KeSEBAE NEWS

A Publication of Kenya Society of Environmental, Biological and Agricultural Engineers

Volume 3 No. 2 | FEBRUARY/MARCH NEWS UPDATE

DEAR READER

Welcome to KeSEBAE Newsletter

A fortnightly Newsletter touching on topical issues affecting our environment.

KeSEBAE NEWS is a Newsletter of the Kenya Society of Environmental, Biological and Agricultural Engineers (KeSEBAE).

INSIDE

KeSEBAE NAIVASHA TRAINING

KESEBAE held a training in **Naivasha** from **8 to 12 February 2021** for **Ministry of Agriculture DRSLP and SIVAP Project Staff**. The **theme** of the training was: **Procurement and Contract Management**

The conference attracted the attendance of **Project Managers, Contract Managers and Other Professionals** involved in the world of contract.

In the 3-day event, **thirty-five (35) Senior Project Managers** were trained on the following topics:

No	Topic	Facilitator/Trainer
1.	Introduction to Project Development	• Ezekiel Oranga
2.	Introduction to Procurement	
3.	Introduction to Contracts Management	• Eng. Nderitu Macharia • KESEBAE Team
4.	Contract Preparation, Award and Administration	
5.	Contract Effectiveness	
6.	Use of Subcontracts, Contract Payments and Generation of Interim Payment Certificates	• Eng. Nderitu Macharia • Eng. Mwamzali
7.	Site Organization, General and Particular Conditions of Contracts	
8.	Challenges in Contract Performance and Management	• Prof. Lawrence Gumbe
9.	Contract Documents (Designs, Design Reviews, Bills of Quantities, ESIA Etc.)	• Eng. P. Wambulwa
10.	FIDIC Contracts	
11.	Contract Variations and Adjustments	• Eng. Nderitu Macharia
12.	Standard Management in Contracts	
13.	Defects Liability	
14.	Dispute Resolutions in Contracts	• Eng. Omedi Jura

KeSEBAE NEWS EDITORIAL

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Proceedings of the Naivasha Training

1. Participants at Naivasha Training
2. Eng. Nderitu Presenting on Introduction to Contract Management
3. Eng. Mwamzali Giving his Presentation at the Training
4. Mr. Ezekiel Oranga Giving his Presentation
5. Eng. Patrick Wambulwa Giving his Presentation

MEMBERSHIP RENEWAL

Members of all grades are requested to renew their 2021 Membership.

The annuals fee are as follows:

Membership Category	Annual Subscription Fee (KES)
Fellow	5,000
Member	2,000
Ass. Member	1,000
Aff. Member	500
Student Member	300

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Account No.	***Membership No.***

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Account Name	Kenya Society of Env. Bio. & Agric. Engineers
Account No.	2038150696
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JOURNAL OF ENGINEERING IN AGRICULTURE AND THE ENVIRONMENT (JEAE)

The society published its current edition of the Journal of Engineering in Agriculture and the Environment: JEAE Vol. 6 No. 2 in December 2020.

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For more information, check on our CALL FOR PAPERS TO THE NEXT EDITIONS OF JEAE

EXECUTIVE COMMITTEE MEETING

KeSEBAE Executive Committee held its monthly meetings VIRTUALLY on Tuesday, 9 March 2021 to deliberate on Society matters.

Matter discussed included:

- Professional Training and Growth of Society Members in their Areas of Profession.
- Membership Registration
- 2021 Membership Renewal
- Journal of Engineering in Agricultural and the Environment (JEAE)
- Articles to Subsequent Editions of KeSEBAE NEWS
- Among Others.

CALL FOR ARTICLES TO KeSEBAE NEWS

KeSEBAE NEWS Editorial wishes to call for topical articles for publication in future editions of KeSEBAE NEWS. Please transmit the same to the

Editor: **Ezekiel Oranga**
Email: info@kesebae.or.ke

NOTE: A payment will be made to the author of each selected article.

CALL FOR PAPERS TO THE NEXT EDITIONS OF JEAE

KeSEBAE

JEAE

Journal of Engineering in Agriculture and the Environment

CALL FOR PAPERS

The Journal of Engineering in Agriculture and the Environment (JEAE) is a Publication of the Kenya Society of Environmental, Biological and Agricultural Engineers (KeSEBAE) through which researchers in the fields of Environment, Agriculture and related fields share research information and findings with their peers from around the globe.

The JEAE Editorial Board wishes to invite interested researchers with complete work in any relevant topic, to submit their papers for publication in the next editions of the Journal.

