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Cost and Returns of Renewable Energy in Sub-Saharan Africa: A Comparison of Kenya and Ghana

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COST AND RETURNS OF RENEWABLE ENERGY IN SUB-SAHARAN AFRICA: A COMPARISON OF KENYA AND GHANA

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Abbreviations

AfDB	African Development Bank
BGC	Bulk Generation Charge (Ghana)
CEB	Togo and Benin
CDM	clean development mechanism
CF	capacity factor
CIE	Côte d’Ivoire
CSP	concentrated solar power
DSC	Distribution Service Charge (Ghana)
ECG	Energy Commission of Ghana
ECOWAS	Economic Community Of West African States
ECREEE	(ECOWAS) Centre for Renewable Energy and Energy Efficiency
EPC	engineering, procurement and construction
ERC	Energy Regulatory Commission (Kenya)
EUT	end-user tariff (Ghana)
FCC	fuel cost charges (Kenya)
FERFA	foreign exchange rates fluctuation adjustment (Kenya)
FiT	feed-in tariff
GCP	Ghana Capital Partners
GHG	greenhouse gas
GHI	global horizontal irradiance
GRIDCo	Ghana Grid Company Limited (Ghana)
GLSS6	Sixth Round of the Ghana Living Standard Survey
IA	inflation adjustment
IDC	interest during construction
IEA	International Energy Agency
IPP	independent power producer
IRR	internal rate of return
IRENA	International Renewable Energy Agency
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KITE	Kumasi Institute of Technology and Environment (Ghana)
kWh	kilowatt-hour
KPLC	Kenya Power and Lighting Company
LCOE	levelised cost of energy
META	World Bank Model for Electricity Technology Assessments
MoE	Ministry of Energy (Ghana)
MW	megawatt
MWp	megawatt-peak
NEDCo	Northern Electricity Distribution Company Limited (Ghana)
NPV	net present value
O&M	operating and maintenance
PDD	project design documents
PPA	power purchase agreement
PURC	Public Utility Regulatory Commission (Ghana)
PV	(solar) photovoltaics
RE	renewable energy
REP	Rural Electrification Programme (Kenya)
SE4ALL	(United Nations) Sustainable Energy for All
SSA	sub-Saharan Africa
TSC	Transmission Service Charge (Ghana)
TWh	terawatt-hour

UNFCCC COP21	United Nations Framework Convention on Climate Change 21st Conference of the Parties
UNEP	United Nations Environment Programme
UNES	University of Nairobi Enterprise Services
VRA	Volta River Authority (Ghana)
WACC	weighted average cost of capital
WARMA	water levy for the use of hydro resources (Kenya)
WB PPI	World Bank Private Participation in Infrastructure

Abstract

The allocation of finance for the provision of green electricity in sub-Saharan Africa (SSA) should be informed by two questions. Which generation technologies are financially viable? And which generation technologies are affordable? Our analysis addresses these for Kenya and Ghana by calculating the levelised cost of energy (LCOE) and internal rate of return (IRR) for a portfolio of renewable energy (RE) technologies under different scenarios. Our results show better fundamentals in Kenya for the successful implementation of renewable energy projects. Wind and geothermal technology offer low-cost electricity and healthy returns on investment. Solar photovoltaics (PV) could be competitive with expensive diesel generation but its current price does not allow for cost recovery. Kenyan feed-in tariffs (FiTs) protect investors against currency devaluation and the off-taker is creditworthy. Ghana's renewable electricity (except hydro) is expensive in comparison and offers lower returns. This is mainly due to high financing costs and lower-quality RE resources. Additionally, RE investors in Ghana are not protected against further currency devaluation by the existing FiT scheme and there are concerns about the creditworthiness of the off-taker. Policymakers should target these key constraints to affordability and profitability to support a higher penetration of renewables in the country. The role of public finance and public–private partnership is particularly highlighted as a way forward to improve the financial performance of renewable energy in SSA.

Keywords: renewable energy, Africa, cost, finance

1 Introduction

Renewable energy (RE) is often hailed as a win-win solution for sub-Saharan Africa (SSA). Electrification with renewables could jointly tackle the severe electricity access deficit in the region, concerns about energy security and the challenge of climate change mitigation. A number of initiatives have risen to the challenge of providing sustainable energy for all in SSA, such as the United Nations Sustainable Energy for All (SE4ALL), the US-led Power Africa initiative, the African Development Bank's (AfDB) New Energy Deal for Africa or the Africa Renewable Energy initiative announced by Africa's leaders during the recent United Nations Framework Convention on Climate Change 21st Conference of the Parties (UNFCCC COP21) held in Paris in December 2015.

It could be argued that finance abounds for renewable energy projects in SSA. There is, however, a caveat to this enthusiastic support, relating to financial viability and affordability. In countries with budget constraints and large energy access deficits, support for anything other than least-cost generation could divert scarce finance from other development priorities, could slow down progress towards the target of universal access or could adversely affect final consumers if tariffs go up as a result. African leaders are therefore interested in getting power to the 634 million people who lack it and to productive activities starved of a reliable supply, at the least-cost and fastest alternative, whatever the source. On the other hand, financiers with several investment alternatives need to have a better understanding of which generation technologies in which countries will be able to repay their debt and provide a healthy return to equity.

Hydropower has long been a least-cost electricity source in SSA, as evidenced by its large share in the energy mix of many countries. Evidence about other renewable energy technologies is scarce. Some literature indicates that renewables are increasingly the least-cost alternative in many developing countries. Onshore wind and solar photovoltaics (PV) are becoming sources of low-cost electricity where large-scale deployment has driven down installed costs (IRENA 2015b). Recently announced long-term remuneration contract prices for renewable power to be commissioned between 2015 and 2019 show prices as low as US$5.1 cents per kilowatt-hour (kWh) for onshore wind and US$6.5 cents per kWh for solar PV in South Africa, which is below the cost of generation with fossil fuel-based plants (IEA 2015a). However, data for SSA outside South Africa is very thin due to very low implementation levels. Policy decisions to support specific technologies must therefore rely on cost assumptions taken from other regions. But the cost of renewables is highly context and time specific. It depends on local resource availability and cost structures, which are determined by financing costs, local capabilities, accumulated experience, technological progress and existing infrastructure in the host country. Assumptions based on the experience of other countries are likely to deliver misleading results. To assume that the whole SSA region has a similar cost structure and resource potential is also deeply flawed.

Very few studies have used country-specific factors to estimate the cost of renewable energy generation in Africa. For example, Ondraczek *et al.* (2015) take country-specific data on capacity factors and financing costs to calculate the levelised cost of energy (LCOE) of solar PV. They find that solar PV is an expensive option in African countries with high solar irradiation because high financing costs are particularly damaging for projects with high upfront costs and low operating costs. Ondraczek (2014) used an LCOE comparison to estimate the cost of solar PV in Kenya, finding that solar PV is already competitive with fossil fuel-based peak load technologies. However, for its calculations it used lower discount rates than those reported by investors and estimates for installed costs of solar PV based on rooftop solar PV at prices before 2011.

With more climate finance potentially being made available for green electrification in Africa, it is imperative to provide policymakers with evidence on the real cost of renewables in African countries and the main drags to financial viability for investors and affordability for consumers. This report aims at filling this gap by providing estimates of the LCOE and the returns on equity for a range of renewable energy technologies in two SSA countries: Kenya and Ghana. Due to data and time constraints this report only looks at utility-scale, grid-connected renewable energy and considers generation costs per individual technology, ignoring system-related costs and benefits. There is an emerging body of literature that is looking at the value of intermittent renewable energy generation dynamically within the systems where they operate (see, for example, Arent 2016). We will seek to contribute to this body of literature in a further study that will look at the value of wind power generation in Ghana.

Kenya and Ghana are the investment hubs in East and West Africa and present very different challenges to attract investment in renewable energy. On the basis of an extensive data collection exercise in these countries, our report addresses the following research questions:

- What is the real cost of RE generation in Kenya and Ghana? Is it affordable?
- What returns can an investor expect in each technology and country? Are they attractive enough?
- Which main obstacles to affordability and financial viability should policymakers target in each country?

The report starts by providing a background to the renewable energy sector in the two target countries. It continues by detailing the methodology used to select technologies for further study, to calculate costs and returns, and to assess the affordability of electricity for people living in poverty. It then describes the data collection process and presents the data. The subsequent section presents cost and returns results and elaborates on a number of scenarios to test their sensitivity to several parameters. We undertake an affordability analysis of renewable electricity in each country. The discussion section answers the research questions about affordability, financial viability and policy needs. The final section concludes.

2 The landscape for renewable energy in Kenya and Ghana

The electricity systems of Kenya and Ghana share several characteristics with other SSA countries: a growing demand for electricity but insufficient generating capacity; a large share of hydropower but a desire to diversify the generation mix to avoid being hostage to erratic rainfall patterns; ambitious expansion plans but low implementation rates; long lead times to financial closure and construction; and social discontent as a consequence of unreliable and/or expensive electricity. In both countries, the government is turning to expensive short-term solutions such as leased emergency power from diesel plants in Kenya or emergency gas and diesel power barges in Ghana.

We also find government disposition to support renewables as shown by the approval of feed-in tariffs (FiTs), target shares for renewable energy in Kenya and Ghana, and regulations for net metering to facilitate the sale to the grid of electrical energy generated from renewable energy systems in both countries. But despite overwhelming interest from project sponsors, the actual implementation of FiTs and net metering has been very slow in both countries. Ghana has shown a will to move from a FiT scheme towards competitive auctions, with the recent launch of a competitive bid for a 20 megawatt-peak (MWp) solar PV plant.[1] Off-grid and back-up solutions are booming, whether diesel generators or solar home systems, to palliate the shortcomings of national utilities.

There are some palpable differences in the energy landscapes of both countries. Kenya is among those African countries with the lowest electrification rates at 20 per cent (IEA 2015b).[2] More than 35 million Kenyans (17 million according to Kenya Power) are yet to access electricity. Ghana is instead one of the best performers, with a national electrification rate of 72 per cent and a higher per capita consumption of electricity than the rest of SSA excluding South Africa (IEA 2015b). However, wide disparities exist between rural and urban settings. Less than 50 per cent of Ghana's rural dwellers have access to grid electricity, mainly a result of the inability of the government to meet the huge investment cost for grid extension to such small settlements (IRENA 2015a).

Kenya and Ghana are following different approaches to diversify from hydropower. The Kenyan government has decisively supported geothermal energy, which is the cornerstone of its energy policy. Ghana does not have geothermal resources and is experiencing a strong growth of fossil fuel-based thermal generation, which is now the leading contributor to greenhouse gas (GHG) emissions in the country. With current low prices, existing diesel-based plants are not expensive to run. New renewable energy sources (bioenergy, solar, wind, biogas, etc.) remain the least tapped in Ghana and receive timid public support. This is despite the government policy direction in 2010 of generating 10 per cent of the country's electricity from renewables by 2020 (Energy Commission of Ghana 2013). At the end of 2014, the contribution of new renewables was estimated to be 0.05 per cent of the total generation mix.

The management of the national utility and the electricity tariff regimes also present significant differences. Kenya has made an effort to restore the financial sustainability of the national utility by approving cost-reflective tariffs that automatically adjust to changes in

[1] Press advertisement for Government of Ghana invitation for prequalification for 20MWp Solar PV independent power producer (IPP) Project
(GOG/MOP/20MWSP/2015/01).
[2] Kenya Power provides an alternative access rate of 40 per cent in its 2014/15 annual report.

inflation, foreign exchange rates and fuel costs. Ghana’s electric utilities are struggling, as tariffs are kept too low to allow for cost recovery and electric bills are not paid. The country is making efforts to acquire full cost recovery of electricity generation and distribution through the introduction of an automatic adjustment formula for the calculation of electricity tariffs (IRENA 2015a).

This study reveals more of the differences between Kenya and Ghana that influence the financial performance and affordability of renewable energy, including financing costs, country poverty lines, renewable energy potential, macroeconomic conditions and cost structures. Both countries have common challenges but also very different policy needs to increase the penetration of renewable energy.

3 Methodology

Three different measurements are used in our study to assess the economic and financial performance of renewable energy projects in Kenya and Ghana: the LCOE, the project internal rate of return (IRR) and the equity IRR. Their calculation has followed eight steps:

1. Selecting the technologies and projects to assess in each country
2. Developing a model to input the data required to estimate the LCOE, IRR and equity IRR of specific projects
3. Collecting project-specific data in Kenya and Ghana to populate the model
4. Identifying data gaps and referring to country, regional and international literature to make informed assumptions about missing data
5. Calculating the expected LCOE and IRR for each of the technologies in Kenya and Ghana, under a reference scenario
6. Performing a sensitivity analysis for the key parameters of costs and returns
7. Drawing implications for affordability of electricity
8. Comparing Kenyan and Ghanaian results.

3.1 Selection of target technologies and projects for further assessment

For our analysis we focus on renewable energy resources that are widely available in the target countries but are underutilised. We assess this by comparing renewable energy resource potentials, when this information is available, with the installed and planned capacity using the resource.

Data for concentrated solar power (CSP), solar PV and wind potentials for most African countries was obtained through the International Renewable Energy Agency (IRENA 2014). The report estimates the geographic potential, which takes into account areas that are suitable and usable for specific renewable energies. It sets exclusion criteria to estimate realistically the available land area (e.g. exclusion of urban areas for large-scale wind power production, protected land, sloped areas and water bodies). The technical potential would be calculated as the geographic potential minus the losses from conversion into secondary energies like electricity and constrained by the requirements related to large-scale installation, such as spacing factors, grid transportation losses, and technological, structural, ecological and legislative restrictions. A good source for hydro potentials is the World Energy Council *Survey of Energy Resources* (2013).

In addition to international sources, country-specific resource assessments were used, such as those provided by Ondraczek (2014), Kenya Power (2014), Government of Kenya (GoK) (2014) and Kiplagat *et al.* (2011) for Kenya; or Kalitsi (2003) and Edjekumhene *et al.* (2001) for Ghana. Data on installed and planned renewable energy capacity is retrieved from national planning documents.

3.2 LCOE model

The LCOE measures the total cost of producing a kilowatt-hour (kWh) of electricity over the lifetime of a project. It does so by dividing the total cost over the project life by the amount of electricity generated over the same period, to give an average cost, usually expressed in US cents per kWh. Costs comprise capital investment, operating and maintenance (O&M)

costs and decommissioning costs. Both costs and total generation per year are discounted to a reference date[3] using a discounting rate that reflects the cost of capital.

The following formula applies for calculating the LCOE for new plants:

$$\mathrm{LCOE} = \frac{\sum_{t=0}^{n} \frac{I_t + A_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{M_{t,el}}{(1+i)^t}}$$

Where:

- I_t: Investment (or capital) costs in common currency.[4] They include all expenses incurred before the plant can be operational and any further investments during the lifetime of the plant to maintain or improve the performance level. This will typically involve engineering, procurement and construction (EPC) costs; infrastructure and connection costs; development costs including permitting advisory services or land; energy resource assessments; insurance and contingencies.
- A_t: Annual total costs in year t in common currency. They include fixed and variable O&M costs. Fixed costs refer to operating labour, planned and unplanned maintenance, land use, insurance, network use charges and replacement costs. Variable O&M include fuel and residue disposal and treatment. They are not applicable to non-biomass renewables.
- $M_{t,el}$: Produced quantity of electricity in the respective year in kWh. It is calculated as the nameplate capacity, times the number of hours in a year that the plant is operational. The capacity factor is a general measurement of available capacity. It is measured as the percentage of hours in a year when the plant is operational and it is highly technology and site specific. Some adjustment is required to account for degradation. For solar PV, most assume that degradation is around 0.5 per cent per year (Ondraczek 2014). For wind, results are highly dependent on wind speed conditions. A recent publication indicates average degradation factors of 1.6 ± 0.2 per cent per year obtained from 282 wind farms in the United Kingdom (Staffel and Green 2014).
- i: Discount rate. The selected discount rate has a considerable influence on the calculated LCOE, with renewable energy technologies more sensitive to high discount rates than fossil fuel plants due to relatively high capital costs and relatively low recurrent costs. We use both the social discount rate as provided by national documents and the actual cost of finance to calculate the LCOE. The social discount rate reflects the country's financing cost in the absence of specific market or technology risks. The actual finance cost takes into account these market and technology risks.[5] We obtain it by looking at financing costs from specific renewable energy projects.
- n: Operational lifetime in years.
- t: Year of lifetime (1, 2, ...n).

In principle, we neglect scrap values at the end of life, as they have been estimated to be close to decommissioning costs (Mott Macdonald 2010) and the discounted value of the difference at the end of life is expected to be very small. We account for uncertainty in all of these model inputs by building different scenarios for a range of values for each parameter, keeping all other parameters equal.

[3] The annual amount of electricity generation in kWh is also discounted to account for the fact that the further electricity generation is in the future, the lower its cash value (Kost *et al.* 2013). Otherwise, costs in the future would be relatively too small as compared to generation in the same time period, which would render an artificially low LCOE.
[4] If all investment is incurred in year 0, it does not need to be discounted and can leave the summation term.
[5] The weighted average cost of capital (WACC) is calculated by multiplying the actual cost of equity and debt by their proportional weight in the total investment and taking the sum of the results.

The main advantage of the LCOE is that it allows for cross-technology and cross-country comparisons, as it is the most widely used measurement of costs. The main shortcoming is that it treats different generation plants independently, ignoring their interaction with other generators within the power system in which they operate (Rose *et al.* 2016). For example, intermittent generation from solar PV or wind may be more valuable in circumstances when it displaces expensive peaking capacity provided by diesel, kerosene or natural gas plants. Also, generation from intermittent sources may be less valuable when their penetration level is overly high, causing less costly technologies to be curtailed or ramped up extensively. In this case, their individual LCOE would not reflect cost increases at the system level.

3.3 IRR model

LCOEs do not provide insights into the financial performance and profitability of particular projects, which requires an analysis of their cash flows and a comparison with investment alternatives. We estimate the project and equity IRR to assess the financial performance of RE projects in Kenya and Ghana and compare them to the yield provided by national bonds. The internal rate of return is defined as the rate of return that brings a series of positive and negative cash flows to a net present value (NPV) of zero, where the NPV is the sum of the present values of incoming and outgoing cash flows over a period of time. The IRR is hence a measure of the underlying return that investors expect to achieve. The equity IRR reflects the return to the equity investor and only includes the equity share of investment as a negative cash flow in the first year. It then includes interest payments and loan repayment as part of the cash outflows of subsequent years. We assume a standard amortizing loan to calculate interest and principle payments. A standard amortizing loan has constant payments over its term. Therefore, a large percentage of the payment in the early years is applied to interest but in the later years, as the loan balance slowly declines, more and more of each payment is applied to the principle.

The project IRR includes the full investment outflow (equity and debt) in the first year and excludes the financing cash flows (interest or loan repayments) in subsequent years.

The additional parameters that we need to incorporate to the model of returns, as compared to the LCOE calculation are revenues, taxes and financing cash flows (for the equity IRR). Revenues are calculated as the electricity produced per year times the agreed feed-in tariff (FiT) for as long as it is guaranteed in the power purchase agreement (PPA) or relevant regulation. Beyond that time, we assume that the price converges towards grid parity. In Kenya, for example, we assume that beyond the guaranteed period, the price paid will be equivalent to the long-run marginal cost of electricity, which is currently set in the Least Cost Power Development Plan as 14.86 US cents/kWh. In Ghana, we could not find information on the long-run marginal cost of electricity. Therefore we use the expected cost of planned gas plants in Ghana of 13 US cents per kWh as a reference. For taxes, we take the corporate tax rate of the country considering tax holidays if there is evidence that these are applied to investors in the sector.

For the calculation of financing cash flows we need information on debt maturity, interest rate and grace period (if applicable).

The following formula applies for the calculation of the IRR:

$$NPV = \sum_{t=0}^{n} \frac{C_n}{(1+r)^n} = 0$$

Where:

- NPV is the net present value, estimated as the discounted cash flows of the project
- C_n are the cash flows of the project
- r is the IRR, that brings the NPV equal to zero.

