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Wind energy in Kenya: A status and policy framework review

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ABSTRACT

This article provides a review of the latest status and policy framework for wind energy in Africa. In addition, it takes a close look at Kenya, which is one of the most successful African countries in terms of attracting renewable energy (RE) investments, including the largest wind farm on the continent. Globally, wind energy development needs strong government policy. Following numerous bilateral and multilateral efforts, by 2016, the majority of African countries had defined RE supporting policies, with nearly half also having defined their wind energy targets. However, the review of such policies on the continent as a whole, as well as a closer examination of the situation in Kenya, indicate that established supportive policies and fiscal incentives remain important for the development of wind energy on the African continent but are not the decisive factors. It also suggests that international private participation in energy generation and renewable/wind energy expansion in Africa is critical and expected to increase. Consequently, it may be challenging to ensure that African countries capitalise on their inherent advantage in terms of clean energy during their energy transition processes.

1. Introduction

Facilitating a transition to sustainable energy systems is required to mitigate climate change [1]. A clean energy transition occurs when the share of renewable energy (RE) in the power mix is growing faster than those of other energy sources [2]. Typically, the contemporary energy transition is strongly shaped by economic development, technological innovation and policy changes [3]. However, it appears that supporting policies as well as effective institutions are among the most prominent factors shaping energy transition processes [4]. Globally, most countries have committed to do more to achieve a clean energy transition in order to fulfil the ambitions of the Sustainable Development Goals (SDG) agenda regarding SDG 7 (energy and energy access) and SDG 13 (climate change), as well as the commitments made during the 21st Conference of the Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCCC) in Paris in 2015. The analysis of energy transitions of developed countries has been well documented [see i.e. [2–8], but less attention has been given to the analysis of such transitions in developing countries, particularly on the African continent.

Africa faces a serious challenge in fulfilling the above-mentioned global commitments. The continent's rapid growth trajectories imply a higher volume of emissions and it is highly unlikely that it will shelve its developmental aspirations in favour of climate change mitigation objectives. A recent wave of oil and gas discoveries in African countries, and the enthusiasm that it created, is only one example supporting this argument [9]. With over 588 million Africans still lacking access to electricity [10], the deficit of energy is easily supplemented with diesel generators [11]. However, Africa's energy sector has a unique feature: a major portion of African energy currently comes from renewable energy resources, primarily from unreliable hydropower. With great sun, wind, geothermal, and hydropower potential, the continent has an inherent advantage in terms of clean energy [12–14]. Therefore, the clean energy transition in the African context should be understood not as a transition per se, but rather as clean energy modernisation and expansion [1,15].

A number of initiatives have emerged to address Africa's energy challenges and to support the necessary expansion and modernisation, notably programmes such as Sustainable Energy for All, the African Union's Programme of Infrastructure Development in Africa (PIDA), Power Africa, the Africa-EU Energy Partnership, the African Clean Energy Corridor, as well as numerous bilateral, civil society and community efforts. Finally, in 2015, the African Union, supported by the G7 countries, officially launched the Africa Renewable Energy Initiative (AREI) at COP 21 in Paris. AREI objectives, aligned with the African Regional Flagship Programme (ARFP) on Sustainable Energy, include strengthening policy, regulatory support and incentive frameworks of African countries to develop their energy sector and achieve a sustainable energy mix, with priority given to, among others, the promotion of wind energy [16].

Wind energy is the world's fastest growing renewable energy technology [17–19]. It costs very little to maintain and, to date, it has

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proven to be one of the cheapest resources per unit of generated electricity [18]. Proponents of wind energy argue that "[i]ncreased use of wind energy […] will spur economic growth, create job opportunit [ies], enhance national security, protect consumers from price spikes or supply shortages associated with global fuel markets and dramatically reduce the pollutant that is warming the planet which causes greenhouse effect" ([19]: 1745). Wind energy has been the fastest-growing energy technology since the 1990s, but the growth of wind energy in terms of installed capacity is not evenly distributed around the world. Eighty-five per cent of the total wind capacity is installed in ten countries in Asia, North America, Europe and Latin America [20]. With only 4370 MW, Africa is lagging behind, constituting only 0.81 per cent of the globally installed wind capacity in 2017. However, Africa's indicative potential for wind power is 109,000 MW [20,21]. Therefore, it is important to investigate why, currently, only a very small portion of such considerable potential is used, while the total primary energy demand on the continent continues to increase.

Kenya has one of the highest potentials for wind generation in Africa. The present contribution of wind to the total energy mix is marginal; however it is expected to increase substantially in the coming years. Kenya has been particularly successful at attracting renewable and wind energy investments [22,23], including the 310 MW Lake Turkana Wind Power (LTWP) project, the largest wind farm on the continent. LTWP is also the largest private investment in the country and is located on the south-east side of Lake Turkana in Marsabit County – a remote and so far neglected part of Kenya. Additionally, a number of other large-scale wind power projects are under development, including Kipeto (100 MW), Isiolo (100 MW), Meru (60 MW), Ngong (51 MW) and the Baharini Electra Wind Farm project in Lamu (90 MW) [24–26]. Since the 1990s, Kenya has reformed its legal and institutional frameworks to accelerate the energy expansion process. Therefore, by taking Kenya as the main case study, the objective of this article is to investigate the changes in regulatory, institutional and policy framework supporting the wind energy sector in Africa, specifically in Kenya. This can be seen as a starting point for understanding and critically reflecting on the process of clean energy transition in the African context.

To analyse energy transition in the wind energy sector, this article builds on the work of Saidur et al. [19] and Mukasa et al. [27], who previously conducted research into the global and African wind energy sector, respectively. Furthermore, the general framework for the analysis of energy transition developed by Cherp et al. [3] will be loosely adopted, but the focus will be limited to the role of policy changes in the Kenyan energy system. Information used is drawn from an extensive review of the literature on energy transition (with the primary focus on Africa), African governments' documents, as well as media and internet sources. The review is supplemented with a number of interviews with government representatives from the Kenyan Ministry of Energy and developers of a major wind energy project in Kenya. The interviews were conducted from June 2016 to October 2016 and in August 2017.

