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Critical Success Factors Influencing the Implementation of Sustainable Energy System in Uganda: A Case of Inter-University Council of East Africa Energy Project at the Head Quarters in Kampala, Uganda

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Abstract

The widespread usage of clean and sustainable energy sources is leading to a significant transformation of the world's energy systems. Over-reliance on only the national grid energy system has made institutions fail to sustain energy systems. The council is only connected to the national grid electricity supply system, with diesel generators as the only alternative, which is unhealthy and unsafe. Surprisingly, even with such alternatives, power shortages have persisted despite government efforts to provide a solution to the shortages by installing numerous off-grid systems. Due to such a situation, the council would construct a sustainable energy system as a remedy. Thus, the purpose of this study was to establish critical success factors influencing the implementation of a sustainable energy system at the Inter-University Council of East Africa (IUCEA) Head Quarters, Kampala-Uganda. A cross-sectional survey design was used; a sample size of 84 participants was selected. Questionnaire survey and interview methods were utilized. The study found that the most significant ($p < 0.05$) critical factors in the implementation of sustainable energy in institutions are; the use of innovative technologies and infrastructure, the use of efficient zero emissions for heating and cooling, integration of renewable energy use in the existing buildings, building and renovating in an energy-efficient way, integrating regional energy systems, improving energy efficiency in the buildings, enhanced zero emission power technologies, energy efficient equipment in place and stakeholder empowerment in energy management. This study concludes that institutions like; the Inter-University Council of East Africa (IUCEA) need to clearly state policies and actions of energy management. The roles and responsibilities of each member have to be clearly stated while capturing the activities involved in energy conservation, energy security and energy efficiency.

Keywords

Precarious Aspects, Execution, Viable Energy Arrangement, Inter-University Council, Energy Effectiveness, Energy Safety and Energy Management

1. Introduction

1.1. Background to the Study

The widespread usage of clean and sustainable energy sources is leading to a significant transformation of the world's energy systems. With dispersed, small-scale energy generation projects that increasingly use renewable energy sources, the electric power system is a sustainable future addition to the central and large-grid-reliant systems of today. It also relies on cyber technologies to ensure resilience and efficient resource distribution [1]. Coal, oil, and natural gas are the main contributors to one-third of the world's greenhouse gas emissions [2]. Uganda has one of the lowest per capita electricity consumption rates in the world, and hydropower, together with heavy fuel oil and biomass cogenerate on power plants, dominate the generation capacity [3]. Unpredictable rain and droughts, however, have recently hampered the availability of energy and resulted in frequent load shedding. Energy-related issues in the nation include severe power shortages, rising demand, and stalled new power-generation projects. Alternately, growing global oil prices make thermal power production highly expensive, and fuel supply issues prevent it from happening in the nation, which has an impact on how well most organizations function there.

1.2. Problem Statement

Uganda is abundantly blessed with renewable energy means for energy creation and the extension of energy, with an estimated energy potential of about 5300 MW [3]. Hydro and biomass are taken as the largest potential for electricity generation in Uganda [3]. However, even with balanced growth in the solar PV market in the last 15 years, most urban institutions majorly rely on the national grid system for their daily activities [4]. Unfortunately, over-reliance on only the national grid energy system has made such institutions including the Inter-University Council of East Africa headquarters in Kampala-Uganda fail to sustain energy systems for their daily operations. The council is only connected to the national grid electricity supply system, with a diesel generator as the only alternative, which is unhealthy and unsafe for staff in the institution. Surprisingly, even with such alternatives, power shortages have persisted despite government efforts to provide a solution to the shortages by installing numerous off-grid systems [3]. As a result, the cost of connecting the alternative energy sources from the off-grid system is extremely expensive at 0.27 US$/kWh, making it difficult for the council to afford. Based on these issues, the council would construct a sustainable energy system as a remedy, failing which employee productivity and overall organization performance would suffer. Therefore, energy security, energy efficiency, and energy conservation measures must be taken into account in all attempts to achieve this. Hence it is based on this ground that this study seeks to establish critical success factors influencing the implementation of a sustainable energy system at the Inter-University Council for East Africa headquarters in Kampala-Uganda.

1.3. Purpose and Objectives of the Study

To establish critical success factors influencing the implementation of a sustainable energy system at The Inter-University Council for East Africa Head Quarters Kampala, Uganda.

The study sought to establish factors influencing the implementation of a sustainable energy system at the Inter-University Council of East Africa (IUCEA). The study also sought to determine the effect of the established factors on the implementation of a sustainable energy system at the IUCEA.

Contributions of the study: The findings of this study may contribute to decision-making process in the energy sector, mainly on critical success factors influencing the implementation of sustainable energy systems for organizations and also determine the effect of such factors on the development of sustainable energy systems. Hence this contributes to better policy formulation for the implementation of sustainable energy systems in Uganda.

Paper Organization: This section covers the introduction, statement of the problem, objectives of the study, research questions, justification, the scope of the study, publications, and contributions. The key words here are critical success factors for the implementation of sustainable energy systems in Uganda. Chapter two presents a conceptual review, review of previous works, research gaps, problem formulation and chapter conclusion. Chapter three presents the methodology, which is a road map for the study, which includes a review of previous methods, proposing research methods and stating a conceptual framework.

