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The untapped potential of solar energy in Kenya: Factors limiting the integration of solar PV into the electricity grid

Lara Millan

Joanes Atela

African Centre for Technology Studies (ACTS)
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Abstract

Solar energy has been highlighted as a potentially important source of renewable energy for Kenya's green economy transitions as well as the country's intended national commitments to the Paris Agreement and the Sustainable Development Goal Number 7. However, the role that solar energy is going to play in the electricity generation mix in Kenya is still uncertain. In this time of change, the high and untapped potential of solar energy generates a lot of interests in the country. This paper identifies and analyses the factors limiting the integration of solar PV into the electricity grid. Based on the data collected from interviews over a two-month period in Kenya, the working paper completes an investigation of the institutional structure, an analysis of the policy framework and an assessment of the market dynamics of the country. The findings demonstrate that the weak grid infrastructure, and the centralization of power in the electricity sector along with the lagging electricity demand are the main factors impeding the adoption of solar PV within the Kenyan grid. However, the rapid decline in global solar PV prices as well as the advancements in renewable energy storage and the recent entry into force of the Paris Agreement might change the story.

This research project was conducted in a period of new institutional establishments in the energy sector in Kenya including the establishment of the new energy and climate change Acts both of which are targeting to promote renewable energy technologies such as solar. The findings in this study therefore represent a great opportunity to inform the policies especially with regards to some of the barriers that could impede successful transition to green economy via solar.

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List of Abbreviations

ACTS	African Centre for Technology Studies
ERC	Energy Regulatory Commission
FiT	Feed-in-Tariff
GDC	Geothermal Development Company
GoK	Government of Kenya
IPP	Independent Power Producer
KenGen	Kenya Electricity Generating Company Limited
KETRACO	Kenya Electricity Transmission company Limited
KIRDI	Kenya Industrial Research and Development Institute
KPLC	Kenya Power Lighting Company
LCPDP	Least Cost Power Development Plan
MoE&P	Ministry of Energy & Petroleum
MSD	Medium Speed Diesel
PPA	Power Purchase Agreement
PV	Photovoltaic
SHS	Solar Home System
SEI	Stockholm Environment Institute

1. Introduction

Solar photovoltaic (PV) is the renewable energy technology with the most dynamic development in the last years. Not only is this technology an important tool to address the SDG Number 7, it also contributes to the world's commitment to a low carbon future. Since the universal adoption of the Paris Agreement in December 2015, renewable energies set new records for investment (FS-UNEP, 2016). This, as a result, slowly puts an end to the era of fossil fuels and boosts alternative sectors including the solar industry. Over the past years, many countries like Germany, the U.S. and Japan already begun to integrate solar PV into their grid electricity generation mix. Today, large-scale solar power plants and net-metering[1] schemes are rapidly emerging, driven by the falling prices of solar PV due to the mass production of modules.

In Africa, the total installed solar PV capacity more than quadrupled in the last two years (IRENA, 2016). Solar energy holds a big promise in this continent, where Kenya is considered the most advanced in this market (The Energy and Resources Insitute, 2015). But with only 0.02% of solar contributing to the national grid, the potential of solar power remains largely untapped. The recent cost-competitiveness of solar PV marks a turning point for Kenya where the solar sector could shift from small-scale, off-grid PV systems to mini-grid and grid-connected PV installations. Indeed, the goals set by the Vision 30 - the new long-term development blueprint for the country, projects a massive push for the expansion of electricity generation capacity in the upcoming years. With a wide portfolio of renewable energies at hand and a rapidly changing energy profile, the role that solar energy is going to play in the electricity generation mix is still uncertain.

The high and untapped potential of solar energy in Kenya raises a lot of attention and generates much excitement from a policy and investment perspective. But the solar market in Kenya displays some limitations that are specific to the country. Many studies (Hansen, 2014; Stephen Karekezi & Waeni Kithyoma, 2002; The Energy and Resources Insitute, 2015) have explored the barriers responsible for the limited uptake of solar energy in Kenya, mostly focusing on off-grid or mini-grid applications. Some point out the lack of awareness about the technology, and the lack of technical and end-user capacity. Others highlight the value chain financing, or the inadequate policy framework. However, only a few studies (Hansen, Nygaard, & Pedersen, 2014; Hille & Franz, 2011; Rose, Stoner, & Pérez-Arriaga, 2015) have explored the prospects for the integration of solar PV into the Kenyan grid. While they all optimistically depict the uptake of solar PV, none of them considered the barriers to the implementation of grid-connected solar PV projects. It is in this context that this working paper aims to understand the dynamics in the country's electricity sector and identify some of the factors limiting the integration of solar PV into the national grid. .

In order to do so, this working paper is assessing the Kenyan electricity infrastructure and its ability to integrate intermittent sources of power like solar PV. The institutional structure of the electricity sub-sector of the country is presented in the next Section, revealing a centralization of power through the entire electricity network.

1. Net-metering allows consumers who generate some or all of their own electricity to use that electricity anytime, instead of when it is generated, by feeding it to the grid.

The role of politics and policies on the diffusion of solar PV is then addressed in the next Section, which depicts the electricity generation planning strategy and the solar energy financial schemes. And finally, the last Section provides an overview of the market supply and demand in order to understand the government's project prioritization on electricity expansion plans.