The paper starts with a literature review concerning the state of RE and wind power in Africa, as well as a review of the supporting policies. Section 3 examines the energy transition taking Kenya as the main case study. It takes a historical approach to the reforms that have occurred in the energy sector more broadly and analyses the current energy mix. Finally, wind energy, supporting policies, as well as challenges to the expansion of wind projects in Kenya are discussed. The main conclusions are given in Section 4.

2. Wind energy in Africa: literature review

Since 2002, sub-Saharan Africa (SSA) has gained increasing attention in scholarly work related to the energy situation on the continent [28], with Mandelli [15] providing the most comprehensive review of African (renewable) energy status, policies and literature to date. An increased number of detailed case studies focusing on the renewable energy policies of particular African countries have also been published (for example: [14] for South Africa, Egypt, Nigeria and Mali, [29] for Ghana, [30] for Morocco, or [18] for South Africa, Egypt and Nigeria). Nevertheless, less attention has been given to the status and policies supporting wind energy development as such, despite wind energy being considered one of the most cost-effective options among renewable energy sources [31], but also needing particularly strong government policy for development [32]. With only 0.81 per cent of global wind capacity installed in Africa in 2017 [20], reviews concentrating solely on the African region and an incentive system for its further integration and development are scarce [19,27].

In their review of global wind energy policy, Saidur et al. [19] include only two North African countries (Egypt and Algeria) and do not take into consideration sub-Saharan Africa. This gap was closed by Mukasa et al. [27], who provided the first comprehensive overview of the total region's wind energy sector (including both Northern Africa and SSA) up until 2010. Both Saidur et al. [19] and Mukasa et al. [27], as well as other scholars analysing energy transition, conclude that in order to guarantee the energy transition and development of the wind energy sector, two factors in particular are considered crucial on the global level, namely: adequate infrastructure and a supportive national legal framework [3,4,19,27,33]. Regarding the necessary infrastructure, it has been proven that systems with pre-existing hydropower can accommodate irregular wind power more easily [9]. However, to encourage higher usage of wind energy in Africa, there is a major need to provide further extensions to grid infrastructure [13,22,33,34]. Regarding the supportive energy policies, the study of the global wind champions[1] showed that the existence of wind energy policies contributed significantly to the increase in wind power generation [19].[2] The question thus remains whether the same applies in the case of Africa.

The indicative potential for wind power in Africa is 109,000 MW [21], with the best wind being found in the coastal regions [27]. The Horn of Africa, eastern Kenya, parts of West and Central Africa bordering on the Sahara and parts of Southern Africa also show high quality wind resources [17,27]. Somalia is considered to have the highest onshore potential, followed by Sudan, Libya, Mauritania, Egypt, Madagascar and Kenya [35], while the offshore wind energy potential is optimal off the coast of Madagascar, Mozambique, Tanzania, Angola and South Africa. By 2016, almost half of African countries (26 countries) have set ambitious wind energy targets (Table 2), and some are ranked among the highest in the world [36]. Although the installed wind capacity is expected to quadruple within the coming five years [37], the current low speed of adding capacity indicates that it is unlikely that this goal will be achieved in the assumed timeframe.

In 2017, only 4370 MW – a tiny fraction of the total potential – was being exploited in Africa (Table 1). This wind energy was produced by only 16 African nations, and was concentrated predominantly within three of them, namely South Africa, Egypt and Morocco, which together held 84 per cent of the continent's total installed wind capacity (Table 1). Most of the wind development was located onshore [9] and there was no installed wind capacity offshore on the continent [20]. Although the amount of installed wind capacity in Africa has nearly quadrupled within the last five years (Table 1), and a total of 140 wind farms with a cumulated capacity of 21,000 MW are expected to be operational in Africa by 2020 [38], the installed wind capacity remains low and far from reaching the continent's ambitious targets.

The main reason behind this can be the fact that established policies and regulations appear not to be the decisive factors for the development of wind farms in Africa [27]. Table 2 indicates that 5 out of 16

[1] The study of USA, Canada, Denmark, Germany, Turkey, Australia, China, Japan and South Korea.

[2] Although another study [109] showed that in some EU countries policies didn't have a strong effect on wind power development.

Table 1
Wind energy installed capacity (MW) in Africa 1995–2017 [15,18,20,32,37,39–71].

	1995	1999	2001	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	%
South Africa				3	3	3	8	8	10	10	10	10	570	1053	1471	2085	47.7%
Egypt	5	15	125	145	230	310	365	430	550	550	550	550	610	810	810	810	18.5%
Morocco			54	64	124	124	134	253	286	291	291	291	787	787	787	787	18.0%
Ethiopia									30	30	52	171	171	324	324	324	7.4%
Tunisia				20	20	20	54	54	104	104	104	104	245	245	245	245	5.6%
Mauritania												4	4	34	34	34	0.8%
Kenya				0.4	0.4	0.4	0.4	0.4	5	5	5	5	5	26	26	26	0.6%
Cape Verde		3	3	3	3	3	3	12	24	24	24	24	24	24	24	24	0.5%
Mauritius								1	1	1	1	1	1	1	11	11	0.3%
Algeria													10	10	10	10	0.2%
Seychelles												6	6	6	6	6	0.1%
Somalia											2	2	2	3	3	3	0.1%
Nigeria				2	2	2	2	2	2	2	2	2	2	2	2	2	0.05%
Madagascar										1	1	1	1	1	1	1	0.02%
Chad															1	1	0.02%
Eritrea						1	1	1	1	1	1	1	1	1	1	1	0.02%
Total	**5**	**18**	**182**	**237**	**382**	**463**	**567**	**761**	**1013**	**1019**	**1043**	**1172**	**2440**	**3327**	**3756**	**4370**	**100%**

African countries involved in wind energy production have no explicit wind energy policy or established targets. Simultaneously, 11 out of 23 countries[3] with established targets for wind energy production are currently not active producers of such energy. Such findings suggest that in the African context the presence of legislation is important, but, despite this, it remains insufficient in the energy transition process.