2. Literature Review

2.1. Review of Concepts

Sustainable energy is a form of energy that can be utilized recurrently without exposing the danger of depletion to the source [5]. The term "energy efficiency" refers to energy technology that accomplishes related activities with less energy [6]. It may also be described as a measurement of the amount of energy used to complete an activity. Energy security is the presence of enough energy supply at affordable prices [7]. It is also known as the "unlimited physical accessibility of energy in the market of energy goods at a rate that is affordable for all consumers". Energy conservation is the practice of voluntarily choosing to employ energy-efficient technology, such as electricity, fuel oil, natural gas, and other non-reproducible energy sources, to reduce the amount of energy used [8].

2.2. Factors Influencing the Implementation of Sustainable Energy Systems

It is also known as the "unlimited physical accessibility of energy in the market of energy goods at a rate that is affordable for all consumers. Energy conservation is the practice of voluntarily choosing to employ energy-efficient technology, such as electricity, fuel oil, natural gas, and other non-reproducible energy sources, to reduce the amount of energy used [9]. However, due to the fact that an improvement in energy efficiency does not necessarily translate into a rise in overall energy consumption, this must be done with prudence [9]. The Sustainable Development Goals (SDGs) may be achieved more efficiently through energy use, which is widely viewed as having various economic, social, and environmental advantages [10]. It is also acknowledged that great progress has been achieved in energy efficiency, with the United Nations Economic Commission for Europe (UNECE) area reducing its energy intensity from 2012 to 2014 at an average rate of 2.0% per year, only behind the world pace, in order to provide a sustainable energy system.

2.3. Established Factors and Their Effects on the Implementation of Energy Systems

Energy efficiency not only lowers carbon emissions but also impacts a variety of other areas, such as macroeconomic growth, industrial productivity, health and well-being, and energy security [11]. In order to tackle environmental problems and lessen their negative impacts, especially on future generations, energy efficiency has emerged as a critical tactic [12]. Energy efficiency has a huge potential to boost economic development and lower greenhouse gas emissions, according to the International Energy Agency, despite the fact that worldwide advancement is slowing down, a trend that has serious implications for consumers, businesses, and the environment [13]. The impact of these technical efficiency gains on energy consumption is being diminished by structural factors like changes to transportation modes and increased building floor space per person, which are stalling increases in the world's energy intensity despite the fact that adopting current technology and processes is more efficient [13].

2.4. Considerations for Developing a Guiding Framework for the Implementation of Energy Systems

An energy supply that promotes electrification and energy efficiency in the energy system may be promoted by proper enabling frameworks through innovations, new technologies, technology transfer, and system improvements [14].

The demand side of the energy system may be made more active through influencing customer decisions, involvement, demand response and management, energy saving, and behavioral modification (such as choosing public transit over operating a personal automobile). How and how rapidly the energy transition takes place will be determined by the legislative, regulatory, and governance frameworks, including the incentives put in place and the underlying economics of the technologies involved [14]. These had an effect on the diverse roles, business and financial models, and level of involvement in the organizational energy system of the primary stakeholders. The best "good practice" frameworks for policy, legislation, and governance provide an environment that is trust-inspiring and sends out clear signals to attract and maintain investment in energy companies, technologies, and the necessary measures to align this investment. They also assist the development of human capital, the energy and financial sectors, as well as innovation and change for the transition to a low-carbon economy [15].

Kassahun and Asfaw employed an Extended Multiple-Criteria Decision-Making (MCDM) Model in the Identification of key factors influencing sustainable development for traditional power generation groups in a Market in China [16]. Approaches of sustainable energy indicator identification have been proposed in many studies, such as a data envelopment analysis approach, the five-force model, the stepwise approach, the analytic hierarchy process method, Principal Component Analysis, Grey Relational Analysis, the Fuzzy Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS method), as well as a modified TOPSIS methodology [6].

Nurcan and Ilya took twenty years of data spanning where data from 2000 to 2020 was analysed to determine factors influencing the decision of renewable energy investors in the Organisation for Economic Co-operation and Development (OECD) of Brazil, Russia, India, China, and South Africa (BRICS) countries [17]. Annual data from the World Bank, the International Reliable Energy Agency and the International Energy Agency are analyzed using quantitative methodologies. A quantitative method was used to test the hypotheses from the conceptual framework. Hypotheses were tested using empirical models to answer the research issue [17]. From 2000 to 2020, panel data analysis was utilized to compile a country level panel dataset for OECD and BRICS countries. The RE capacity was modeled using explanatory variables.

Soft qualitative analysis was used by Azzuni and Breyer to measure energy security in Jordan following conceptual depersonalization. The same qualitative analysis was carried out to analyze the negative impacts of the energy transition on energy security [16]. Furthermore, Azzuni and Breyer's analysis of energy security in Jordan utilized quantitative methods [18].

2.5. Proposed Methods

2.5.1. Research Design

This assessment was steered by a cross-sectional survey design, which included collecting facts from a descriptive sample at a single point in time, analyzing this data and making generalizations of the findings to the target population [11]. This design was also used in this study since it allowed triangulation, utilizing qualitative and quantitative strategies of data collection and analysis.

2.5.2. Sample Size Determination

Since the study population was relatively small, sample size was determined using Krejcie and Morgan (1970) method of determining sample size [19]. Therefore, a study population of 45 individuals was corresponding to a sample size of 40 participants and a population of 50 individuals was corresponding to 44 participants. Hence a total of 84 participants were selected to take part in this study.

