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Conceptualizing Energy Efficiency of Manufacturing Firms in a Developing Economy

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Abstract

Globally, economic transformation and industrialization requires efficient utilization of energy resources. This therefore necessitates countries, authorities, bodies, policymakers and private players to invest in energy efficiency (EE). This is based on the fact that energy efficiency is an adequate means that minimises adverse effects of climate change, improving energy security, enhances competitiveness and making energy consumption more affordable for all users. The purpose of this study was to comprehend insights surrounding how energy efficiency is conceptualized, the methods/measures, indicators, and gaps still existent in its implementation. The methodology adopted was a systematic literature review of previous scholarly work on methods, measures and gaps that inform energy efficiency in the context of manufacturing firms. The main results from this review indicated that about 8% of reviewed studies had been carried out in developing economies like Uganda & Sierraleone as compared to developed countries like Russia, and United Kingdom that constituted 15%. Such is a signal of energy efficiency gaps in a developing context. Moreso, energy intensive manufacturing firms were revealed to include steel, aluminum, pulp & paper under which IEA predications for energy efficiency were projected to improve by more than 15% and yield sufficient energy savings and sustainable energy consumption during manufacturing activities. The novelty of this study hinges in the fact that a comprehensive review of both developed and developing economies was done to have a balanced views of how energy efficiency is conceptualized, measured and the magnitude of existent energy efficiency gaps in an industrial setting.

Key words: Energy efficiency, Indicators, developing economy, manufacturing firms, SDG 7

Introduction

Rusydiana et al. (2021) state that activity is said to be efficient if the effort that has been done provides maximum output, both in quantity and quality. Efficiency and productivity can be used to measure the performance of a unit of economic activity. In this regard therefore, energy efficiency (EE) improves the sustainability and resilience of communities and contributes to near-term reductions in pollution and greenhouse gas emissions (Energy Efficiency Means Business, 2022). Solnørdaln and Thyholdt (2019) show that increased energy efficiency in manufacturing firms is important for confronting climate challenges. Furthermore, energy efficiency reduces demand for energy imports and lowers costs at household and economy levels. Energy efficiency is widely recognized as a key resource that has latent to lower both the economic cost and negative environmental side effects of transitions to low-carbon energy systems (Mandel et al., 2022). Lackner (2022) also indicates how energy efficiency, has been widely recognized as an ample and cost-efficient means to save energy and to reduce greenhouse gas emissions to the extent that up

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to one-third of the worldwide energy demand in 2050 can be saved by energy efficiency measures. The is in agreement with Malinauskaite et al. (2020) who indicates that energy efficiency is one of the key principles of the Energy Union, mainly due to it being the most cost-effective way to reduce emissions, improving energy security, enhancing competitiveness and making energy consumption more affordable for all consumers.

Energy sources are very important for the survival and economic growth of a country (Saddam, 2015) such that it is needed for facilities in producing food and health equipment, agriculture, education, information, and other infrastructure facilities. Energy is used in the industrial sector to process and assemble products, steam and cogeneration, process heating and cooling, lighting, heating, among others. SDG 7 aims at doubling the global rate of improvement in energy efficiency and increasing substantially the share of renewable energy in the global energy mix by 2030 (WHO, 2018). International Energy Agency (IEA) describes Sub-Saharan Africa (SSA) as one epicentre for the global challenge to overcome energy poverty (Munro et al., 2020). Also, Ganda and Ngwakwe (2014) identified some current challenges facing Sub-Saharan Africa to include lack of access to energy, inadequate maintenance and use of out-dated equipment (EIA, 2012) all that could lead to energy wastage. Gustavsson (2015) equally asserts that the industrial sector uses a lion's share of the electricity supply (59.4%) yet electricity makes up less than 2% of Uganda's primary energy supply. Siitonen et.al (2010) as indicated in the WEO-2009 report shows that by 2030, the energy saving and CO_2 reduction achieved by national policies and measures compared to baseline emissions will be bigger in the industrial sector than in any other final energy consumption sector. The biggest emission reduction compared to baseline emissions can be achieved in iron and steel and cement sectors: more than half of the reduction of global industrial energy-related CO_2 emissions (IEA, 2009).