A number of countries around the world consider Feed-in-Tariffs (FiT), Renewable Portfolio Standard (RPS), production incentives, pricing law and quota requirements as key policies for increasing the use of RE [19]. The main advantage of the FiT scheme is its predictability, but it also eliminates price competition. Within Africa, the FiT scheme is not very popular, with only 13 countries adopting the scheme (and 11 of these schemes consider wind energy). The FiT rates also differ substantially from country to country, with the cheapest rates found in Algeria (10 US cent per kW h) and the highest rate of 16.5 US cent per kW h in Tanzania.[4] The average FiT rate across African countries is 12.6 US cent per kW h.[5] Among the top three wind-producing countries, only Egypt has an active FiT scheme, while all of them engage in competitive tendering processes. Competitive bidding is currently the most popular form of tendering for RE and is also considered a more effective method for driving the prices of RE down [27,72]. The example of South Africa shows that since the introduction of this process, competitive tenders have attracted new and substantial private investments, while bid prices for electricity production from wind and solar PV power fell by 46 per cent and 71 per cent respectively in nominal terms [72]. RPS and tradeable Renewable Energy Certificates (REC) are much less popular on the continent, with the latter being adopted only by Ghana. What appears to count more than a strong regulatory framework are fiscal incentives and public financing. The majority of countries that generate electricity from wind, including those without an explicit wind energy policy or established targets, do offer reductions in sales or taxes, and/or provide public loans, grants, capital subsidies or rebates (Table 2).

It is argued that a clear regulatory framework will attract new investors, but in the African context it is not a prerequisite. What appears to be more important is creating a conducive environment to attract wind and other RE projects. Kenya is the only country on the continent that has not only implemented major reforms to its energy sector and introduced a range of fiscal incentives and public financing possibilities (Table 2), but has also been particularly successful in attracting renewable and wind energy investments in recent years [22]. It is therefore worthwhile investigating what the process behind Kenya's energy transition was and the extent to which the adequate infrastructure and supportive national legal frameworks have addressed the energy demand gap in the country.

3. Case study: energy transition in Kenya

3.1. The energy sector in Kenya

In 2017, Kenya's total installed energy capacity stood at 2333 MW. The whole system generated 10,205 GW h, out of which 74 per cent came from the state-owned Kenya Electricity Generating Company and 24 per cent from a number of Independent Power Producers (IPPs). The remaining 2 per cent was imported from neighbouring countries, mostly from Uganda. Electricity currently reaches 55 per cent of the population, which shows major progress with regards to the electrification of Kenya (in 2013 only 27 per cent of the population had access to electricity) [55,80]. It is estimated that 77 per cent of electricity is generated using renewable energy sources, which are predominantly hydro (33 per cent) and geothermal (44 per cent), while 21 per cent comes from thermal plants, thus from fossil fuels [55]. The further expansion of other renewable energy sources, including wind, has been given a high priority in key national policies (Kenya Vision 2030, the Rural Electrification Master Plan) [81,82].

3.1.1. Short history of Kenya's energy sector and first reforms

In 1906, Clement Hirtzel, an ambitious electrical engineer from Britain, established the Nairobi Electric Power and Lighting Syndicate, a company with the exclusive right to supply electric light and power to the town and district of Nairobi. In 1908, a wealthy merchant in Mombasa, Hassanali Esmailijee Jivanjee, bought the electricity generating plant from the Electric Company of Zanzibar, which was the first of its kind in Africa. This plant was sold to the newly formed Mombasa Electric Light and Power Company Limited. The two companies (Nairobi Electric Power and Lighting Syndicate and Mombasa Electric Light and Power Company Limited) merged in 1922 to become the East African Power and Lighting Company (EAP&L). In 1983, the company was renamed Kenya Power and Lighting Company Limited (KPLC) and then again as Kenya Power in 2011, however the acronym KPLC is still in use today [62,83].

For a long time, Kenya has relied heavily on hydropower plants for its electricity generation capacity. However, the droughts in the 1990s, which resulted in severe power shortages and crippled the formal economy, forced the government to initiate a number of policies and reforms [84]. Moreover, in the mid-1990s, as the country emerged from

[3] In total, 25 countries have established targets for wind energy production, however for Togo and Mali this target is set for zero MW.

[4] Mauritius' rate of 33 US cents per kW h is the highest, yet this rate applies to very small wind projects < 50 kW.

[5] Excluding Mauritius.

Table 2
Renewable energy support policies, Targets for wind power per country in Africa (2016) [18,36,46,59,66,67,73–79].

Country	All Renewable energy targets	Renewable energy in INDC or NDC	Wind energy targets (or a % of total energy mix)	Current wind energy production	Regulatory policy			
					Feed-in tariff/premium payment	Feed-in tariff set for wind (US cents/kW h)	Electric utility quota obligation/RPS	Net metering
Algeria	X	X	5100 MW by 2030	10 MW	X	10		
Angola	X	X	100 MW by 2025					
Benin	X		10 MW by 2020		X[a]			
Botswana	X		30 MW by 2016					
Burkina Faso	X	X						
Burundi	X	X	10 MW by 2020					
Cape Verde	X	X	76 MW by 2020	24 MW				X
Cameroon	X	X						
Central African Republic (CAR)	X	X						
Chad				1 MW				
Comoros								
Côte d'Ivoire	X	X						
Democratic Republic of the Congo	X	X						
Djibouti	X							
Egypt	X	X	7200 MW by 2020	810 MW	X	11.5		X
Equatorial Guinea								
Eritrea	X		5 MW (no date)	1 MW				
Eswatini (Swaziland)	X							
Ethiopia	X	X	7000 MW by 2030	324 MW				
Gabon	X							
Gambia	X	X						
Ghana	X	X			X	16	X	X
Guinea	X	X	2% by 2025					
Guinea-Bissau	X							
Kenya	X	X	2036 MW by 2030	26 MW	X	11		X
Lesotho	X	X	6000 MW by 2025					X
Liberia	X	X						
Libya	X		1000 MW by 2025					
Madagascar	X	X	5% by 2030	1 MW				
Malawi	X	X			X	13		
Mali	X	X	0					
Mauritania	X			34 MW				
Mauritius	X	X	6% by 2020 &8% by 2025	11 MW	X	33		
Morocco	X	X	2000 MW by 2020	787 MW				X
Mozambique	X	X	2000 MW (no date)		X	13		
Namibia	X	X			X	10.6		
Niger	X	X						
Nigeria	X	X	40 MW by 2025	2 MW	X	12.5	X	
Republic of the Congo								
Rwanda	X	X			X[b]			
Sao Tome and Principe	X							
Senegal	X	X					X	X
Seychelles	X	X		6 MW				X
Sierra Leone	X		2 MW by 2030					
Somalia				3 MW				
South Africa	X	X	9200 MW by 2030	2085 MW			X	
South Sudan	X							
Sudan	X	X	680 MW by 2031					
Tanzania	X	X	50–100 MW by 2030		X	16.5		
Togo	X	X	0					
Tunisia	X	X	1800 MW by 2030	245 MW				X

