2FNet-MeteringReport%2520Kenya.pdf&ei=-iCeVcKrI7CQ7Abz5KHoCg&usg=AFQjCNF5y_dZBx_cB31-9DmkUIwZeuP7Cg&sig2=WlQsT_EDTHfOeMA3w3gE4w
[82]https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCEQFjAA&url=http%3A%2F%2Fwww.africansolardesigns.com%2Fasddocumentation%2FNet-MeteringReport%2520Kenya.pdf&ei=-iCeVcKrI7CQ7Abz5KHoCg&usg=AFQjCNF5y_dZBx_cB31-9DmkUIwZeuP7Cg&sig2=WlQsT_EDTHfOeMA3w3gE4w

- The Energy Regulatory Commission (ERC) has put in place a zero-rated (0%) import duty and has removed Value Added Tax (VAT) on imported renewable energy equipment and accessories in 2011. Therefore, there is an exemption from VAT and dutiesfor imported solar PV and SHS accessories, including locally manufactured solar batteries. The VAT exemption is applicable for buying a complete package of SHSs[83].
- The promotion of renewable energy alternatives with the aim of increasing their share on the national energy mix has been strongly reflected in the Sessional Paper No. 4 on energy of Kenya. However, the policy framework does not specifically articulate issues relating to solar energy[84].
- The Energy Solar Photovoltaic Systems Regulations, 2012 has been put in place to ensure safe, fair and quality business practices around solar technologies. It specifies the licensing and registration requirements for solar technicians, manufacturers, importers, vendors and contractors. It also specifies the procedures for the design, repair and maintenance of solar PV technologies[85]
- The solar PV Systems regulations provide a licensing framework for the solar PV value chain and facilitate proper design, installation and use of solar PV systems while avoiding supply of sub-standard components and installations. The government requires license for installations over 500 kW[86].
    a. According to the regulation, Energy Regulatory Commission (ERC) only provides the license accreditations for solar installation technicians.
    b. The copy of the 'Energy (solar photovoltaic systems) regulations (2012)' can be found at: [http://www.kenyacic.org/sites/default/files/Solar_regulation_2012.pdf]

2. Overviews on current status quo of wind energy projects in Kenya

[83]https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCEQFjAA&url=http%3A%2F%2Fwww.africansolardesigns.com%2Fasddocumentation%2FNet-MeteringReport%2520Kenya.pdf&ei=-iCeVcKrI7CQ7Abz5KHoCg&usg=AFQjCNF5y_dZBx_cB31-9DmkUIwZeuP7Cg&sig2=WlQsT_EDTHfOeMA3w3gE4w
[84]https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0CCEQFjAA&url=http%3A%2F%2Fwww.africansolardesigns.com%2Fasddocumentation%2FNet-MeteringReport%2520Kenya.pdf&ei=-iCeVcKrI7CQ7Abz5KHoCg&usg=AFQjCNF5y_dZBx_cB31-9DmkUIwZeuP7Cg&sig2=WlQsT_EDTHfOeMA3w3gE4w
[85]http://www.roedl.de/de-DE/de/medien/publikationen/fachaufsaetze/erneuerbare-energie/Documents/Kenya-article.pdf
[86]http://www.pv-magazine.com/news/details/beitrag/special-report-africa--kenya_100013508/#axzz3eiH9glXA