3.4 Affordability for the poor

Affordability for the poor of different alternatives of electricity supply is defined as the possibility to purchase a subsistence level of consumption without spending more than a given share of the household budget. The subsistence level of consumption and the affordability threshold need to be predefined but will always require subjective values and calculations. We set 50kWh as this is a threshold commonly used in Africa as a consumption level benchmark, and that sets the upper limit for lifeline tariffs in Kenya and Ghana.

We consider an affordability threshold of 5 per cent of household expenditure, based on historic trends of household expenditure patterns and results of willingness-to-pay surveys in Africa (Banerjee *et al.* 2008; Briceño-Garmendia and Shkataran 2011).

The household budgets of people living in poverty can be defined in terms of the overall national poverty line. Multiplying the national poverty line by the mean household size of the target countries, we can estimate household budgets at the poverty line. Monthly subsistence electricity tariffs affordable for those living in poverty should therefore not be more expensive than 5 per cent of household budgets.

Another arguably more important element of affordability refers to upfront costs, which include connection fees, wiring, light bulbs and additional appliances such as a radio or mobile phone. However, these are independent from the generation source, and therefore will not be the focus of our study.

4 Data collection

4.1 Target technologies

Kenya has vast renewable energy resources within a total land area of 582,253km^2. It is particularly well endowed with solar, wind and geothermal energy. Hydro and geothermal resources have been harnessed to some extent but wind and solar PV remain largely untapped.

As at December 2014, the installed capacity of hydropower generation was 821MW (megawatt) equivalent to 38 per cent of total installed capacity. It is estimated that the undeveloped hydroelectric power potential of economic significance is 1,449MW of which 1,249MW is for projects of above 10MW. In Kenya a hydropower station with capacity below 10MW is considered small. The total estimated potential of small, mini, micro and pico hydro systems is 3,000MW of which about 25MW has been developed (June 2015 Draft National Energy and Petroleum Policy). Current dependence on hydropower for electricity generation has created energy security concerns when the country has faced droughts. As a result, Kenya has been drawn to rely heavily on expensive and dirty fuel oil-powered emergency generators.

Geothermal power has been a dominant source of electricity in the recent past, making a contribution of more than 50 per cent of generation. There is still a large geothermal potential left to exploit, with resources along the Rift Valley with an estimated potential of more than 10,000MW. The Kenyan government has shown a strong commitment to support further development to secure supply.

Kenya has a good average solar irradiation due to its location along the equator, but it does not yet have large commercial solar generation. The small off-grid solar PV market, however, is booming. Kenya also has high-quality wind energy resources in specific locations, mainly in Marsabit, Samburu, Isiolo, Nyeri and Nairobi, but at the moment there is one single plant in operation (Ngong Hills) and another one under construction (Turkana).

Biomass power generation potential is mainly in the sugar industry that uses bagasse (a biowaste from the sugarcane processing industry) as a primary fuel. The sugar industry potential capacity is estimated as 193MW (Kiplagat *et al.* 2011). Mumias and Kwale are currently the only sugar factories that are self-sufficient and able to export surplus power to the grid, with 38MW capacity as at November 2014 (ERC 2015) from Mumias and 18MW from Kwale International Sugar Company (Republic of Kenya 2011; Kenya Power 2014) while about 1,000MW has been planned to 2030 (REN21 2015).

Table 4.1 shows the estimated potential for each generation technology, as well as the existing capacity in operation and targets to add further capacity. On the basis of their large potential and availability of data, we focus our study of costs and returns of renewables in Kenya on solar PV, wind, hydro and geothermal.

Table 4.1 Renewable energy potential in Kenya

Technology	Potential (TWh/y or MW)	Capacity in operation as at Nov 2014 (MW)	Targets (MW)
CSP (geographic potential)	15,399 TWh/y	-	-
Solar PV (geographic potential)	23,046 TWh/y	20[6]	423*
Wind turbine CF>20% (geographic)	22,476 TWh/y	25.5	635* 2,000**
Wind turbine CF>30% (geographic)	4,446.4 TWh/y		
Wind turbine CF>40% (geographic)	1,739.6 TWh/y		
Large hydro (technical potential)	1,500 MW	821	794**
Small hydro (<10MW) (technical potential)	3,000 MW	32	
Geothermal (technical potential)	10,000 MW	593	1,900* 5,000**
Biomass (bagasse cogeneration) (technical)	192.8 MW	38	1,000**

Notes: TWh/y refers to terawatt hours per year. * target by 2016; ** target by 2030. CF refers to capacity factor.

Sources: IRENA (2014) for CSP, solar PV and wind resource potentials; Kiplagat *et al.* (2011) for hydro, biomass cogeneration potential; Republic of Kenya (2011) for geothermal resource potential; ERC (2015) for operating capacity; Kenya Power (2014) and REN21 (2015) for targets.

Ghana is 40 per cent the size of Kenya (238,761km^2) and its renewable energy potential is considerably smaller except for large hydropower, as shown in Table 4.2. Hydropower potential has been harnessed to a large extent but substantial potential is still untapped and several areas have been marked as potential sites for medium and mini hydropower plants. Other sources remain largely unused, with several projects proposed but implementation slow. Wind energy potential is located along the coastal areas and along the border with Togo. According to the United Nations Environment Programme (UNEP) (2005), wind potential along the border of Ghana and Togo is estimated to be about 2,000MW. While this is small compared to Kenya's potential, it is more than the Ghanaian system could integrate at the moment, with a total installed capacity of 2,831MW (ECG 2015b). Solar energy resources are particularly good in the northern regions, with a mean annual global horizontal irradiance (GHI) of 5.74kWh/m^2/day (ECREEE 2015).

On the basis of resource potentials and data availability, our analysis of costs and returns of renewable energy in Ghana focuses on wind, solar PV and hydro.

[6] See Waruru (2015).

Table 4.2 Renewable energy potential in Ghana

Technology	Geographic (TWh/y) or technical (MW) potential	Capacity in operation as at Dec 2014 (MW)	2020 Targets (MW)
Concentrated solar power (CSP)	229TWh/y	-	-
Solar PV	7,644TWh/y	2.5MW	150
Wind turbine CF>20%	606TWh/y	-	200
Wind turbine CF>30%	2.4TWh/y		
Wind turbine CF>40%	-		
Large hydro (technical potential)	2480 MW	1580 MW	150
Small hydro (<10MW) (technical potential)	1.2-14MW		
Modern biomass and waste-to-energy			90

Sources: IRENA (2014) for CSP, solar PV and wind resource potentials; Ministry of Energy (2012) and Kalitsi (2003) for hydro potential; Energy Commission of Ghana (2015a) for installed capacity; Ministry of Energy (2012) for 2020 targets; interview with Energy Commission of Ghana for solar targets.

4.2 Data sources

We draw from project-specific data and international and country-specific literature sources to find the parameters required to populate our LCOE and IRR models. The specific projects targeted for data collection are detailed in Table 4.3. The table shows the country where they are located, size, technology and the sources of data about the project. Only the three Kenyan geothermal projects are operational and can therefore provide the most accurate data. The other projects are at different stages of project development. Ghana's wind power plants and two of the solar PV plants have not yet reached financial closure. Nzema solar PV plant is unlikely to be implemented due to its large size, but it can provide useful information on investment costs. The 20MW solar plant has already been built, but we could only find limited information about it in the press. There is also a 4.5MW solar PV plant operational in Ghana, but we were unable to obtain relevant information. In Kenya, all wind plants have reached financial closure and the Turkana wind farm has begun construction.

Table 4.3 Projects analysed in Kenya and Ghana

Country	Technology	Capacity (MW)	Project name	Sources and date
Ghana	Solar PV	155	Nzema solar PV	Project website 2015 Press 2014 World Bank Private Participation in Infrastructure (WB PPI) database 2012 ECG documentation, 2015 Expert elicitation 2015
Ghana	Solar PV	28	Ghana Capital Partners solar	Climate Technology Initiative – Private Financing Advisory Network presentation 2015 Interview of project sponsor 2015
Ghana	Solar PV	20	BXC Solar Ghana	Press 2015
Ghana	Wind	100	Generic project	ECG documentation, 2015 Expert elicitation 2015
Ghana	Hydro	140	AIE Ankobra hydro	WB PPI database 2012

(Cont'd).

Table 4.3 (Cont'd).

Country	Technology	Capacity (MW)	Project name	Sources and date
Ghana	Hydro	93	Generic project	ECG documentation, 2015 Expert elicitation 2015
Ghana	Small hydro	18	Generic project	ECG documentation, 2015 Expert elicitation 2015
Kenya	Solar PV	40	Isiolo solar	ERC interview 2015 Press 2015
Kenya	Wind	310	Turkana Wind Power Plant	WB PPI database 2012 Clean development mechanism (CDM) project design document (PDD) 2011 Project website[7] 2015 Lake Turkana Wind Power 2014 Interview of project manager 2015
Kenya	Wind	61	Ngong Wind	WB PPI database 2012 KenGen annual report 2010
Kenya	Wind	100	Kipeto	CDM PDD 2012
Kenya	Hydro	60	Mutonga	Least Cost Power Development Plan, 2012
Kenya	Hydro	140	Lower Grand Falls	Least Cost Power Development Plan, 2012
Kenya	Hydro	160	Kiambere	ERC interview, 2015
Kenya	Micro-hydro	0.514	Gikira	ERC interview
Kenya	Geothermal	140	Olkaria I	KenGen presentation, 2012 CDM PDD, 2012
Kenya	Geothermal	140	Olkaria IV	KenGen presentation, 2012 CDM PDD, 2012
Kenya	Geothermal	13, 48, 84	Ormat Olkaria III (three phases)	WB PPI database 2012 Micale, Trabacchi and Boni (2015)

When we relied on interviews for data collection our informants were reluctant to provide detailed costing information on the basis of confidentiality. In Kenya, the Energy Regulatory Commission (ERC) provided high-level data such as the electricity prices, technical life-time, and debt and equity ratios. The approach for data collection in Ghana involved the review of relevant project documents from their original sources at the Energy Commission of Ghana. The Renewable Energy Division of the Energy Commission of Ghana was the focal sub-institution for gathering these relevant data as it is the mandated regulatory and licensing body of renewable energy projects in Ghana and therefore had custody of all the renewable energy projects' documents, whether planned, constructed or operational. With permission from the Executive Secretary of the Energy Commission, information needed for the analysis of the financial and economic viability of renewable energy types was extracted from these projects' documents. In most cases, project data in these documents were very scarce. We designed and administered questionnaires for purposefully selected respondents in order to capture the relevant non-existent information in the projects' documents. The data gathered from the administered questionnaires complemented those that were extracted from the projects' documents. Key institutional players in Ghana's renewable energy sector that were earmarked for responses to the questionnaires are shown in Table 4.4.

[7] Project website: www.ltwp.co.ke/the-project/overview.

Table 4.4 Institutions served with questionnaire

Institution	Focal person
Energy Commission of Ghana	Head of Strategic Planning; Acting Director of the Renewable Energy Directorate
Ministry of Energy (MoE)	No response
Volta River Authority (VRA)	Head of Engineering Department
Ghana Grid Company Limited (GRIDCo)	No response
Kumasi Institute of Technology and Environment (KITE)	Chief Executive Officer
Public Utility Regulatory Commission (PURC)	Senior Officer at the Economic Division

Collection of project-specific data also relied on the use of secondary sources such as the World Bank Private Participation in Infrastructure (WB PPI) database (World Bank 2015), project websites and project design documents (PDD) available from the clean development mechanism website.

We used the information available in the economic and financial analysis of projects that were requesting registration as a clean development mechanism (CDM) from the UNFCCC. For our target technologies, only Kenyan projects had been submitted for CDM registration. Their project design documents include general project data (i.e. nameplate capacity, project life and electricity tariff); investment cost (i.e. pre-project costs, and interest during construction (IDC) costs); annual costs (such as O&M) and debt schedule data (debt/equity ratio, maturity and interest rates). It is worth noting that in their PDDs, project developers need to demonstrate the need for carbon credits to achieve economic viability. This may have biased upwards some of the cost assumptions made in the PDDs.

The WB PPI database includes renewable electricity generation projects in developing countries with private participation of at least 25 per cent, with a capacity of at least 1MW or that are worth at least US$1m. The general PPI database only includes projects that have reached financial closure. The Renewable Energy database, part of the WB PPI database, also includes from 2012 pipeline projects that have not reached financial closure. Relevant project data in the database include: total investment (US$), capacity (MW) and debt/equity ratio. We found two relevant projects from Ghana (one solar PV and one large hydro) and five from Kenya (two wind and three geothermal).

International, Kenyan and Ghanaian sources to fill data gaps not covered by our project data collection are presented in a table in the Annexe. The table describes each source as well as the specific parameters that they provide to populate our LCOE and IRR model. For the calculation of LCOE and IRR of each technology and each country we give more weighting to the most recent sources and to those that are specific to Kenya and Ghana.

5 Costs and return parameters

In this section, we show for each parameter the different values provided by the sources used. We then select a representative value for each technology and country calculated as an average. The level of uncertainty of these final values is very high because the value for each parameter is context and project specific. We even find different values for the same project when provided by different sources. This is particularly the case for investment costs and capacity factors.

Country-specific sources and the most recent literature are given more weight when selecting parameters. This is especially important for unit investment costs where the most recent sources are likely to present the most reliable data, as the total cost of the project is more accurately known the closer it is to the construction stage. We also show international and African averages, which can be used as benchmarks. All values are presented in 2015 US dollars. We present uncertainty ranges at a 95 per cent confidence level for each parameter when this is possible.

5.1 Unit investment costs

Obtaining reliable data on investment costs in Kenya and Ghana is difficult because there are few operational non-hydro RE projects. Table 5.1 shows the unit investment costs reported by different sources for each country and technology. The final parameters shaded in grey are calculated as the average of the unit investment costs of different projects or literature sources. Investment costs are presented in 2015 US$/kW to allow comparability.

Because project estimates are based on a very small pool of projects that have not yet been commissioned, we tested the reliability of our data by creating confidence intervals for unit investment costs with a sufficient number of observations in each country and in Africa. We also compare representative values for each country to values in the SSA region or internationally.

Table 5.1 Unit investment costs (2015 US$/kW)

	Kenya	Ghana	Africa	International
Wind onshore	**2,538.8** (2,225.3; 2,852.4)	**1,860**	**2,368.4**	**1,316.1 (China)** **1,787.3 (USA)**
Sources	Turkana 2,339.4 Ngong Hills 2,812.5 Kipeto 2,808 Kinangop 2,434.3 Republic of Kenya (2011) 2,300	ERC (2015)	McKinsey (2015) 2,563 WB PPI (2012) 2,265 IRENA (2015b) 2,232	IRENA (2015b)
Solar PV	**2,150**	**2,014.52** (1,429.3; 2,599.7)	**3,472**	**1,306 (lower)** **5,425 (upper)** **3,000 (LDC)**
Sources	Isiolo 2,150 ECA and Ramboll (2012) 2,765 Hille *et al.* (2011) 2,713.2	Nzema 2,258.1 GCP 2,000 ERC 2,300 BXC 1,500	IRENA (2015b) 3,117.5 WB PPI 3,978	IRENA (2015b) Rose *et al.* (2016)

(Cont'd).

Table 5.1 (Cont'd).

	Kenya	Ghana	Africa	International
Hydro (large)	**3,829**	**2,362.1**	**2,538**	**1,004.7 (lower)** **3,516.4 (upper)**
Sources	Kiambere	Ankobra 1,123.7 ERC 3,229	McKinsey (2015)	IRENA (2015b)
Hydro (small)	**2,589**	**3,199**	**2,645**	**Similar to large scale**
Sources	ECA and Ramboll (2012)	ERC (2015)	WB PPI (2012)	
Geothermal (conventional)	**3,901 (conventional)** **4,045.5 (binary)**	**-**	**-**	**2,419 (conventional)** **3,290 (binary)**
Sources	Olkaria I 3,891 Olkaria IV 3,994 Ormat Olkaria III 4,045.5			IRENA (2015b)

Table 5.2 shows descriptive statistics and 95 per cent confidence intervals for wind and solar PV unit investment costs, including all our observations for Kenya, Ghana and Africa. It was not possible to build confidence intervals for other technologies due to the small number of observations.

Table 5.2 Descriptive statistics and 95 per cent confidence intervals for wind and solar PV unit investment costs

	Obs.	Mean	sd	95% confidence interval
Wind	11	2,237.41	450.95	(1,934.46; 2,540.37)
Solar PV	9	2,487.57	676.83	(1,967.31; 3,007.82)

Unit investment costs of wind power in Ghana are below the lower bound of the confidence interval and they are likely to have been underestimated. Ghana does not have previous experience in wind power and therefore has not yet been able to benefit from learning effects or economies of scale. The value reported for Ghana is based on information for a single generic wind project that would have not reached financial closure yet. Therefore it will be important to carry a sensitivity analysis of costs and returns to higher investment costs. On the other hand, unit investment costs of wind power in Kenya are just below the upper bound of the confidence interval. This could be as a result of lack of experience, lack of specialised transport and installation or higher concrete and steel prices.

Utility scale solar PV costs in both Kenya and Ghana are lower than the African average. The Ghanaian average includes a lower bound of US$1,500/kW based on a 20MW plant recently built by Chinese developers, which is reported to have cost US$30m.[8] The lower cost of Kenyan and Ghanaian projects could be due to the continuous decline in solar PV installed costs, which makes more recent projects less costly than older ones. The values are within the range of international estimates provided by IRENA (2015b).

Installed costs of hydropower plants are very site and size specific, presenting a broad variation across sources. We have very few observations for Kenya and Ghana. The Kenyan large-scale value is above the African average and the international upper bound, but it is

[8] RECP – Africa-Europe Renewable Energy Cooperation Programme, www.africa-eu-renewables.org/2015/11/23/20mw-solar-plant-in-ghana-takes-trial-run/.

based on a single project and therefore is not representative. The Ghanaian value is in line with the African average and within the international cost range. The small-scale value in Ghana is based on a single project and hence it is not representative, but it is within the international range and not too far from the African average. The Kenyan small-scale value is not far from the African average and within the international range, but it is based on a single source.

Conventional geothermal values in Kenya based on observations from 140MW Olkaria I and IV and 110MW Olkaria III plants are high compared to international figures provided by IRENA (2015b).

It is important to take into account Africa's history of cost overruns as part of our sensitivity analysis. An analysis of 16 African power generation projects completed or near completion found average budget overruns of 33 per cent (McKinsey 2015). Larger and more complex projects have largest overruns, with wind projects having the largest overrun.

5.2 Operations and maintenance costs

O&M costs are presented in Table 5.3 as a percentage of investment cost. Kenyan and Ghanaian values are quite similar and are not far from African and international estimates in most cases. In Kenya, the Turkana wind farm shows higher O&M costs than observed in other projects. This could be as a consequence of its very high capacity factor, which delivers a low O&M cost per kWh generated but a high O&M cost as a percentage of investment costs. RE technologies (other than biomass) are characterised by high investment costs and low O&M costs, as shown by the values in Table 5.3.

Table 5.3 Operations and maintenance costs (%)

	Kenya	**Ghana**	**Africa**	**International**
Wind onshore	**3.25 %**	**2.4%**	**3%**	**0.8%**
Sources	Turkana (2011) 4% Kipeto (2012) 2.5% ECA and Ramboll (2012) 1.36%	ECG and expert elicitation, 2015	IRENA (2015b)	World Bank Model for Electricity Technology Assessments (META) (2011)
Solar PV	**1%**	**1%**	**-**	**1.05%**
Sources	ECA and Ramboll (2012) 1.31% ERC (2015) 1%	ECG, 2015 0.2% Ghana Capital Partners (GCP) solar (2015) 1%		WB META (2011) 0.3% Ondradzek *et al.* (2015) 1.5%
Hydro (large)	**-**	**1%**	**-**	**1.4%**
Sources		ECG and expert elicitation, 2015		WB META (2011) 0.8% IEA (2010) 1.5–2.5%
Hydro (small)	**2.8%**	**2.7%**	**-**	**1.5% – 2.5%**
Sources	ECA and Ramboll (2012) 2.8%	ECG and expert elicitation, 2015		IEA (2010) 1.5–2.5%
Geothermal (conventional)	**65 US$/kW (fixed) 0.0116 US$/kWh (var)**	**-**	**-**	**3–6%**
Sources	Olkaria I and IV (2012)			IRENA (2015b) 2.9–5.8%

5.3 Capacity factors

The capacity factor measures the percentage of total hours in the year when the project is operational. This depends on resource availability and technology performance. Capacity factors were obtained from project-specific data in Kenya and Ghana and were complemented with values provided in the literature. We also provide African and international averages for comparison.