(*continued on next page*)

Table 2 (*continued*)

Country	All Renewable energy targets	Renewable energy in INDC or NDC	Wind energy targets (or a % of total energy mix)	Current wind energy production	Regulatory policy			
					Feed-in tariff/premium payment	Feed-in tariff set for wind (US cents/kW h)	Electric utility quota obligation/RPS	Net metering
Uganda	X	X			X	12		
Zambia	X	X						
Zimbabwe		X						

Country	Regulatory policy				Fiscal incentives and public financing			
	Transport obligation/ mandate	Heat obligation/ mandate	Tradable REC	Tendering	Investment or production tax credits	Reductions in sales, energy, VAT or other taxes	Energy production payment	Public investment, loans, grants, capital subsidies or rebates
Algeria				X			X	X
Angola	X							X
Benin				X				
Botswana						X		X
Burkina Faso				X	X	X	X	
Burundi				X		X		
Cape Verde				X	X		X	
Cameroon						X		
Central African Republic (CAR)								
Chad						X		
Comoros								
Côte d'Ivoire				X		X		
Democratic Republic of the Congo						X		
Djibouti								
Egypt				X		X		X
Equatorial Guinea								
Eritrea								
Eswatini (Swaziland)								
Ethiopia	X					X		X
Gabon								
Gambia						X		
Ghana	X		X			X		X
Guinea						X		
Guinea-Bissau								
Kenya		X		X		X	X	X
Lesotho				X	X		X	X
Liberia						X		
Libya						X		
Madagascar						X		
Malawi		X		X		X		X
Mali	X					X		X
Mauritania								
Mauritius				X		X		X
Morocco				X		X		X
Mozambique	X					X		X
Namibia		X						
Niger						X		
Nigeria	X			X		X		X
Republic of the Congo				X				
Rwanda				X		X		X
Sao Tome and Principe								

(*continued on next page*)

Table 2 (*continued*)

Country	Regulatory policy				Fiscal incentives and public financing			
	Transport obligation/ mandate	Heat obligation/ mandate	Tradable REC	Tendering	Investment or production tax credits	Reductions in sales, energy, VAT or other taxes	Energy production payment	Public investment, loans, grants, capital subsidies or rebates
Senegal				X		X		
Seychelles					X	X		X
Sierra Leone						X		
Somalia						X		
South Africa	X	X		X		X		X
South Sudan								
Sudan	X							
Tanzania						X	X	X
Togo						X		
Tunisia						X		X
Uganda				X		X		X
Zambia				X		X		X
Zimbabwe	X					X		X

INCD – Intended Nationally Determined Contribution, NCD – Nationally Determined Contribution, RPS – Renewable portfolio standard(s), REC – Renewable Energy Certificates.
[a] For solar and biomass only.
[b] For hydropower only.

an aid embargo, the reforms in Kenya's electricity supply sector were critical, as the country intended to attract much-needed private sector investments to complement limited public sector funding [23,85]. Consequently, following the Electric Power Act of 1997, it was decided to split KPLC's core functions into two entities: the Kenya Electricity Generating Company (entirely state-owned KenGen; responsible for power generation) and KPLC (responsible for the transmission and distribution of power). The Electric Power Act of 1997 also stipulated that the government's primary function, through the Ministry of Energy and Petroleum (MoEP), is policy formulation, thus devolving its regulatory authority to a newly established Electricity Regulatory Board (ERB) that became functional in 1998. Despite the reforms, electricity in Kenya remained unreliable and beyond the reach of most of its citizens. In 2004, further reforms were instituted through the National Energy Policy (Sessional Paper No. 12 of 2004) and the subsequent enactment of the Energy Act of 2006. These reforms reorganised the sector again by, among others, the establishment of the Rural Electrification Authority (REA) and restructuring of the Electricity Regulatory Board (ERB) to the Energy Regulatory Commission (ERC), whose mandate was expanded to encompass the entire energy sector. Additionally, the Geothermal Development Company (GDC) and the Kenya Electricity Transmission Company (KETRACO) were created to promote geothermal development and facilitate transmission network expansion, respectively. The government also committed to facilitating the development of a competitive market structure for the generation, distribution and supply of electricity [23,62,83,84].

3.1.2. *Reforms towards market liberalisation and current institutional set-up*

Further reform efforts and strategic targets followed. In 2008, Kenya's 2030 Vision set a new generation target of 23,000 MW by 2030. This ambitious target represents a ten-fold increase from the country energy capacity in 2008 and it is planned to be achieved through a mix of hydropower, geothermal, wind, coal, liquefied natural gas and imported power [86]. To realise the high growth rates assumed in the Vision 2030, the government emphasised the importance of enabling private sector participation in the process, which led to the development of a subsequent comprehensive investment framework for Public-Private Partnerships (PPPs). The First Medium Term Plan (2008–2012) provided the basis for improving the institutional and regulatory framework for PPPs, while the final policy was formalised with the passing of the PPP Act in 2013. Meanwhile, at the generation level, the ERC stated that “electricity generation in Kenya is liberalised,” with Independent Power Producers (IPPs) given an opportunity to enter the sector and compete alongside the state incumbent KenGen [87]. A competitive market structure became a goal and the proposed National Energy and Petroleum Policy and Energy Bill 2015 suggested further reforms to legal and institutional frameworks to facilitate a competitive wholesale market structure in the country. Despite market liberalisation, and a growing number of IPPs present in the sector, KenGen and the KPLC remain the dominant players [23,84]. Below, Table 3 gives an overview of the key institutions and their current functions in the power sector in Kenya, while Fig. 1 visualises the relations between different actors in Kenya's Electricity Sector.