2.5.3. Data Collection Methods

Questionnaire survey method was utilized to collect data, and a questionnaire was self-administered to 40 staff of the Inter-University Council of East Africa. The use of questionnaires was aided by participants' ability to read, comprehend and write. The questionnaire method was preferably good for this study since it helped to maintain privacy and anonymity of responses provided by the respondents. Interviews were conducted with 44 staff of Umeme in Ntinda-Kampala office. This data collection method was a flexible method since it enables use of multiple channels of data collection like verbal and non-verbal. This method was further adopted in this study because it explored the study problem in-depth to understand participants' opinions.

3. Results and Findings

3.1. Factors Influencing the Implementation of a Sustainable Energy System

This research project established several factors that determine the implementation of a sustainable energy system at the Inter-University Council for East Africa headquarters in Kampala, Uganda (UCEA) by ranking them according to their Relative Importance Index (RII).

It was established that integrating renewable energy use is the most relatively important (RII = 0.83) factor followed by integrating regional energy systems in the organization with (RII = 0.82), the third relative important (RII = 0.79) factor was using innovative technologies and infrastructure like efficient lighting bulbs at the council, stakeholder empowerment like training of organization staff on efficient energy system management was the fourth relative important factor with (RII = 0.76). The fifth relative important factor (RII = 0.75) was use of efficient zero emissions for heating and cooling such as sensors which are inform of temperature sensors, light sensors, smoke sensors, water leak sensors and air quality sensors. Use of energy efficient equipment was the sixth with (R = 0.71). Enhancing the use of zero emission power technologies at the council was the seventh relative important (R = 0.71) factor, while building and renovating in an energy efficient way was the eighth relative important (RII = 0.70), use of storage technologies and renewable fuels like solar energy was the ninth with (RII =

0.69). General improvement of energy efficiency in organization buildings is the tenth relative important (RII = 0.68) factor, enhancing zero emission power technologies like diesel generators being readily available was the eleventh relative important (R = 0.63) factor, then optimizing integrated Ugandan clean energy system such as reliable electricity was the twelfth relative important (R = 0.55) factor. The thirteenth relative important (R = 0.54) factor was integrating organizational energy systems, then the fourteenth factor was having policies and actions which support sustainable energy use in the organization with (RII = 0.52), followed by use of water in cooling systems as the fifteenth with (RII = 0.52), supplying clean, affordable and secure energy was the least relative important factor with (R = 0.46).

The established factors were validated using average relative importance index (RII). Those factors whose average RII was equal or greater than the average RII were adopted for regression analysis. This helped to ascertain the effect of such factors on the implementation of sustainable energy. The regression findings were categorized according to the effect of energy efficiency, energy security and energy conservation.

3.2. Effect of Energy Conservation

Table 1 shows regression findings on the effect of energy conservation on sustainable energy at the council. The findings show the relationship between the components of energy conservation, that is, building and renovating in an energy efficient way, use of efficient zero emissions for heating and cooling, integrating renewable energy use in the existing buildings and use of innovative technologies and infrastructure and sustainable energy at the council.

The findings from the regression model above indicate that 98.8% of the changes related to energy conservation that occurred in sustaining energy at the council, were as a result of using innovative technologies such as efficient lighting bulbs, use of efficient zero emissions for heating and cooling such as smart motion sensors, integrating renewable energy use in the existing buildings through providing

Table 1. Effect of energy conservation on sustainability of energy.

Model	Number of Observations	R-Square	Root Mean Square Error	Probability > F-statistic, Confidence Interval = 95%,	
1	40	0.988	0.420	0.000	
	Model	Coefficients	Standard. error	t-statistic	Significance (p > |t|)
1	Use of innovative technologies and infrastructure	0.242	0.059	4.12	0.00
	Use of efficient zero emissions for heating and cooling	0.219	0.051	4.30	0.00
	Integrating renewable energy use in the existing buildings	0.138	0.058	2.37	0.00
	Building and renovating in an energy efficient way	0.340	0.045	7.56	0.00

a. Dependent variable: Sustainable energy.

windows which can be used to provide natural lighting to the buildings, and building and renovating in an energy efficient way. The regression model was also significant since $p < 0.05$, which was an indication that conserving energy had a significant effect on sustainability of energy system at the Inter University Council of East Africa headquarters in Kampala-Uganda.

It was found out that using innovative technology, use of efficient zero emissions for heating and cooling, integrating renewable energy use in the existing buildings and building and renovating in an energy efficient way had significant ($p < 0.05$) effects on sustainability of energy system at the council. Consequently, the regression coefficients also indicate that unit increases in use innovative technology like efficient lighting bulbs, use of efficient zero emissions for heating and cooling like smart motion sensors, integration of renewable energy use in the existing buildings and building and renovating in an energy efficient plan on average led to 0.24, 0.219, 0.138 and 0.341 respective increases in sustainability of energy system at the Council.

Use of innovative technologies and infrastructure involves developing and demonstrating integrated organizational lighting, heating and cooling systems, which are novel technologies that enable use of clean energy in a sustainable manner. This research project found out that there was a significant effect of using innovative technologies and infrastructure on sustainability of energy system at the council. This involves taking an extra step to implement smart grid technologies and energy management systems. These systems allow for real-time monitoring and control of energy consumption, optimizing energy usage in the organization. They can automatically adjust lighting, heating, and cooling systems based on occupancy, weather conditions, and energy demand. These findings relate to what was established by the Energy Information Administration (EIA) that the use of modern technologies such as efficient lighting bulbs and smart motion sensors promotes energy conservation which is one way of ensuring sustainability of energy in organization buildings.