2. Methodology

Located on the equator, Kenya displays a diverse climate and geography, ranging from warm and humid tropical climate on its Indian Ocean coastline to the temperate and forested area in the Western region, from the permanent snow of the peaks of Mount Kenya to the tropical grasslands in the savannah around the capital city Nairobi. Nairobi is the country's commercial and cultural hub. It hosts thousands of Kenyan businesses and over 100 international companies and organisations, including the United Nations Environment Programme (UNEP) and the United Nations Office at Nairobi (UNON). Kenya has the largest economy (by GDP) in East and Central Africa. The major economic drivers of the country include the tea, coffee, and fresh flowers agriculture, tourism and the service industry. With a growing population of almost 48,000,000 habitants, the energy demands are continuously increasing. In the recent years, the Government of Kenya has developed a strong focus on expanding geothermal power, which is considered a key enabler for Kenya's economic growth. As such, the electricity generation mix is currently based on large-scale hydropower, thermal and geothermal power plants whilst other renewables such as solar and wind only play a minimal role.

The research project was conducted over an 8 weeks period in May and June 2016 under the auspices of the *Transformative Pathways to Sustainability: Learning across Disciplines, Contexts and Cultures project of the Africa Sustainability Hub hosted* at the African Centre for Technology Studies (ACTS) in Nairobi, Kenya. Data was mainly collected through in-depth analysis of Kenya's energy policy documents complemented with in-depth semi-structured interviews with key stakeholders in the energy sector. The interviewees were identified according to their involvement in the solar sector or their influence on the Kenyan electricity network. These interviewees were mainly drawn from both state and non-state based organizations such as the Ministry of Energy & Petroleum (MoE&P), the Ministry of Environment & Natural Resources, the Energy Regulatory Commission (ERC), Kenya Power Lighting Company (KPLC), KenGen, the National Treasury, KIRDI, Green Africa Foundation, the Stockholm Environment Institute (SEI), Kenergy and Strauss Energy among others. Data was analysed through coding and thematic categorisation of qualitative data sets in line with key objectives of the study. One main limitation in the methodological approach is that only one individual per organization was interviewed and this might not truly represent the stance of the whole organization. Also, not all of the relevant stakeholders were interviewed. Three key actors that could have complemented the research project were missing because they did not favourably respond to the interview requests: the Rural Electrification Authority (REA), the Kenya Private Sector Alliance (KEPSA), and the Kenya Renewable Energy Association (KEREA). In addition, the research project was solely conducted in the county of Nairobi. This prohibited any interview with government authorities at the county level, which play an important role in the land acquisition in Kenya, an issue that concerns most energy projects. And finally, the research did not address the conceivable influence of the fossil fuel industry that can represent an obstruction to the uptake of solar energy in the country.

3. Findings: Factors limiting the integration of solar Pv into the electricity grid

3.1. Institutional Structure of electricity in Kenya

The energy sector is one of the most important sectors in the Kenya. *Figure 1* depicts the main actors of the electricity grid network in Kenya.

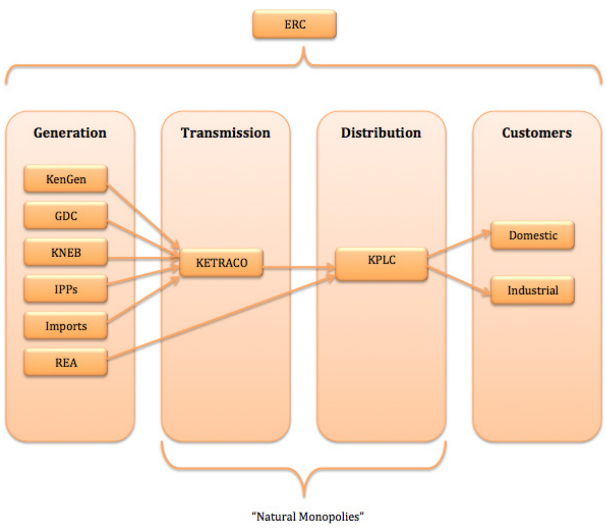


Figure 1. *Overview of the electricity grid network*

In *Figure 1*, the singularity of the bodies responsible for the transmission and distribution is clear and even referred to as "natural monopolies" by the GoK (MoE&P, 2015). What is less clear is the centralization of power through the entirety of the electricity network. Although the Kenyan government has been encouraging investments in domestic energy supply through the liberalization of the electricity production, this sector remains in the hands of the governmental electricity utilities elite.

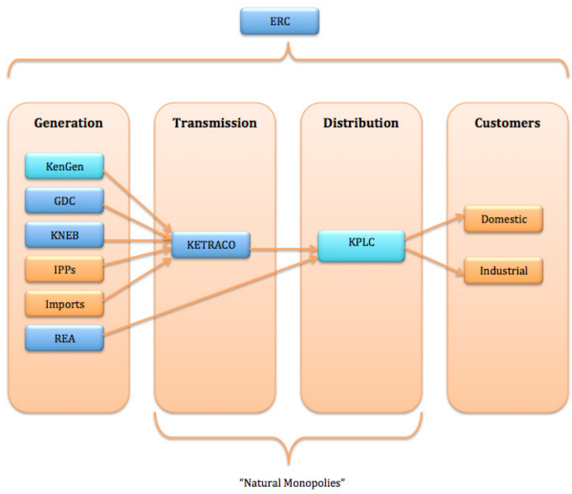


Figure 2. *Overview of the electricity grid network with distinction between partly state owned (light blue) and fully state owned (dark blue) bodies.*

Figure 2 highlights the shareholding of the different actors across the electricity grid network. When looking at the ownership of the electricity utilities, one can easily spot the omnipresence of the government (blue). If fact, GDC, KNEB, REA, KETRACO, and most importantly the ERC are fully state-owned, meaning that they operate on behalf of the GoK. With KenGen[2] and KPLC[3] being mostly state-owned, the only bodies outside the governmental elite are the independent power producers (IPPs) and the imports, which represent only a slight fraction of the electricity. The institutional structure is such that the GoK dominates the electricity market. The implications of such institutional structure on the adoption of grid-connected solar energy are further discussed in the next Section.