3.1.3. *Private participation in power generation on a big scale*

The introduction of the Feed-in-Tariffs (FiT) policy in 2008 was a specific intervention designed to truly accelerate the energy expansion process and encourage more investors in the RE sector. The first iteration of this policy, however, failed to attract many investors and tariffs were subsequently reviewed in January 2010 [88]. A second FiT regime was introduced two years later (Table 4). While the FiT policy has increased investor confidence to some extent, it is generally held that rates have not yet reached a cost-reflecting level [23,89].

In 2009, the ERC established a multi-stakeholder Least Cost Power Development Planning Committee (LCPDP). In 2013, the 5000+ MW

Table 3
Key institutions and their functions in the power sector in Kenya [64,83].

Key institution	Functions
Ministry of Energy and Petroleum (MOE&P)	In charge of making and articulating energy policies to create an enabling environment for efficient operation and growth of the sector.
Energy Regulatory Commission (ERC)	Responsible for regulation of the energy sector. Its functions include licencing, retail and bulk tariff setting and oversight, coordination of the development of Indicative Energy Plans, monitoring and enforcement of sector regulations.
Energy Tribunal (ET)	An independent legal entity, established to arbitrate disputes in the sector.
Kenya Electricity Generating Company (KenGen)	The main player in electricity generation, with installed power system of 7513 MW (2017). It is listed at the Nairobi Stock Exchange with 70% shareholding by the Government of Kenya and 30% by private investors. The company accounts for about 74% of the installed capacity from various power generation sources that include hydropower, thermal, geothermal and wind.
Geothermal Development Company (GDC)	A fully government-owned Special Purpose Vehicle (SPV) intended to undertake surface exploration of geothermal fields, conduct exploratory, appraisal and production drilling and manage proven steam fields as well as enter into steam sales agreements with potential investors.
Independent Power Producers (IPPs)	Private investors in the power sector involved in generation either on a large scale, or for the development of renewable energy under the Feed-in-Tariff Policy. Current players are: IberAfrica; Tsavo; Or-power; Rabai; Imenti; Mumias; Thika Gikira; Triumph; Gulf; Biojule and Regen-Terem. Collectively, they account for about 24% of the country's installed capacity from thermal, geothermal, hydro, biomass and biogas.
Rural Electrification Authority (REA)	Established in 2007 with a mandate to implement the Rural Electrification Programme
Kenya Power (KPLC)	The off-taker in the power market buying power from all power generators based on negotiated Power Purchase Agreements for onward transmission, distribution and supply to consumers. It is governed by the State Corporations Act and is responsible for existing transmission and distribution systems in Kenya. KPLC is a listed company on the Nairobi Stock Exchange with the ownership structure being 50.1% by the National Social Security Fund (NSSF) and the GoK and 49.9% owned by private shareholders.
Kenya Electricity Transmission Company (KETRACO)	Incorporated in December 2008 as a State Corporation, 100% owned by the Government of Kenya. The Mandate of KETRACO is to plan, design, construct, own, operate and maintain new high voltage (132 kV and above) electricity transmission infrastructure.

capacity and expansion programme was launched with the goal of deploying 5000 MW within 40 months. The programme was presented by the Government of Kenya as the means to transform the country, by providing adequate generation capacity at a competitive rate [90]. The 2013–33 LCPDP was further modified to support the 5000+ MW programme and to champion the development of indigenous resources, including geothermal power, wind power, coal and, potentially, gas. While KenGen was to be the anchor investor in most of the projects, the plan relied heavily on independent power producers, with the latter expected to develop 70 per cent of the new installed capacity [23]. However, nearly two years from its inception in 2013, the 5000+ MW programme was scaled back. Lack of adequate (transmission and distribution) infrastructure proved to be a major obstacle to adequately absorbing and handling the envisioned rapid capacity additions. The roll-out and subsequent scaling back of the 5000+ MW programme sheds light on how planning and procurement are handled in the nation: when KenGen is unable to finance new investments, the private sector is invited to participate [23].

Typically, bids for IPPs are requested by the KPLC, and winners are selected via a competitive process, although in some cases (such as for the emergency thermal generators required in 2000 and 2011, and tenders for large LNG and coal plants in 2014) procurement has been handled by the government, either directly or through its appointed agent – KenGen. The government, through the Ministry of Energy and Petroleum, may also consider unsolicited bids. The majority of current IPPs were procured through competitive bidding or direct negotiations with the government. Most IPP capacity is supplied by diesel generators (75 per cent), followed by a geothermal installation (20 per cent), and biomass, a small hydro and biogas installation (altogether 5 per cent). Only two wind farms are a result of the FiT scheme, and the construction of one of these was later cancelled [23]. The percentage of IPP capacity has grown considerably since 2005 (see Table 5), however the share of renewable energy sources other than geothermal has so far been very limited [23].

Private participation in power generation is not new to Kenya; what is new, however, is the anticipated scale. For instance, of the capacity envisioned in the 5000+ MW programme, the majority (70 per cent) would be through the private sector. In 2017, Kenyan IPPs[6] accounted for approximately 30 per cent of the installed capacity in Kenya (691 MW). What is noticeable is the importance and involvement of international actors in the Kenyan energy sector. The budget of the Ministry of Energy is for two thirds offset through appropriations in aid [91–95]. Furthermore, the majority of companies behind current IPPs, are international investors, mostly from Europe and the USA, with international and multilateral funding. Private Kenyan companies are also present but their involvement is limited to two heavy fuel oil emergency power plants and 20 per cent stake in one of the wind energy projects (Table 6). LTWP, when commissioned in late 2018, will add 13 per cent of capacity to the national grid [96]. That will mean that 43 per cent of Kenyan energy will be in private, mostly international, hands. That may have a major implication for the country's energy security in the future.

3.2. Wind energy in Kenya

The potential for wind generation in Kenya is among the highest in Africa with a total of 346 W/m^2, which, theoretically, could fulfil power requirements for the whole country [68,98]. Geographically, Kenya has a number of specific areas with significant wind resources throughout the year, as a result of its complex topographical features and varying nature of surfaces in various regions [99]. Mostly the North West of the country (Marsabit and Turkana districts), the edges of the Rift Valley as well as the coastal area enjoy fairly good wind speeds and have the potential to be successfully exploited [68,100].