Use of efficient zero emissions for heating and cooling takes the form of transition from traditional fossil fuel-based heating and cooling systems to renewable energy-based systems. Therefore the council installed technologies such as geothermal heat pumps, solar thermal systems, or biomass boilers. These systems utilize renewable energy sources to provide heating and cooling, reducing or eliminating greenhouse gas emissions associated with traditional fossil fuel combustion. This further includes putting in place heat recovery systems to capture and reuse waste heat generated during heating or cooling processes. This can be achieved through technologies like heat exchangers or heat pumps. By reusing waste heat, energy consumption is reduced, and the overall efficiency of the system is improved. This finding is in line with Akhtar *et al.*, who revealed that unlike traditional incandescent bulbs which used more energy to yield light and are no longer made. 90% of the energy was given off as heat and energy lost was money thrown away. For example, Light Emitting Diode (LED) bulbs use 25% - 30% of the energy and last 8 to 25 times more than halogen incandescent.

Light Emitting Diode bulbs are currently available in many forms such as substitutes for 3 W, 4 W, 5 W, 6 W, 10 W, 12 W, 40 W, 60 W, and 75 W traditional incandescent, reflector bulbs often used in recessed fixtures, and small track lights [20]. The Light Emitting Diode bulbs can conserve energy and can last longer than the traditional incandescent bulbs, hence making them more suitable for sustainability of energy in the organizations.

Integrating renewable energy use in existing buildings refers to the process of incorporating renewable energy technologies and systems into buildings that were originally designed and constructed without them. It involves retrofitting or modifying the existing infrastructure to harness renewable energy sources for electricity generation, heating, cooling, or other energy needs. This study found out that integrating renewable energy use in the existing buildings in the inter-university council of East Africa has a significant influence on sustainability of energy at the council. Some key aspects of integrating renewable energy in existing buildings include install solar panels on rooftops or other suitable areas of the building to capture sunlight and convert it into electricity. This renewable energy source can be used to power various building systems and appliances, reducing reliance on traditional grid electricity. It also involves integrating renewable energy often requires implementing energy management systems to optimize energy use and distribution within the building. These systems monitor energy generation, consumption patterns, and optimize the balance between renewable energy sources and grid electricity or storage to ensure efficient and reliable operation. This finding agrees with Zhou & Razaqpur who stated that the use of a building form and shell to accept, store, and distribute energy from renewable sources appropriate for buildings is commonly defined as the passive solar design. Passive systems mainly use solar energy and fresh air by means of space heating, cooling, and lighting without mechanical or electronic equipment [21].

3.3. Effect of Energy Security

Table 2 shows regression findings on the effect of energy security on sustainable energy at the council. The findings show the relationship between the components of energy security, that is, improving energy efficiency in the buildings, use of storage technologies and renewable fuels, integrating regional energy systems and sustainable energy at the council.

The results from regression analysis above indicate that; 98.3% of the variations related to energy security which occurred in sustaining energy were as a result of integrating regional energy systems such as diesel generators, use of energy storage technologies and renewable fuels and improving energy efficiency in organization buildings. Consequently, the regression model is significant ($p < 0.05$) which is an implication that energy security had a significant effect on sustainability of energy system at the Inter University Council of East Africa headquarters in Kampala, Uganda.

Table 2. Effect of energy security on sustainability of energy.

Model	Number of Observations	R-Square	Root Mean Square Error	Probability > F-Statistic, Confidence Interval = 95%,	
1	40	0.988	0.420	0.000	
	Model	Coefficients	Standard. error	t-statistic	Significance (p > |t|)
	Integrating regional energy systems	0.469	0.050	9.98	0.000
1	Use of storage technologies and renewable fuels	0.155	0.100	1.60	0.119
	Improving energy efficiency in the buildings	0.313	0.100	3.14	0.003

a. Dependent variable: Sustainable energy.

There were significant ($p < 0.05$) effects of integrating regional energy systems such as diesel generators and improving energy efficiency in the organization buildings on sustainability of energy at the council. However, there was no significant ($p > 0.05$) effect using energy storage technologies and renewable fuels on sustainability of energy at the council. Relatedly, the regression coefficients from the model above indicate that a unit increase in integration of regional energy systems on average led to 0.469 increase in sustainability of energy at the council, a unit increase in the improvement of energy efficiency at the council buildings on average led to 0.313 increase in sustainability of energy and energy storage technologies and renewable fuels on average led to only 0.154 increase in sustainability of energy at the council.