The high capacity factors in Kenya reflect a very rich renewable energy resource potential. Certain regions (such as Marsabit, Turkana, Ngong and the Coastal region) enjoy wind speeds ranging from 8m/s (metres per second) to 14m/s, allowing for capacity factors above 40 per cent (Kiplagat *et al.* 2011). The Turkana wind power plant, in particular, claims a capacity factor of 62 per cent in corporate presentations. However, they claimed a much lower value of 46 per cent in their project design document to request registration as a clean development mechanism. Kenya's solar resource is also vast. Geothermal resources, located in the volcanic centres around the Rift Valley are unique in Africa. Ghanaian resources are more modest, with average wind speeds of 6.4m/s to 7.5m/s and no geothermal resource potential. Capacity factors of hydropower are estimated at around 50 per cent internationally. Actual availability depends on rainfall patterns, which have been unpredictable in Kenya and Ghana, both suffering severe droughts in recent years.

Table 5.4 Capacity factors (%)

	Kenya	**Ghana**	**Africa**	**International**
Wind onshore	**45%**	**25%**	**32%**	**30%**
Sources	Turkana 46% (CDM-PDD 2011) 62% (LTWP, 2014) Kipeto 46% Republic of Kenya (2011) 40%	ERC (2015)	IRENA (2015b)	WB META (2011)
Solar PV	**20%**	**17%**	**22%**	**20%**
Sources	ECA and Ramboll (2012) 20% Isiolo 21% Ondraczek *et al.* (2015) 19.4%[9]	GCP solar (2015) ECG, 2015 Ondraczek *et al.* (2015) 16.9%	IRENA (2015b)	WB META (2011)
Hydro (large)	**55%**	**50%**	**-**	**50%**
Sources	Mutonga 60% Lower Grand Falls 60% Kiambere 50%	ECG, 2015 50%		WB META 50% IRENA (2015b) 50%
Hydro (small)	**50%**	**34%**		
Sources	Gikira 50%	ECG, 2015 34%		
Geothermal	**92%**	**-**	**-**	**90%**
Sources	ECA and Ramboll (2012) 90% Olkaria I 92% Olkaria II 92% Republic of Kenya (2011) 93%			WB META (2011)

[9] We calculate the values based on Ondraczek *et al.* (2015) figures of global horizontal irradiance (GHI) and performance ratio for each country, taking an average performance ratio of 80 per cent.

5.4 Financing costs

Renewable energy projects are particularly sensitive to high financing costs, as they are characterised by high upfront costs and low operational costs. We calculate the LCOE of different RE generation technologies using both the social discount rate and the true financial cost for investors operating in our target countries. As per the true financial costs, we consider a low cost and a high cost scenario.

Social discount rates measure 'the rate at which a society is willing to trade present for future consumption' (Lopez 2008). Policymakers use them in cost-benefit analyses of social projects. Countries with high social discount rates will tend to favour projects with short-run benefits as opposed to those that deliver benefits in the long term. The World Bank typically uses a social discount rate of 10 per cent to assess infrastructure investments in developing countries. This rate, twice as high as the one used in OECD countries, reflects a higher time discount in poorer countries. Cost-benefit analyses in Kenya use a social discount rate of 10 per cent (UNES 2014). A higher rate of 12 per cent is used in Ghanaian policy documents (Energy Commission of Ghana 2013).

Three elements determine financing costs: the debt to equity ratio, the cost of equity and the cost of debt. The cost of debt depends on the interest rate, maturity and grace period of the loans provided. Equity investors usually require rates of return of at least twice the cost of debt, as they assume a higher risk. Projects with high equity shares therefore bear higher financing costs. Smaller and riskier projects typically require higher equity shares as they struggle to be attractive for debt investors. In any case, data collected for Kenya and Ghana showed a debt–equity ratio of 70:30, which is similar to that observed in developed countries with lower perceived risks.

Project developers in Kenya and Ghana can access both commercial and concessional finance. Commercial finance is faster to obtain but it charges highest rates and typically offers lower maturities. Concessional finance offers better terms but usually involves larger transaction costs and a slow turnaround. Both domestic and international banks can provide commercial debt for project developers in Kenya and Ghana. International banks usually offer better rates and leaner processes, as they have more experience in renewable energy and more capital available.

We found that projects owned by national utilities in Kenya usually access finance with better terms than those available to private investors. Publicly owned geothermal projects in Kenya can access debt finance at very low interest rates, long maturities and generous grace periods. For example, Olkaria I and IV pay average interest rates of 1.05 per cent and 2.05 per cent for their debt, with average maturities of 23 years and 13.4 years and grace periods of between three and six years. Publicly owned wind projects would access debt finance at a 4.5 per cent rate with 14 years tenure. Independent power producers (IPPs) in the wind and geothermal sectors pay higher interest rates, between 6 per cent and 10 per cent, and have maturities of between 12 and 19 years.

We also found access to better financing conditions in Kenya than in Ghana. We relied on financing costs data published by the Central Bank of Ghana and interviews with stakeholders, as we could not access financing costs data from any Ghanaian project having reached financial closure. Access to international finance is key for the viability of renewable energy projects in Ghana, given the high cost of local finance. Average debt rates for international finance, with some concessional finance, are 7.5 per cent. Fully commercial debt would require 12 to 16 per cent interest rates. Domestic lending rates are significantly higher, at 21 to 37 per cent. Loan maturities are 9 to 15 years. Rates of return required by equity investors can be as high as 30 per cent (GCP 2015). Ghana's 90-day treasury bill rates at December 2014 stood as high as 24.25 per cent, showing the availability of highly lucrative, investment alternatives.

Commercial lending rates in Kenya are 16 per cent in nominal value, as published by the Central Bank of Kenya for December 2014. The cost of private equity is between 16 per cent and 20 per cent, according to investors. On the other hand, Kenya's 90-day treasury bills, which could be an alternative for investors, paid nominal rates of 8.6 per cent as per December 2015.

An additional factor to take into account is the emergence of China as a non-traditional financier in the region. China is now the largest financier of power projects in Africa (Eberhard and Shkaratan 2012). Chinese investment is mainly focused on large hydro projects, but it has also led to the first privately owned solar PV IPP in Ghana, a 20MW plant financed by BXC Beijing China, at an estimated cost of more than US$30m.[10] We could not obtain further details about the financing structure of this project, but Chinese-supported projects typically access soft loans and export credit from Chinese development banks. The interest rate of Chinese development banks is about 3 per cent to 4 per cent (Libor plus 200 or 300 basis points (bp)) for Ghana's sovereign risk. When the borrower's credit rating is lower than that of the Government of Ghana, the interest rate can be higher by 50 to 100 bp, reaching 4 per cent to 5 per cent.[11] This is not far off the cost of international debt as reported by a private investor in solar PV in Ghana (GCP 2015).

Table 5.5 Financing costs of Kenyan and Ghanaian RE projects

	Kenya	**Ghana**
Social discount rates	**10%**	**12%**
Sources	UNES (2014)	ECG (2013)
Cost of equity	**10% KenGen (assumed)** **18% IPP**	**27% IPP**
Sources	ECA and Ramboll (2012) 18% Waissbein *et al.* (2013) 18% Central Bank of Kenya (2015)[12] 8.6% Turkana 15–20% Ormat Olkaria 16%	Central Bank of Ghana (2015) 24.2% GCP (2015) 30%

(Cont'd).

[10]RECP – Africa-Europe Renewable Energy Cooperation Programme. www.africa-eu-renewables.org/2015/11/23/20mw-solar-plant-in-ghana-takes-trial-run/.
[11] Written communication with Wei Shen, Research Fellow at the Institute of Development Studies, 24 February 2016.
[12] The information on treasury bill rates for Kenya and Ghana is provided in the website of their central banks: Central Bank of Ghana www.bog.gov.gh; and Central Bank of Kenya www.centralbank.go.ke (both accessed December 2015).

Table 5.5 (Cont'd).

Cost of debt	**2.7% KenGen projects** **8% IPPs**	**7.5% (concessional-international)** **15% (commercial-assumed)**
Sources	Olkaria I 1.05% Olkaria IV 2.5% KenGen Ngong Wind (2008 and 2010) 4.5% Ormat Olkaria III 6.2% Turkana 7.5% ECA and Ramboll (2012) 8% Waissbein *et al.* (2013) 8.5% Kipeto 10% Kenya CB commercial lending rate Dec 2015 16% WB lending rate (2014) 16.5%	ECG, 2015 7.5% Ghana CB commercial lending rate Dec 2015 21%–37% GCP (2015) 5.15% (assumes a cost of US$ LIBOR+ 400 basis points)
Debt maturity (years)	**16.5 years**	**12 years**
Sources	Olkaria I, 23 years Olkaria IV, 13.4 years Ormat Olkaria III, 10 to 19 years Kipeto, 17.5 years KenGen (2008 and 2010) 14 years Turkana, 12 years	GCP (2015) 9 years ECG and expert elicitation, 2015 15 years Assumption for FiT design: 10 years
Grace period	**4.5 years (only public geothermal)**	**-**
Sources	Olkaria I 5.7 years Olkaria IV 3.3 years	-
Debt–equity ratio	**70:30**	**70:30**
Sources	Olkaria I, 70:30 Olkaria IV, 70:30 Turkana Wind, 70:30 ERC (2015), 70:30 Kipeto, 80:20	ECG and expert elicitation, 2015 GCP (2015)
WACC	**5% (KenGen)** **11% (IPP)**	**10% (concessional)** **18.6% (commercial)**
Sources	Calculated based on data above	Calculated based on data above

5.5 Electricity tariffs

This section explains the different methods used by Kenyan and Ghanaian regulators to set up electricity tariffs and the resulting values. It also presents the FiT schemes approved in both countries. Finally, it compares tariff levels in both countries and comments about the implications of these differences for investors.

5.5.1 Kenya

The Energy Regulatory Commission (ERC) in Kenya sets electricity tariffs. Kenya has made a significant effort to design cost-reflective tariffs that enable all the operators in the electricity system to maintain their financial integrity, attract capital, operate efficiently and fully compensate the investor for the risks assumed (ERC 2010).

Tariffs comprise a fixed charge, a demand charge and an energy charge. The fixed charge is set to recover the customer-related costs of metering, meter reading, inspection, maintenance billing and customer accounting. These costs remain constant but vary with the customer category, being higher for larger consumers. The demand charge recovers the costs associated with the transmission and distribution network. It is derived directly from the long-run marginal cost related to the transmission and distribution network. Domestic consumers and the smallest commercial consumers are not required to pay a demand charge and hence transmission and distribution costs are fully covered by industry. They remain constant but are smaller for larger consumers. The energy charges per kWh are set on the long-run marginal costs tariff rates adjusted to the real financial revenue requirement of Kenya Power and Lighting Company (KPLC). Energy charges are set progressively for residential tariffs, with less affluent and lower-use consumers paying less than wealthier, more intensive-use consumers. Commercial and industrial tariffs work the other way, with the largest consumers paying less per kWh. Energy charges for commercial consumers are lower than those for residential consumers, but commercial consumers are subject to higher monthly fixed charges and demand charges. Current tariffs, as published in the *Kenya Gazette* on 17 January 2014, are presented in Table 5.6.

Table 5.6 Kenya electricity effective from 1 July 2015

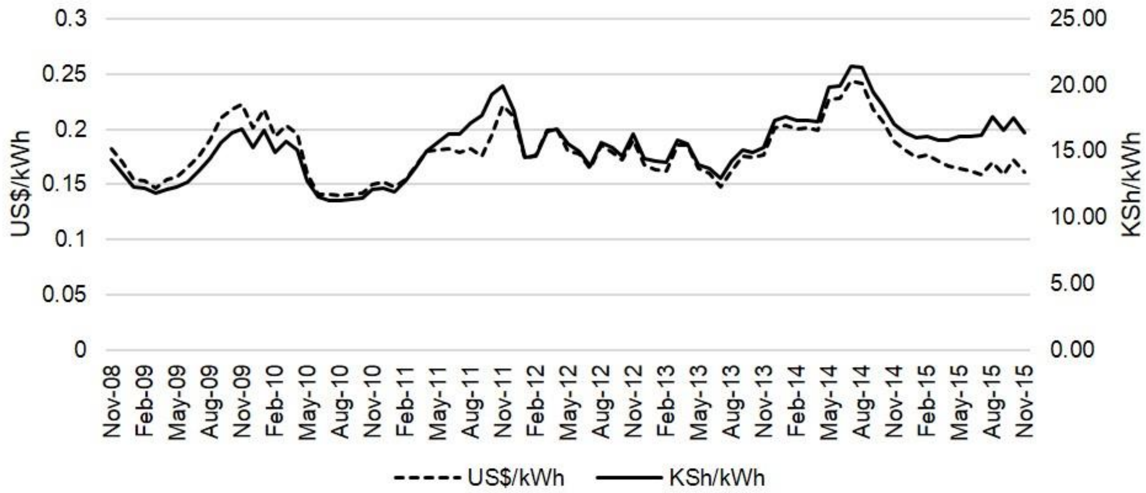
	Monthly fixed charge		Energy charge		Demand charge	
	KSh	**US$**	**KSh/kWh**	**US$/kWh**	**KSh/kVA***	**US$/kVA**
DC (Domestic, 240 V)	150	1.52			-	-
First 50kWh			2.50	0.03		
50 to 1500kWh			12.75	0.13		
Thereafter			20.57	0.21		
SC (Small Commercial, 240 V)	150	1.52	13.50	0.14	-	-
CI1 (Commercial, 415 V)	2,500	25.41	9.20	0.09	800	8.13
CI2 (Commercial, 11 kV)	4,500	45.74	8.00	0.08	520	5.29
CI3 (Commercial, 33 kV)	5,500	55.90	7.50	0.08	270	2.74
CI4 (Commercial, 66 kV)	6,500	66.07	7.30	0.07	220	2.24
CI5 (Commercial, 132 kV)	17,000	172.79	7.10	0.07	220	2.24
IT (Domestic water heating)	150	1.52	13.50	0.14	n/a	

* kVA refers to 1,000 volt amps. Exchange rate 98KSh/US$ or 0.01 US$/KSh, calculated as monthly average in 2015 based on data published by the Central Bank of Kenya, December 2015, www.centralbank.go.ke/index.php/rate-and-statistics/exchange-rates-2

A key feature of Kenya's tariff schedule is the automatic pass-through on a monthly basis of generation fuel costs and exchange rate fluctuations through fuel cost charges (FCC) and the foreign exchange rates fluctuation adjustment (FERFA), as well as inflation adjustments every six months through an inflation adjustment (IA). Additionally, consumers pay a water levy for the use of hydro resources (WARMA) at 5 cents per kWh, the Energy Regulatory Commission Levy at 3 cents per kWh, the Rural Electrification Programme (REP) Levy at 5 per cent of the base rate and VAT at 16 per cent on everything except the water levy, ERC and REP levies and the IA (ERC 2013).

Figure 5.1 shows the trend of the average electricity tariff (across all residential and non-residential categories) within the last seven years, including surcharges but excluding fixed and demand charges. Tariffs have experienced some volatility in recent years, mainly due to changes in the cost of fossil fuels.

Figure 5.1 Trend in average electricity end-user tariff, Kenya



Source: Authors' elaboration based on data from https://stima.regulusweb.com/ and US dollar conversion using monthly exchange rates from www.investing.com/currencies/usd-kes-historical-data

Kenya has approved FiTs to promote investment in renewable energy generation. The FiT policy was first published in 2008. It has since been revised twice to include additional technologies, to change capacity limits and to change tariffs when they were not deemed attractive enough for investors. The last revision took place in December 2012. The main elements of the FiT are guaranteed tariffs, a connection obligation for the transmission company and a purchase obligation for the off-taker. The FiTs include an allowance for interconnection costs, which must be borne by the developer. The off-taker must guarantee priority purchase, transmission and distribution for small renewable energy projects and must comply with the terms of a negotiated power purchase agreement (PPA) for large-scale renewable energy projects. The off-taker can pass through the costs of the FiT to the final consumer.

FiTs are denominated in US dollars or other selected foreign currency and they are guaranteed for 20 years. They have a fixed value and an indexed component related to O&M costs, which are the only costs that will vary during the 20-year guaranteed period. Different tariffs are set for projects below and above 10MW. A maximum cumulative capacity is also set for large-scale projects.

Tables 5.7 and 5.8 present the FiT values, as well as the capacity limits and the indexed portion for each technology. The values presented in the tables are therefore not significantly higher than the energy charges or the current electricity tariffs.

Table 5.7 FiT values for small grid connected renewable projects in Kenya (up to 10MW) in US$

	Installed capacity (MW)	**Standard FiT (US$/kWh)**	**Percentage escalable portion of the tariff**	**Minimum capacity (MW)**	**Maximum capacity (MW)**
Wind	0.5–10	0.11	12%	0.5	10
Hydro*	0.5	0.105	8%	0.5	10
	10	0.0825			
Biomass	0.5–10	0.10	15%	0.5	10
Biogas	0.2–10	0.10	15%	0.2	10
Solar (Grid)	0.5–10	0.12	8%	0.5	10
Solar (Off-grid)	0.5–10	0.20	8%	0.5	1

Source: Ministry of Energy, Feed-In Tariffs Policy 2nd Revision December 2012.

Table 5.8 FiT values for large grid connected renewable projects in Kenya (above 10MW) in US$

	Installed capacity (MW)	**Standard FiT (US$/kWh)**	**Percentage escalable portion of the tariff**	**Minimum capacity (MW)**	**Maximum capacity (MW)**	**Maximum 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

Source: Ministry of Energy, Feed-In Tariffs Policy 2nd Revision December 2012.

Some projects have negotiated PPAs separate from the FiT scheme, resulting in different tariffs. For example, Turkana wind power plant negotiated a PPA with Kenya Power, signed in 2011, with euro-denominated tariffs guaranteed for a period of 20 years. The negotiated price is 7.52 € cents per kWh (8.42 US cents where €1=US$1.12).[13] Another example of an IPP signing a PPA independently from the FiT scheme are Ormat Olkaria III geothermal projects. The tariff in the PPA for Olkaria III is also guaranteed for a period of 20 years. It comprises two main elements: fixed monthly capacity payments and floating energy payments for the energy delivered.

5.5.2 Ghana

In Ghana, the Public Utilities Regulatory Commission (PURC) sets electricity tariffs. Tariffs are composed of three parts: the Bulk Generation Charge (BGC) paid to generators, the Transmission Service Charge (TSC) paid to the transmission system operator GRIDCo, and the Distribution Service Charge (DSC) paid to distribution companies – Electricity Company

[13] Lake Turkana power plant website (accessed in February 2016) www.ltwp.co.ke/the-project/overview.

of Ghana Limited and Northern Electricity Distribution Company Limited (NEDCo). All these elements are added up to form the end-user tariff (EUT). EUTs are retail prices charged by distribution companies to final consumers.

There are two tariff categories: residential and non-residential. PURC has set a progressive tariff scheme where residential consumers pay less than non-residential ones and those with lower consumption pay less per kWh than more energy-intensive consumers. Under the scheme, there is effectively a cross-subsidy from non-residential consumers and from the wealthier residential consumers to the poorer residential consumers. There are also special load tariffs for low, medium and high voltage consumers. The latest tariff schedule is presented in Table 5.9, as well as US dollar equivalents converted at the average exchange rate during 2015 calculated from monthly figures published by the Central Bank of Ghana.