2. 70% state-owned, 30% private investors.
3. 50.1% government, 49.9% private investors.

3.2. Electricity Infrastructure in Kenya and Impacts on Solar

The electricity infrastructure has often been highlighted as an important barrier to the integration of solar energy into the national grid. In fact, the Kenyan electricity infrastructure is weak and out-dated, making it challenging to support emerging intermittent renewable energies. All the interviewees involved in the generation, transmission, and distribution of electricity in Kenya disclosed a fear of grid fluctuations when discussing the integration of solar PV into the national grid. But according to the CEO of Kenergy - a developer of renewable power generation, the grid is currently not strong enough to handle fluctuations, even without variable sources like solar and wind. She mentions that power cuts occur frequently in the country, even though the sources of power are fixed and abundant. An engineer at the ERC confirms: ”the power shortages result from a poor distribution system, not from a lack of capacity”. The grid thus requires a serious update of the electricity infrastructure, regardless of the integration of intermittent renewable energies. This involves major efforts and investments in the transmission and distribution sub-sectors. Actually, the Government of Kenya (GoK) is already taking measures to improve the aging infrastructure. KETRACO - the organization responsible for the electricity transmission throughout the country, is presently making important investments to upgrade the transmission lines at high voltage level[4]. The ERC has also provided funds for network upgrade at low voltage[5]. Additionally, a new grid-code[6] has been proposed by the ERC in order to replace the draft Kenya Electricity Grid Code from 2008, which “does not include sufficient consideration of technological advancements, international best practices in grid operation and maintenance and, in particular, the integration of renewable resources” (ERC, 2016).

4. Interview with Willis Ocheing (KenGen).
5. Interview with David Kariuki (ERC)..
6. The Kenya National Transmission Grid Code (KNTGC) and the Kenya National Distribution Code (KNDC).

In general, the variable nature of many renewable energy sources like wind and solar represent a challenge for electricity grid operators. Solar power, which is weather dependent and cannot be stored, indeed necessitates more complex grid management techniques and preferably a smart-grid[7] infrastructure. In fact, the power that is fed into the grid must always be supplied to users at the rate at which it is demanded because energy cannot be effectively stored for delayed use (Lofthouse et al., 2015). Ideally, electricity must be generated, transmitted, and used instantly. If too much electricity is supplied, the voltage within the grid becomes unstable and burdens the entire grid infrastructure. More importantly, in this case, the grid operator – KPLC, is unable to take the electricity that it has already paid for through the Power Purchase Agreement (PPA) scheme. This loss is referred to as “deemed energy costs”[8]. In the case where there is limited availability of electricity, the grid operator must fire expensive Medium Speed Diesel (MSD) emergency power plants, which dramatically increases the electricity bills for end users. In the eventuality of the integration of solar PV into the grid, the grid operator would need to anticipate the forecasted[9] solar power output (which

7. Smart-grid is a generic label for the application of computer intelligence and networking abilities into a basic electricity distribution system.
8. Interview with Boniface Kinyanjui (KPLC)
9. « Methods for solar power forecasting include cloud tracking and numerical weather prediction models, which use current weather data to predict future weather patterns » (Lofthouse et al., 2015).

changes throughout the day) and adjust the dispatchable power plants to ensure a steadily electricity supply. Unfortunately, the practice of manually reducing or increasing power systems outputs is very costly (Lofthouse et al., 2015). So from a technical perspective, the integration of intermittent energy sources like solar PV into the grid represents additional costs for the grid operator.

There are solutions to mitigate abrupt fluctuations of intermittent energy sources, but these are not necessarily available in Kenya. Indeed, devices that could control fluctuations are very expensive and not mature yet, and the country hasn't reached a level of grid connectivity that would allow them to distribute the excess capacity to the neighbouring countries. The grid operator must hence deal with intermittent power by its own means within the country. The CEO of Kenergy points out: "Power utilities have been used to have a fixed source of power". According to her, the variability of solar power is predictable and can be managed. The power utilities already have to continuously adjust the electricity supply to match the fluctuating demands for power. There is a need for the grid operator to learn how to use variable sources of power such as wind and solar. She adds, "Of course it is going to be harder, but it can be done."

In a nutshell, the intermittent and less predictable nature of solar power makes it more difficult for the grid operator (KPLC) to maintain the delicate balance between electricity supply and demand. This involves major efforts and investments in the transmission and distribution sub-sectors that could represent a major impediment to the integration of solar PV to the grid.

3.3. Politics and Policies

In the recent years, the GoK has put in place a number of initiatives and regulatory frameworks to stimulate investments in the energy sector, with a particular emphasis on renewable energy technologies. However, the various policies regarding solar power are often inconsistent and can be confusing for any actor involved in the energy sector.

Electricity Generation Planning Strategy

The various governmental energy plans[10] do not significantly feature grid-connected solar in the energy development prospectus, despite the high potential of solar in Kenya. The National Energy & Petroleum Policy Draft (2015) even states, "the percentage of solar energy harnessed for commercial and domestic applications is insignificant relative to the potential".

The main reason for the lack of solar in Kenya's energy planning is the fact that it is not included within the Least Cost Power Development Plan (LCPDP)[11]. In fact, the LCPDP authors are the current energy providers, and it would thus not be in their best interest to promote an alternative form of energy. As Ondraczek (2014) points out, while the LCPDP selects geothermal, wind and hydropower as the cheapest base load technologies, it only considers gas turbines and MSD as peak load sources. This is despite the fact that solar costs are lesser than some of the peak

10 Energy Act (2006), LCPDP (2011 & 2013), National Climate Change Action Plan (2013-2017), Draft National Energy & Petroleum Policy (2015), Medium Term Plan (2015-2020), Kenya's Intended Nationally Determined Contribution (2015).