2.1. The Kenyan wind energy sector overviews, key facts and figures

- Renewable energy sources (primarily hydropower) contribute to nearly 80% of Kenya's electricity production. Researchers estimate that Kenya has a total physical potential of approximately 9 terawatts (TW) of wind energy. Others have estimated Kenya's wind potential to be as 1604GW in wind speed of Class III, 642GW in Class II and 4.6GW in Class I[87]. Despite this potential, wind contributes to only 3% of the country's installed electric power capacity in 2012[88].
- Wind energy in Kenya was first introduced by European settlers at the turn of the 20th century. The wind mills, imported from Europe, were used for water lifting for agricultural purposes. These were later replaced by diesel and petrol engines[89].
- During the late 1970s early 1980s, a number of windmill projects were started, however most of these projects were quickly abandoned because of inadequate feasibility assessment, poor planning and lack of funding[90].
- In 1993, the Belgium government funded the first wind energy farm in Ngong hills. The Ngong windmills consist of two 200 kW wind turbines that feed power to the national gird. These wind turbines are no longer operational today. However, expansions are currently underway. Nigong hills are considered among the high-potential sites for wind power in Kenya[91].
- The Kenyan power sector was liberalised in 1977 allowing for the participation of independent power producers (IPPs). The Kenyan energy power sector was previously under the monopoly of the Kenya Power and Lighting Company (KPLC). Although this was not directly aimed at wind energy at the time, it had created a way for private investment by IPPs along with KPLC in other sectors[92].
- For many years, wind energy in Kenya has remained untapped (only 5.1 MWp as of 2013 accounting for 0.3% of the total installed capacity of the country). This was due to lack of sound data on wind power potential spots of the country, large initial capital requirement of

[87]https://www.windforce-management.com/uploads/articles/rahul_kumar_kandoi-scaling_up_of_wind_energy_development_plans_in_kenya_963709.pdf
[88]http://brage.bibsys.no/xmlui/bitstream/handle/11250/219722/Torrie_2014.pdf?sequence=1
[89]http://www.renewableenergy.go.ke/index.php/content/32
[90]http://www.renewableenergy.go.ke/index.php/content/32
[91]http://www.renewableenergy.go.ke/index.php/content/32
[92]http://www.renewableenergy.go.ke/index.php/content/32

wind projects for investors,poor infrastructure and lack of stable grid and disconnect among potential stakeholders[93],[94].

- Kenya's Wind Atlas was developed in 2003 by the Ministry of Energy aimed at providing wind energy data for potential investors[95].
- In 2008, the government of Kenya launched the 'Wind energy data Analysis and Development Program' within the Energy Sector Recovery project funded by the World Bank to supplement the Wind Atlas. Within this program the Ministry of Energy installed 95 wind speed measuring masts (data loggers)[96] across different regions of Kenya[97]. Subsequently, the Ministry of Energy hired WinDForce Management Services Private Limited Company to carry out a wind resource assessment with funding from the World Bank. The assessment showed that 3% of the total area of the country experiences annual mean wind-speeds more than 6 m/s at 100m above ground. It further revealed that the wind regimes in many parts of Kenya, especially in the northern and eastern regions, such as Marsabit, Ngong and the Coastal region, are suitable for large-scale wind power generation[98].
- Kenya's annual electricity demand is increasing at the rate of 13.5% per year fuelled by the rapidly increasing population and expanding economy. To meet this rising demand, the Government of Kenya estimates that 500 MW of wind capacity has to be installed within the 2015 to 2017 period and 2 GW by 2030. To encourage investment in large-scale wind power, the government has put in place a feed-in tariff (FiT) policy[99]. Currently, a number of large-scale wind projects are underway (many of them at their feasibility stage) that aim to benefit from the FiT scheme. These projects also aim to contribute to the government's ambitious plan of installing a total of 5000MWp of electricity by the end of 2017.

2.2. Overviews on current wind projects

- Wind projects in Kenya may broadly be classified as 'micro and small-scale', producing up to 50KW, and industrial and utility scale or 'large-scale' that produce over 50 KW.

[93] http://www.ieakenya.or.ke/publications/doc_download/284-energy-in-kenya
[94] http://www.renewableenergy.go.ke/asset_uplds/files/Wind%20Sector%20Prospectus%20Kenya.pdf
[95] http://www.renewableenergy.go.ke/index.php/content/32
[96] Some sources put this figure as 55 (see: http://kerea.org/renewable-sources/wind-energy/)
[97] https://www.windforce-management.com/uploads/articles/rahul_kumar_kandoi-scaling_up_of_wind_energy_development_plans_in_kenya_963709.pdf
[98] http://www.renewableenergy.go.ke/asset_uplds/files/Wind%20Sector%20Prospectus%20Kenya.pdf
[99] http://www.renewableenergy.go.ke/asset_uplds/files/Wind%20Sector%20Prospectus%20Kenya.pdf