Integrating regional energy systems is the process of connecting and harmonizing different energy systems within a specific geographic region. It involves optimizing the coordination and interaction between various energy sources, such as electricity, natural gas, heating, cooling, and transportation, to create a more efficient, reliable, and sustainable energy network. This study found out that there was a significant effect of integrating regional energy systems on sustainability of energy at the Inter University council of East Africa headquarters in Kampala, Uganda. This was done to overcome the limitations and challenges associated with individual energy systems by leveraging their synergies and promoting a holistic approach. It involved the integration of diverse energy technologies, infrastructure, and markets to enable the exchange and sharing of energy resources, services, and information. This involves integrating various energy sources and technologies, such as renewable energy generation, energy storage systems, and demand response programs, to enhance system flexibility, resilience to ensure energy security at the council and thus sustainability of the energy. This finding relates to Mirjana, Siniša and Stevan who stated that diesel generators are used as substitutes or renewable types of energy in buildings. Therefore, use of diesel generators encourages use of clean and environmentally friendly energy, thus promoting energy security which leads to sustainable use of energy [20].

Improving energy efficiency refers to the implementation of measures and strategies to reduce energy consumption and optimize energy use within commercial, institutional, or industrial buildings. This study also established that there was a significant influence of improving energy efficiency at the council buildings on sustainability of energy. It involved adopting technologies, practices, and policies that aim to maximize the performance of building energy systems while minimizing energy wastage and associated costs, thus ensuring energy security in the organization. In line with this finding, Mirjana also established that energy security is essential for realizing a sustainable energy system in an organization or buildings, which includes safety of both supply and infrastructure, which are diesel generators and electric power connections [15].

3.4. Energy Efficiency

Table 3 shows regression findings on the effect of energy efficiency on sustainable energy at the council. The findings show the relationship between the components of energy efficiency, that is; stakeholder empowerment in energy management, enhanced zero emission power technologies, energy efficient equipment in place and sustainable energy at the council.

The results of the model above show that 95% of the changes related to energy efficiency, which occurred in sustaining energy at the Inter University Council for East Africa headquarters in Kampala, are as a result of stakeholder empowerment in energy system management, enhancing zero emission power technologies and having energy efficient equipment. The regression expression above was also significant ($p < 0.05$) which indicates a significant influence of energy efficiency on sustainability of energy at the council. There were significant ($p < 0.05$) effects of stakeholder empowerment in energy system management, enhancing zero emission power technologies and having energy efficient equipment on energy efficiency on sustainability of energy system. Consequently, a unit increase in stakeholder empowerment in energy system management, enhancing zero emission power technologies and having energy efficient equipment on average led to 0.45, 0.30 and 0.39 increases respectively in sustainability of energy at the council for East Africa headquarters in Ntinda-Kampala, Uganda.

Table 3. Effect of energy efficiency on sustainability of energy.

Model	Number of Observations	R-Square	Root Mean Square Error	Probability > F-statistic, Confidence Interval = 95%,	
1	40	0.946	0.868	0.000	
Model		Coefficients	Standard. error	t-statistic	Significance (p > |t|)
1	Stakeholder empowerment in energy management	0.453	0.095	4.75	0.000
	Enhanced zero emission power technologies	0.295	0.095	3.10	0.004
	Energy efficient equipment in place	0.389	0.125	3.11	0.004

a. Dependent variable: Sustainable energy.

Stakeholder empowerment in energy system management refers to the involvement, engagement, and participation of various stakeholders in the decision-making processes and actions related to the planning, operation, and governance of energy systems. This study found out that stakeholder empowerment in energy management had a significant influence on sustainability of energy at the council. This practice recognizes the importance of including and considering the perspectives, needs, and preferences of stakeholders who are affected by or have an interest in energy systems. This finding is related to what Awan found out that lack of technical staff directly affects energy efficiency and thus sustainability in an organization [21]. This agrees with the International Energy Agency, (IEA) report that energy efficiency has tremendous potential to boost economic growth and avoid greenhouse gas emissions [22].

Enhancing zero emission power technologies refers to improving and advancing the development, deployment, and performance of energy generation technologies that produce no greenhouse gas emissions during operation. This study found out that enhancing zero emission power technologies had a significant influence on sustainability of energy at the council. Zero emission power technologies primarily include renewable energy sources such as solar, wind, hydroelectric, geothermal, and biomass. Enhancing these technologies involves improving their efficiency, reliability, and cost-effectiveness to enable wider adoption and integration into the power grid. These technologies are crucial for mitigating climate change and transitioning to a more sustainable and low-carbon energy system. This finding agrees with Sudhakara who established that higher proper energy use enhances production, promotes economic growth and improves standard of living [11]. Additionally, enhancing zero emission power technologies is essential for achieving a carbon-neutral or carbon-free energy system. By reducing reliance on fossil fuels and minimizing greenhouse gas emissions, it mitigates climate change, improves air quality, and fosters a sustainable and resilient energy future.

Consequently, a majority of Umeme staff from Ntinda, Kampala offices revealed during an interview that; the positive effects of factors like turning off lights when not in use, maximizing use of task lighting, examining opportunities for tenancy sensors among other factors is that; there shall be reduced energy loses, reduced power consumption, reduced cost of electricity in the organization, minimized voltage drop on lines, improved quality of electricity supplied, reduced nonproductive loading on the energy system, increased energy system capacity. Therefore, using electricity for only productive functions reduces energy losses and consumption, which leads to energy conservation and reduced cost of electricity used (energy efficiency).