11 The LCPDP illustrates the long-term (20 year-rolling) electricity plans of the country and can therefore be considered as the country's blueprint of electricity development. The objective of the LCPDP is to estimate the evolution of power demand in the medium and long term in order to plan for adequate generation capacity (ERC, 2015).

load energy sources included in the LCPDP. Ondraczek's most recent study (2014) estimates that the levelized cost of electricity (LCOE)[12] of grid-connected solar PV systems is already lower than conventional power sources such as MSD plants, which represent a significant share of Kenya's current power generation. The exclusion of solar in the LCPDP is hence not justified from a purely economic perspective. On the contrary, the recent cost-competiveness of solar against such conventional energy sources is reflected through the government's plan to transform mini-grid MSD power plants into hybrid plants by incorporating solar PV. Many studies have indeed pointed out the fact that Kenya's decision-makers still perceive solar as only viable for off-grid electrification options. Ondraczek (2014) has argued that this stems from assumed initially high investment costs for solar energy technologies, rending solar economically unattractive for large-scale electricity generation. In fact, the LCPDP, which was last updated in March 2013[13], fails to take into account the recent falling prices of solar PV.

Additionally, the Technical Studies Team who produces the LCPDP lacks knowledge in the modelling software[14] that generates the energy portfolio of the country. This is because the capacity training is not yet complete as a result of insufficient time and resources[15]. This kind of negligence could have consequences on the LCPDP outcome, which could fail to promote the *least cost* power in the electricity mix and thus exclude solar from the national electricity generation mix.

12 A LCOE measures a power plant's average costs over its lifetime, including its construction, fuel, operations, maintenance, and efficiency (Lofthouse et al., 2015).

13 The LCPDP has not been updated since March 2013 in view of the new Energy Master Plan that is currently under elaboration.

14 WASP (Wien Automatic System Planning Package) modelling software.

15 Interview with Boniface Kinyanjui (KPLC).

A lack of technical knowledge and entrenched belief that solar is expensive cannot fully explain the exclusion of solar PV in the LCPDP. By assessing the motivations of each of these stakeholders, the reasons why solar energy does not feature in the LCPDP become apparent. A government representative stated: "In this country, political will is key".

The Energy Act (2006) confers the responsibility of preparing the LCPDP to the ERC. To prepare the LCPDP, the ERC sets up a multi-stakeholder committee to undertake this task on an annual basis.

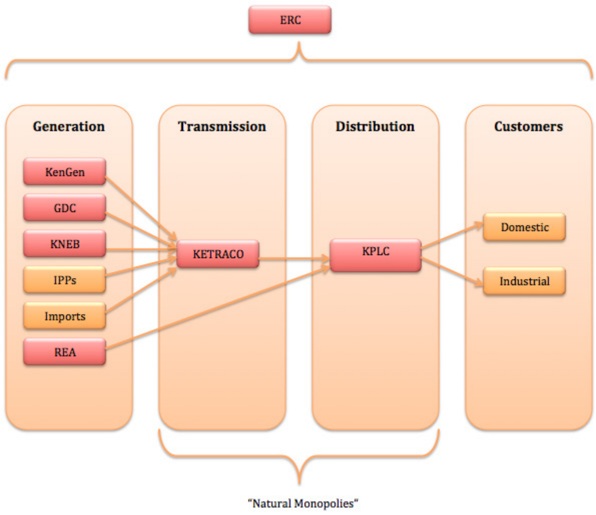


Figure 3. *Overview of the electricity grid network with the actors involved in the formulation of the LCPDP (in red).*

Figure 3 highlights (in red) the bodies involved in the formulation of the LCPDP. Visibly, the team is composed of mostly state-owned bodies (as shown in blue in *Figure 2*) and lacks actors that are external to the existing electricity network. As such, the LCPDP suffers from a lack of expertise in technologies that are not currently integrated within Kenya's electricity generation mix. This is the case of grid-connected solar PV technology that has no representatives in the LCPDP. With no external actors involved, the outcomes of the LCPDP become biased in favour of the interests of the current energy actors.

This supports the argument in which the critical obstacles to bring change in the Kenyan electricity sector lie in the realm of political economy and governance (Newell et al., 2014). As Newell et al. (2014) comment, "The fundamental problem in Kenya is that the political elite have been able to capture public institutions and resources to serve their private interests".

As such, the omission of grid-connected solar energy, in part, results from the inertia of the established electricity network. Although most of them denied it, one member of the Technical Studies Team admitted during an interview that the objectivity of the LCPDP authors might be called into question. However, rather than pointing out the centralization of power discussed above, he indicated the fact that when planning the energy strategy, the earlier committed projects must be taken into consideration. This is a matter that the report analyses in Section 3.4.

Solar Energy Financial Schemes

Even though the energy strategy planning does not explicitly include grid-connected solar power, interests in this sector is recently stemming from the private sector. The recently established financial regulatory framework is a key driver of such arousal.

The liberalization of the energy sector in 1994 failed to attract sufficient foreign investments in the country because of various reasons that will not be discussed in this paper. So further measures had to be established in this regard. After numerous negotiations, the GoK has zero rated the import duty on renewable energy technologies and removed VAT[16] on solar equipment and components (Brückner, 2016). However, the solar private sector still complains about the badly designed tax schemes[17].