It's vital to note that in the last decade, energy demand has increased dramatically in the agriculture and manufacturing sectors to increase the efficiency of production factors (Huang et al., 2008). Such energy demand continues to increase every day while there are energy sources that cannot be renewed so that if there is a lack of energy will affect the economic growth of a country at large. In developing countries, based on the level of economic growth, population growth, and industrialization there is a rapid increase in energy consumption (Omri & Kahouli, 2014; Amri, 2016). As part of Uganda's Sustainable Energy for All (SE4ALL) Action Agenda strategy number three of accelerating the process of achieving energy efficiency, access and other renewable goals (Du Can et al., 2018), it can only be realized through managing costs throughout all stages of preliminaries, implementation/investment up to monitoring and evaluation of the agenda activities. Pudleiner et al. (2017) further indicate that energy efficiency is a core element of ending energy poverty and securing access to affordable, reliable, sustainable, and modern energy. Implementing energy efficiency is parallel with expanding both the electricity grid and new clean energy generation reduces electricity demand which helps to optimize the power supply so that it can serve more customers reliably at minimum cost.

ODYSSEE 2020, indicates that Energy efficiency has different meaning and frontiers (economic efficiency versus technical efficiency). The data base also indicates a range of advanced energy efficiency indicators that can be used to assess progress in energy efficiency & savings to include like energy efficiency index, quantified energy savings, financial indicators, benchmarking indicators, decomposition of energy consumption variation and avoided CO_2 emissions.

On the contrary Proskuryakova and Kovalev (2015) emphasize on the adoption of thermodynamic indicators describing energy efficiency at the physical, technological, enterprise, sub-sector and national levels. Giacone and Mancò (2012) also assert that the measurement of the energy efficiency of a system or process is an essential step towards the control of the energy consumption and energy costs. Although energy efficiency is positively related to a manufacturing firms' performance (Fan et al., 2017; Martin et al., 2012) and compliance with both social pressure and stricter environmental regulations (Apeaning & Thollander,2013), firms tend to avoid adopting energy-efficient technologies that are economically and environmentally attractive (Abadie et al., 2012).

Saving energy in the context of commercial buildings has a dual potential of reducing operational costs as well as creating a wider impact on mitigating climate change. Kumar et.al. (2016). The need for reducing energy costs of commercial establishments is even more compelling in developing countries due to two key features i.e. frequent outages and high air conditioning loads as developing countries in Asia and Africa have tropical climate. Such Outages are often backed up by on-site diesel generators. However, such generators are expensive from both capital and operational expenditure perspectives with power from DGs costing approximately 3-4 times the grid price. The above energy efficiency gaps/ dilemma derives the motivation for such a topical subject matter to understand how energy efficiency is generally conceptualized in a developing context.

Crucial Research Questions

This study will be underpinned by the following research questions:

i) How is energy efficiency perceived at a global & local context?

i) What methods and measures, and reasons underpin energy efficiency in manufacturing firms?

ii) What are the gaps still existent in conceptualizing energy efficiency in manufacturing firms?

This study in form of systematic review will inform the above questions in the later sections of this work.

Methods and Materials

This study espoused a systematic literature review approach/methodology. According to Wee and Banister (2016), literature review papers are helpful for researchers in that the reader gets an up-to-date and well-structured overview of the literature in a specific area, and such a review adds value, research gaps are made explicit and readers who plan to do research in the same area for the first time. It’s also helpful for the reader/researcher who needs to interpret and use the findings and also help to refresh the information base of a researcher returning to a subject area after some time away from it. In this regard, previous empirical studies that assessed energy efficiency of manufacturing firms in a developing economy context were collected and analyzed to derive a range of energy efficiency measures & indicators and still existent energy efficiency gaps within manufacturing firms. Using an inclusion and exclusion criteria for a systematic literature review, *Figure.1* shows the appropriate articles that were eligible and therefore included and analyzed for this study in addition to the other briefs, conference extracts and reports accessed in the line of energy efficiency. These eligible articles and other relevant reports were then subjected to review and thoughtfulness to draw conclusions and recommendations that could address the research questions of the study.