3.5. A Framework for Guiding the Implementation of a Sustainable Energy at the Inter-University Council for East Africa Head Quarters in Kampala, Uganda

Figure 1 represents a framework for guiding implementation of sustainable energy

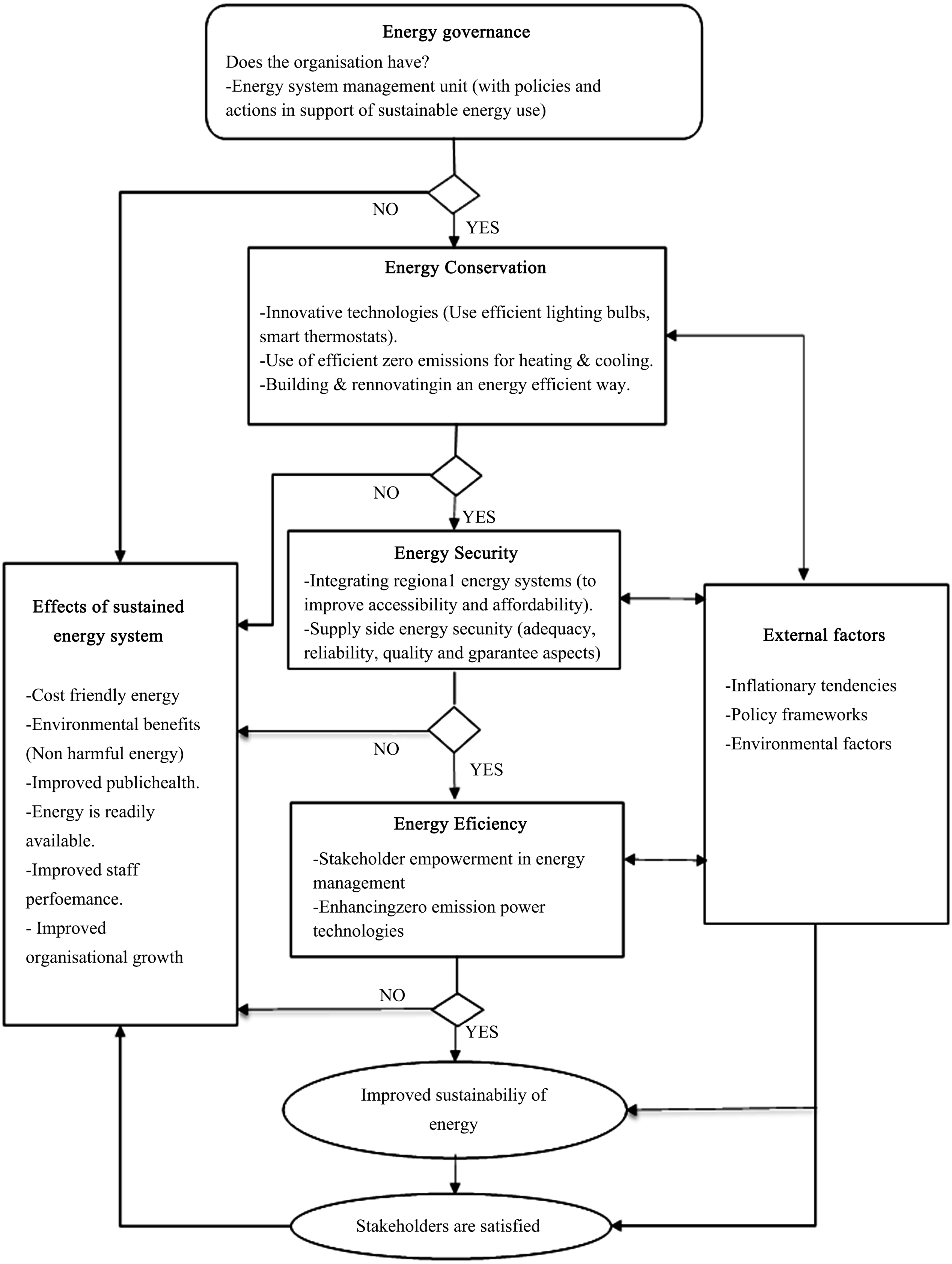

Figure 1. A framework for guiding implementation of sustainable energy.

at the council. It was developed using the most significant factors that influenced sustainability of energy system at the council as illustrated below.

It is observed from **Figure 1** that in order to improve sustainability of the energy at the Inter University Council of East Africa headquarters, there has to be effective governance of energy system with the management unit in the administration structure of the organization. This unit has to present policies and actions in support of sustainable energy use. If energy governance is not properly implemented, then there shall be no positive effects that can be realized from any effort towards sustaining energy use in the organization. This is achieved by the use of innovative technologies like efficient lighting bulbs and smart thermostats, use of efficient zero emissions for heating and cooling and also building and renovating in an energy efficient way.

If energy is properly conserved at the council, it leads to energy security. This is attained by integrating regional energy systems such as solar energy, diesel generator and thermal energy. This improves energy access and affordability in the institution, while on the supply side the energy shall be adequately supplied to the institution, reliable and of good quality and guaranteed aspects in energy supply. Unlike if energy is not properly conserved in the organization, no benefits shall be realized from any action taken towards sustaining energy. Similarly, if energy is accessible, affordable, adequate, reliable, quality and guaranteed aspects of usage, then energy shall be efficiently used for productive functions. Unlike if no energy security is maintained then no benefits shall be attained from all actions taken to sustain energy use in the organization.