In order to further encourage investments in the generation of electricity from renewable energy sources, the GoK also issued a Feed-in-Tariffs (FiT) Policy[18] in 2008. Through this policy, the Kenyan government is aiming at attracting further investments in standardized power purchase agreements for embedded power for solar, biogas, biomass, wind, small hydro, and geothermal technologies. As underlined by the Deputy Director of Climate Change, the GoK is in a situation of trade-off in which it has to balance the FiT between the return to investment necessary to bring investors on board, and the affordability for end-users in order to pursue the country's Vision 30 goals. Indeed, the relatively low population incomes require that all introduced energy systems are economically viable and do not add a burden to electricity consumers. The FiT Policy (2012) includes a provision for a tariffs review every three years from the date of publication. Surprisingly, the tariff for solar (disclosed in the *Table 1* below), remains the same since 2012 despite the recent fall in solar PV prices. Various studies have underlined that the latest FiT for solar is currently too low to attract domestic and foreign investors that lean toward more profitable projects (Ondraczek, 2014). But with the latest global solar PV trend, this rate is becoming attractive to foreign investors. The CEO of Kenergy, which is responsible for one of the first 5 solar projects approvals in Kenya, approves that grid-connected solar wasn't viable

16. The standard 16% VAT is generally levied on goods in Kenya.

17. Interview with Tony Nyagah (Strauss Energy) and Khilna Dhodia (Kenergy).

18. The Feed-in-Tariff "allows power producers to sell renewable energy generated electricity to an off-taker at a pre-determined tariff for a given period of time." (Ministry of Energy, 2012). FiT values are calculated on a technology-specific basis using the principle of cost plus reasonable investor return." (Ministry of Energy, 2012)

back in 2013. But she asserts that it is a viable investment to date. She concedes that geothermal is still cheaper than solar but argues that a gradual uptake of solar now will bring the costs further down in the future.

Excitingly, the National Energy & Petroleum Draft Policy (2015) also delivers a provision on net-metering measures, which could (if passed by the Senate) generate a great incentive to stimulate the uptake of grid-connected Solar Home Systems in Kenya. Net-metering would indeed allow residential, commercial and industrial consumers to invest in small renewable energy systems on a competitive, free-market based approach. A study from 2011 has argued that a net-metering policy would be a low cost and low risk approach to introduce grid-connected solar PV in Kenya (ACTS, 2015). However, the non-traceability of Solar Home System (SHS) power added to the grid could be an issue for the electricity grid operator (KPLC) who wants to be ready to "host" the increased amount of electricity generated (through SHS) without risking a power quality deviation[19].

In a nutshell, the GoK has failed to provide a clear framework for the uptake of grid-connected solar technology. They have put in place a number of general policy and regulatory frameworks that appear to promote the uptake of solar energy. However, these lie in contrast to a number of other energy policy plans. This lack of coherence in the government's stance is important as the FiT Policy, as well as the potential introduction of net-metering, is widely expected to boost investments in solar PV. It would therefore appear that the GoK is deceiving investors by both encouraging investment whilst at the same time excluding solar projects from the country's electricity grid expansion strategy, a matter that is further discussed in the next Section.

19. Interview with Hannah Wanjiru (SEI).

3.4. Electricity Market: Demand and supply and Implications for Solar

According to KPLC, the electricity demand is expected to increase considerably as the economy grows and various energy intensive commercial activities emerge across Kenya. The following graphs illustrate the government's anticipation of the peak demand (*Figure 4*) and correlated installed generation capacity (*Figure 5*) for the next decades.

Table 1. *Feed-in-Tariffs by renewable energy source (MoE&P, 2015)*

The FiT values for renewable projects above 10 MW of installed capacity

	Installed capacity (MW)	Standard FiT (US $/ kWh)	Percentage Escalable portion of the Tariff	Min. capacity (MW)	Max. capacity (MW)	Max. Cumulative capacity (MW)
Wind	10.1-50	0.11	12%	10.1	50	500
Geothermal	35-70	0.088	20% for first 12 years and 15% after	35	70	500
Hydro	10.1-20	0.0825	8%	10.1	20	200
Biomass	10.1-40	0.10	15%	10.1	40	200
Solar (Grid)	10.1-40	0.12	12%	10.1	40	100