- According to GVP [http://www.gvepinternational.org/en/business/small-scale-wind], cheap pico-wind turbines with capacities ranging 50W and 1,000W are simple products that have been produced locally.Indeed there are a number of private companies that manufacture or import and market small wind turbines in Kenya. These include RIWIK (a Dutch Company), WindGenEA; CraftskillsEA, Kenital solar, Davis & Shirtliff, Chloride Exide and Power Point Systems EA.[100] However, the market penetration of small wind turbines is limited[101]. It is estimated that about '80-100 small wind turbines (400 W) have been installed to date, often as part of a Photovoltaic (PV)-Wind hybrid system with battery storage'[102].
- Indeed, despite high potentials of generating power using 'micro and small-scale' wind systems in Kenya (since over 25% of the land cover is suitable for wind power generation with existing technology[103]), there are no known projects that are expected to produce power between 2012 and 2018[104]. This means that there are no significant projects currently underway in the category of 'micro and small-scale' wind systems in Kenya. In fact at present all small-scale renewables (small hydro, biomass, small wind, small geothermal, small biogas and small PV) contribute only 3% of the installed capacity[105].
- On the other hand, there are a number of large-scale wind projects currently underway (some of them looking for funding after completing feasibility studies). These include Lake Turkana Wind Power Project (LTWP), Kipeto wind farm project in Kajiado County, Isiolo Wind farm and Marsabit Wind farm. Some details on these projects are provided inTable 5. There is also an increasing interest from investors. As of 2014, the government has received about 23 applications, of which 20 proposals (with an envisaged power production capacity of over 1000MW) are accepted[106].

[100]http://elearning.jkuat.ac.ke/journals/ojs/index.php/jscp/article/viewFile/1135/937
[101]http://elearning.jkuat.ac.ke/journals/ojs/index.php/jscp/article/viewFile/1135/937
[102] https://energypedia.info/wiki/Kenya_Energy_Situation
[103] http://kerea.org/renewable-sources/wind-energy/
[104]http://www.renewableenergy.go.ke/asset_uplds/files/ECA%20Final%20Report%20Kenya%20Small%20Scale%20Renewables.pdf
[105]http://www.renewableenergy.go.ke/asset_uplds/files/ECA%20Final%20Report%20Kenya%20Small%20Scale%20Renewables.pdf
[106]http://www.renewableenergy.go.ke/asset_uplds/files/Wind%20Sector%20Prospectus%20Kenya.pdf

Table 5: Current large-scale wind projects in Kenya

Name of the project	Brief description	Key actors	References
Lake Turkana Wind Power Project (LTWP)	This is expected to be the largest wind power farm in Africa. The project is expected to be finalised by 2017 and begin generating power, nearly after 10 years after its inception. It will be constructed near Laisamis, 550km north of Kenya's capital Nairobi with a total of 365 wind turbines (each with a capacity of 850 kW). The project is expected to produce 310MWp when completed, which will save the country $178 million in fuel imports every year. "[A] consortium of investors under the auspices of the European Union is financing this $690 million project with the African Development Bank as the lead arranger". This investment by consortium of European banks makes this wind energy project in Africa unique as most other wind projects are often financed by the Chinese. At a total cost of KES. 70 billion (US$800 million), the LTWP is considered as the 'the largest single private investment in Kenya's history'. The LTWPhas been 'registered as a Clean Development Mechanism (CDM) project by the United Nations Framework Convention on Climate Change (UNFCCC) in February	Vestas Wind Systems (Danish wind company); Lake Turkana Wind Power Consortium (LTWP)comprising KP&P Africa B.V., Aldwych International, Industrial Fund for Developing Countries (IFU), and Norwegian Fund for Developing Countries(Norfund);DEWI,Government of Kenya; Kenya Electricity Transmission Company (KETRACO); Spanish Government; Spanish contractor, IsoluxCorsanS.A; Aldwych Turkana International Limited; KLPNorfund Investment AS; Danish Investment Fund for Developing Countries (IFU) Denmark; .Finnish Fund for	http://qz.com/444936/kenya-is-building-africas-biggest-wind-energy-farm-to-generate-a-fifth-of-its-power/ http://www.ltwp.co.ke/the-project/overview