Wind energy in Kenya was introduced at the turn of the 20th century by European settlers and it was one of the earliest forms of industrial energy introduced into the country [98,101]. The first windmills were imported from Europe and used for agricultural water-lifting purposes. They were later replaced by diesel and petrol engines [102]. A number of wind projects started in the late 1970s and early 1980s, but most of them were abandoned because of inadequate feasibility assessments, poor planning and lack of funding [103]. Non-subsidized wind energy production in Kenya became competitive only after a substantial increase in the price of oil in 2005. The contribution of wind

[6] In addition to Kenyan IPP, approximately 184 MW was purchased via regional IPPs (Uganda Electricity Transmission Company Limited and Ethiopia Electricity Power Company) in 2017 [55].

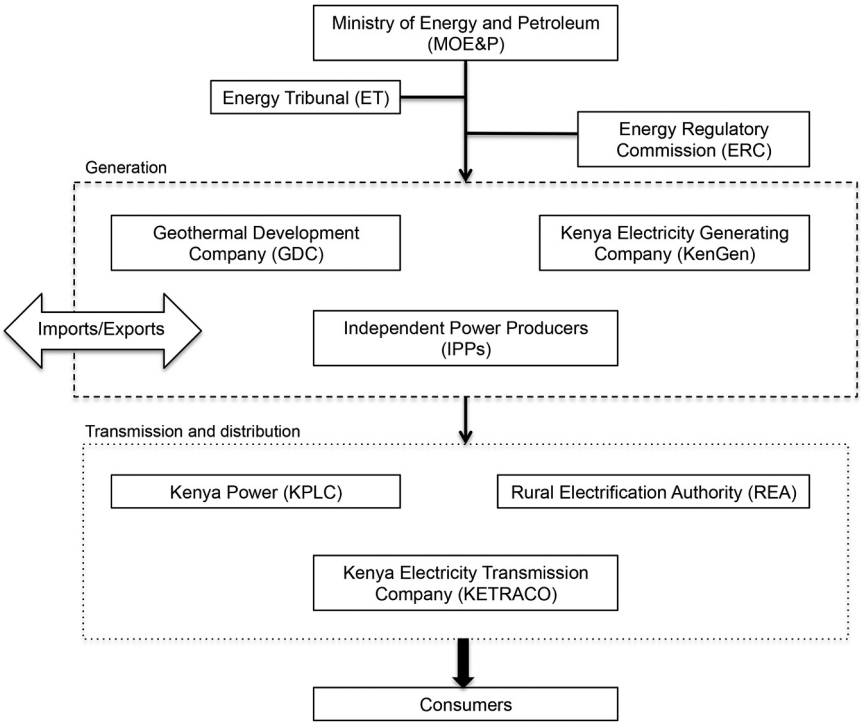

Fig. 1. Overview of Kenya's Electricity Sector [adopted from [83]].

as a source of energy in 2017 was very small – only 1.09 per cent. It came from the only wind project connected to the grid installed near Nairobi on Ngong Hills (25.5 MW).[7] It is, however, expected to jump upwards significantly in the next years. In 2016, four wind IPPs with a combined capacity of 221 MW were licenced under the FiT scheme; another six with a total capacity of 390 MW were in the queue to obtain licences, and nine envisioned projects were conducting feasibility studies [26]. Finally, the LTWP (310 MW) wind park is ready and awaiting official launch in late 2018 [104].

Regarding supportive wind energy development policies, Kenya's new constitution does not explicitly provide for the right to access energy. Nevertheless, it commits to sustainable development, which requires access to energy, preferably renewables, as stipulated in subsequent documents [105]. Kenya Vision 2030 and the updated LCPDP set a target of 2036 MW of wind power, or 9 per cent of the expected total maximum generation capacity to be developed by 2030 [103,106]. With other planned wind power project development efforts, Kenya expects to reach almost 2500 MW by 2035. Furthermore, the FiT scheme allows a private investor to sell wind electric power to the national grid at a fixed tariff of US Cents 11.0 per kilowatt-hour for 20 years (for IPPs between 500 kW and 100 MW – see Table 4 above). This rate remains one of the cheapest on the continent. The Ministry of Energy is currently considering introducing energy auctions (following the example of South Africa) and net metering (to encourage citizens to invest in RE). The Government has also put in place a zero-rated import duty for wind energy equipment. Similarly, it has removed VAT on imported renewable energy equipment and accessories [68]. Finally, the Energy Act of 2006, National Climate Change Response Strategy of 2010 and the LCPDP Committee all emphasise the facilitation of wind energy development to meet Kenya's long-term energy ambitions.

Table 4
FiT regime in Kenya [88].

	Duration	Installed capacity (MW)	Standard FiT (USD$/kW h)	Max capacity (MW)
FIT FOR PROJECTS LESS THAN 10 MW				
Wind	20 Years	0.5–10	0.11	10
Hydropower		0.5	0.105	10
		10	0.0825	
Biomass		0.5–10	0.10	10
Biogas		0.2–10	0.10	10
Solar (grid)		0.5–10	0.12	10
Solar (off-grid)		0.5–10	0.20	1
FIT FOR PROJECTS MORE THAN 10 MW				
Wind	20 Years	10.1–50	0.11	500
Geothermal		35–70	0.088	500
Hydropower		10.1–20	0.0825	200
Biomass		10.1–40	0.10	200
Solar (grid)		10.1–40	0.12	100

3.3. Challenges to the wind power expansion in Kenya

Kenya is a growing economy with highly ambitious energy targets set out in the Kenya Vision 2030. If Kenya wants to achieve these targets, it must build over 80 per cent of the additional wind energy capacity by 2030.[8] A number of large-scale wind power projects are under development, including Lake Turkana Wind Power project (310 MW), Kipeto (100 MW), Isiolo (100 MW), Meru (60 MW), Ngong (51 MW) and the Baharini Electra Wind Farm project in Lamu (90 MW) [24–26]. This presents an attractive investment opportunity in the area of wind power generation, including transmission and distribution in the years to come. Nevertheless, investors report a number of challenges linked to national wind energy development.