Manuscripts may be submitted online or via email to:
Prof. Lawrence Gumbe Chairperson, JEAE Editorial Board
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a. Are written in the English language
b. Are relevant to the application of engineering and technology in agriculture, the environment and biological systems
c. Have not been previously published elsewhere, or, if previously published are supported by a copyright permission
d. Deals with theoretical, practical and adoptable innovations applicable to engineering and technology in agriculture, the environment and biological systems
e. Have a 150 to250 words abstract, preceding the main body of the article
f. The abstract should be followed by the list of 4 to 8 “Key Words”
g. Manuscript should be single-spaced, under 4,000 words (approximately equivalent to 5-6 pages of A4-size paper)
h. Should be submitted in both MS word (2010 or later versions) and pdf formats (i.e., authors submit the abstract and key words in MS Word and pdf after which author uploads the entire manuscript in MS word and pdf)
i. Are supported by authentic sources, references or bibliography

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Member	2,000	1,000	2,000
Ass.Member	1,000	1,000	2,000
Aff.Member	500	1,000	2,000
Student	300	100	-

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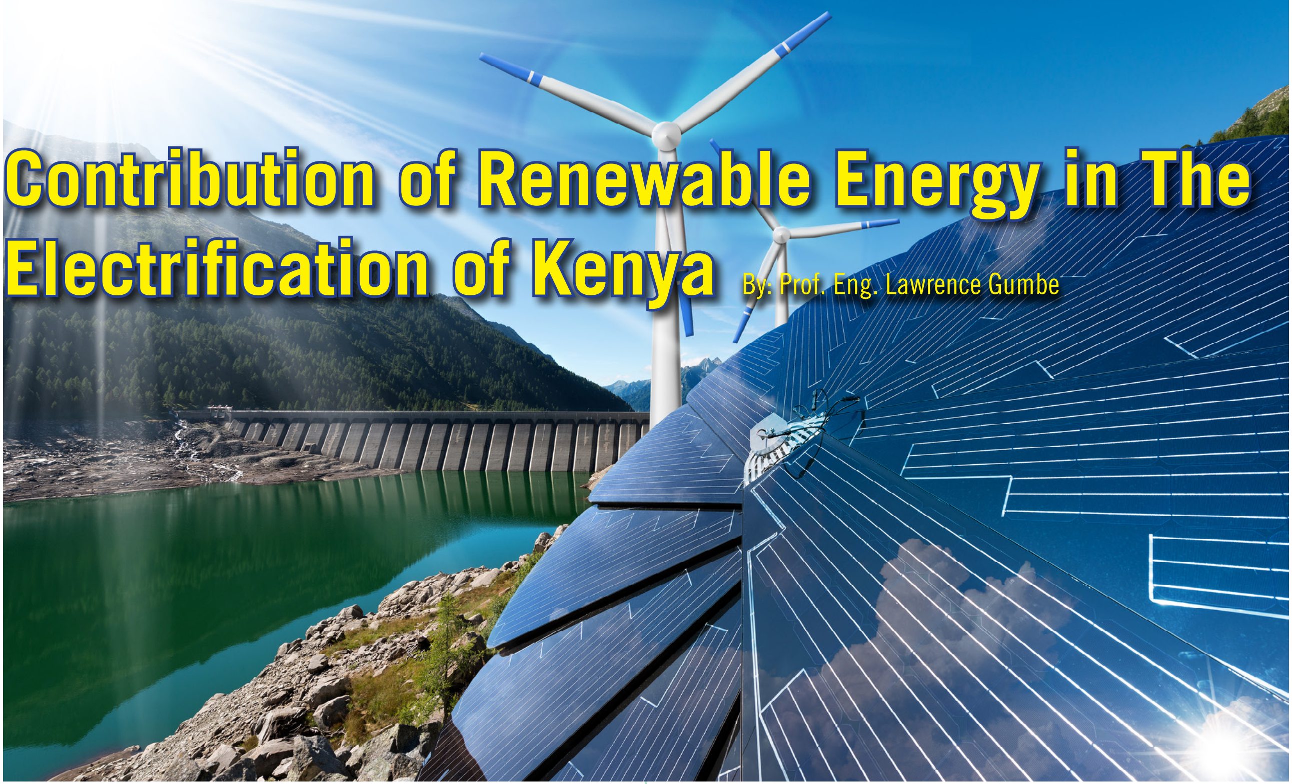
KeSEBAE: ***"Promoting Engineering and Research for Environmentally Sustainable Biological and Agricultural Systems"***

Contribution of Renewable Energy in The Electrification of Kenya

By: Prof. Eng. Lawrence Gumbe



1.0 Introduction

Kenya is a middle-income economy with a GDP per Capita of USUS dollars 1, 432 [1]. According to World Bank[1], a middle-income economy has a GDP per capita between US dollars 1,045 and US dollars 12,736, a low-income economy has a GDP of less than US dollars 1,045. A high-income economy has a GDP higher than US dollars 12,736.