	2011 with the Gold Standard rating'. The power produced will be sold to the national gird on the basis of the Kenya's FiT policy over a period of 20 years. Detailed info on the project can be found at the project's website: http://www.ltwp.co.ke/	Industrial Cooperation Ltd (Finnfund); Sandpiper Limited; African Development Bank; The government of the Netherlands	
Kipeto wind farm project in Kajiado County	This is the second largest wind farm project to be constructed at the total cost of $316 million.The funding is mobilised by the Overseas Private Investment Corporation (OPIC), a US public agency. The total installed capacity of the wind farm is 102.06 MW. It comprises of 63 wind turbines, each with a generating capacity of 1.62 MW. The project is expected to commence as early as 2015 and to be finalised in 2016.	International Finance Corporation (World Bank);General Electric; KPLC; Kipeto Energy Limited; African Infrastructure Investment Managers	http://www.evwind.es/2014/10/23/ge-to-install-63-wind-turbines-for-new-kenyan-wind-energy-project/48284 https://cdm.unfccc.int/filestorage/Q/Y/7/QY75LFE0M32XTVAZIKHCGOPBS1WD46/Kipeto%20Wind%20Energy%20Project%20-%20PDD.pdf?t=bmx8bnIyM25hfDAx8VbvyGrdXJO--M831J-E

			http://www.businessdailyafrica.com/Kajiado-wind-power-farm-gets-Sh17bn-boost/-/539546/2082030/-/7xvyg5/-/index.html
Kinangop Wind Farm	This is a 60.8 megawatt wind farm in Kenya's Kinangop region primarily owned by the African Infrastructure Investment Managers (AIIM). 'The project has reached Financial Close and commissioning is expected to occur in mid-2015.' The power it generates will be sufficient to power over 150 000 homes in the country. Similar to Lake Turkana Wind Power Project, Kinangop Wind Farm has been registered for United Nations Clean Energy Mechanism. The power generated will be fed to the national grid under the Power Purchase Agreement with theKenya Power and Lighting Company (KPLC).'The objective of the 60 MW Kinangop Wind Park Project, which has been proposed by Aeolus KenyaLimited, is to add about 178,520 MWh per year of wind-generated electricity to the Kenya national grid system.' More detailed expositions on the project can be found at:	Iberdrola Engineering; General Electric; Aurecon; Aeolus Kenya; Kinangop Wind Farm Ltd.	http://www.norfund.no/eastern-africa/kinangop-wind-park-article1027-319.html https://cdm.unfccc.int/filestorage/l/y/GVM9IOHK8EF6S5D2CUWYNL3ABZX017.pdf/Kinangop_Wind_PDD_vor04.pdf?t=Qld8bnIyZm5xfDDR6qs-SOM7GihewNUmJ26G

	https://cdm.unfccc.int/filestorage/I/y/GVM9IOHK8EF6S5D2CUWYNL3ABZX017.pdf/Kinangop_Wind_PDD_vor04.pdf?t=Qld8bnIyZm5xfDDR6qs-SOM7GihewNUmJ26G		
400 MW wind farm in Meru	A recent news article (dated July 3, 2015) shows the Kenya Electricity Generating Company (KenGen) has embarked to develop a 400 MW wind farm in Meru county. The project is expected to be financed by 'a consortium of development financiers namely the French Development Agency and the German Development Bank'. The first phase of the project is planned to be finalised by end of 2017.	The Kenya Electricity Generating Company (KenGen); French Development Agency; German Development Bank	http://www.evwind.es/2015/07/03/wind-power-in-kenya-kengen-develops-400-mw-wind-farm/53156
Ngong Wind Project Phase II	The Ngong wind Power Station was installed in 1993 supported by the government of Belgium. The station had two turbines, which at present are no longer operational. However, in 2009 the second phase of the project was commissioned and upgraded to a 5.1 MW of power station. The project was further expanded to consist of 24 additional turbines with a total installed capacity of 25.5MW at the cost of KES 1.6 billion (US$ 18 million).	Electricity Generating Company (KenGen);Vestas Wind Systems (Danish wind company)	http://www.evwind.es/2015/07/03/wind-power-in-kenya-kengen-develops-400-mw-wind-farm/53156
Isiolo Wind project	Isiolo wind project is expected to produce a total of 150MWp when completed in two phases. The first phase is planned to produce 50MWp.As of 2014, the feasibility study for the project is		http://www.renewableenergy.go.ke/asset_upld s/files/Wind%20Se