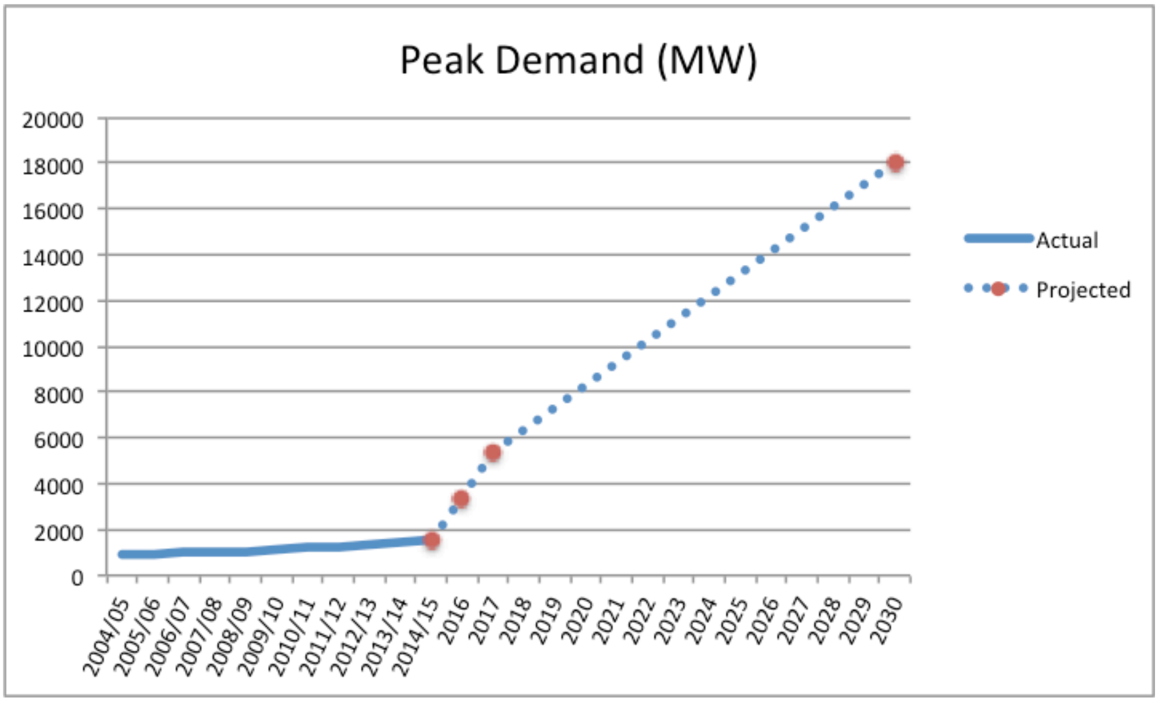


Figure 4. *The actual and projected peak demands in Kenya (data from the National Energy & Petroleum Draft Policy 2015).*

To meet the ambitious projected electricity demands, the GoK plans a massive push for the expansion of electricity generation capacity in the upcoming years, triggering investor's attention. However, in reality, the peak demand is evolving much slower than anticipated and the capacity generation installation process is already going faster than the demand growth[20]. And in order to maintain the balance between supply and demand, the country can only increase its electricity generation capacity by a limited amount. As new electricity generation project proposals line up for approval, discussions are on going on how to prioritize the already committed electricity generation projects. According to the coordinator of the LCPDP team, private investors have currently proposed 172 projects (representing 3000 MW) in renewable energy under the FiT policy, of which 57 % are grid-connected solar. However, none of them have been approved yet. In fact, looking at the power sector planning programme from May 2016, solar projects (representing a total of 61.5 MW) are not projected to be implemented until 2021[21]. An ERC energy planner points out, "From a purely economic perspective, it would be irrational to develop the proposed solar projects if there is no one that requires that power". Indeed, KPLC holds various power purchase agreements throughout the country to steadily supply electricity to end-users. Those PPAs last for 20 years (sometimes 25 years), a period during which KPLC is obliged to "take or pay" the energy agreed upon at a fixed tariff. KPLC is therefore already stranded to various energy inputs through former committed PPAs and does not have the freedom to engage into new ones. From an economical perspective, new PPA commitments would represent important losses for KPLC. In this context, the delay in PPA approvals for grid-connected solar PV projects can be

20. Interview with David Kariuki (ERC)

21. The dates given in the power sector planning programme are likely to change because of the challenges that Kenya is facing regarding renewable technologies.

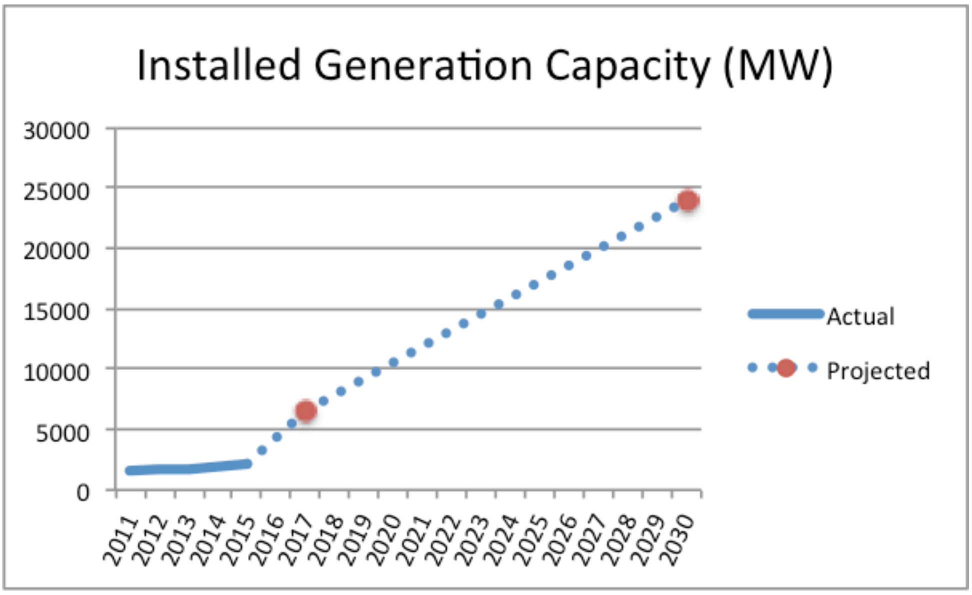


Figure 5. *The actual and projected installed generation capacity in Kenya (data from the National Energy & Petroleum Draft Policy 2015).*

justified. Similarly, one can argue that solar PV net-metering could represent a loss of revenue for KPLC. In fact, the study by Eid et al. (2014) reveals that the increasing number of "prosumers" (consumers that both produce and consume electricity) with solar PV net-metering results in reduced incomes for many network utilities worldwide. The chief engineer at KPLC even states: "Net-metering can indeed represent a loss of revenue as KenGen has already invested in different energy projects (which KPLC is stranded through committed PPAs). The mismanagement of net-metering could cost a lot to the government".