Table 5.9 Ghana electricity tariffs at 30 June 2015

	Gp/kWh	**US$/kWh**
Bulk Generation Charge		
VRA	14.60	0.039
Composite (VRA+IPP)	23.74	0.063
Transmission Service Charge	4.30	0.011
Distribution Service Charge	16.46	0.044
End-user Tariff – residential		
0–50	21.08	0.056
51–300	42.29	0.112
301–600	54.89	0.146
601+	60.98	0.162
Service charge (Gp/month)	397.72	1.056
End-user Tariff – Non-residential		
0–300	60.80	0.161
301–600	64.70	0.172
601+	102.08	0.271
Service charge (Gp/month)	662.87	1.76

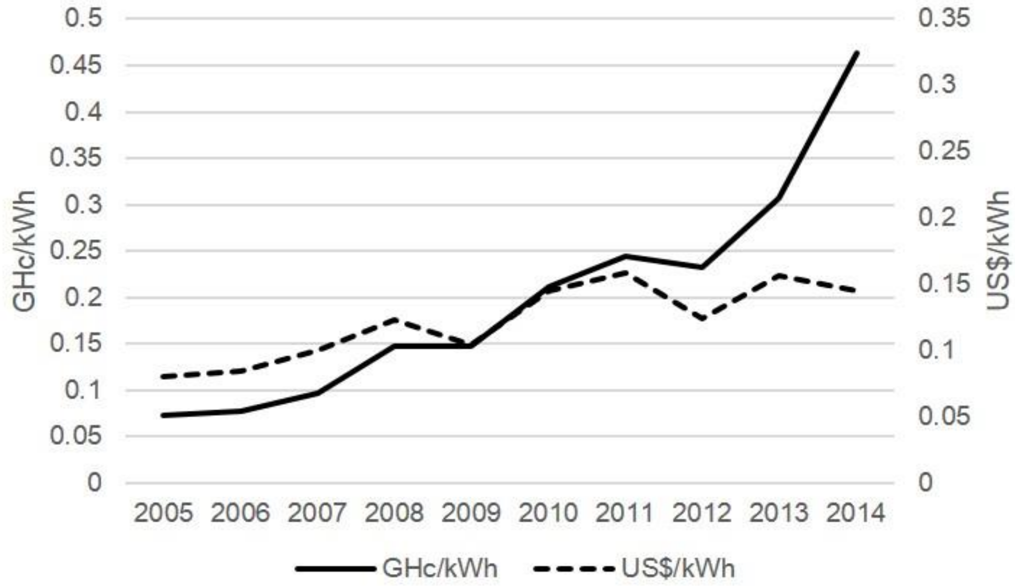
Source: PURC 2015; Exchange rate 3.766 GHc/US$ at June 2015, Statistical Bulletin of the Central Bank of Ghana. (Gp is Ghanaian pesewa, equivalent to one hundredth of a Ghanaian cedi.)

Tariffs are very low as compared to those in Kenya and are among the lowest in Africa. Ghana's traditional reliance on old hydroelectric plants has led to consumers, regulators and politicians becoming used to very low electricity costs. The addition of new thermal units has pushed prices up, as reflected by the composite BGC, although not enough to cover all costs. The current TSC is also considered insufficient to allow GRIDCo to recover its fixed and variable costs and provide a return to investment. Consequently, GRIDCo requested an upward review of the TSC from Gp4.0453/kWh to Gp5.3100/kWh in October 2015, an increase of 31.26 per cent over the existing TSC.[14] The request is on the basis of an increased transmission assets base and O&M costs due to the extension of the network, larger financing costs and the depreciation of the Ghanaian cedi.

[14] GRIDCo advert – Proposed transmission service charge for 2015 major tariff review. www.gridcogh.com/en/posts/gridco-advert---2015-tariff-proposal-summary-51.php

Figure 5.2 shows the trend of Ghana's electricity prices. Large inflation rates (close to 17 per cent year-on-year in 2015) have led to very rapid increases in local currency-denominated electricity prices. In 2013, PURC approved a tariff increase of 78.9 per cent for all customer categories except for the lifeline tariff, which got a 65 per cent increase (IRENA 2015a). Nevertheless, US dollar-denominated tariffs have remained relatively stable in the last five years. Prices are low compared to Kenya, and less responsive to changes in fossil fuel prices. Additionally, there is a high macroeconomic risk due to the considerable depreciation of the Ghanaian cedi against the dollar.

Figure 5.2 Trend in average electricity end-user tariff, Ghana



Source: Authors' own, based on ECG (2015b), National Energy Statistics 2005–2014.

Under the Renewable Energy Act, the PURC is also in charge of setting FiTs for renewable energy generation. The FiT scheme consists of a renewable energy purchase obligation, a FiT rate and a connection to transmission and distribution systems. FiTs for renewable generation were first published by the PURC in August 2013, and then reviewed and considerably increased in the *Ghana Gazette* in November 2014. The FiTs are only guaranteed for a period of ten years, but calculated to allow for repayment of debt and interest rates during that period. After that period, the FiTs would undergo a biennial review. The second FiT publication also includes caps to total and per plant solar PV and wind capacity without grid stability/storage systems. No details are provided about what grid stability and storage systems entail. According to this, only 300MW of total wind capacity and 150MW of solar PV without grid stability systems would be allowed to the Ghanaian system. The maximum capacity of individual solar PV plants would be 10MWp when connected to the distribution system and 20MWp when connected to the transmission system. The rates are denominated in Ghana pesewas and do not consider indexation factors, as these have been considered in fixing the ten-year FiT. In any case, if inflation grows faster than anticipated the schedule allows for an adjustment formula to ensure that investors obtain a fair risk-adjusted return on their investment. Table 5.10 shows the up-to-date FiT, as well as the US dollar equivalent, using both the September 2014 exchange rate used by PURC for its estimates and the average 2015 rate.

Table 5.10 Ghana feed-in tariffs, effective October 2014

	Gp/kWh	US$/kWh Sept 2014 rate	US$/kWh 2015 av. rate
Wind with grid stability systems	55.7	0.17	0.15
Wind without grid stability systems	51.4	0.16	0.14
Solar PV with grid stability/storage	64.4	0.20	0.17
Solar PV without grid stability/storage	58.4	0.18	0.15
Hydro <= 10MW	53.64	0.17	0.14
Hydro <100MW>10MW	53.9	0.17	0.14
Biomass	56	0.18	0.15
Biomass (Enhanced technology)	59	0.19	0.16
Biomass (Plantation as feed stock)	63.3	0.20	0.17

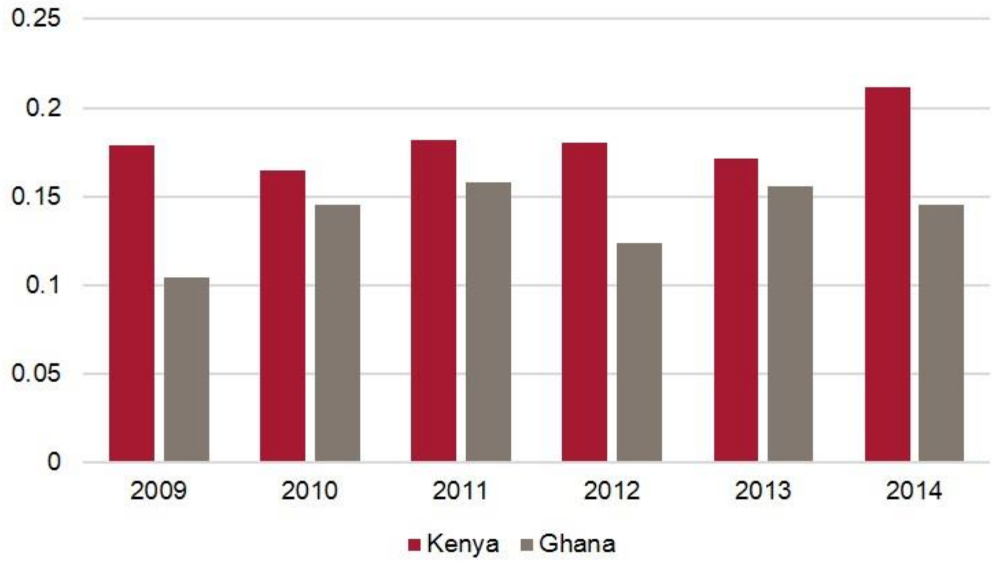
Note: September 2014 rate is 3.1986 Gp/US$c as per PURC (2014); the average rate for 2015 (January to September) is 3.77 Gp/US$c as per the Central Bank of Ghana.

FiTs for all renewable energy technologies are at least twice as high as the 23.74Gp/kWh composite Bulk Generation Charge. However, further increases in the BGC are expected as current tariffs are insufficient to cover the cost of planned fossil fuel-based thermal plants. FiTs are also higher than those set in Kenya, but are subject to a higher foreign exchange risk.

5.5.3 Comparison

The Ghanaian scheme offers cheaper and more predictable tariffs for consumers than the Kenyan scheme. However, the Kenyan system allows generators to recover their costs and insures them against fuel cost and exchange rate fluctuations, which are automatically passed through to consumers. Very high inflation rates and strong devaluation of the Ghanaian cedi against the US dollar introduce a significant risk for generators in Ghana.

Figure 5.3 Average electricity end-user tariffs in Kenya and Ghana (US$/kWh)

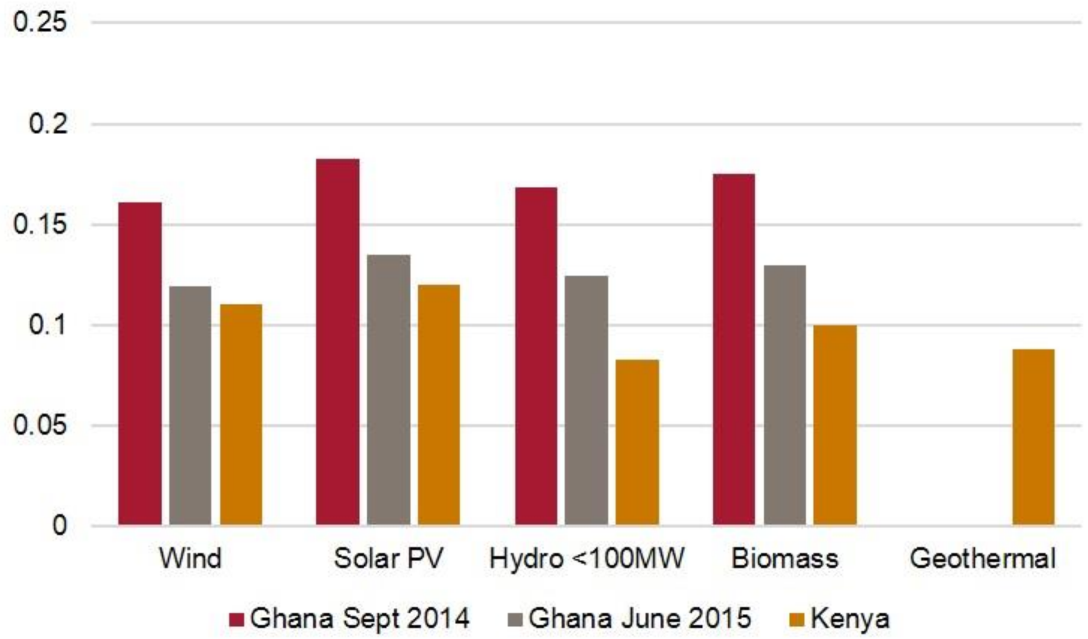


Source: Authors' own, with data from PURC 2015 and the *Kenya Gazette* (2014) using US dollar exchange rates from the Statistical Bulletin of the Central Bank of Ghana and the Central Bank of Kenya.

Both countries have introduced a FiT scheme to attract renewable energy investors. Fixed tariffs are guaranteed for 20 years in Kenya and ten years in Ghana. After ten years, Ghana introduces biennial reviews. Kenyan FiTs are denominated in foreign currency, to eliminate currency fluctuation risks, and are partially indexed to account for inflation. Ghanaian FiTs are denominated in the local currency and are not indexed. Investors in RE in Ghana are hence exposed to significant macroeconomic risks. For example, between September 2014, when FiTs were approved in Ghana, and June 2015, the US dollar value per kWh decreased by 26 per cent.

Figure 5.4 compares the FiT levels in Kenya and Ghana converted to US dollars. Because Ghanaian FiTs are set in the local currency, we show both the levels using the 2014 exchange rate, when the tariffs were approved, and the average 2015 exchange rate. On approval, the Ghanaian fees were significantly higher than those set in Kenya, but currency devaluation has brought them closer to Kenyan levels. A comparison of FiT levels per technology reveals particularly large differentials for hydro and solar, which reflects an unwillingness to support these technologies in Kenya.

Figure 5.4 Kenyan and Ghanaian feed-in tariffs in US$/kWh



Source: Authors' own with data from PURC (2014) and the Ministry of Energy of Kenya (2012).

5.6 Other parameters

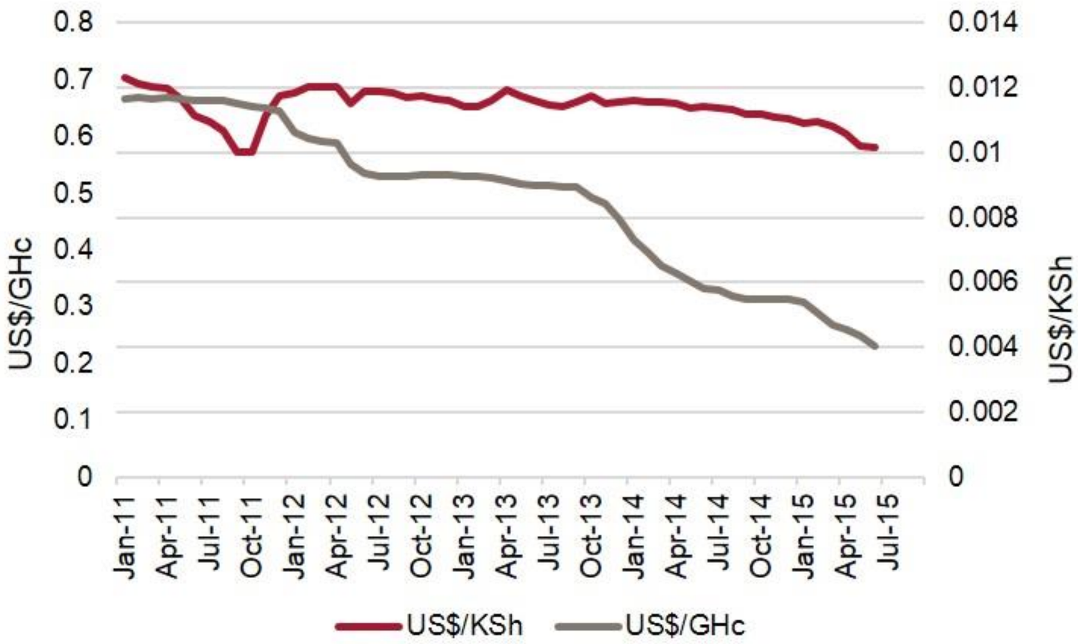
5.6.1 Foreign exchange and inflation rates

Debt and equity in SSA are usually denominated in US dollars or other foreign currency. The devaluation of the local currency therefore affects the ability of the project to repay investors. This risk can be mitigated by denominating power tariffs in foreign currency, such as the Kenyan FiT. However, in cases of fast devaluation this can jeopardise the financial sustainability of the national utility.

Foreign exchange risk is higher in Ghana than in Kenya, as illustrated by Figure 5.5. In the last two years, the Ghanaian cedi has lost 55 per cent of its value against the dollar, compared to a 13 per cent fall in the value of the Kenyan shilling against the US dollar.

The volatility of the local currency makes investors very vulnerable unless tariffs have foreign exchange guarantees.

Figure 5.5 Foreign exchange rates US$ per Ghanaian cedi and Kenyan shilling



Sources: Authors' elaboration with data from the Bank of Ghana Statistical Bulletin September 2015 and Bank of Kenya Statistical Bulletin June 2015

Renewable energy projects are characterised by high upfront costs and low operational costs. Therefore, only a small share of costs are vulnerable to high inflation rates. The Kenyan FiTs are indexed for a percentage of between 8 per cent for hydro and 20 per cent for geothermal. Ghanaian FiTs do not consider indexation factors but allow for an adjustment formula if inflation grows faster than anticipated. In this case, macroeconomic risks are also higher for Ghana. Year-on-year inflation rates were close to 17 per cent in 2015, as compared to 6.5 per cent in Kenya.

5.6.2 Taxes

Corporate tax rates are 25 per cent in Ghana and 30 per cent in Kenya. Information sourced through expert interviews in Ghana indicated that investors can expect a two-year tax holiday. The financial analysis of CDM projects in Kenya indicates that Kenya has a seven-year tax holiday for renewable energy.[15] However, this information could not be verified in any official document and we used a more conservative figure of two years as in Ghana.

5.6.3 System costs

System costs include both transmission and distribution costs and system balancing costs for intermittent renewable energy. Balancing costs refer to the need for other controllable technologies to provide operating reserve to manage the uncertainty of variable renewable energy technologies, such as wind and solar. The question of whether these effects should be included somehow in LCOE calculations remains controversial, and including it is not

[15] Financial analysis of Lake Turkana and Kinangop wind parks, as part of their project design document, 9 July 2012 and 28 February 2011 https://cdm.unfccc.int/Projects/DB/JCI1341790980.26/view and http://cdm.unfccc.int/Projects/DB/SGS-UKL1298369167.94/view.

entirely natural as it is a whole-system cost issue not confined to one technology alone. For simplicity in our analysis we will keep the assessment of balancing costs outside LCOE calculations.

It is worth noting some factors that contribute to increasing balancing costs. Low variable renewable energy shares do not pose many problems and there are several ways to deal with the variability of shares up to 20 per cent of the electricity supply while minimising system balancing costs (IRENA 2015b; Brouwer *et al.* 2014). However, many of these approaches are challenging in low-income countries and can cause curtailment in situations of surplus production. Some factors that contribute to lower balancing costs are: the geographic diversification of variable generation across countries or continents; good interconnection with neighbouring countries; an appropriate transmission capacity and a large share of flexible generation sources, mainly hydroelectricity but also geothermal and gas-fired combined cycle turbines. A large penetration of inflexible baseload plants, mainly coal or nuclear, can increase integration costs of variable renewables (Rose *et al.* 2016).

The Kenyan and Ghanaian electricity systems are small, with 2,177MW in Kenya in March 2015 and 2,831MW in Ghana, in December 2014. A share of 20 per cent of variable renewable energy would involve the penetration of more than 430MW of wind and solar at workable balancing costs. This is far higher than the shares observed today. Both Kenya and Ghana have a large share of flexible generation capacity, which could respond to wind and solar intermittency. The Ghanaian transmission system is further developed than the Kenyan one. Ghana has more than 4,000km of high voltage transmission lines and is interconnected with the power grids of neighbouring Côte d'Ivoire (CIE), Togo and Benin (CEB). The Kenyan transmission network was below 4,000km in December 2014, even though it has more than twice the surface area of Ghana and a 70 per cent larger population. Kenya's level of interconnection with its neighbouring countries is also low, although several interconnection projects may reverse this in the future. They include the Kenya–Tanzania and Kenya–Uganda 400kV interconnectors and the Kenya–Ethiopia 500kV interconnector, which will give Kenya access to the large Ethiopian hydro resources.

Transmission costs would be expected to be higher for Kenya than for Ghana, as bespoke transmission lines need to be built to connect remote, resource-rich areas to centres of demand. Such is the case of Lake Turkana wind park, in Marsabit, which requires the construction of a 428km transmission line at a cost of around US$190m to evacuate its power. Because the Kenyan transmission and distribution system is currently being extended, new lines will be shared by several projects and it is not possible to allocate costs to a single project. Therefore, our LCOE estimates do not take into account the construction of new transmission infrastructure required for a single project.

6 Results

To calculate the LCOE and rates of return we depart from a reference scenario, in which our model feeds from the average values of the parameters in Kenya and Ghana presented in Section 5. Three financing scenarios are considered: a financing cost equal to the social discount rate of the country, a scenario with low access to concessional finance and another of high access to concessional finance. These financing scenarios are built using actual data from our target countries. In Kenya, the scenario with a large share of concessional finance applies mostly to projects sponsored by the national utility KenGen. IPPs typically face higher interest rates and lower grace periods. In Ghana the scenario with low financing costs is based on the assumptions of the ERC, with debt and equity costs significantly lower than the commercial rates observed in the country.