The main problem is obtaining and finalising a PPA in a reasonable

[7] The first two wind turbines (already retired) were commissioned in 1993 from Belgian TPF-Econoler SA (TPFE). This further expanded to six windmills, the wind power plant was generating 5.1 MW of clean electricity and it was upgraded again in 2015 to 25.5 MW capacity. The wind farm is owned by KenGen. Ngong Wind Phase II is planned and the total potential for annual energy yield is estimated to be 14.9 GWh, which represents almost 3000 full-load hours [110].

[8] Assuming that LTWP is already fully operational in 2018.

Table 5
List of Kenyan Independent Power Producers (IPPS) and their energy generated between 2005 and 2017 [55–58,60–65].

Kenyan Independent Power Producers (IPPs)	Type	Capacity (MW) as at 30.06.2017		Energy purchased in GW h												
		Installed	Effective	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OrPower 4 – Geothermal I, II, III & IV[a]	Geothermal	139	139	115	117	112	98	276	400	372	392	503	851	955	1066	1172
Iberafrica I&II Power	Heavy fuel oil	108.5	108.5	330	408	321	306	344	621	722	705	592	550	198	128	252
Tsavo Power	Heavy fuel oil	74	74	508	569	547	556	566	495	368	283	178	152	83	39	121
Mumias – Cogeneration	Biomass	26	21.5	–	9	4	9	4	99	87	100	71	57	14	–	–
Rabai Power	Heavy fuel oil	90	90					–	318	394	338	443	633	609	536	606
Imenti Tea Factory hydro	Hydro	0.3	0.3					–	0.3	0.4	0.8	0.7	0.1	0.5	0.7	0.3
Thika Power	Heavy fuel oil	87	87					–	–	–	–	–	454	233	70	168
Gikira small-hydro	Hydro	0.514	0.514					–	–	–	–	–	0.4	1.6	1.9	1
Triumph Power	Heavy fuel oil	83	83											4.8	82	83
Gulf Power	Heavy fuel oil	80.32	80.32											60	8	61
Biojule Kenya Limited	Biogas	2	2											–	0.3	0.7
Westmont Power Kenya Ltd.	Kerosene	–	–	3												–
Regen-Terem	Hydro	5	5													1
IPP Total		**696**	**691**	**956**	**1103**	**984**	**969**	**1190**	**1933**	**1943**	**1819**	**1788**	**2698**	**2159**	**1932**	**2466**

[a] OrPower 4 – Geothermal IV (29 MW) became operational as of 2016.

time period and the fact that the PPAs are not indexed. Consequently, the tariff set in the PPA will apply for many years and will not be adjusted to inflation or the consumer price index. Such PPAs may be sufficient for now to mitigate the risks of potential investors; however, such a solution will not be sufficient in the long-term, as the price of wind energy will need to reduce further. A PPA inflation adjustment would help Kenya to protect the real value of renewable energy project revenues against changes in the broader economy and further reduce investors' risks [106,107]. Moreover, the FiT scheme is applicable only for wind power projects with a generation capacity of up to 50 MW, while most of the ongoing projects are above this capacity. Both Kipeto (100 MW) and Kinangop (60 MW) were commissioned through the FiT scheme, but tariffs for LTWP (310 MW) were negotiated directly with KPLC. This demonstrates an inconsistency in the government's handling of wind projects above 50 MW.

Secondly, developers contend that the wind energy tariff would only be viable on sites with constant high wind speeds [23,89]. That means that projects must be stretched to their limits to become profitable. For example, LTWP installed capacity of 310 MW was necessary to ensure the financial viability of the project in their remote location. The wind farm also had to be big enough to justify and capitalise on two associated, major infrastructure investments that accompany the wind park, namely the construction of a local road and transmission lines.

Thirdly, land and community issues remain problematic for the wind projects that, per definition, require space to operate. Kinangop, Kenya's first FiT wind project, is a prominent example of a wind power project that was halted due to exactly these issues. The wind park was already in development and had the necessary agreements with the local community, while some local landowners made additional claims. A series of protests ensued (in 2015), resulting in the death of one citizen. Following unsuccessful mediation between the company and the local community by the Kenyan government, the project was halted in late 2015 and ultimately cancelled in 2016 [23].

A final issue with installing wind projects in Kenya is linked to the current grid infrastructure. For wind energy, the issue of transmission and integration are particularly important, as the intermittent character of wind power can potentially increase grid instability. The Kenyan grid has been recently upgraded to absorb the additional high amount of planned energy, including energy to be produced by the LTWP. Nevertheless, the ready wind park was awaiting connection to the grid for over a year as the transmission line construction has been severely delayed. KETRACO, responsible for the grid extension, was faced with a number of challenges regarding how to connect the remote LTWP with the main substation near Nairobi. Among other challenges, the process of land acquisition for the line has been very lengthy and more expensive than initially anticipated. Furthermore, KETRACO has been accused of being ineffective due to their business model and having an inefficient internal structure, which does not encourage a quick finalisation of the lines' construction. This example shows that the Kenyan government should consider investing more in connecting other remote areas in the North, which have the highest potential for wind energy generation, with the existing network. The example of LTWP and a similar case, the Tarfaya wind farm in Morocco (301 MW), imply that an additional developmental effect could be created by transforming the currently neglected parts of the African continent into a productive producer of green energy by becoming a major contributor to the continent's energy security [108].

4. Conclusions

The presence and enforcement of well-designed national supportive policies and incentives to guide development and use of renewable energy resources is vital, although not sufficient to promote wind energy development in Africa. Following numerous bilateral and multilateral efforts, by 2016, the majority of African countries had defined RE supporting policies, with nearly half also having defined their wind energy targets. However, among those 23 countries, 11 are currently not active producers of such energy. In contrast, a third of 16 African countries involved in wind energy production have no explicit wind energy policy or established targets. Fiscal incentives and public financing provided by the government appear to be very important for potential investors, as is the possibility of negotiating the terms directly with governments. With such inconsistency and lack of transparency, it is, therefore, much more challenging to ensure that African countries are and will be capitalising on their inherent advantage in terms of clean energy where it exists.