Efficient use of energy in an organization brings improvement in sustainability of the energy in the organization, which in turn leads to organization stakeholders' satisfaction. Once all these factors are taken into consideration, then positive effects such as availability of cost friendly energy, environmentally friendly energy which is non-harmful, public health shall improve, energy becomes readily available, staff performance improves and generally organizational growth, shall be realized. The process of ensuring sustainable energy in the organization starts with clear governance of the energy system. The organization needs to clearly state policies and actions of energy management in the unit responsible for energy management. The roles and responsibilities of each member in this department have to be clearly stated, while capturing the activities involved in energy conservation, energy security and energy efficiency. The set policies and actions taken should be channeled to fairness and justice principles (including procedural, recognition, and distributional ones) should be at the Centre of designing and implementing clean energy technology transition solutions. For this, relevant methods and tools from social sciences and humanities need to be applied. It is from the energy department that energy conservation, security and efficiency work plans are drawn. Once these entire steps are clearly followed, then there shall be guaranteed effort towards sustaining the energy of the organization. This finding agrees with Polack who found out that energy governance structures create a favorable environment that provides assurance and clear signs to attract benefits and maintain investment in energy businesses. They also foster supportive infrastructure, energy and financial markets, human capital and accommodate innovation and change for the transition to a low-carbon economy [15]. Thus ensuring that clean and environmentally friendly energy is used, hence promoting sustainable use of energy. However, there is also external influence of other factors like environmental factors, inflationary tendencies, and government policy frameworks.

4. Conclusions

This research project established the most critical factors as; integrating energy use in the existing building, followed by integrating regional energy systems to enable staff to continue with their functions, then use of innovative technologies and structures like efficient lighting bulbs as opposed to traditional incandescent bulbs for better energy conservation and user efficiency. Validation of results: this finding was also validated through regression analysis where it was established that there was a realistic effect of stakeholder engagement in energy system management, which consequently leads to the sustainability of the energy system at the council.

The research project determined that among the established factors, there were significant effects of innovative technologies and infrastructure, integrating energy use in the existing buildings and constructing and repairing houses in an energy-efficient way on the sustainability of energy at the council. The findings were validated through tests from regression analysis. The research project established that the use of energy storage technologies had no significant effect on the sustainability of energy at the council. The finding was validated through statistical tests for significance from regression analysis on the use of efficient zero emissions for heating and cooling, improvement of energy efficiency in the buildings and enhanced zero emission power technologies on sustainability of energy. The research project also developed a framework for guiding the implementation of sustainable energy.

5. Recommendations

This research recommends that the government of Uganda should explore the use of innovative and zero emission technologies which are regarded as the energy system's enabling renewable energy technologies. These include technologies like hydropower, carbon capture, utilization, and storage, concentrated solar power, solar thermal, photovoltaic (PV), offshore and onshore wind, geothermal energy, and heat pumps. Additionally, there are technologies for storing energy such as batteries, thermal storage, hydrogen, and compressed air as well as technologies that make energy demand more flexible, contribute to electrification, and create a cleaner industry.

This study recommends the need to build and renovate organization buildings in an energy-efficient way to enable direct access to natural light through windows and enable staff to perform day to day functions even in situations when there is an electric power blackout. Starting with an energy-efficient building design that maximizes natural lighting utilizes proper insulation, incorporates efficient heating, ventilation, and air conditioning systems, and minimizes air leakage. Considering factors like building orientation, window placement, and shading to optimize energy efficiency. This encourages better staff productivity and thus improves organizational performance.

This research advocates that organizations' administrations should improve the ability of existing and new buildings to produce, store, and use energy efficiently in the residential and non-residential sectors. These efforts should include public and commercial buildings, service buildings, and buildings for transportation infrastructure, providing solutions and technologies. For example, architects responsible for any building constructions in the organizations should select the best choice of windows after a feasibility assessment of the geographical location, so as to select the type of windows that match the weather patterns of the area.

This study recommends managers or administrators in organizations integrate multidimensional innovations that take into account technology as well as techno-economic, sociotechnical, and environmental considerations to integrate a multitude of renewable, storage, and low-emission technologies into a dispersed yet dependable and resilient energy system where users play a vital role. The facets between these dimensions should be where the energy transition happens.

This study recommends institutions to aim at improving the potential of the entire technology and zero emission power technologies by increasing conversion efficiency per unit by 30% to 40% and reducing technology production costs by 35% to 50% by 2030. Institutions should also aim to improve their energy system integration properties and impact. Other than using diesel generators to ensure energy supply security. Solar photovoltaic (PV) systems convert sunlight directly into electricity without emissions. They harness energy from the sun using solar panels and can be installed on rooftops or in large-scale solar farms.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Anvari-Moghaddam, A., Mohammadi-ivatloo, B., Asadi, S. and Shahidehpour, M. (2022) Sustainable Energy Systems Planning, Integration and Management (Volume II). *Applied Sciences*, **12**, Article 10914. https://doi.org/10.3390/app122110914

[2] Karmaker, A.K., Rahman, M.M., Hossain, M.A. and Ahmed, M.R. (2020) Exploration and Corrective Measures of Greenhouse Gas Emission from Fossil Fuel Power Stations for Bangladesh. *Journal of Cleaner Production*, **244**, Article ID: 118645. https://doi.org/10.1016/j.jclepro.2019.118645

[3] Ganda, F. and Ngwakwe, C.C. (2019) Problems of Sustainable Energy in Sub-Saharan Africa and Possible Solutions. *Mediterranean Journal of Social Sciences*, **5**, 453-463.