Costs are compared to fossil fuel power generation costs in each country and to international fossil fuel-based generation estimates. The cost of fossil fuel generation in Kenya was estimated at 11.3 US cents per kWh for gas turbines and 12.7 US cents per kWh for coal plants at 8 per cent discount rates in 2011 (Republic of Kenya 2011). The cost of diesel-based generation is in the range of 26 to 42 US cents per kWh (Rose *et al.* 2016). Ghana's plants running on oil will cost 19 US cents per KWh and those running on gas will cost 13 US cents per kWh (ECG 2015a). These prices may have gone down as a consequence of the decline of fossil fuel prices, but we have been unable to find updated estimates. International estimates of the cost of fossil fuel-based generation present a range between 4.5 and 14 US cents per kWh (IRENA 2015b).

We carry out sensitivity analysis to changes in those parameters with a greater impact on costs and returns, namely: investment costs, capacity factors and prices. The chapter finalises analysing affordability of renewable electricity for people living in poverty.

6.1 Kenya

6.1.1 Reference scenarios

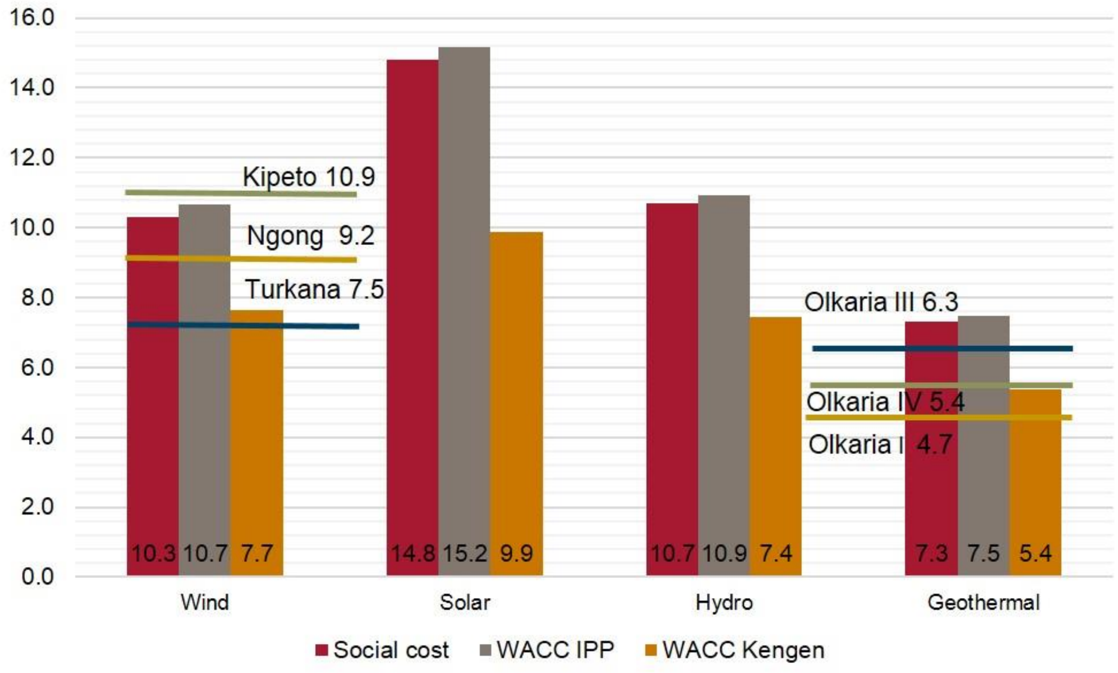
Our analysis shows that geothermal is the most favourable generation technology in Kenya for both investors and consumers. It offers very high rates of return for equity investors and the lowest cost for consumers. The results are particularly favourable at the very low financing costs that geothermal enjoys thanks to its alignment with the country's development strategy and strong political support. This allows a very competitive cost per kWh at 5.4 US cents per kWh, far below the cost of fossil fuel alternatives. For the project Olkaria I, with exceptionally low financing costs, the LCOE could be as low as 4.7 US cents per kWh. Our analysis also shows that geothermal would still be competitive with fossil fuel generation at higher financing costs. This suggests that access to concessional finance is not essential for the viability of this technology and that prices can be set well below the FiT for those projects accessing finance at a very low cost.

Hydropower and wind power plants can also offer electricity costs below fossil fuel alternatives at the financing costs accessible to IPPs. Solar PV would only be cost-competitive at very low financing costs. At the typical financing costs accessed by IPPs, the cost of solar PV would be above the FiT set for this technology and hence unprofitable for investors.

At financing costs available to IPPs, wind power shows a higher LCOE than international averages between 6 and 9 US cents per kWh (IRENA 2015b). Further cost reductions could be expected as installed costs go down thanks to learning effects and improvements in Kenya's infrastructures and as investors gain more access to concessional finance. Utility-scale solar power would be within the lower range of international LCOE estimates, between 11 and 28 US cents per kWh, mainly due to high capacity factors. Hydro technology LCOE is in the higher range of international averages between 2 and 15 US cents per kWh due to high installed costs. Geothermal LCOE is close to the lower bound of international averages between 4 and 10 US cents per kWh.

Figure 6.1 compares the estimated LCOE for RE generation in Kenya using the social discount rate (10 per cent), the average financing costs for IPPs (11 per cent) and the very low cost financing available for public geothermal and wind projects (5 per cent).

Figure 6.1 LCOE of Kenyan RE generation technologies at social discount rates and WACC, 2015



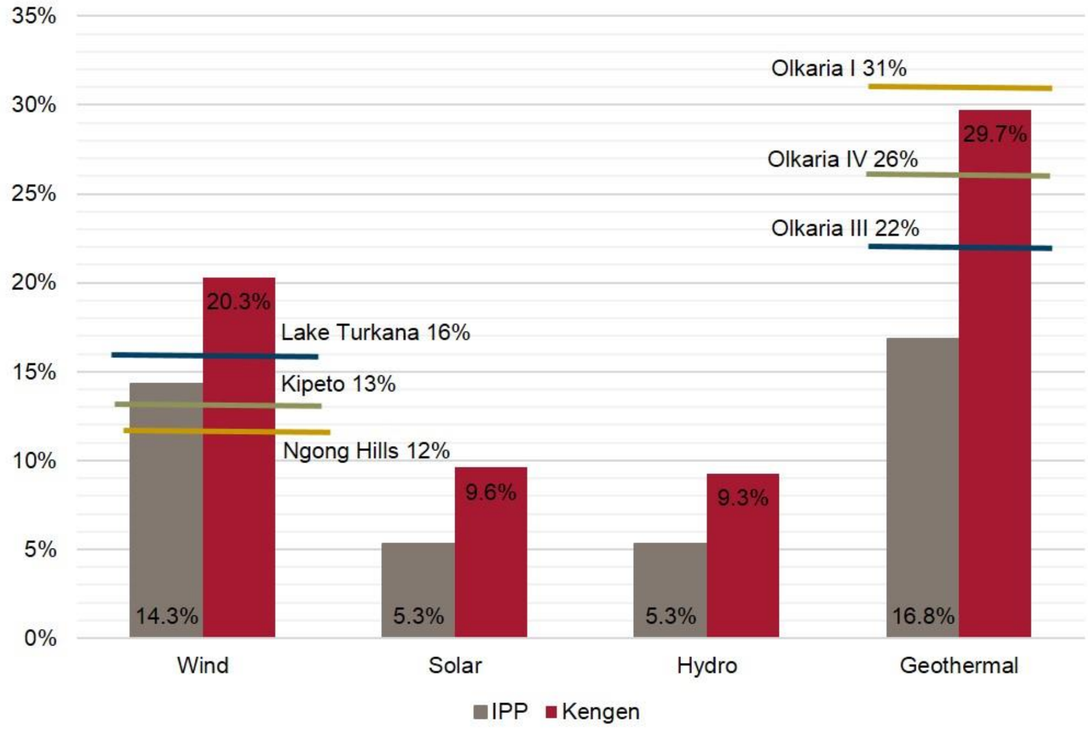
Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

Figure 6.2 shows the equity IRR at both the concessional finance costs typically accessed by KenGen projects and at higher financing costs reported for IPPs in Kenya. The graph also shows the estimated equity IRR of specific wind and geothermal projects in Kenya. Geothermal shows very high rates of return (close to 30 per cent) at the low financing costs accessed by KenGen projects when we take the approved FiT as the going price. At this price level, geothermal energy is also attractive at the higher financing costs accessed by IPPs, delivering a 17 per cent return. Olkaria I and Olkaria IV projects deliver very high returns thanks to low financing costs.

Wind can provide attractive returns of 14 per cent with low shares of concessional finance, but they may not be sufficient for equity investors requiring rates closer to 20 per cent. These rates can be achieved with lower cost finance (5 per cent WACC) as typically accessed by KenGen projects. We estimate a 16 per cent return for Lake Turkana wind farm, even with prices below the FiT. This is made possible by a very high capacity factor enabled by exceptional wind resources. The returns of Kipeto and Ngong Hills wind farms are estimated as just below 15 per cent.

On the other hand, solar PV and hydro deliver returns below 10 per cent even at low financing costs, and hence need higher tariffs to be attractive for investors.

Figure 6.2 Equity rates of return of Kenyan RE generation technologies 2015 (%)



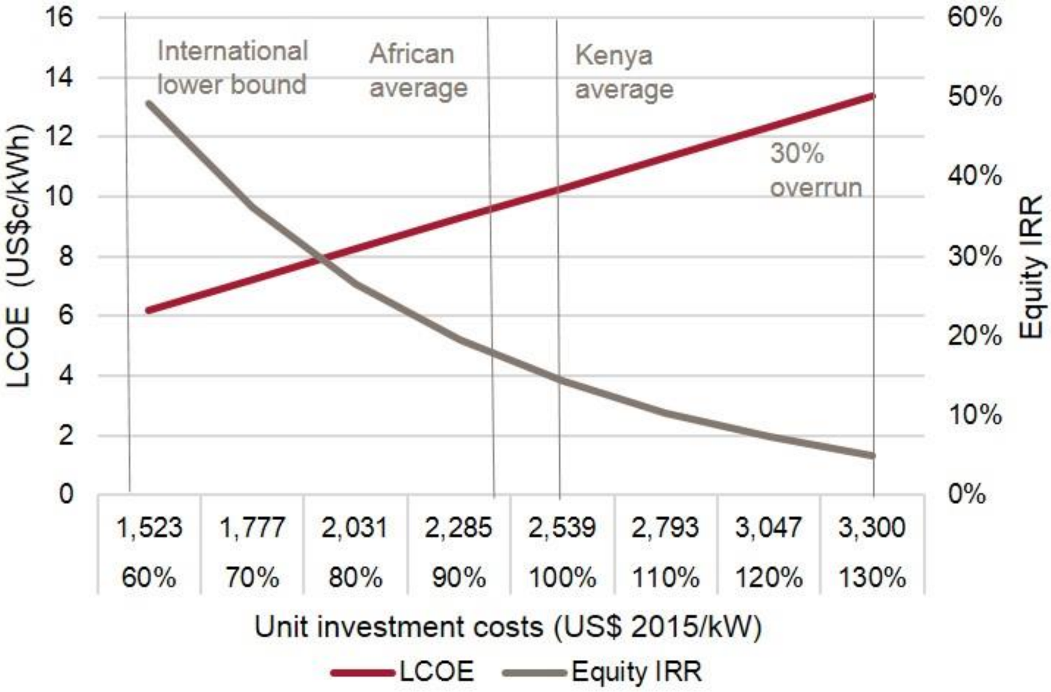
Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

6.1.2 Sensitivity analysis

We test the sensitivity of costs and returns of wind, hydro and solar PV to two key parameters: investment costs and capacity factors, keeping all other factors from the reference scenario equal and using the social discount rate of 10 per cent, assuming a cost of debt of 7.5 per cent. Because solar PV and hydro are further from financial viability, we also estimate the prices that would make them attractive for investors.

The average unit investment cost in Kenya is higher than the African and international averages. Figure 6.3 shows that if investment costs could go down with experience by 10 per cent to 20 per cent, the LCOE could go down to 8 to 9 US cents per kWh and rates of return could reach 26 per cent. If Kenya could reduce installed costs by 50 per cent, like the international lower bound, the LCOE would be as low as 5 US cents per kWh. On the other hand, if wind projects experienced up to 30 per cent investment cost overruns, their financial viability would be seriously compromised. Equity IRR would go down to 5.6 per cent, far below the requirements of investors, and the LCOE would go up to 13 US cents per kWh, above current tariffs.

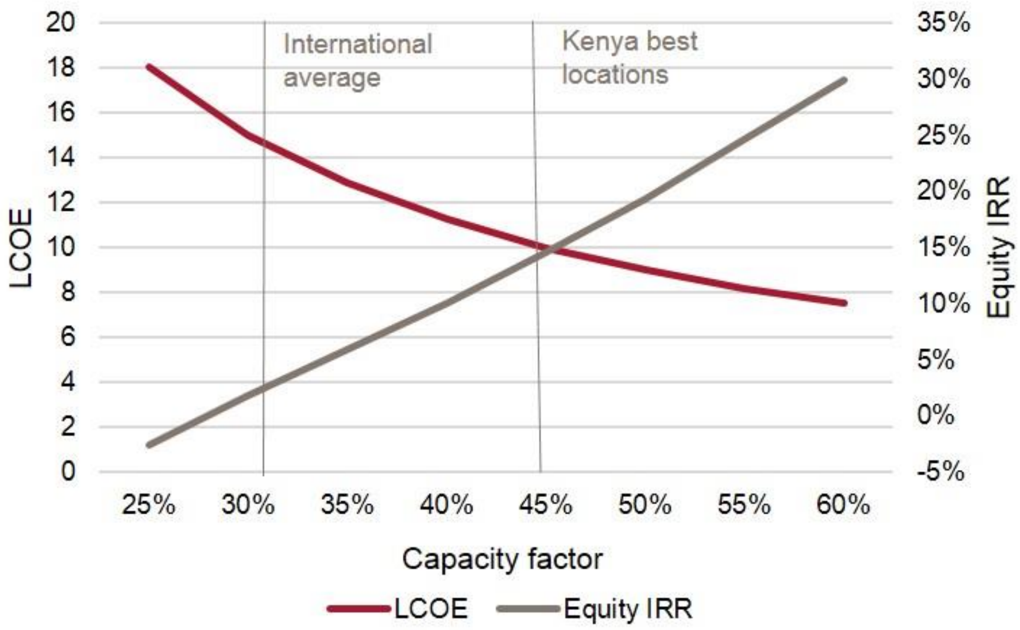
Figure 6.3 Sensitivity of Kenya's wind LCOE and equity IRR to changes in investment costs at 10% WACC



Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

Wind power plants are very sensitive to capacity factors, as illustrated in Figure 6.4. The financial viability of Kenyan wind projects relies strongly on the abundant resource in the country. At a 10 per cent WACC, only the projects in locations with the best and most consistent wind speeds can achieve the rates of returns required by investors. Projects with a typical capacity factor of 30 per cent, as in the international or African averages, would not be viable, with 2 per cent equity rates of return and an LCOE of 15 US cents per kWh. Projects with capacity factors of 60 per cent, as could be found in some good locations in Kenya, would achieve equity rates of return close to 30 per cent and a LCOE of 7.5 US cents per kWh.

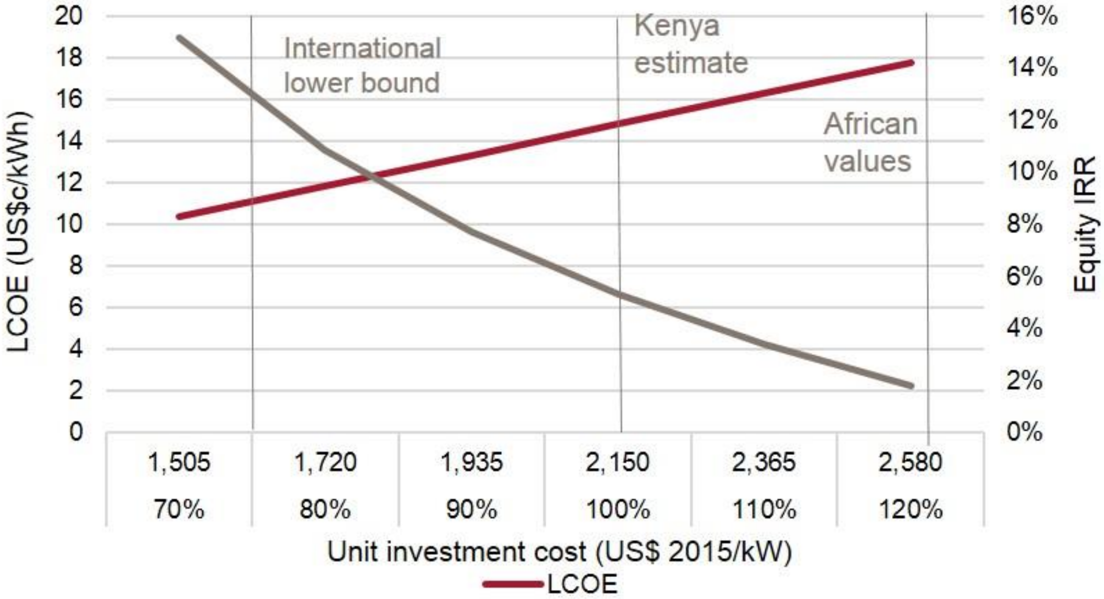
Figure 6.4 Sensitivity of Kenya's wind LCOE and equity IRR to capacity factor at 10% WACC



Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

Our estimated solar PV investment costs according to available information are below the African average. Unit investment costs are 20 per cent higher than our estimate for Kenya, but still lower than the African average with close to zero rates of return and an LCOE of 18 US cents per kWh. Solar PV projects with investment costs close to the lower bound of international values, found in China, would reach equity rates of return of 15 per cent and an LCOE of 10 US cents per kWh, below the FiT. Significant learning needs to take place in Kenya before such cost reductions can be achieved and there is not to date a functioning utility-scale solar PV project in the country that can start the learning process. And still, the price would be too low for equity investors to get a return that is attractive enough compared to alternatives.

Figure 6.5 Sensitivity of Kenya's solar PV LCOE and equity IRR to changes in investment costs at 10% WACC

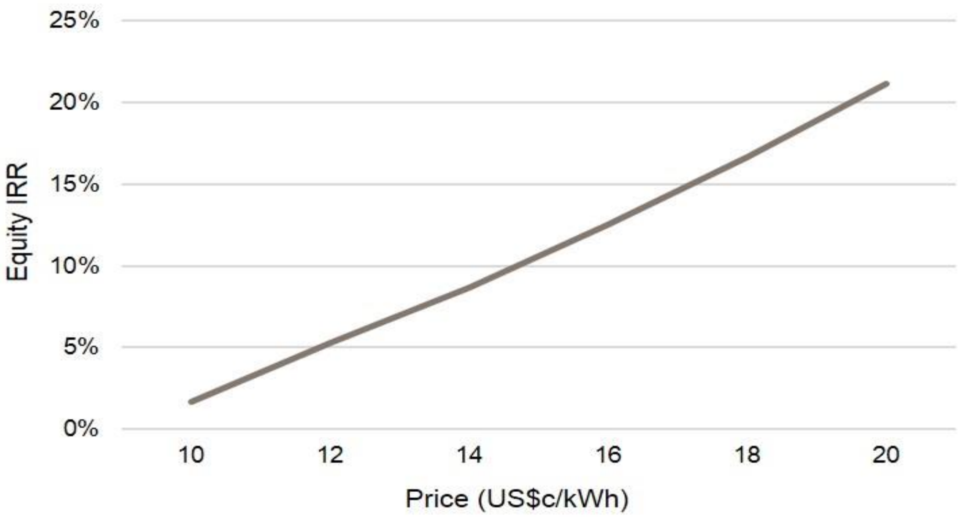


Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

A sensitivity analysis of solar PV capacity factors shows that projects in Kenya would only be financially viable at current tariffs and financing costs for capacity factors of 30 per cent or higher.