Yet, the bigger obstacle for the implementation of solar projects is usually the government's letter of support[22], which is issued by the National Treasury. The letter stipulates that the government will ensure the payment of electricity generation capacity proposed and will undertake certain risks in events that are of an unusual nature such as political events. Kenegy's CEO adds: "Lenders will only give financing if the government issues a letter of support". As such, the letter of support is the key to stimulate the financials of energy projects. Since the government is responsible for issuing the letter, it actually has the absolute power to decide upon which projects go forth and which do not.

Project Prioritization

Even though the GoK is setting the energy goals, controlling the PPA final approvals and issuing letters of support, donors - who have always been heavily involved in the Kenyan energy sector, still influence the low carbon energy access agenda. According to Newell et al. (2014), the "cost recovery of tariffs allows donors to promote the private sector and ensure that international capital will have the confidence to invest". As such, it is clear that the priority is

22. Interview with David Kariuki (ERC).

given to projects that are the most cost-competitive and generate the greatest return to investment[23]. As solar PV offers generally slower returns to investment than other energy sources such as wind and geothermal, the GoK is more inclined to exclude solar projects from the country's electricity grid expansion strategy.

According to a study on the political economy of low carbon energy in Kenya (Climate and Development Knowledge Network, 2014), the attractiveness of renewable energies is based on: the affordability compared to conventional energy sources (fossil fuels), the compatibility with grid extension plans, and the ability to serve broader growth objectives through their revenue generation potential. While solar energy meets the first criteria, it fails to fulfil the last two. The usual energy "trilemma" shown below comprising Energy Security (locker logo), Energy Equity (plug logo), Environmental Sustainability (tree logo) becomes therefore a "tetralemma" in which policy makers and energy planners also have to promote the greatest return to investment, or as they more politically correct name *least cost*.

The role that different renewable energy sources play in the country's massive push for expansion of electricity generating capacity is thus shaped by energy security, energy affordability, environmental sustainability and most importantly, project bankability[24]. Here, project bankability is fairly emphasized, as it was the recurring feature that government officials mentioned for utility-scale project approvals in Kenya[25]. In this very specific context, geothermal is the renewable energy source that seems to prevail by far.

23. Interview with Hannah Wanjiru (SEI)
24. A project is considered bankable when it is guaranteed to bring profit.
25. Interview with Pacifica Achieng (MoE), Boniface Kinyanjui (KPLC), David Kariuki (ERC), Hannah Wanjiru (SEI).

Geothermal Energy Focus

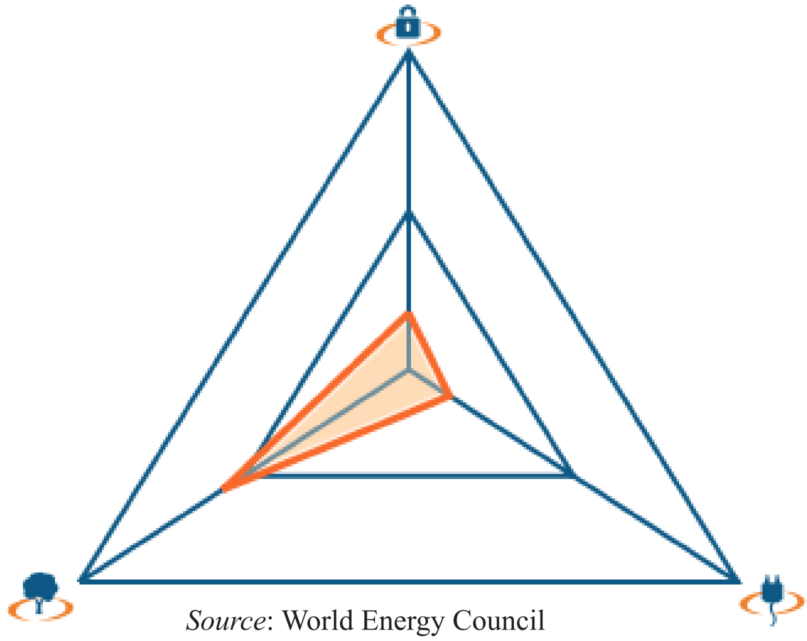
Geothermal is fully integrated in the country's long-term national power expansion plans. With a resource potential that is (like solar) very high, it is the preferred resource choice for future generating capacity in the LCPDP. This results in a strong focus on expanding geothermal power, which is considered a key enabler for Kenya's economic growth.

Although geothermal displays long lead times[26], this source of energy already accounts for approximately 25% of the grid-connected capacity in Kenya. Like most of the renewable power generation technologies, geothermal displays high capital costs and low operational costs, making it vulnerable to interest rates (Newell et al., 2014). While KenGen operates most of the geothermal capacity, the Geothermal Development Company subsidises the initial phases of development of the plants. Via the GDC, the government undertakes the integrated development of geothermal by conducting the initial exploration, drilling, resource assessment, and building of necessary infrastructure within geothermal sites. This approach allows the government to absorb the development risks associated with geothermal power and attract investors who do not need to provide private capital expenditure anymore. When commercial liability is reached, the government can then sell the sites to a project developer (Acore, 2015).

There are several reasons for the government's interest in geothermal power. This source of power has certain assets that solar PV has not. *Table 2* regroups the key characteristics of both sources of energy (geothermal and solar PV) in

26. Lead time is the latency between the initiation and the execution of a process.

ENERGY TRILEMMA BALANCE



Source: World Energy Council

order to understand the government's stance. Contrary to solar that is only suitable for peak load electricity generation; geothermal is a dispatchable source of energy that is suitable for base load electricity generation. Another fact is that the electricity generation from geothermal is not climate variable. One can argue that concerns regarding the climate dependent sources of energy have arisen from the drought-induced power shortages in the past. But most importantly, it affects the technology's capacity factor. The high (90%) capacity factor of geothermal technology compared to solar PV (20%) creates faster cost returns for the same installed generation capacity, placing geothermal above on a purely economic perspective. As Newell et al. (2014) point out in their paper; the Lake Turkana wind project got approved because the high winds in this area provide the ability to cover the project's costs within months of completion.