The example of Kenya shows that supportive policies and fiscal incentives have indeed stimulated the energy transition, through the modernisation and some expansion of the sector. However, the energy demand gap persists, while the country's high wind energy potential remains untapped. Therefore, the public sector should continue to invest in further sectorial development by improving the capacity and effectiveness of the sector's institutions, conducting feasibility studies as well as investing in grid expansion and upgrades. This is especially important if the government wants to stimulate the development of wind power projects in remote and currently neglected parts of their country, with a view to such projects having an additional developmental impact on the local and national level.

Table 6
Independent power project sponsors and debt holders in Kenya [23,97].

Project	Type	Equity partners (country, % of equity held)	Debt provider
Westmont[a]	Kerosene	Westmond (Malaysia, 100%)	Equity financed
OrPower4	Geothermal	Ormat (Israel/USA, 100%) since 1998	Equity financed until 2009, European DFIs $105 mln loan in 2009, then OPIC loan of $310 mln drawn down in 2012–13
Mumias	Biomass	Mumias Sugar Company Ltd. (Kenya, 100%)	Not available
Iberafrica	Heavy fuel oil	Union Fenosa (Spain, 80%), Kenya Power Pension Fund (Kenya, 20%) since 1997	Union Fenosa ($12.7 mln in direct loans and guaranteed $20 mln); Kenya Power Pension Fund ($9.4 mln in direct loans and guaranteed $5 mln through local Kenyan bank)
Tsavo	Heavy fuel oil	Cinergy (USA) and IPS (Int'l) jointly owned 49.9%; Cinergy sold to Duke Energy (USA) in 2005, CDC/Globeleq (UK, 30%), Wartsila (Finland, 15%), IFC (Int'l, 5%) retain remaining shares since 2000	IFC own account ($16.5 mln), IFC syndicated ($23.5 mln), CDC own account ($13 mln), DEG own account (€11 mln), DEG syndicated (€2 mln)
Rabai	Heavy fuel oil	Aldwych International (Netherlands/UK, 34.5%), BWSC (Danish, but owned by Mitsui of Japan, 25.5%), FMO (Netherlands, 20%), IFU (Danish bilateral lender, 20%)	FMO ($126 mln), Proparco (25%), EAIF (25%), DEG (15%), European Financing Partners (10%)
Thika	Heavy fuel oil	Melec PowerGen (part of Matelec Group) (Lebanon, 90%)	AfDB (€28 mln), IFC (€28 mln), Absa Capital (€28 mln)
Triumph	Heavy fuel oil	Broad Holding (Kenya), Interpel Investments (Kenya), Tecaflex (Kenya), Southern Inter-trade (Kenya)	Industrial and Commercial Bank of China (ICBC) ($80 mln), Kenya's CFC Stanbic Bank ($28 mln) (of which Standard Bank is the parent, in which ICBC has 20% stake)
Gulf	Heavy fuel oil	Consortium of Gulf Energy Ltd. (Kenya) and Noora Power Ltd. (Kenya)	$76 mln in long-term debt financing (IFC A Loan, and commercial lending through IFC B Loan and OPEC Fund for International Development)
Kipeto Wind Power Project	Wind	AIIF 2 (South Africa/Mauritius, 55%), Craftskills Wind Energy International (Kenya, 20%), IFC (Int', 20%) The Kipeto Community Trust (Local community, 5%)	Overseas Private Investment Corp (OPIC) ($232.6 mln/€208.8 mln)
Kinangop[b]	Wind	AIIF2 (South Africa/Mauritius, 81%), Norfund (Norway, 19%)	Kenyan CFC Stanbic
Lake Turkana Wind Power	Wind	Aldwych International (UK, 30.2%), KP&P Africa B.V. (Netherlands, 26.5%), Norfund (Norway, 12.3%), FinnFund (Finland, 12.3%), Vestas (Denmark, 12.3%), IFU (Denmark, 6.1%), Sandpiper (Mauritius, 0.2%)	EIB (€200.0 mln), AfDB (€135.0 mln), FMO (€35.0 mln), ICCF (€30.0 mln), Proparco (€20 mln), PTA Bank (€10 mln), Triodos (€5.5 mln); [Mezzanine: DEG (€20 mln), PTA Bank (€10 mln), EADB (€5 mln), AfDB (€5 mln)] [Preference shares: EU-AITF (€25 mln)]

Notes: AfDB = African Development Bank, AIIF = African Infrastructure Investment Fund, BWSC = Danish Engineering company owned by Mitsui; CDC = Commonwealth Development Corporation, DEG = German Investment and Development Corporation, DFI = development finance institution; EADB = East-African Development Bank; EAIF = Emerging Africa Infrastructure Fund; EIB = European Investment Bank; EU-AITF = EU-Africa Infrastructure Trust Fund; FinnFund = Finnish Fund for Industrial Cooperation Ltd; FMO = Netherlands Development Finance Company; ICCF= Interact Climate Change Facility; IFC = International Finance Corporation; IFU= Danish Investment Fund for Developing Countries; Norfund = Norwegian Investment Fund for Developing Countries; OPIC = Overseas Private Investment Corporation; OPEC = Organisation of the Petroleum Exporting Countries.

[a] Westmont did not renew its contract in 2004 after it failed to agree on tariff levels.

[b] Project stalled.

The example of Kenya also indicates that international private participation in the generation and expansion of renewable energy is critical for an African country to meet the global SDG 7, SDG 13 and COP 21 commitments. Private participation is also expected to increase. For two decades, private and public power projects in Kenya have been developed in parallel. Private developers have been essential in mobilising funding to meet the nation's demand for electricity, and their involvement has gradually expanded to complement publicly owned projects. They appear to be a driving force for national policy, grid adjustment and upgrades rather than a result of it. This can, however, seriously challenge and even compromise the function and responsibilities of the national accounting mechanism. The fact that predominantly international Independent Power Producers, including the forthcoming Lake Turkana Wind Power project, will soon account for 43 per cent of the country's energy generation demonstrates just how big the role of the international private sector is in Kenya's energy security. It should be noted that this is not only symptomatic to Kenya, but also to other African countries and it will clearly influence the continent's ongoing energy transition.

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Declaration of interest

None.

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