All our calculations show, therefore, that under different scenarios of more favourable financial costs, capacity factors or investment costs, solar PV is still not financially viable with the current price set at 12 US cents per kWh in Kenya's FiT. We calculate the price level that would make solar PV projects financially viable in Kenya, as presented in Figure 6.6. A price of 18 US cents per kWh would start providing attractive returns to investors. This price is well above current tariffs and above other renewable and non-renewable energy alternatives (excepting diesel). It is, however, in line with the prices obtained in the South African auction scheme (Eberhard 2014).

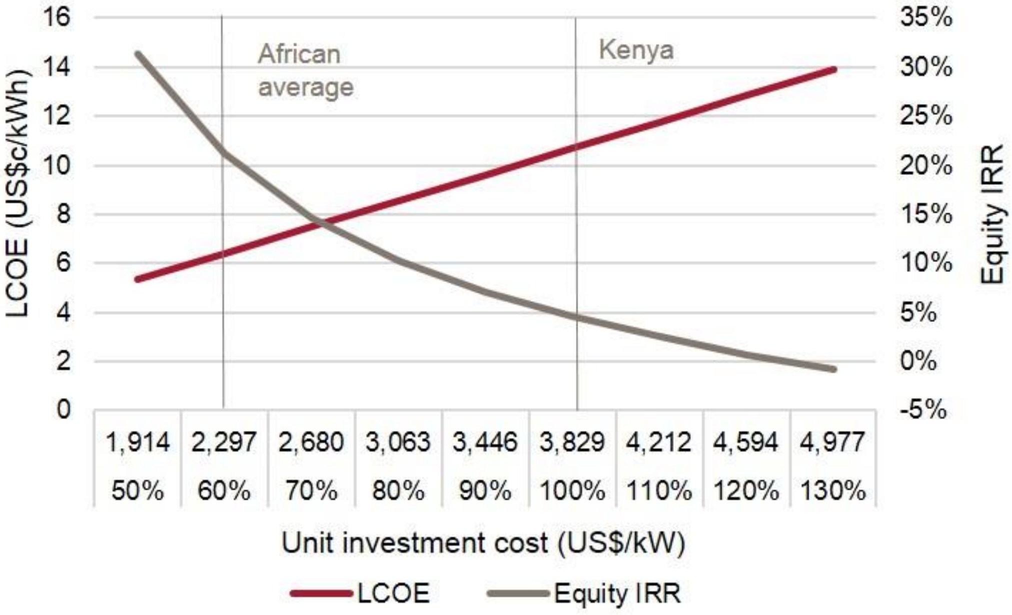
Figure 6.6 Sensitivity of solar PV equity IRR to electricity prices



Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

The LCOE of large-scale hydro in Kenya is in the upper level of international estimates and at the current FiT hydropower would not provide attractive returns to investors. Unit investment costs reported for hydro in Kenya are higher than the international upper bound, which is bringing up the LCOE. Because our unit investment cost estimates are based on a single project, it is important to understand the effect that lower or higher unit investment costs could have on the cost and returns of hydropower. Our analysis in Figure 6.7 shows that unit investment costs closer to the figures reported for Africa would increase equity rates of return to 21 per cent and reduce the LCOE to 6.4 US cents per kWh. This is better than the values provided by geothermal power when using the social discount rate. Cost overruns of 30 per cent would bring negative returns and a LCOE of 14 US cents per kWh.

Figure 6.7 Sensitivity of hydro LCOE and equity IRR to changes in unit investment costs at 10% WACC



Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

At current investment costs, hydropower would need prices to go up to 12 US cents per kWh (from 8.25 US cents per kWh) to yield attractive returns for equity investors. However, because of the unreliability of rainfall patterns, the Kenyan government has sought to diversify the generation mix away from hydropower and is not likely to promote a higher fee.

6.1.3 Affordability

The cost of renewable electricity in Kenya from all sources except solar PV is in line or below current grid tariffs. The average energy charge to cover for generation costs is 11 US cents per kWh, similar to the LCOE of wind power and hydropower. Geothermal plants can offer lower rates. Feed-in tariffs have been set at a level that is very close to the current generation charge, with only solar PV slightly above the average, at 12 US cents per kWh.

In addition to energy charges, domestic consumers must pay a monthly fixed charge of KSh150 (US$1.52) and several surcharges: fuel cost charges (FCC), foreign exchange rates fluctuation adjustment (FERFA), inflation adjustment (IA), water levy for the use of hydro resources (WARMA) at 5 cents per kWh, Energy Regulatory Commission (ERC) levy at KSh3 cents per KWh, Rural Electrification Programme (REP) levy at 5 per cent of the base rate and VAT at 16 per cent on everything except the water levy, ERC and REP levies and inflation adjustment (ERC 2013). The fuel cost charges, foreign exchange rates fluctuation adjustment and inflation adjustment change every month. Taking all these charges into account, the average cost of electricity for all types of consumers in Kenya was 17 US cents per kWh in 2015. A subsistence consumption of 50kWh would be charged at a lower, subsidised fee of 3 US cents per kWh but be subject to all other charges, therefore we estimate a cost for subsistence consumers of 10 US cents per kWh. This would involve a monthly cost of US$5 for a consumption of 50kWh. The unsubsidised equivalent for this level of consumption would be US$8.5 per month.

To assess the affordability of renewable electricity in Kenya, we compare the monthly cost of a subsistence level of consumption to an affordability threshold for the population at the poverty line. Data from the latest household budget survey carried out in Kenya in 2005/06 showed that 46 per cent of Kenyans were poor, having levels of consumption insufficient to meet basic food and non-food needs. In rural areas overall poverty was 50 per cent in 2005/06, while in urban areas it was 34 per cent in the same period. These figures have worsened since this census was undertaken. The Kenya Institute for Public Policy Research and Analysis (KIPPRA) (2013) estimates that the number of people living in poverty increased from 17.8 million in 2006 to 20.1 million in 2012. This involves an increase in the poverty rate from 46 per cent in 2006 to nearly 50 per cent. Rural poverty has remained higher than urban poverty and is estimated at 55 per cent of the population in 2012 as compared to 35.5 per cent of urban poverty. The rise in the number of people falling into poverty since 2006 is as a result of the violence that resulted from the disputed 2007 elections, and low and inequitable economic growth.

The affordability threshold for the population just below the poverty line is estimated as 5 per cent of the household budget in the poverty line. The overall national poverty line was estimated at KSh1,562 and KSh2,913 in monthly adult equivalent terms for rural and urban areas respectively, in the latest study on the topic, for 2006 (Kenya National Bureau of Statistics 2007). We have updated these figures to reflect current purchasing power by using price indices as provided by the Kenya National Bureau of Statistics, according to which the monthly poverty lines would be KSh4,100 (US$42) in rural areas and KSh7,646 (US$78) in urban areas. Considering a mean household size of 5.1 people in Kenya, this would represent poor monthly household budgets of KSh20,910 (US$212.5) in rural areas and KSh38,995 (US$396.4) in urban areas per average household.[16]

A 5 per cent threshold means that monthly subsistence electricity tariffs affordable for people living in poverty should not be more expensive than KSh1,045 (US$10.6) for rural consumers or KSh1,950 (US$20) for urban consumers in 2015. These figures are consistent with estimated monthly expenditures on energy services that can be provided by electricity of US$7 to US$23 pre-electrification in Kenya (Tenenbaum *et al.* 2014).

Our estimates, at US$5 monthly for subsidised consumers and US$8.5 monthly for unsubsidised consumption, show costs below this threshold. These figures show therefore that a subsistence level of grid electricity consumption is affordable for those with budgets at the level of the poverty line in Kenya, as it would not take more than 5 per cent of the household budget. Wind, hydro and geothermal power, which offer costs consistent with the current tariffs, are considered as affordable generation technologies. On the other hand, the cost of solar PV is above the threshold.

Another, arguably more important, element of affordability refers to upfront costs, which include connection fees, wiring, light bulbs and additional appliances such as a radio or mobile phone. Affordability can be assessed in terms of the share of the household budget

[16] Exchange rate applied KSh1 = US$0.01, as average of monthly data in 2015 published by the Central Bank of Kenya.

of the poor that these costs represent. Before the launch of the last mile connectivity project in Kenya in May 2015, household connection fees to the main grid were KSh35,000 (US$385). This represented close to twice the monthly rural household budget and the urban household monthly budget at the poverty line. This was not affordable for those living in poverty. The project has more than halved the connection fee for these people to KSh15,000, which can be paid in instalments through the monthly electricity bills for a period of three to five years. Also of importance is the innovative ready board issued to consumers to address the wiring costs and consists of a socket, a switch and bulb holders.

Besides this, some news reports anticipate that this fee may double in the next financial year as the Treasury plans to remove a large subsidy (Mutegi 2014). A finance facility exists to provide credit for connection charges (Stima loan). The loan is provided by KPLC in partnership with the French Development Agency and allows customers to pay upfront only 20 per cent of the connection fee and spread the remaining 80 per cent over a period of 24 months at a 5 per cent administration fee (one-off payment).[17] This would reduce the burden of the first payment to around half the monthly budget at the rural poverty line, still representing a significant effort.

Grid electricity supply includes prepayment options. KPLC had installed 335,018 prepaid meters at customer premises, as of June 2013, to enable customers to control their power bill. Mobile money transfer platforms such as Mpesa allow customers to pre-pay for their energy consumption and access their balance at any time.

6.2 Ghana

6.2.1 Reference scenarios

Hydro technology is the most favourable for consumers and investors in Ghana. It provides an LCOE of 6.8 US cents per kWh at low financing costs and 11.2 US cents per kWh at higher financing costs. These are lower than the cost of electricity from fossil fuel plants in Ghana. The equity IRR for hydropower plants would be close to 40 per cent at low financing costs and more than 30 per cent at higher financing costs. A high FiT for hydro leads to these high rates of return. These good outcomes of hydropower should nevertheless take into account the uncertainty of Ghana's hydro resource. Insufficient rainfall has led to plants operating below their intended capacity factor. The impact of lower capacity factors on the viability of hydropower generation will be tested later in this section.

Wind and solar PV show high costs and low rates of return. With high financing costs both technologies would be uncompetitive with fossil fuel-based generation. At lower financing costs within the Ghanaian range, wind power would be able to compete with fossil fuel-based generation but would still be unable to provide the rates of return required by equity investors.

Financing costs in Ghana are higher than those observed in Kenya and internationally, and are largely to blame for the poor financial performance of RE generation, other than hydropower. Average capacity factors of wind and solar PV in Ghana are also lower than African and international averages, which contributes to low performance. On the other hand, installed costs for hydro, solar and wind power plants reported in Ghana are lower than the African and international averages gathered in the literature. O&M costs reported in Ghana are also in line or lower than the international average.

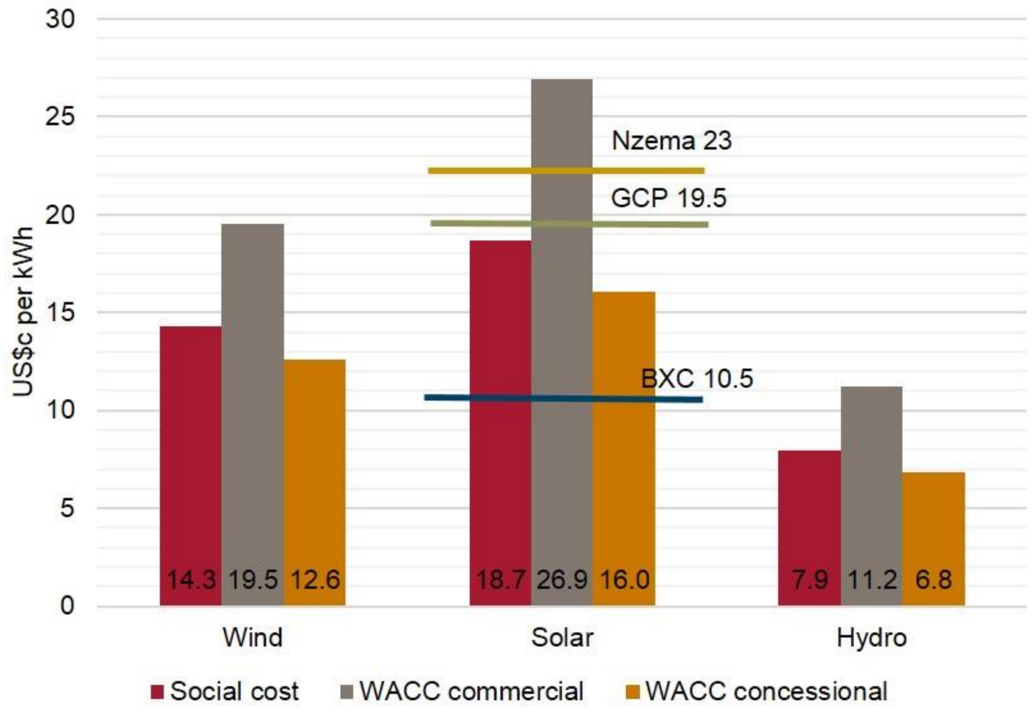
Electricity prices are defined by the FiTs agreed in September 2014, converted to US dollars at the average exchange rate between January and September 2015. The devaluation of the

[17] Loan website: http://kplc.co.ke/content/item/77/Stima-Loan.

Ghanaian cedi means that FiTs would have lost 15 per cent of their value in one year unless projects could ensure foreign exchange guarantees. Even under this devaluation, prices are higher than in Kenya and higher than those bid for in the last round (third) of South Africa's Renewable Energy IPP procurement programme.

Figure 6.8 shows the estimated LCOE using three different financing costs: social discount rates, high shares of commercial finance and high shares of concessional finance. It also highlights particular solar PV projects for which we could gather some information. The figure shows that very competitive solar electricity could have been achieved by the first solar IPP in the country, developed by BXC Ghana, a subsidiary of the Chinese company BXC Beijing. This low-cost electricity would have been achieved through very low investment costs, presumably as a result of the accumulated expertise of the Chinese company and low factor costs, and low financing costs thanks to concessional finance provided by Chinese development banks. The other two solar projects analysed show a higher LCOE, more expensive than fossil fuel-based alternatives, even though we assume low financing costs.

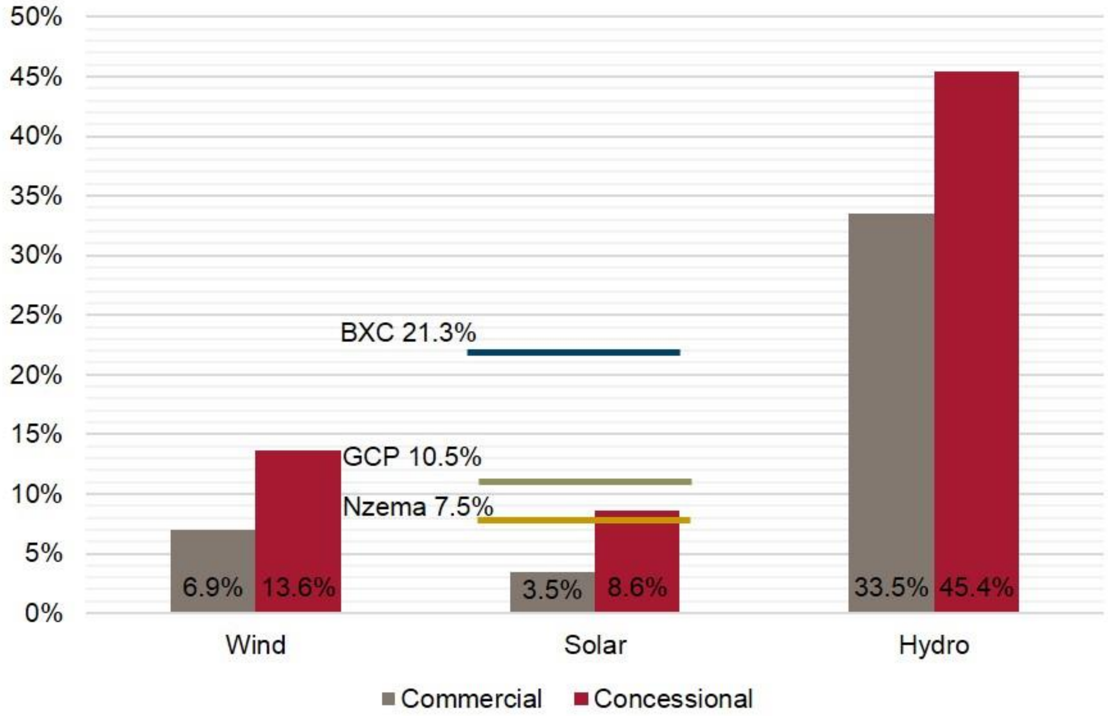
Figure 6.8 LCOE of Ghana's RE generation technologies at social discount rates, WACC of commercial finance and WACC of concessional finance (US cents per kWh 2015)



Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

Rates of return as presented in Figure 6.9 show healthy returns for hydropower but insufficient returns for wind and solar. Estimates for specific solar PV projects show sufficient returns for the BXC 20MW solar plant, thanks to low investment and financing costs.

Figure 6.9 Rates of return of Ghana's RE generation technologies, 2015 (%)



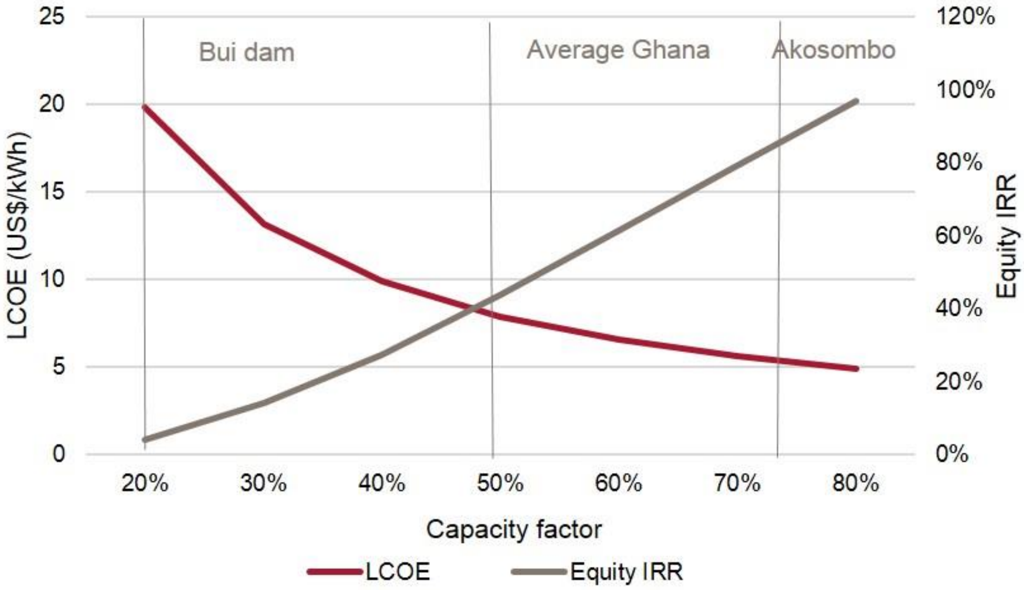
Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

6.2.2 Sensitivity analysis

For our sensitivity analysis we take the 12 per cent social discount rate as an estimate of the cost of capital, assuming a 70:30 debt–equity ratio, a 9 per cent interest rate for debt and a 20 per cent cost of equity.