	completed.KENGEN (Kenya Electricity Generation Company) states that the project is to be commissioned in 2015. It is estimated that the project will cost at total of $400million.		ctor%20Prospectus%20Kenya.pdf
90 MW Baharini Electra Wind Farm power project	A news article (dated March 17, 2013) shows that the National Environment Management Agency (NEMA) has received an environmental impact assessment report on a proposed 90 MW Baharini Electra Wind Farm power project. The proposed wind farm will consist of a maximum of 45 wind turbines (each with a generation capacity of 1.8 to 3 MW).	Electra Winds Kenya Limited (subsidiary of Belgian power company Electrawinds NV	http://www.businessdailyafrica.com/Nema-seeks-public-views-on-90MW-Lamu-wind-power-project/-/539552/1722624/-/ed8kx2/-/index.html

2.3. Overview of current enabling environment of wind energy in Kenya

- Kenya's Government considers renewable energy sources as an important means to ensure energy security, power Kenya's development, diversify its energy sources and create employment and income generating opportunities to the growing Kenyan population[107]. One of the landmark policy frameworks that support the development of renewable energy in Kenya is the Energy Act 2006. Within the Energy Act the 'Promotion of Renewable Energy and Energy Conservation' has given the mandate to the Ministry of Energy to promote the use of renewable energy generated from a range of renewable sources, including wind. The Act also has put in place the Rural Electrification Authority (REA) and the Rural Electrification Fund to facilitate the provision of electricity to remote and off-grid locations[108].
- The key national economic development plan—the Kenya Vision 2030—sets a target of developing 2036 MW of wind power by 2030 to meet the energy requirements of the country, which is growing at 13.5% annually[109]. The vision has articulated the risk posed by climate change in meeting development targets. In response to this, the Government had launched the National Climate Change Response Strategy in 2010. The strategy outlined core principles of sustainability, including the Government's ambitions of increasing the share of renewable energy in the total energy installed capacity[110].
- In order to guarantee security and market stability for investors, the Ministry of Energy drafted the FiT policy in which independent power producers (IPPs) can deliver power generated from wind, small hydro and biomass sources to the national grid. The FiT scheme allows a private investor to sell wind power to the national grid at a fixed tariff of US $ Cents 11.0 per kilo watt hour for twenty years. This tariff is applicable to an independent wind power producer whose 'effective generation' is between 500 kW and 100 MW[111],[112]. "Potential investors in the RE [renewable energy] sector, however, claim that there is still a need for further revision [of the FiT Policy] as the gazette tariffs do not reflect the cost of

[107] http://www.energy.go.ke/downloads/FiT%20Policy,%202012.pdf
[108]http://www.erc.go.ke/energy.pdf

[109]https://www.windforce-management.com/uploads/articles/rahul_kumar_kandoi-scaling_up_of_wind_energy_development_plans_in_kenya_963709.pdf
[110]http://cdkn.org/wpcontent/uploads/2012/04/NationalClimateChangeResponseStrategy_April2010.pdf

[111]https://www.windforce-management.com/uploads/articles/rahul_kumar_kandoi-scaling_up_of_wind_energy_development_plans_in_kenya_963709.pdf
[112]http://www.erc.go.ke/erc/fitpolicy.pdf

investment and O&M… the FiTs are not indexed for inflation so that the profitability slowly disappears with the years to pass. Calculating a theoretical financial forecast is thus an impossible task, which does not increase the willingness to invest[113].”