Electrification of an economy is a necessary condition for development and industrialization. Electricity is generated, transmitted and distributed. Generation of electricity means production of electric energy or the amount of electric energy produced by transforming other forms of energy into electric energy, expressed in (kilowatt hour) kWh or (megawatt hour) MWh [2]. Transmission of electricity is the use of a line that carries electricity at voltages of 69kV or greater and is used to transmit electric power over relatively long distances, usually from a central generating station to main substations. Distribution of electricity is the transfer of electricity from a high voltage line to a lower one [3]. A grid is a network of transmission lines it includes substations and transformers that deliver electricity from power plants to consumer[2]. A mini grid is a set of electricity generators and possibly energy storage systems interconnected to a distribution network that supplies electricity to a localised group of customers [4].

Kenya's development agenda is enshrined in its ***Vision 2030*** which seeks to transform the country to a globally competitive and prosperous nation with high quality of life by 2030 [5]. Energy is identified as one of the most driving factors of making this vision. Kenya Consumption of electricity in Kenya is only 9% of the total energy. Biomass leads with 68% [6].

To achieve Vision 2030, the country's electricity generation, transmission and distribution needs to be developed in order to attain a consumption rate of 3,000kWh/capita from the current level of 160 kWh/capita. The current level is way below the global average of 7,000kWh/capita [7]

There is great potential for contribution to electricity supply through renewable energy sources such as solar, biogas, wind etc.

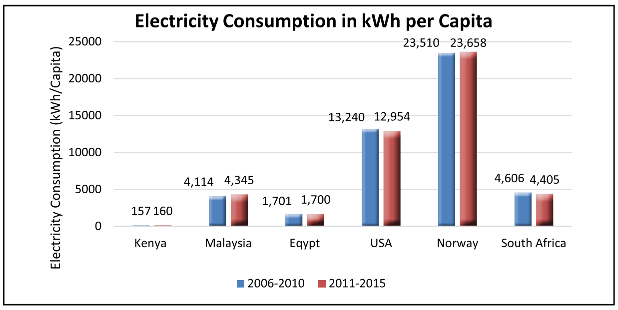


Figure 1: Electric consumption in different countries in 2010 and 2015 [8].

1 **WB. World Bank (2014).** Kenya Economic Update.

2 **U.S Department of Energy (2011).** Energy efficiency and renewable energy.

3 **Western Governors Association (2014).** An introduction to electric transmission.

4 **Pittet A (2013).** An Overview of Technical Aspect of mini-grids.

5 **Republic of Kenya (2008).** Kenya Vision 2030

6 **Institute of Economic Affairs (IEA). (2015).** Situation analysis of energy industry, policy and strategy for Kenya.

7 **Africa progress panel (2015).** Power people planet 'seizing Africa's energy and climate opportunities.

8 **WB. World Bank (2016).** World Bank data.

2.0 Electricity Consumption and Demand in Kenya

The aim of Vision 2030 is to electrify every home, office, factory, farm and all other production and recreational facilities. Only 18% of Kenyans are currently connected to the grid.

The current electricity demand for those connected to the grid in Kenya stands at 1,700MW from 1,569MW recorded in October 2015 according to Energy Regulatory Commission [9] However, the figure is expected to hit 2,000MW by the end of the year. The rise is attribute to the establishment County governments, with the numerous economic activities, electrification of the designated rail lines and new economic zones. Electricity consumption has been rising since 2007 to 2014, this is because there is an equal rise in Gross Domestic Product (GDP) this can be seen from figure 2 [10].

There is rise in demand for electricity in Kenya but there is inadequate power supply capacity due to the inability to install additional generation plants [11]. The figure below shows electricity consumption with GDP in Kenya.