The key role of the GoK as an "entrepreneurial state" taking risks (exploration and drilling) provides strong financial incentives for geothermal development. The absorbed associated risks ultimately open opportunities for both public and private participation. The major role that the government is playing in relation to geothermal energy critically contrasts with solar where it has delegated this supportive role to the private sector and donors. Additionally, the high capacity factor combined with the government subsidies allow geothermal FiT to be significantly low and thus more attractive to KPLC. Newell et al. (2014) suggest that there may also be a "rent-seeking dimension" in which government officials aspire to maintain control over access to sites infrastructures and profits flowing from geothermal electricity generation. The ease of control of geothermal by state elites could thus explain the appeal for this source of energy.

Although geothermal and solar PV display an equal amount of assets, the characteristics of geothermal are more in line with the government's top priorities i.e. bankability and affordability. Without the equivalent support from the GoK, solar has in fact not reached grid parity yet. So, even though the GoK took a step toward the integration of solar power to the national grid via the FiT Policy (2012), it remains cautious about locking KPLC into high cost solar for 20 years through long-term PPAs. It seems like this dynamic will perpetuate as long as the solar PV prices continue to fall. Indeed, the energy planners appear to be waiting for solar PV prices to reach a bottom threshold before incorporating the technology in the long-term energy strategy. Like the representative from the National Treasury said, "Solar is now competitive. It is still expensive but in the next 2-3 year there should be a boost occurring". This supports Newell et al. (2014) argument that in the short term, solar PV may be a victim of its high price relative to other renewable energy sources but also of its declining price. And while the government is perpetually waiting to implement solar, it heavily supports geothermal development. Once the geothermal power projects are well aligned, they generate more interest from the private sector which further accelerates their development (Acore, 2015). The interest in geothermal may thus "crowd out" the attention to other sources of renewable energy.

4. Discussion and conclusion

This working paper has analysed a number of obstacles that inhibit the adoption of grid-connected solar PV in Kenya. While the government's efforts on grid extension provide incentives for the integration of solar PV, the weak electricity infrastructure is one of those obstacles. The integration of solar PV, along other intermittent sources of power, cannot occur until the aging electricity infrastructure is improved, which requires major efforts and investments.

In the eyes of the governmental energy actors, solar remains cost-competitive for off-grid energy generation only. This fact does not solely stem from their lack of knowledge in solar PV technology but rather from the centralization of

Table 2. *Comparative characteristics of geothermal and solar PV technologies*

Geothermal		Solar PV
High	Resource potential	High
Yes	Dispatchable	No
Yes	Location-specific	No
No	Climate variable	Yes
High	Capital costs	High
Long	Lead time	Short
Low	Operation & Maintenance costs	Low
High	Required technical know-how	Low
90 %	Capacity factor	20 %
High	Government support	Low
0.088	FiT (above 10MW of installed capacity)	0.12
Yes	LCPDP	No
Yes	Long-term energy plan	No

power in the electricity network. Such institutional structure has major impacts on the integration of solar PV in the country's energy expansion plans. In fact, the various governmental energy plans do not significantly feature grid-connected solar in the energy development prospectus, despite the high potential of solar in Kenya. The exclusion of solar - despite its cost-competitiveness against other energy sources that are included in the LCPDP could be indicative of a wider political economy challenge occasioned by diverse interests. The key stakeholders who steered the LCPDP largely consist of the existing electricity providers and regulators who in one way or another may not have as much interest in solar electricity but are instead concerned more with other sources e.g. geothermal and hydroelectric power sources that have had historical control over the energy mix.

Further, an important institutional barrier to the implementation of grid-connected solar projects lies within the power purchase agreement and the letter of support, which are both managed by the government through various institutions. This barrier roots from the lagging demand that restricts the implementation of electricity generation projects in general. While KPLC is attentive to the already committed PPAs, discussions are on-going regarding the prioritisation of the newly approved PPAs. And since projects are driven from the outside (i.e. donors and foreign investors), those who generate the greatest returns to investment are prioritized. Due to their relatively slow returns to investment, grid-connected solar PV projects are overtaken by more lucrative projects such as geothermal. The high capacity factor of this technology combined with the government's strong financial incentives result in great returns to investment as well as low retail prices, which is overall more attractive to KPLC. As others suggest, there may be a rent-seeking dimension in which the government officials aspire to maintain control over profits flowing from geothermal electricity generation. The major role that the GoK is playing in relation to geothermal energy critically contrasts with solar where it has delegated this supportive role to the private sector. Without the equivalent support from the GoK, solar has in fact not reached grid parity yet. So even though the GoK took a step toward the integration of solar power to the national grid via the FiT scheme, it remains cautious about approving solar power purchase agreements that would lock KPLC into buying electricity at high prices for 20 years. The government's focus on geothermal development has thus been identified as a limiting factor to the diffusion of solar PV across the national grid.

The implications of the identified factors impeding the integration of solar PV into the Kenyan grid will inform stakeholders on the role that solar energy is going to play in the future electricity generation mix. Although the prospects of grid-connected solar PV in Kenya are not very optimistic to date, the global energy transition toward an integrated management of intermittent renewable energies might set the tone for energy development in developing countries and enable the grid-connected solar movement in Kenya.

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