- The Government has put in place zero-rated import duty. It has also removed Value Added Tax (VAT) on imported renewable energy equipment and accessories[114].
- The Energy Act of 2006, National Climate Change Response Strategy in 2010, Least Cost Power Development Plan (LCPDP) all emphasise the facilitation of renewable energy development so as to meet the long-term development strategy of the country articulated by Vision 2030 of the Kenyan Government[115].
- The 2011 Updated Least Cost Power Development Plan (LCPDP) states that the projected share of wind energy (by 2030) is going to be over 9% of the total generation capacity of the country[116].

3. Summary of overall observations

The major objective of this review has been to get the feel of what is happening around solar and wind energy in Kenya. The assessment suggests that Kenya has abundant solar energy resources. The country has also a long experience in solar PV technology, which dates back to the 1970s. In the early decades of solar PV diffusion in Kenya, donors had played an important role. However, the residential solar PV sector has gradually become less dependent on donor aid in the 1990s, increasingly being driven by the private sector. The major driver for commercial success of solar home systems diffusion was the need by off-grid communities to power TV and radios. Despite the widespread diffusion of solar PV technologies, poor technical capability of PV-installation technicians had been a major challenge. This challenge persists today although there is voluntary accreditation framework in place.

At present, there is a strong market for solar technologies, largely dominated by cheap solar lanterns imported from China. Assessment on the current solar PV projects suggests that the majority of

[113] http://trinomics.eu/wp-content/uploads/2015/05/Market-study-to-strenghten-economic.pdf
[114]https://www.windforce-management.com/uploads/articles/rahul_kumar_kandoi-scaling_up_of_wind_energy_development_plans_in_kenya_963709.pdf
[115]http://cdkn.org/wpcontent/uploads/2012/04/NationalClimateChangeResponseStrategy_April2010.pdf

[116] http://trinomics.eu/wp-content/uploads/2015/05/Market-study-to-strenghten-economic.pdf

them can be classified into five categories, depending largely on the power output of the PV systems.

The first group is related to Pico-Solar-Home-Systems. These are over the counter products, which are often sold to individual customers. There are a number of solar lantern distributors, retailers and wholesalers in Nairobi. In this assessment, we have been able to identify over 15 solar lantern commercial distributors located in Nairobi. Perhaps the most well-known platform of Pico-Solar-Home-Systems in Kenya is 'Lighting Africa' project. This project, funded by the World Bank, promotes modern off-grid lighting products in sub-Saharan Africa, including Kenya.

The second types of projects are related to solar home systems (SHS). These solar systems, installed at individual homes in remote off-gird locations, are believed to have largely been driven by the private sector since the 1990s. However, there have also been some international donors, who have been active in the diffusion of solar home systems in Kenya. These include the World Bank and giz. Similar to Pico-Solar-Home-Systems, solar home systems are mostly over the counter products. However, there are also projects, which are employing unique business models, such as pay-as-you-go system, using cloud computing. A typical example of such types of projects is M-KOPA.

The third category of solar projects might be grouped under Stand-alone institutional PV systems, which are often installed at social institutions under government procurement. Our assessment suggests that Kenya's first experience of solar PV technology is through stand-along PV institutional systems, installed at broadcast stations located far from the national grid. There has also been a recent enthusiasm by the government to power public institutions in off-grid areas. The Government has reported that as of 2014 about 700 institutions have been hooked up to standalone institutional PV systems.

The fourth group of solar projects fall under the category of mini-grids sometimes coupled with hybrid PV-Diesel or Wind. These types of solar PV applications have emerged recently, driven by the Government's Rural Electrification Master Plan (2008) that encourages existing diesel generators to install PV components. There are currently about six hybrid mini-grids that have integrated solar power into their generation capacity. Although the notion of mini-grid suggests that power is distributed to communities within isolated villages, we have included standalone systems that produce power in the range of 5 kW to 1 MWp in this category. This means that a number PV projects, for instance installed at flower farms, have been included in the mini-grid category in this review.