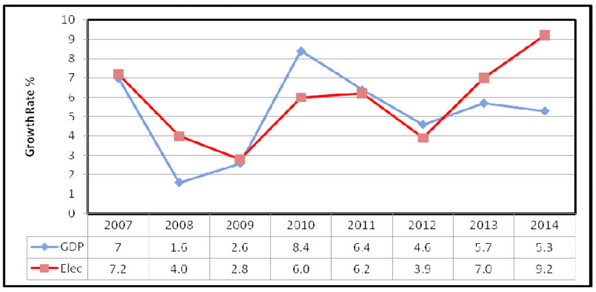


Figure 2: Electricity and GDP growth in Kenya, 2007-2014 (Source:[12])

Electricity growth is highly sensitive to regional differences, countries' income levels, urbanization rates and the supply risks according to a research on electricity consumption and economic growth. Growth in the country's GDP brings about rise in the Electricity consumption [13].
The figure below shows how GDP affects electricity consumption. Electricity consumption is directly proposal to GDP i.e., rise in GDP of country brings about rise in electricity consumption, since most people can afford it.

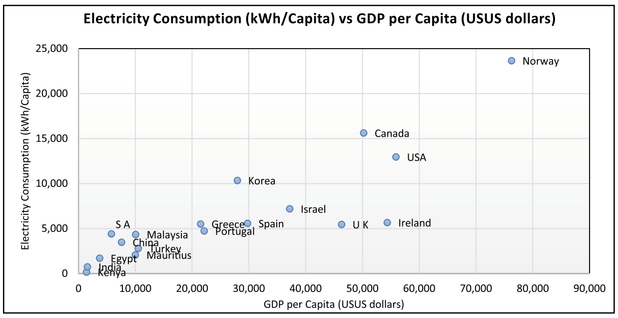


Figure 3: Electric Consumption in kWh per capita versus GDP per capita [8].

2.1 Challenges

The current electricity consumption in Kenya is 160kWh/capita, this is 3.7% of a typical middle economy country like Malaysia which has a consumption of 4345kWh/capita. To attain this electricity consumption is a challenge since it need increase in generation, transmission and distribution networks.

2.2 Kenya Vision 2030 Demand

The Vision 2030 aims at transforming the country into a newly industrialized, middle income economy providing a high quality of life to all its citizens in a clean and secure environment. Energy is identified as one of the most driving factors of making this Vision a reality. There are conflicting figures of Vision 2030 demand. The Vision 2030 document in part projects 18,000 MW [5] and [14] projects 20,000 MW.

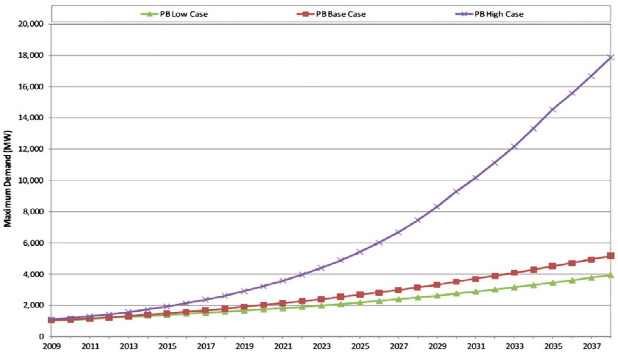


Figure 4: Peak demand forecasts for Kenya [14] to 2038

The above projections are very low when we compare it to other middle economy country like Malaysia whose current electricity consumption stands at 4345kWh/capita and Kenya is at 160kWh/capita, with Kenyan generation at 2,229MW then by 2030 Kenya should be generating between 50,000MW to 60,000MW.

9 **(ERC, 2016).** Report provided by Managing Director, Energy Regulatory Commission.

10 **Republic of Kenya (2015):** Ministry of Energy and Petroleum, 'Power to transform Kenya.

11 **Ministry of Energy and Petroleum (MOE and P), (2014b).** Long and Short-Term Challenges facing Energy sector in Kenya.

12 **Republic of Kenya, (2015).** Power Sector Medium Term Plan (MTP). (2015-2020)

13 **Karanfil, F and Yuanjing Li, (2014).** Electricity consumption and economic growth. Exploring panel specific difference. IPAG Business School.

14 **Lavalin S.N.C (2010).** Regional Power System Master Plan EAC and EAPP.

This was achieved by dividing Malaysia consumption of 4,345 kWh with the Kenya consumption of 160kWh/capita and multiplying it with current Kenya generation capacity of 2,229MW we get possible generation by 2030 to be 60,531MW

i.e., $\frac{4{,}345 kWh/cpitapita}{160 kWh/cpita}$ x 2,295MW = 62,323MW.

Many demand projections do not take into account the lifestyle and production changes which emerge as a consequence of Kenya becoming a middle-income economy.