Hydropower appears as financially viable in Ghana at high and low shares of concessional finance. However, due to insufficient rainfall and bad management of water resources, some hydropower plants in Ghana operate below their estimated capacity factors. For example, 400MW Bui hydropower plant operated at 20 per cent in 2014 and 2015 (ECG 2015a). This has contributed to the electricity crisis that the country suffers today. We test the viability of hydro plants in Ghana under low capacity factors as well as the impact of high capacity factors. Results presented in Figure 6.10 show that, at Ghana's high prices for hydropower, only projects with capacity factors of 30 per cent or lower would stop becoming financially viable. Capacity factors as low as the 20 per cent experienced in Bui Dam in 2014 and 2015 would deliver a 4 per cent rate of return and an LCOE of 20 US cents per kWh. These are, however, unlikely for the lifetime of the project. Higher capacity factors of 70 per cent would provide least-cost electricity at 5.7 US cents per kWh and extremely high returns. Accurate water resource predictions and a good management of water resources are therefore essential to ensure the financial viability of hydroelectric plants in Ghana.

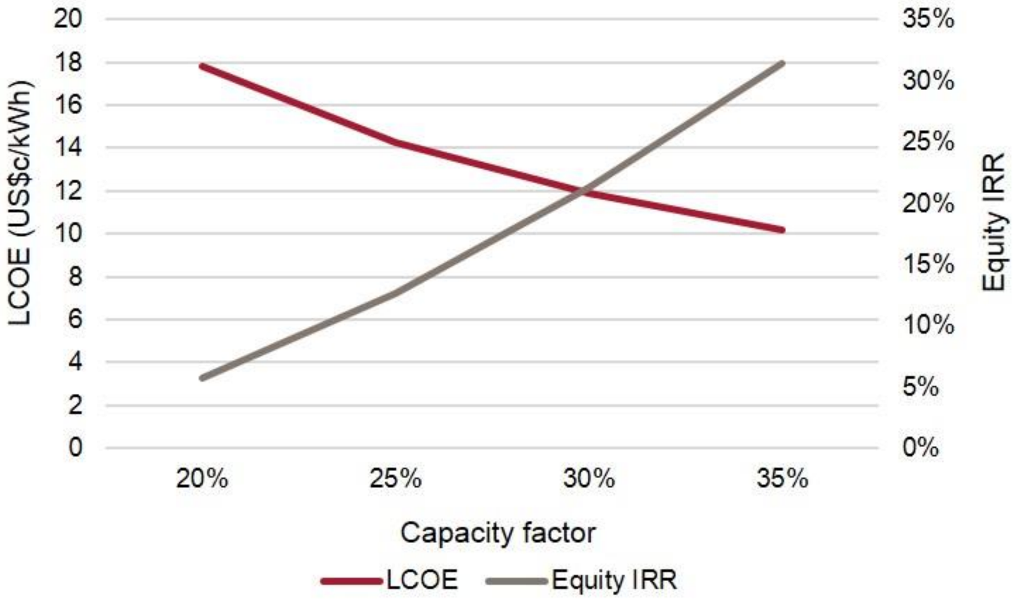
Figure 6.10 Sensitivity of Ghana's hydro LCOE and equity IRR to capacity factors at 12% WACC



Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

Wind power plants are very sensitive to the quality of the wind resource. Our sensitivity analysis shows that wind power plants with capacity factors below 25 per cent are not attractive for equity investors and the electricity they produce is costly compared to electricity generated by existing plants. Plants in the best locations in Ghana with capacity factors of 35 per cent would be able to produce returns higher than 35 per cent. These plants would supply electricity at a cost of 10 US cents per kWh. However, the potential for projects with this high-quality wind resource in Ghana is very limited.

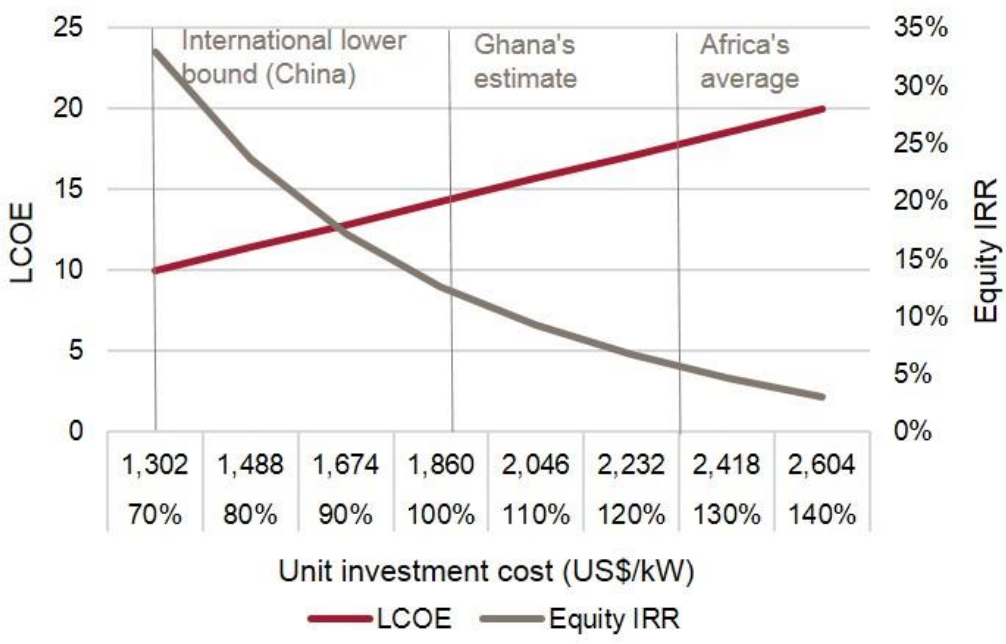
Figure 6.11 Sensitivity of Ghana's wind LCOE and equity IRR to capacity factors at 12% WACC



Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

Installed costs of wind power plants estimated by our sources in Ghana may have been underestimated as they are well below the international and African averages even though Ghana has no experience in utility-scale wind power. We test the sensitivity of the LCOE and equity rates of return along a range of installed costs, from the lower bound of international figures, found in China, to the upper bound of African figures, also considering up to a 40 per cent overrun with respect to the reported cost for Ghana. Results presented in Figure 6.12 show that a 20 per cent increase of investment costs would lead to very expensive electricity at 16 US cents per kWh and low returns below 7 per cent. Projects with unit investment costs as low as in China would provide a 33 per cent return on equity and an LCOE of 10 US cents per kWh. However, it is unlikely that Ghana can reach these low costs soon as it cannot provide the scale, experience and local knowledge available in China.

Figure 6.12 Sensitivity of Ghana's wind LCOE and equity IRR to investment costs at 12% WACC



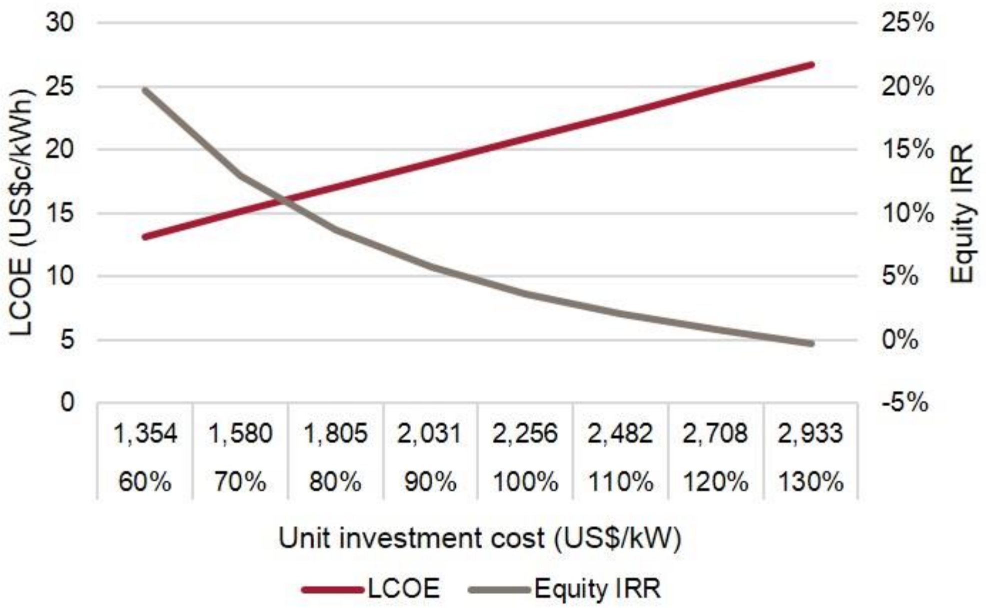
Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

Solar PV also faces important challenges to becoming financially viable in Ghana. We tested the sensitivity of our financial outcomes to changes in the capacity factor of solar PV plants and found that only plants with capacity factors of more than 25 per cent would be able to deliver returns on equity above 15 per cent and an LCOE of 14 US cents per kWh.

Estimated installed costs of solar PV in Ghana are lower than the average value for Africa and in the lower range of international values. We test the sensitivity to changes in investment costs and find that investment costs similar to the African average (30 per cent higher than those estimated for Ghana) would have serious consequences for the project's viability, rendering negative rates of return and an LCOE of 27 US cents per kWh.

Investment costs as low as those reported by the press for the solar PV plant developed by the Chinese group BXC Beijing China (60 per cent of the average value) would deliver a 20 per cent return on equity and an LCOE of 13 US cents per kWh. The LCOE would be even lower if the plant had accessed finance at a cost below 12 per cent.

Figure 6.13 Sensitivity of Ghana's solar PV LCOE and equity IRR to investment costs at 12% WACC



Source: Authors' own based on data from several sources for different parameters as detailed in Section 5.

6.2.3 Affordability

The cost of renewable generation in Ghana, except hydro, is currently well above the country's subsidised generation charge to the final consumer of 6.3 US cents per kWh. In the case of solar PV it is more than three times as high. However, the cost of generation with renewables would be below that of oil plants at low financing costs. Wind power could also be cheaper than gas if it had access to large shares of concessional finance.

Feed-in tariffs have been set at more than twice the composite generation charge for wind and hydro and nearly three times as high for solar PV. High FiTs as compared to current tariffs could lead to social opposition. If the difference with existing tariffs was to be covered by the national budget, it could further damage Ghana's fiscal balance. Price increases are expected in any case as it is agreed that the current level of tariffs is not sustainable.

A monthly subsistence consumption of 50kWh would cost a Ghanaian household GHc4.52 (US$3.35) per month, at the subsidised fee including the service charge. The unsubsidised equivalent would be GHc20.80 (US$5.20). To assess affordability of current grid fees we compare them to the threshold of 5 per cent of the household budget at the poverty line.

From the Sixth Round of the Ghana Living Standard Survey (GLSS6) (Ghana Statistical Service 2014), Ghana's upper poverty line is set at GHc1,314 per annum or GHc109.50 a month. Incomes below this value are classified as poor. According to the Ghana Statistical Service (2014) about 24.2 per cent of Ghana's population is poor, with a poverty gap index of 7.8 per cent. This is an indication that the mean annual income (i.e. GHc1,211.50) of the 24.2 per cent of the population who are poor is below the poverty line by 7.8 per cent (GSS 2014). We calculate the poverty line in 2015 by multiplying this value by an inflation rate of 17 per cent, getting a 2015 monthly poverty line of GHc128.10 (US$34).

The mean household size in Ghana is four people (Ghana Statistical Service 2008). We therefore estimate a monthly household income on the poverty line to be GHc512.4 (US$136.1). Using the 5 per cent threshold adopted for the paper, a poor household could be spending GHc25.6 (US$6.8) of its income on electricity. Anything beyond this would be unaffordable. Both the subsidised and unsubsidised fees would therefore be affordable as they are below that threshold.

Therefore, 50kWh of renewable electricity, including transmission and distribution charges would cost US$9.9 (wind), US$13.2 (solar) and US$6.7 (hydro) at their LCOE using the social discount rate. Electricity from wind and solar PV plants would therefore not be affordable for households on and below the poverty line, whereas hydroelectricity would be just below the affordability threshold. The cost of 50kW of renewable electricity for the consumer if they paid the gazetted FiT and including transmission and distribution charges would be GHc38.23 (US$10.2) for wind electricity, GHc42.58 (US$11.3) for solar PV and GHc37.33 (US$9.9) for hydroelectricity. All technologies would therefore be above the affordability threshold in Ghana at the current FiT. These figures do not take into account consumer connection charges in Ghana, which would not differ between fossil fuel and renewable generation.

Our calculations therefore show that grid electricity is currently affordable for households at the poverty line, but wind and solar PV are not. The government of Ghana's introduction of the lifeline tariff attests to the unaffordability of electricity for those living in poverty but evidence abounds to suggest that even with the introduction of this intervention, these people still cannot afford electricity (PURC 2010; ISSER 2012). Besides, there is an agreement that current electricity fees are not enough to cover the costs of generation. As a result, Ghana will soon introduce the Automatic Adjustment Formula law of setting utility tariffs, which seeks to adjust automatically electricity and other utility tariffs to reflect the economic cost of production over time (PURC 2015), similarly to Kenya. This will worsen affordability of electricity for people living in poverty, as the cost of generation is expected to rise soon with new fossil fuel power plants and potentially with the introduction of renewables. However, cost-reflective tariffs will likely improve the quality of the service by improving the financial viability of generators.

7 Discussion

7.1 Is RE financially viable in Kenya and Ghana?

Kenya offers attractive returns for wind and geothermal power generation under a reference scenario particularly, but not exclusively, when there is access to concessional finance. Feed-in tariffs in Kenya for hydro and solar appear to be too low to make projects profitable unless we consider hydro scenarios with lower unit investment costs, closer to the African and international averages. Hydropower in Ghana could also offer very healthy returns for equity investors, but profitability is threatened by decreasing water resources, with some hydropower plants operating at 20 per cent of their capacity. Although FiTs for wind and solar are significantly higher in Ghana than in Kenya, they are not high enough to yield attractive returns in a reference scenario.

The cost of renewable energy is significantly lower in Kenya than in Ghana. All renewable sources in Kenya except solar PV would be competitive with national and international fossil fuel power generation costs. Geothermal technology in Kenya offers least-cost electricity at 5.4 US cents per kWh when it can access finance at a very low cost. The costs of wind and solar PV electricity in Kenya are in line with international averages, while hydroelectricity has a higher cost than the international average due to higher installed costs. Ghana's wind and solar PV electricity is more costly than international benchmarks. The LCOE of wind is at the upper bound of international cost estimates, but it would be more competitive than planned oil power plants in Ghana and close to competitive with gas power plants. Grid-connected solar PV would only be competitive with fossil fuel alternatives in Ghana under scenarios of low installed and financing costs.

The high cost of finance is an important drag to financial viability in Ghana. Investors in the country have high-yield alternatives at a lower risk than renewable energy projects. For example, 90-day treasury bills offer a 24 per cent rate.[18] Commercial bank lending in the country is mainly short term and at rates between 21 and 37 per cent nominal.[19] Investors in renewable energy are therefore forced to reach out to international commercial finance or concessional finance to make their projects viable. Our finance scenarios show that if renewable energy investors in Ghana had access to concessional loans offered to geothermal in Kenya (3 per cent loans with long maturity), wind power could reach equity rates of return of 30 per cent, whereas solar PV returns would remain modest. Investors that could bypass the constraint of high financing costs in Ghana would have higher chances of succeeding in project development and financial viability. For example, the only private solar PV plant in Ghana, developed by a subsidiary of BXC Beijing, can access low cost finance from Chinese development banks, as well as the low investment costs of Chinese developers.

Our analysis has shown that public authorities have the ability to attract finance at better terms than IPPs. Although the majority of SSA countries are looking at IPPs as the main and foremost solution to their generation capacity deficit, there is an important role to play by public stakeholders to secure affordable finance. Successful models could include public–private partnerships, such as Kenya's approach to geothermal development in which the public sector assumes the cost of drilling and exploration, hence reducing the risk for private investors. The role of national development banks should also be further analysed.

[18] Central Bank of Ghana, at December 2015.
[19] *ibid.*

It is also the case that Ghana has a lower renewable energy potential than Kenya. The typical capacity factor of a wind power plant in Ghana would be 25 per cent as compared to 45 per cent in Kenya. Solar resources are also higher in Kenya and its geothermal resource is unique in Africa. The low prices set in Kenya for renewable energy mean that only those projects with the best fundamentals are financially viable. Thanks to higher prices, the best wind projects in Ghana with capacity factors of 30 per cent offer a similar rate of return to the best projects in Kenya, but a much higher LCOE.

The financial viability of renewable electricity in Kenya would improve considerably if all technologies could access the financing conditions enjoyed by geothermal power and if solar PV and hydropower could get a higher tariff. However, this would damage affordability for the final consumer.

From the analysis it is clear that the seemingly generous FiT scheme approved in Ghana is not enough to ensure financial viability of renewable energy projects other than hydro. High financing costs could be inhibiting potential investors and the high differential of FiTs with current power tariffs could bring about social opposition to renewable energy. Furthermore, foreign exchange risk is high in Ghana, but the FiTs have been set in local currency in order not to overburden the national budget in case of further devaluation. This increases the risk of foreign investors not being able to repay their debt and can increase the cost of projects if they must obtain foreign exchange guarantees.

An additional risk in Ghana comes from the short duration of the FiT price guarantee, for ten years or less than half the lifetime of the project. Kenya instead has denominated its FiT in foreign currency and guarantees them for 20 years. Still the adoption of FiTs in Kenya is being slow. The largest RE IPPs, such as Lake Turkana Wind Power or Orpower Geothermal, have signed individual power purchase agreements (PPA) with the Kenyan off-taker, sometimes at a lower price than the one in the FiT scheme. This shows that, whereas FiTs have raised investor interest in both countries, they have not been the main catalysts of final investment, as there are risks in both countries that cannot be addressed by FiT schemes alone. However, the conditions seem to be more favourable in Kenya than in Ghana, and this is reflected in the lower costs achieved and the higher number of projects reaching financial closure.

7.2 Is RE affordable in Kenya and Ghana?

In this report we have defined grid-connected renewable electricity that is affordable for the poor as the one that would allow a household on the poverty line to consume a subsistence amount without spending more than 5 per cent of their household budget. It is a narrow definition, as it does not consider consumer connection costs or the costs of the appliances required to turn electricity into useful energy services. It is also incomplete, because renewable electricity would only be part of a system and the final cost to consumers would depend on the cost of other sources in the generation mix. We do not include connection and appliances costs because they are independent from the generation cost. Our results show that renewable electricity, other than solar PV, is affordable in Kenya. In Ghana, only hydroelectricity would be affordable if priced at the level of the LCOE. At the current FiT levels, RE is unaffordable for households below the poverty line. This is in contrast to current electricity tariffs in Ghana, which are set at a low level affordable for populations with household budgets at the poverty line.

Another way of assessing affordability of renewable energy sources for the country would consist of comparing their cost to fossil fuel alternatives. To ensure reliability of supply, the Kenyan system operator relies on a combination of owned and leased diesel power generation at a cost in the range of 26 and 42 US cents per kWh (Rose *et al.* 2016).

Another estimate of the cost of fossil fuel-based peak load technologies values them at 15.1 to 30.2 US cents per kWh (Ondraczek 2014). The Ghanaian system operator has announced new thermal plants to relieve the current energy crisis in the country, which will provide electricity at a cost between 13 US cents per kWh for gas plants, and 19 US cents per kWh for oil plants. If these are taken as the costs of alternative generation sources, renewable electricity is affordable in both countries, with the exception of solar PV in Ghana, unless it can enjoy more favourable financing costs and lower investment costs than the averages assumed in this report. It is as yet unknown how declining fossil fuel costs impact on the competitiveness of renewables in Kenya and Ghana. On the one hand, it makes it cheaper to run diesel generators, but on the other, it makes planned investments in oil and gas extraction in both countries unattractive.

Renewable electricity also brings additional benefits as compared to fossil fuel alternatives that have not been valued in this study, most importantly, environmental benefits but also lower risks, avoiding dependence on fuel supply from foreign countries, the volatility of fossil fuel prices and the possibility of stranded assets under potentially high future carbon prices. Solar PV in particular has the advantage of low technological complexity, a quick turn-around and the possibility of being financed and deployed incrementally. Renewable energy will also be most likely to attract better financing conditions than dirty alternatives, which could further reduce its cost.