The last group of projects that have been assessed in this review are large-scale grid-connected PV systems. There is some interest by the Government (and the private sector) for large-scale solar power in Kenya. Indeed the Government has put in place a Feed in Tariff (FiT) policy for commercial projects that wish to contribute to the national grid. About 25 FiT-approved solar projects are currently underway, most of them in their early development stage. The Government has also received proposals of over 112 large-scale solar projects in 2012. Although solar does not feature prominently in the Government's updated Least Cost Power Production Plan, there is target of producing 500MW of power by 2030. In general, however, many experts believe that the Government's focus on solar in its long-term power planning (compared to geothermal and wind) is minimal. The development of large-scale solar is impeded by large upfront cost requirement, complicated land tenure rights, insufficient incentives, poor infrastructures and limited linkages among public and private actors. In this desk assessment, we have been able to briefly review seven current and recent projects on large-scale solar in Kenya, many of which are expected to produce about 40 to 50 MWp. Until end of 2014, there are no finalised large-scale projects producing power and benefiting from the FiT scheme.

Overviews on current enabling institutional environment around solar energy in Kenya suggest that there are a number of policy and regulatory frameworks that support solar PV technology diffusion. The most prominent policies are the Sessional Paper No.4 of 2004, the Energy Act 2006, the Kenya Rural Electrification Master Plan, the Feed-in Tariff Policy, the Kenya vision 2030 and The Kenya National Climate Change Response Strategy. There have also been discussions for a net-metering policy; and tests have been underway over the last couple of years at SOS Mombasa Children's home, Uhuru flowers Kenya and Strathmore University. There has also been 0% import duty and removal of Value Added Tax (VAT) on imported solar accessories since 2011. The vat exemption is only for solar home systems and it has been criticised as insufficient for large-scale promotion of solar technologies. Considering low level of technical capability of solar technicians and poor quality products often imported from China, a Photovoltaic Systems Regulations has been put in place since 2012. A quality assessment laboratory has also been launched at the University of Nairobi for off-grid lighting solutions[117].

[117] A recent PhD study, which details many aspects of solar energy in Kenya, can be found at: http://www.fnu.zmaw.de/fileadmin/fnu-files/publication/phd-thesis/140827_PhD_Thesis_-_Janosch_Ondraczek_public.pdf

Our desk assessment on wind energy in Kenya also reveals that the country is endowed with untapped potential for large-scale electric power production in a number of locations, particularly Marsabit, Ngong and the Coastal regions. In contrast to solar (which emerged in the 1970s), wind energy was introduced to Kenya in the early 1900s. However, the country saw the first modern windmill installation in 1993, when the Belgium Government supported the installation of two turbines at Nigong hills. A recent development of Kenya's Wind Atlas has increased interest for wind power in the country. Indeed, we have been able to identify about seven projects currently underway (at least two projects have achieved financial closure). One of the flagship projects is the Lake Turkana Wind Power Project (LTWP), which is commissioned recently after 10 years of commencement. This project involves a number of key actors, that includes Vestas Wind Systems (Danish Wind Company) and a Consortium of companies and finance institutions.

Assessment on the enabling environment of wind energy in Kenya suggests that there are a number of policy frameworks, which have been put in place by the Kenyan Government. These include the Energy Act 2006, the Kenya Vision 2030, the FiT policy and Updated Least Cost Power Development Plan (LCPDP).

In general, this assessment suggests that both solar and wind energy sectors in Kenya have to go a long way to contribute significantly to the national electric energy generation capacity. While there has been a long history of solar energy use in Kenya, there is no large-scale solar project that feeds power to the national grid currently (except those plants connected to test net-metering). Large-scale solar project investors face uncertainty and lack confidence (in the sector) despite some of the encouraging institutional arrangements that have been put in place. Challenges related to poor infrastructure, limited involvement of research, educational and financial institutions and insufficient incentive mechanisms appear to have contributed to low or under investment in large-scale solar energy technologies. Similarly, the wind sector faces a range of structural challenges, such as insufficient incentives, poor infrastructure and lack of sound and sufficient data and research on wind regime of the country. This preliminary desk assessment therefore appears to suggest that the IREK project is an exciting opportunity to delve into the national (as well as the international) institutional environment of solar and wind energy technologies and explore local learning experiments. By doing so, such studies will be able to identify major system weaknesses and suggest appropriate systemic instruments to boost the functioning of national innovation systems related to these technologies in Kenya.