According to Energy and Regulatory commission, the projected sectorial energy consumption will be as discussed below:

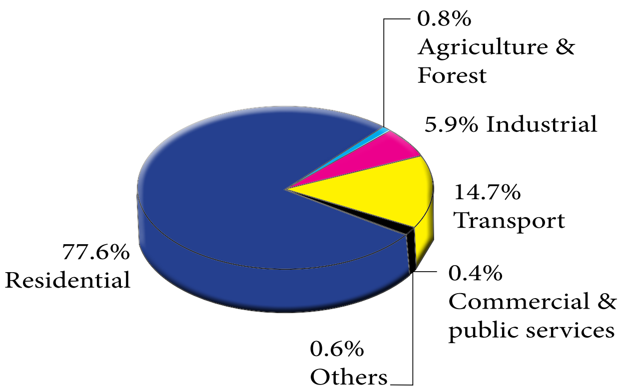


Figure 5: Source: [15]

2.2.1 Domestic

Domestic electricity is also household electricity which has different uses in the household such as lighting, refrigeration, air conditioning, water heating, television, space heating and cooling, clothes dryers and computing.

The current average world consumption of electricity in the household by 2014 was 3,396kWh/household [16]. The country in Africa with a close household consumption to the world average is South Africa with consumption of 3,254kWh/household. Kenya's electricity consumption is way below at 500kWh/household.

The domestic power consumption is expected to increase due to improved living standards envisaged in Vision 2030. The projected power consumption domestically will be about 40% (Mutua, Personal Communication, January 2016) of the total installed capacity from 27% currently [15]. We estimate that about 24,000MW of installed generation capacity will go toward domestic consumption as Vision 2030 is met.

15 **Kiplagat J.K, Wang R.Z and Li T.X (2011).** Renewable energy in Kenya: resource potential and status of exploitation.

16 **WEC. World Energy Council (2016).** Energy Efficiency Indicators (2009-2016).

2.2.2 Agriculture

Electricity is used in agriculture, and livestock production in: Production including in greenhouses, chicken housing, irrigation and water supply; processing, including primary processing on farms like drying, grading, sorting, fermentation, cooling and refrigeration, mixing and size reduction; and in farm dwellings, offices and fences.

Electricity is being used in Kenya in the firm for pumping water to be used in irrigation, agricultural processing industries such as tea, coffee, sugar refining, milk processing, fruit canning and also in the research field of agriculture such as KARI (Kenya Agricultural Research Institute).

Vision 2030 envisages the transformation of agriculture transformation from the current peasant based to a modern commercial oriented one. For example, the ongoing projects like Galana Kulalu Irrigation Scheme. [15] estimate that 5% of installed will go towards agriculture, i.e., about 800MW.

2.2.3 Industry

Industries in Kenya are the main consumers of electricity. These industries include cement industry, steel, aluminium and iron industries, vehicle assembly industry, oil refining, commercial ship repair industry and small-scale consumer goods industries e.g., plastics, furniture, clothing, soaps, cigarettes and flour. It is anticipated that the attendant demand for the installed capacity will come from the proposed Vision 2030 projects which include iron ore smelting, with approximate of 315 MW [17].

Industrial sector is expected to grow steadily if we are to realize the Vision 2030. This growth is will increase the electricity consumption to approximately 30-35% of the total installed capacity [9]. Vision 2030 industry demand is likely to require bout 20,000 MW of generation capacity.

2.2.4 Transport and Mining

Transport and mining are one of the sectors that also consumes a lot of electricity, with the transport sector using it street lighting and in the mining.

Transport sector is projected to consume approximately 11-15% [9] of the total installed capacity. Under the Vision 2030 electricity consumption in this sector will increase with some of these projects underway such as the electrified Standard Gauge Railway and light rail systems, Konza Techno City Systems and ICT parks, with approximate of 440MW, and the LAPSSET project [17].The projected demand would require up to 10,000 MW of installed generation capacity.

17 **Kariuki K and Ngure E (2013).** Power Sector Report East Africa.

2.2.5 Office

In the office set up there are different uses for electricity and this include: lighting, computing, photocopying, scanning, internet, blueprinting etc.

The office electricity consumption is expected to be about 0.4% of the installed capacity [15]. This projected demand would require about 600MW of installed generation capacity.

2.2.6 Summary

Table 1: below outlines a summary of Vision 2030 electricity consumption in different sectors in Kenya.