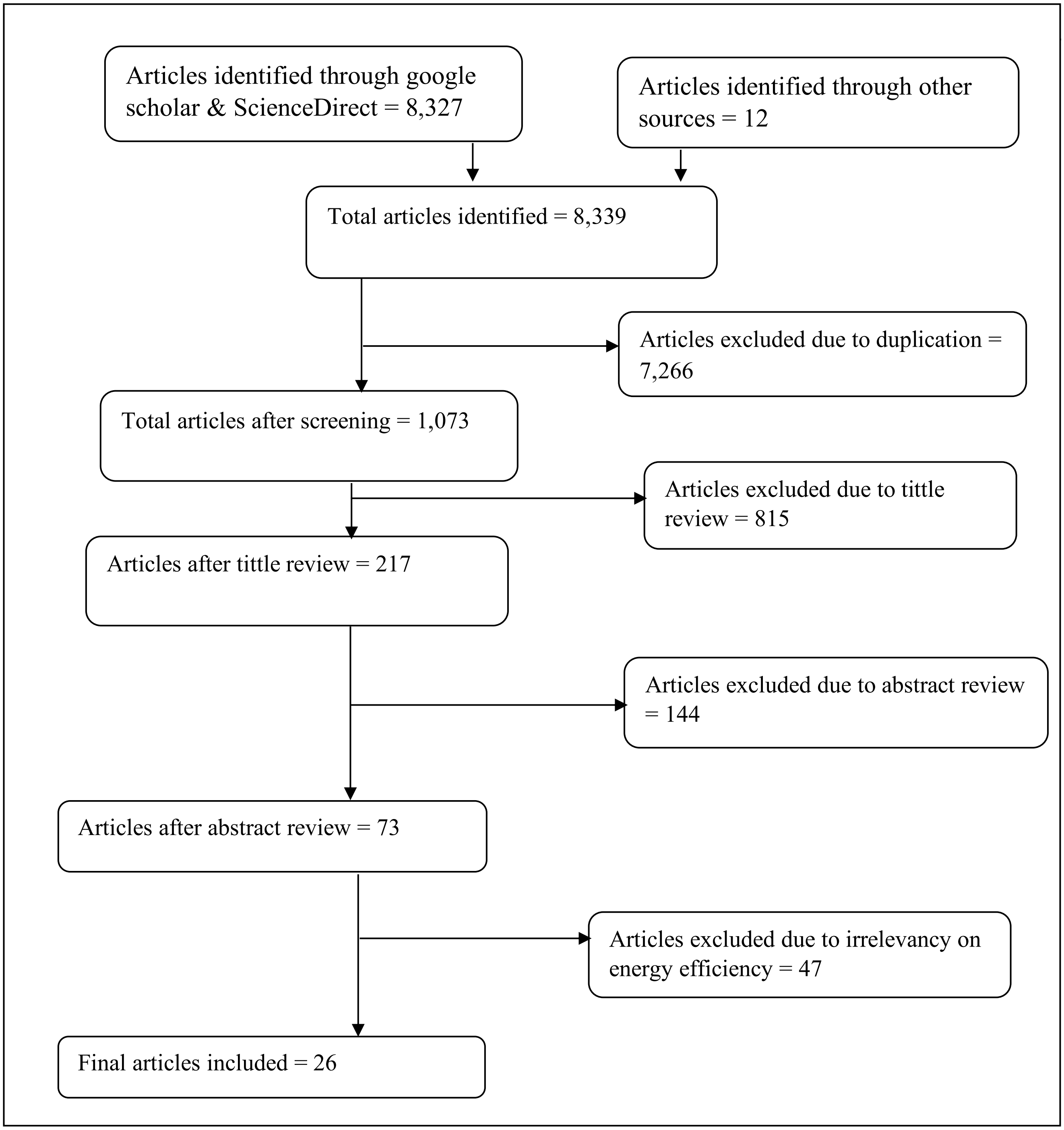

Figure.1: Flowchart for the systematic article selection. (Author's construction)

Materials

To obtain the above most suitable and relevant articles, reports and other conference proceedings that befits the area of energy efficiency, the following procedure was used.

Database Selection
This was based on article tittles and abstracts in the area of study. Attention was paid to metadata in regards to information like year of publication, journal title, volume, and issue (or article identification number) and Digital Objective Identifier (DOI) number. Therefore, the dominating article sources were Google scholar and ScienceDirect.