https://doi.org/10.5901/mjss.2014.v5n6p453

[4] Chu, S. and Majumdar, A. (2012) Opportunities and Challenges for a Sustainable Energy Future. *Nature*, **488**, 294-303. https://doi.org/10.1038/nature11475

[5] Bishoge, O.K. (2021) The Nexus of Energy Resources and the Environment. *Journal of Ecobiotechnology*, **13**, 1-7. https://doi.org/10.25081/jebt.2021.v13.7445

[6] Cherp, A., Adenikinju, A., Goldthau, A., Hernandez, F., Hughes, L., Jansen, J., Jewell, J., Olshanskaya, M., Soares, R.O., Sovacool, B., Akulenko, S.V., Bazilian, M. and Fisk, D.J. (2012) Chapter 5—Energy and Security: Global Energy Assessment—Toward a Sustainable Future. Cambridge University Press, Cambridge, 325-384. https://doi.org/10.1017/CBO9780511793677.011

[7] Adebayo, F., Mundu, M., Akiyode, O., Lookman, A., Dahiru, S. and Ounyesiga, L. (2018) The Drivers and Barriers of Renewable Energy Applications and Development in Uganda: A Review. *Clean Technologies*, **1**, 9-39. https://doi.org/10.3390/cleantechnol1010003

[8] Hassan, A.A., El Habrouk, M. and Deghedie, S. (2020) Renewable Energy for Robots and Robots for Renewable Energy—A Review. *Robotica*, **38**, 1576-1604. https://doi.org/10.1017/S0263574719001644

[9] Griffiths, V.F. (2018) Win-Win? Balancing People's Uses of Nature with Biodiversity No Net Loss. Master's Thesis, University of Oxford, Oxford.

[10] Laldjebaev, M., Morreale, S.J., Sovacool, B.K. and Kassam, K.A.S. (2018) Rethinking Energy Security and Services in Practice: National Vulnerability and Three Energy Pathways in Tajikistan. *Energy Policy*, **114**, 39-50. https://doi.org/10.1016/j.enpol.2017.11.058

[11] Koushik, M., Bhaskaran, G., Ashish, N., Mostafa, R. and Rupa, D. (2020) Energy Efficiency Effectiveness of Smart Thermostat Based BEMS. *Energy Engineering*, **117**, 165-183. https://doi.org/10.32604/EE.2020.011406

[12] Dong, J., Liu, D., Wang, D. and Zhang, Q. (2019) Identification of Key Influencing Factors of Sustainable Development for Traditional Power Generation Groups in a Market by Applying an Extended MCDM Model. *Sustainability*, **11**, Article 1754. https://doi.org/10.3390/su11061754

[13] Ganda, F. and Ngwakwe, C.C. (2014) Role of Energy Efficiency on Sustainable Development. *Environmental Economics*, **5**, 86-99.

[14] Jagger, P. and Das, I. (2018) Implementation and Scale-Up of a Biomass Pellet and Improved Cookstove Enterprise in Rwanda. *Energy for Sustainable Development*, **46**, 32-41. https://doi.org/10.1016/j.esd.2018.06.005

[15] Maradin, D. (2021) Advantages and Disadvantages of Renewable Energy Sources Utilization. *International Journal of Energy Economics and Policy*, **11**, 176-183. https://doi.org/10.32479/ijeep.11027

[16] Benti, N.E., Gurmesa, G.S., Argaw, T., Aneseyee, A.B., Gunta, S., Kassahun, G.B. and Asfaw, A.A. (2021) The Current Status, Challenges and Prospects of Using Biomass Energy in Ethiopia. *Biotechnology for Biofuels*, **14**, Article No. 209. https://doi.org/10.1186/s13068-021-02060-3

[17] Gunnarsdóttir, I., Davidsdottir, B., Worrell, E. and Sigurgeirsdóttir, S. (2021) Sustainable Energy Development: History of the Concept and Emerging Themes. *Renewable and Sustainable Energy Reviews*, **141**, Article ID: 110770. https://doi.org/10.1016/j.rser.2021.110770

[18] Azzuni, A., Aghahosseini, A., Ram, M., Bogdanov, D., Caldera, U. and Breyer, C. (2020) Energy Security Analysis for Jordan's Transition to 100% Renewable Energy

by 2050. *Sustainability*, **12**, Article 4921. https://doi.org/10.3390/su12124921

[19] Krejcie, R.V. and Morgan, D.W. (1970) Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, **30**, 607-610. https://doi.org/10.1177/001316447003000308

[20] Zeb, A., de Andrade Romero, M., Baiguskarov, D., Aitbayev, S. and Strelets, K. (2016) LED Lightbulbs as a Source of Electricity Saving in Buildings. *MATEC Web of Conferences*, **73**, Article No. 02004. https://doi.org/10.1051/matecconf/20167302004

[21] Anvari-Moghaddam, A., Mohammadi-Ivatloo, B., Asadi, S., Guldstrand Larsen, K. and Shahidehpour, M. (2019) Sustainable Energy Systems Planning, Integration, and Management. *Applied Sciences*, **9**, Article 4451. https://doi.org/10.3390/app9204451

[22] Fairuz, R. and Sayuti, M. (2021) Efficiency and Sustainability. Centre for Global Sustainability Studies. University of Sains Malaysia, Penang, 392-402.