Table 1: Vision 2030 Electricity Consumption

Sector	Percentage Consumption	Consumption (KWh)
Domestic	40	1,738
Agriculture and forestry	5	217.25
Industry	35	1,520.75
Transport and mining	15	651.75
Offices	0.4	17.38
Exports	4.6	199.87
Total	100	4,345

Source: [9]

From table 1, it is evident that largest portion of Vision 2030 electricity consumption will be in domestic and industry sector. Offices will account for the least demand.

3.0 Electricity Generation

3.1 Generation in Kenya

Electricity generation in Kenya is largely the function of the Kenya Electricity Generating Company (KENGEN), it is the leading company in the production of electricity in power stations, generating about 73% of all the electricity consumed in the country [9]. Other electricity producers include Geothermal Development Company (GDC) and Independent Power Producers (IPPs) which accounts for 27% of the installed capacity. Imports is also another source of electricity generation for the Country [18].

The current installed capacity stands at 2,299MW out of which 2,229MW is effective [9]. The hydropower contributes 820.7 MW, geothermal 598.1MW, thermal 800.3, wind power 25.5 MW, cogeneration 26MW, and solar 0.569 MW and a further 27.76 MW off grid installed capacity respectively [9].

The figure below shows the difference in electricity generation between 2013 and 2015. The developing countries experience a rise in their electricity generation faster than those in the already developed countries.

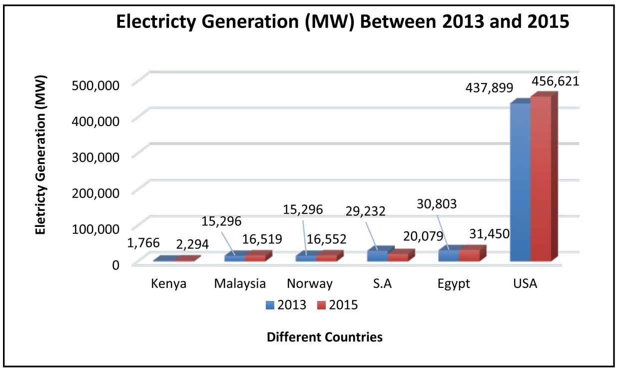


Figure 6: Electricity generation in different countries between 2013 and 2015 [19].

i. Conventional Sources

The conventional sources of energy are generally non-renewable sources of energy, which are being used since a long time (Singh, 2016). These sources include: fossil fuels, which are crude oil, natural gas, coal, oil shales and tar sands. These sources of energy are being used extensively in such a way that their known reserves have been depleted to a great extent [20].

The current conventional sources of electricity in Kenya includes: thermal energy sources which is medium speed diesel, which contributes 800.3MW accounting for 34.4% of the total installed capacity. Some of these plants are: Iberafrica (108 MW -thermal power plant, Tsavo (74 MW- thermal power plant, Gulf (80MW – Diesel, Thika (87MW – Diesel, Rabai (90MW- Thermal power plant, Aggreko (30MW-Emergency thermal plant [9].

ii. New Sources

The new source of electricity energy in Kenya are Liquid Natural Gas (LNP), cogeneration, solar, natural gas and nuclear electricity which the nuclear plant is expected contribute approximately 1000MW within the Vision 2030 framework [10].

iii. Renewable Sources

Renewable energy is the type that is derived from natural processes (e.g., sunlight and wind) that are replenished at a faster rate than they are consumed.

18 **Republic of Kenya (2015):** Ministry of Energy and Petroleum, 'Power to transform Kenya'

19 **Institute of Economic Affairs (IEA). (2015).** Situation analysis of energy industry, policy and strategy for Kenya.

20 **Singh V (2016).** Conventional sources

Solar, wind, geothermal, hydro, and some forms of biomass are common sources of renewable energy [21].

The most common source of solar power utilizes photovoltaic cells to convert sunlight into electricity. Photovoltaics utilize a semi-conductor to absorb the radiation from the sun, when the semi-conductor absorbs this radiation it emits electrons, which are harnessed as electricity.

According to Energy Regulatory Commission hydropower Kenya has an installed capacity of 820.7MW representing 35.9% (ERC, 2016). However, the country's total potential hydropower capacity is estimated at 6,000 MW with the potential for small hydro estimated at 3,000 MW [22].

Compared to other markets such as Egypt and Mozambique where the hydropower capacity is 3,664 MW and 197 MW respectively, Kenya has more capacity in the hydropower sector [22]. Out of the 3,000 MW, less than 30 MW has been exploited, of which only 15 MW supply the national grid. This under exploitation has been attributed to high installation costs, inadequate hydrological data, and lack of capacity to manufacture small hydropower components.