8 Conclusions and policy implications

The allocation of finance for the provision of universal access to clean electricity in SSA should be informed by two questions: Which generation technologies are financially viable? And which generation technologies are affordable in a specific country? Electricity generation that is not financially viable is not sustainable in the long term, while electricity generation that is unaffordable will not contribute to inclusive growth and poverty reduction. Our analysis addresses these questions for Kenya and Ghana. Both countries are actively seeking to attract private investment to relieve their shortage of generation capacity with varying success.

Kenya presents stronger fundamentals for the successful implementation of renewable energy projects. It has vast renewable energy resources and can provide high capacity factors for wind, solar and geothermal plants. It can access lower financing costs than those in Ghana. Feed-in tariffs are not set at a much higher level than the country's electricity tariffs, which reduces social opposition. Besides this, the FiT scheme is protected from currency devaluation and guaranteed for 20 years. If FiTs fell through, investors would be likely to recover their costs as the electricity tariff scheme is designed for cost recovery. Although unit investment costs are higher than in other African countries, large renewable energy resources and access to concessional finance compensate for it. Kenya's government has also contributed in some cases to reducing investment costs by, for example, bearing the costs of exploration for geothermal power or of transmission lines to feed in remote wind resources. Renewable generation technologies, other than solar PV at typical financing costs for IPPs, would be affordable for households' budgets at the level of the national poverty line.

Ghana has enacted a FiT scheme providing high prices for generators, but presents a weaker ground for the expansion of renewable energy. Financing costs are very high and there are large macroeconomic risks from a strong currency devaluation and double-digit inflation rates. Because FiTs are denominated in the local currency, foreign investors are not protected against further devaluation. The wide gap between the prices paid for generation covered by the FiTs and prices paid by final consumers anticipates the possibility of social opposition and a potential withdrawal from the scheme. In fact, there are already movements away from FiTs and towards an auctioning scheme as seen in Ghana's recent launch of a competitive bid for 20MWp of solar PV capacity. On top of that, the national distribution company Electricity Company of Ghana is going through financial difficulties and may be unable to pay for the power it purchases. All this brings considerable uncertainty for investors. Apart from hydropower, renewable energy is not affordable for household budgets at the level of the poverty line, which makes it hard for policymakers to support it. Hydropower appears as the most favourable technology in Ghana, but the government is looking to diversify away from it after years of insufficient rainfall.

Our recommendation for policymakers is to bear in mind the particularities of each country when allocating finance for renewable generation. Because low-cost finance is scarce, it could be counterproductive to fully allocate it to those technologies that don't need it to be profitable, such as geothermal in Kenya or hydro in Ghana. Technologies at the beginning of their learning curves, such as wind and solar in Kenya and Ghana, could be more in need of low-cost finance. Ghana in particular needs to access longer-term and lower-cost finance for renewable energy projects to be able to compete with the growing thermal generation capacity. Even though SSA countries are looking at private investment through IPPs as the solution to their electricity deficit, our analysis shows the capacity of the public sector to access finance at better terms. Therefore, the role of public stakeholders should not be neglected. It could be further encouraged through public–private partnerships through which the public sector assumes some of the risks for renewable generation (such as drilling and exploration for geothermal in Kenya) or through national development banks that can provide financing at better terms for strategic sectors.

Affordability in countries with high poverty rates dictates that only least-cost technologies are supported. Such is the approach in Kenya, where at the current tariffs only those projects with the best renewable energy resource can deliver attractive returns. However, a system's perspective should be adopted when the alternative is expensive electricity from peak diesel generators. For example, even though solar PV appears as an expensive alternative when compared to other renewable energy generation technologies, it presents several advantages, such as fast construction, flexible location, incrementalism and cost reductions for the electricity system when it displaces diesel generation. If these advantages are to be harnessed, tariffs should be set at a level around 20 US cents per kWh to be able to deliver a return to investment.

Even those technologies that appear to be financially viable are not being adopted at the speed and scale required. SSA countries face several constraints that prevent the final implementation of electricity generation projects. Further research is required to identify the most important constraints that, if targeted by the policymaker, could speed up the implementation cycle in a region in dire need of electricity infrastructure.

Annexe

International sources of data for the calculation of LCOE and IRR

Source	Description	Available data	Kenya and Ghana data
Renewable power generation costs in 2014 (IRENA 2015b)	Compares the cost and performance of renewable power generation across technologies and regions. It focuses on equipment costs, total installed cost and the LCOE of generation options	• Capacity factor • Investment costs (US$/kW) • O&M costs (% capex/year) • LCOE (US$/kWh)	Specific data for Kenya and Ghana are not available. Regional African data exists for the following parameters: • Capacity factor of wind and solar PV • Investment costs of wind and solar PV • O&M costs of wind • LCOE of wind and solar PV For the rest of technologies, values provided are at the global level
World Bank Model for Electricity Technology Assessments (META) (Chubu Electric and Meta database) (2011)	Comparative assessment of the levelised costs of several electricity supply options. Options are categorised by scale (micro, mini, middle, large); off-grid, mini-grid and grid-connected; and location, including parameters for large developing countries, Romania, India and the US	• Capacity factor • Investment costs (US$/kW) • O&M costs (% capex/year)	No specific data for Kenya or Ghana, or any African country or region. We infer figures from 'large developing countries'.
Ondraczek *et al*. (2015)	Estimate the cost of solar PV for 143 countries accounting for differences in both the solar resource and the financing cost. They assume uniform global figures for investment costs. Uniform input variables are taken from different sources	Solar PV data: • Investment costs (US$/kWp) • Operating cost (% capex/year) • Scrap value (% capital value) • Degradation factor (% capacity) • Population weighted solar irradiance (kWh/m^2/a) • Real equity IRR • Nominal lending rate • WACC • Residential electricity prices	• Population weighted solar irradiance (kWh/m^2/a) • Real equity IRR – taken from the CDM Executive Board (2011) • Nominal lending rate – Taken from World Bank data on lending rates (2012) • WACC (assuming a 50:50 share of debt and equity)

Source	Description	Available data	Kenya and Ghana data
Central Bank of Ghana – Statistical bulletin	Provides information on the domestic cost of finance	• Commercial banks' lending rates • Treasury bill rates • Inflation rates • Exchange rates	Ghana data
Ghana Public Utilities Regulatory Commission	Provides information on electricity tariffs	• Feed-in tariffs • Grid tariffs	Ghana data
ECA and Ramboll (2012)	The report provides recommendations to reduce transaction costs of small-scale (less than 10MW) grid-connected renewables, including: standardised PPAs, FiT design and values, connection guidelines	It focuses on biomass, biogas, solar, hydro, wind and geothermal • Cost of equity • Load factors per technology • Investment costs per technology • O&M costs per technology	Kenya data
Ministry of Energy of Kenya (2012)	Feed-in tariffs policy on wind, biomass, small-hydro, geothermal, biogas and solar resource generated electricity, second revision	• Standard FiT (US$/kWh) • Installed capacity (MW)	Kenya data
KenGen Annual Report (2008 and 2010)	Financial data on KenGen projects, i.e. wind, hydro and geothermal	• Investment costs (US$) • Interest rates	Kenya data
Energy Regulatory Commission (2015)	Medium-term plan for the power sector between 2014 and 2018	• Capacity (MW) • Estimated investment cost (US$)	Kenya data
ERC documentation	Insight into the challenges facing investments in renewable energy	• Unit investment costs	Kenya data
Central Bank of Kenya	Information on the domestic cost of finance	• Commercial banks' lending rates • Bond interest rates	Kenya data
Energy Regulatory Commission of Kenya	Information on electricity tariffs	• Feed-in tariffs • Grid tariffs	Kenya data
Waissbein *et al.* (2013)	Framework to support policymakers in selecting instruments to promote renewable energy investment in developing countries (Kenya, South Africa, Panama and Mongolia)	It focuses on wind • Cost of debt • Cost of equity • Payback period	Kenya data

References

Arent, D. (2016) 'Prospects for Renewable Energy in Africa', [Special Issue], *Applied Energy* 161

Banerjee, S.; Wodo, Q.; Diallo, A.; Pushak, T.; Uddin, H.; Tsimpo, C. and Foster, V. (2008) *Access, Affordability and Alternatives: Modern Infrastructure Services in Africa*, Background Paper, Washington DC: World Bank

Briceño-Garmendia, C. and Shkaratan, M. (2011) *Power Tariffs: Caught between Cost Recovery and Affordability*, Policy Research Working Paper 5904, Africa Region Sustainable Development Unit, Washington DC: The World Bank

Brouwer, A.; van den Broek, M.; Seebregts, A. and Faaij, A. (2014) 'Impacts of Large-scale Intermittent Energy Sources on Electricity Systems, and How These Can Be Modelled', *Renewable and Sustainable Energy Reviews* 33: 443–66

Castellano, A.; Kendall, A.; Nikomarov, M. and Swemmer, T. (2015) *Brighter Africa. The Growth Potential of the Sub-Saharan Electricity Sector*, McKinsey

Eberhard, A. (2014) 'Feed-in Tariffs or Auctions? Procuring Renewable Energy Supply in South Africa', *Energize RE*: Renewable Energy Supplement – June 2014

Eberhard, A. and Shkaratan, M. (2012) 'Powering Africa: Facing the Financing and Reform Challenges', *Energy Policy* 42

Economic Consultants Associate (ECA) and Ramboll (2012) *Final Report on Technical and Economical Study for the Development of Small Grid Connected Renewable Energy in Kenya*, ECA and Ramboll

Ecreee/Ecowrex (2015) *Renewable Energy Profile of Ghana*, www.ecowrex.org/country_profile/375/2011 (accessed 23 February 2015)

Edjekumhene, I.; Atakora, S.B.; Atta-Konadu, R. and Brew-Hammond, A. (2001) *Implementation of Renewable Energy Technologies – Opportunities and Barriers: Ghana Country Study*, Denmark: UNEP Collaborating Centre on Energy and Environment

Energy Commission of Ghana (ECG) (2015a) *Energy (Supply and Demand) Outlook for Ghana*: *Final Report*, Accra, Ghana: Republic of Ghana

ECG (2015b) *National Energy Statistics 2005–2014*, Accra, Ghana: Republic of Ghana

ECG (2014) *National Energy Statistics: 2000-2013 Final Draft*, Accra, Ghana: Republic of Ghana

ECG (2013) *Strategic National Energy Plan 2000–2020*, Accra, Ghana: Republic of Ghana

Energy Regulatory Commission (ERC) of Kenya (2015) *Power Sector Medium Term Plan 2015–2020*, Nairobi, Kenya: ERC

Energy Regulatory Commission (ERC) of Kenya (2013) *Strategic National Energy Plan 2000–2020*, Nairobi, Kenya: ERC

Energy Regulatory Commission (ERC) of Kenya (2010) 'Working With Cost Reflective Tariffs – The Kenyan Experience', Presentation by Dr Frederick Nyang to the East African Power Industry Convention, Nairobi, Kenya, 31 August – 10 September 2010

Energy Sector Management Assistance Programme (ESMAP) (2012) 'World Bank Model for Electricity Technology Assessment (META) Version 6', www.esmap.org/node/3051 (accessed 23 March 2016)

Ghana Capital Partners (GCP) (2015) '28MW Solar Pv Plant – Ghana', Presentation for WAFCEF Forum, Abidjan, African Development Bank 17 September 2015

Ghana Statistical Service (GSS) (2014) *Ghana Living Standards Survey Round 6 (GLSS 6) Main Report*, August 2014, GSS

Ghana Statistical Service (GSS) (2008) *Ghana Living Standards Survey: Report of the Fifth Round (GLSS 5)*, GSS, www.statsghana.gov.gh/docfiles/glss5_report.pdf (accessed 18 April 2016)

Government of Kenya (2014) *Power Sector: Medium Term Plan (2014–2018)*, Government of Kenya

Hille, G.; Seifried, D.; Laukamp, H.; Rössler, E.; Reich, K. (2011) 'Grid Connection of Solar PV. Technical and Economical Assessment of Net-Metering in Kenya', Eschborn, Germany: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)/German Federal Ministry of Economics and Technology (BMWi)

Institute of Statistical Social and Economic Research (ISSER) (2012) *Ghana Social Development Outlook 2012*, ISSER-UG

International Energy Agency (IEA) (2015a) *Medium Term Renewable Energy Market Report 2015*, Paris: IEA

International Energy Agency (IEA) (2015b) 'Electricity Access Database', *World Energy Outlook 2015*, Paris: IEA

International Energy Agency (IEA) (2010) 'Technological Brief E12-Hydropower', Energy Technology Systems Programs (ETSAP), Paris: IEA, www.etsap.org (accessed 23 March 2016)

International Renewable Energy Agency (IRENA) (2015a) *Ghana Renewables Readiness Assessment*, Abu Dhabi: IRENA

International Renewable Energy Agency (IRENA) (2015b) *Renewable Power Generation Costs in 2014,* Abu Dhabi: IRENA

International Renewable Energy Agency (IRENA) (2014) *Estimating the Renewable Energy Potential in Africa: A GIS Approach,* Abu Dhabi: IRENA

Kalitsi, E.A.K. (2003) *Problems and Prospects for Hydropower Development in Africa*, www.un.org/esa/sustdev/sdissues/energy/op/nepadkalitsi.pdf (accessed 3 March 2015)

Kenya Gazette (2014) 'Gazette Notice No. 281, The Energy Act (No. 12 Of 2006) Schedule Of Tariffs For Supply Of Electrical Energy By The Kenya Power And Lighting Company Limited'

KenGen (2010) *Annual Report and Financial Statements for the Year ended 30th June 2010*, KenGen and Kenya Power

KenGen (2008) *Annual Report and Financial Statements for the Year ended 30th June* 2008, KenGen and Kenya Power

Kenya Institute for Public Policy Research and Analysis (KIPPRA) (2013) *Kenya Economic Report 2013*, Nairobi: KIPPRA

Kenya National Bureau of Statistics (2007) *Basic Report on Well-Being in Kenya, Nairobi*, Kenya National Bureau of Statistics

Kenya Power (2014) *Annual Report and Financial Statements for the Year ended 30th June 2014*, KenGen and Kenya Power

Kiplagat, J.K.; Wang, R.Z. and Li, T.X. (2011) 'Renewable Energy in Kenya: Resource Potential and Status of Exploitation', *Renewable and Sustainable Energy Reviews* 15.6: 2960–73

Kost, C.; Mayer, J.N.; Thomsen, J.; Hartmann, N.; Senkpiel, C.; Philipps, S.; Nold, S.; Lude, S.; Saad, N. and Schlegl, T. (2013) *Levelized Cost of Electricity Renewable Energy Technologies*, Freiburg, Germany: Fraunhofer Institute for Solar Energy Systems

Lake Turkana Wind Power (2014) 'Lake Turkana Wind Power Project', Presentation for the Seminar on Sustainable Energy Investments in Africa Copenhagen, 24–25 June 2014

Lopez, H. (2008) *The Social Discount Rate: Estimates for Nine Latin American Countries*, Policy Research Working Paper 4639, Washington DC: World Bank

McKinsey & Company (2015) *Brighter Africa: The Growth Potential of the Sub-Saharan Electricity Sector,* McKinsey & Company

Micale, V.; Trabacchi, C. and Boni, L. (2015) *Using Public Finance to Attract Private Investment in Geothermal: Olkaria III – Case Study, Kenya*, Climate Policy Initiative

Ministry of Energy of Ghana (2012) 'Opportunities in the Ghana Renewable Energy Act 2011, Act 832', Presentation, April 2012, www.ecreee.org/sites/default/files/ghana.pdf (accessed December 2015)

Ministry of Energy of Kenya (2012) *Feed-In Tariffs Policy on Wind, Biomass, Small-hydro, Geothermal, Biogas and Solar Resource Generated Electricity*, second revision: December 2012

Mott Macdonald (2010) *UK Electricity Generation Costs Update*, 25 May, Brighton: Mott Macdonald

Mutegi, M. (2014) 'Power Connection Cost to Double as Subsidy Withdrawn', *Business Daily*, 14 July, www.businessdailyafrica.com/Power-connection-cost-to-double-as-subsidy-withdrawn/-/539546/2382644/-/mxhxx9/-/index.html (accessed 23 March 2016)

Ondraczek, J. (2014) 'Are We There Yet? Improving Solar PV Economics and Power Planning in Developing Countries: The Case of Kenya', *Renewable and Sustainable Energy Reviews* 30: 604–15

Ondraczek, J.; Komendantova, N. and Pat, A. (2015) 'WACC the Dog: The Effect of Financing Costs on the Levelized Cost of Solar PV Power', *Renewable Energy* 75: 888–98

Power Systems Engineering Consultants and GRIDCo (2010) *Ghana Wholesale Power Reliability Assessment 2010*, March 2010, Power Systems Energy Consulting

Public Utilities Regulatory Commission (PURC) (2015) 'Publication of Electricity Tariffs', 30 June, http://ghana.ahk.de/fileadmin/ahk_ghana/docs/electricity_and_water_tariffs_for_july_september_2015.pdf (accessed 23 March 2016)

PURC (2014) 'Publication of Feed-In Tariffs and Capacity Cap for Electricity Generated from Renewable Energy Sources,' *Ghana Gazette*, 12 November

PURC (2010) 'PURC Tariff Setting: Wash Sector Financing and Tariff Setting in Ghana', PURC presentation, presented at Coconut Grove Regency Hotel, 26 August 2010

Renewable Energy Policy Network for the 21st Century (REN21) (2015) *Renewables 2015 Global Status Report,* www.ren21.net/status-of-renewables/global-status-report/ (accessed 18 March 2016)

Republic of Kenya (2011) *Updated Least Cost Power Development Plan 2011–2031*, Nairobi: Republic of Kenya, Ministry of Energy and Petroleum

Rose, A.; Stoner, R. and Pérez-Arriaga, I. (2016) 'Prospects for Grid-Connected Solar PV in Kenya: A Systems Approach', *Applied Energy* 161.1: 583–90

Staffell, I. and Green, R. (2014) 'How Does Wind Farm Performance Decline with Age?', *Renewable Energy* 66: 775–86

Tenenbaum, B.; Greacen, C.; Siyambalapitiya, T. and Knuckles, J. (2014) *From the Bottom Up: How Small Power Producers and Mini-Grids Can Deliver Electrification and Renewable Energy in Africa*, Washington DC: World Bank

UNEP (2005) 'Thousands of Megawatts of New Renewable Energy Potential', press release, 14 April, Washington DC: United Nations Environment Programme

UNEP–Ghana (2015) *Green Economy Assessment Report – Ghana*, Institute of Statistical, Social and Economic Research (ISSER), University of Ghana, Nairobi: United Nations Environment Programme

UNEP–Ghana (2013) *Green Economy Scoping Study Report – Ghana*, Institute of Statistical, Social and Economic Research (ISSER), University of Ghana, Nairobi: United Nations Environment Programme

University of Nairobi Enterprise Services (UNES) (2014) *Report on Cost-Benefit Analysis for Policy Interventions – Consulting Services on the Pilot Project of the Global Fuel Economy Initiative (GFEI),* No: ERC/PROC/4/3/12-13/189, submitted to the Energy Regulatory Commission, March 2014

Waissbein, O.; Glemarec, Y.; Bayraktar, H. and Schmidt, T.S. (2013) *Derisking Renewable Energy Investment: A Framework to Support Policymakers in Selecting Public Instruments to Promote Renewable Energy Investment in Developing Countries*, New York: United Nations Development Programme

Waruru, M. (2015) 'Solar to Grab Bigger Slice of Kenya's Clean Energy Pie', *Thomson Reuters Foundation*, 23 January, www.trust.org/item/20150123092221-7nuus (accessed 19 February 2015)

World Bank (2015) *Private Participation in Infrastructure Database*, Washington DC: World Bank, http://ppi.worldbank.org/ (accessed 1 December 2015)

World Bank (2014) *Indicators: Lending Interest Rate 2014*, Washington DC: World Bank, http://data.worldbank.org/indicator/FR.INR.LEND (accessed 1 December 2015)

World Bank *Indicators Electric Power Transmission and Distribution Losses (% of Output),* Washington DC: World Bank, http://data.worldbank.org/indicator/EG.ELC.LOSS.ZS/countries?display=default (accessed 1 December 2015)

World Energy Council (2013) *Survey of Energy Resources*. London: World Energy Council

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