Geothermal has an installed capacity of 598.1MW [9]. It is estimated that the country has potential to generate 10,000 MW from geothermal, enough to power 20 million households and businesses. The country aspires to produce at least 1,900 MW of geothermal energy by 2017, and 5,500 MW by 2030, presenting immense investment opportunities [10].

Kenya receives daily insolation of 4-6kWh/m^2 [23]. The current solar installed capacity is 0.569 MW off-grid [9]. Kenya has a proven wind potential of 346 W/m^2 [10]. In 2014, the country installed wind capacity of 25 MW connected to the grid (Republic of Kenya, 2015). The current capacity is 25.5MW [9].This capacity is expected to rise with completion of Lake Turkana Wind Farm in northern Kenya in 2017. The 40,000-acre wind farm, which is Africa's largest, is expected to inject 310 MW into the national grid, with investment from Google, which shifts its US US dollars200 billion clean energy focus to Kenya and the Turkana Wind Project.

The earlier costs of cleaner sources of energy such as solar, wind, geothermal and nuclear power were too expensive for utilities to justify to their shareholders and ratepayers, but with efficiency improvements and other factors wind turbines and the mass production of photovoltaic panels in china to more stringent for coal has eliminated the price penalty [24].

21 **Lynn A.S (2003).** Renewable Energy Sources

22 **Ikiara M (2015).** Renewable energy as a catalyst of economic development in Kenya.

23 **Omwando L.M, Kinyua R, Ndeda J.O.H, Mangi S.N, Kibwage J.K (2013).** Investigation of solar energy potential in Nakuru-Kenya ad its implication on Kenya's energy policy.

24 **Winters J (2016).** Renewable energy competitive on costs. Mechanical Engineering newsletter, 2016 edition.

The data form Lazard, coal power plants have unsubsidized levelised cost of energy ranging from US dollars 65 to US dollars 160 per MWh, the unsubsidized cost for an onshore wind firm is only US dollars32 to US dollars77 per MWh, and a utility scale photovoltaic facility ranges from US dollars50 to US dollars70 per MWh. Gas powered combined-cycle turbine is the only conventional sources with a lower cost of between US dollars52 and US dollars78 per MWh[24].

Other sources include:

i. Cogeneration

Also known as Combined Heat & Power (CHP), it is the simultaneous production of more than one type of energy from a single fuel source (Goth M, 2013). It has various benefits which are; reduction of greenhouse Gas (GHG) emissions, Independency on electricity from the grid, Lower investments in electricity distribution networks, less transmission losses, Contribution to grid capacity and Fuel Savings, it has also shortcomings in that it still burns fossil fuel and hence emit CO_2 to the environment, therefore cannot be a long-term solution on climate or energy. [25].

Just over 8 percent of world electricity generating capacity uses cogeneration totaling to global installed electricity capacity of 325,000 megawatts (MW) [26].

The Government has identified the existence of a substantial potential for power generation using forestry and agro-industry residues including bagasse. The total potential for cogeneration using sugarcane bagasse is 200MW short term and long term of 1,200MW [27]. Mumias Sugar Company (Private entity) generates 35MW out of which 26MW is dispatched to the grid currently[9]. However, opportunities by other sugar factories have not been exploited.

ii.Biogas

Biogas or "renewable natural gas." is the type of gas that is produced in an anaerobic digester, it is made of methane between (55%-75%), carbon dioxide (44%-24%) and other gases making up 1% or less of the mixture plus small amounts of some other gases [28]

It has various advantages which include: it is a renewable source of energy, its non-polluting, it reduces landfills, and it is a cheaper technology and finally reduces greenhouse effects among others. It also some disadvantages which are: contains impurities,

25 **Goth M (2013).** Basics of Cogeneration. STEAG Energy series. GmbH

26 **WI. World watch Institute (2016).** Vision for a Sustainable World.

27 **Ministry of Energy and Petroleum (MOE and P), (2014a).** Draft national energy policy.

28 **ABC. American Biogas Council (2016).** Promoting the Anaerobic Digestion and Biogas Industry Connecticut Ave NW, Suite 650, Washington, DC

not attractive on a large scale and unstable [29].

Although there are several thousand bio digesters installed in Kenya, most of them operate below capacity or are currently in disuse due to management, technical, socio-cultural or economic problems[10].

3.1.1 Challenges

The major challenge in Kenya's generation is reaching the required generation like any other middle income economy country like Malaysia which has a generation of more than 30,000MW to Kenya which has a generation of 2,299MW. This problem of achieving this generation has to be addressed to be in the same level with such countries.

Unrealistic demands by local communities where energy resources like coal, gas and oil are discovered, Low investments in power generation by private investors Many Independent Power Producers (IPPs) are not interested in investing, and those few who show interest take too long to implement projects and sometimes demand enormous terms, such as very high generation tariffs, government guarantees and letters of credit covering several months of payment for both capital and energy charges., and also Dependence on donor funding for various pprojects [30].

High capital cost and lack of sufficient wind regime data are some of the barriers affecting the exploitation of wind energy resource. Moreover, potential areas for wind energy generation are far away from the grid and load centres requiring high capital investment for the transmission lines.

3.2 Kenya Vision 2030 Generation

The Vision aims at enhancing and diversifying national power generation and supply by identifying new generation and supply sources. Nuclear Energy has been identified as one of the sources of energy that would substantially address the prevailing energy deficit and accordingly established the Nuclear Electricity Project Committee. The first nuclear plant is expected to contribute 1,000MW and three further plants to add 3,000MW by 2030 [31].

The Vision 2030 plans indicates that the largest portion of electricity will come from geothermal at 26%, followed by nuclear at 19%, coal at 13 %, liquefied Natural Gas (LNG) at 11%, thermal plants at 9%, wind at 9%, hydro power at 5%, and imports at 8 % [27]. This is shown in the pie chart below.

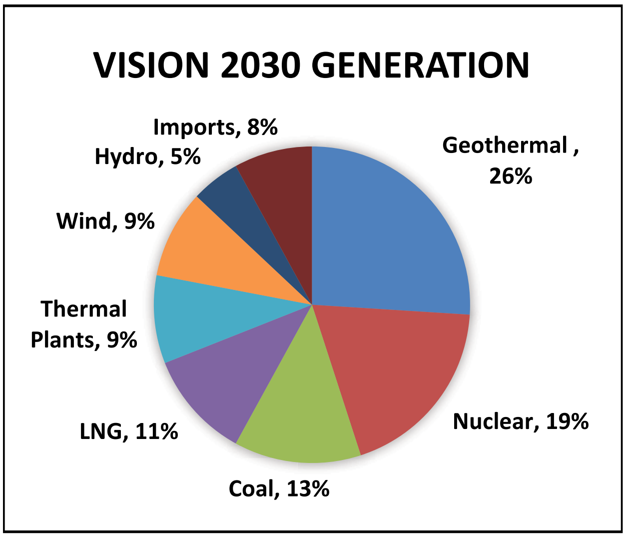


Figure 7: Vision 2030 Generation [27]

To attain consumption per capita of Malaysia at 4,345 kWh/capita at the moment to 160kWh/capita in Kenya, with Kenyan generation at 2,229MW then by 2030 Kenya should be generating between 50,000MW to 60,000MW. This was achieved by diving the Malaysia consumption of 4,345 kWh by the Kenya consumption of 160kWh/capita and multiplying with current Kenya generation capacity of 2,229MW we get possible generation by 2030 to be 60,531MW.

29 **Conserve Energy Future (2016).** Be Green Stay Green.

30 **Ministry of Energy and Petroleum (MOE and P), (2014b).** Long and Short-Term Challenges facing Energy sector in Kenya.

31 **Karanja K. (2012).** Interface between Energy and Vision 2030. Case for nuclear energy. Institute for engineer's conference.

3.3 Conclusion

Table 2: outlines the potential source of electricity generation in Vision 2030 in Kenya.

Table 2: Vision 2030 Electricity Generation in Kenya

	Source	Percentage Capacity	Installed Capacity (MW)	Investment Cost (US dollars)
1.0	Non-Renewable i. Thermal plants ii. Liquid Natural gas (LNG) iii. Coal iv. Nuclear	 9 11 13 19	 5,447.79 6,658.41 7,869.03 11,500.89	 2,982,665,025 11,665,534,332 1,723,317,570 3,274,303,383
2.0	Renewable Hydro i. Hydroelectric ii. Wind iii. Geothermal iv. Solar	 5 9 26 3	 3,026.55 5,447.79 15,738.06 1,815.93	 1,889,021,183 596,533,005 3,446,635,140 477,226,404
3.0	Imports	5	3,026.55	
	Total	100	60,531	26,055,236,042

Table 2: above shows vision 2030 electricity generation in Kenya with geothermal having the highest generation with solar and hydro having the least. Source: [24]

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