Journal Selection
This study focused on journals that were peer reviewed. Hence peer reviewed articles were considered for content collection. Also, journal impact and cite factor were used to identify credible journals from which the articles and records about energy efficiency were extracted. Supplementary literature was searched also looked at using Mozilla fire fox search engine.
Moreso, reports from reputable and credible organizations like International Energy Agency (IEA), SDG.7, Europenan Union (EU), Energy Report for Uganda, Ministry of Energy and Mineral Development (MEMD) were all considered and included in the dataset.

Content/Material Collection
In this regard, through google scholar and ScienceDirect, a search was done using key words like "energy efficiency measures/indicators", "manufacturing firms", "energy costs" and "developing economy" to obtain suitable scholarly work that could underpin this study.

The Inclusion and Exclusion
Inclusion criteria; Here all articles with a tittle and abstract of energy efficiency (in terms of indicators and measures) in an industrial-manufacturing context was considered for review of this study. Adequate and published book chapters, conference proceedings and power point presentations on the same subject matter were considered for review to inform the researcher's knowledge in energy efficiency of manufacturing firms.
Exclusion criteria. On the contrary, all those articles with tittles and abstracts that were not well fitting to the purpose of this study were disregarded.

Articles Criterion
Under this study, a total of 26 articles were included for the final review and analysis using a range of research and analytic approaches about the energy costs and energy efficiency in a manufacturing firm 'context (*Figure.1)* above. Attention was given to issues like the article tittle, abstract, methodology used, key findings, and limitations/gaps in the respective studies.

Results and Discussions
This section presents key findings from the articles selected and reviewed. The findings are majorly informed by the above stated research questions in order to derive constructive conclusions and recommendations that can add value towards realizing maximum energy efficiency and its other associated benefits. The results are hence discussed as below.

Articles Reviewed by Country
It was evidenced from Table.2 below that most studies on energy efficiency measures were carried out in Europe (15%) as developed context. Some relative studies were seen to have occurred in countries like Norway, Washington, Germany, Uganda and UK (all at 8%) under the scope of

coverage and the least countries reviewed at 4%. Uganda and other developing countries like Sierra-Leone are picking interest (8%) to embrace energy efficiency measures and tap into the related benefits like climate change mitigation and general economic development. This is however at a slow rate such as 8% and 4% of the reviewed countries. This could further imply that developing countries have not yet embraced cleaner renewable energy technologies that could would be more times energy efficient.

Table 2: Summary of articles by country

Country Name	Frequency	Percentage (%)
Israel	1	4
Norway	2	8
Europe	4	15
Washington	2	8
Sierra-Leone	1	4
Uganda	2	8
Germany	2	8
Tunisia	1	4
United Kingdom	2	8
Indonesia	1	4
Austria	2	8
Switzerland	1	4
Netherlands	1	4
Russia	2	8
India	1	4
Iraq	1	4
TOTAL	**26**	**100**

Articles Reviewed by Journal Type

The results in Table 3 are hereby presented. Majority (12%) of the articles reviewed were obtained from the journal of "Energy" and "Energy Policy". This was then trailed by the articles from "Energy Efficiency", "Environmental research letters" and "Applied Energy" (8%) and then finally others like "Energies" "Economic Perspectives" and "Research Policy" were reviewed to the extent of (4%). This implies that journals which had relevant applicable/relevant article information on energy efficiency measures and indicators were those at 12% followed by articles of 8%and least to those at 4% respectively.

Table .3: Summary of articles by journal type

Journal Name	Frequency	Percentage (%)
Energy Policy	3	12
Energy and Environment	1	4
Energies	1	4
Energy Efficiency	2	8
Environmental research letters	2	8

Economic Perspectives	1	4
Front knowledge	1	4
MPRA	1	4
Energy Procedia	1	4
Cleaner Production	1	4
Energy	3	12
Energy Economics and Policy	1	4
EESI Smart Grid communication	1	4
Research Policy	1	4
Transport Reviews	1	4
Applied Energy	2	8
IEEE	1	4
Climate Change Mitigation & Adaptation	1	4
Social Sciences	1	4
TOTAL	**26**	**100**

Table 4: Summary of articles on energy efficiency of manufacturing firms

Author & Year	Article Tittle	Methodology	Key Findings	Limitation
Lackner (2022)	Energy Efficiency: Comparison of Different Systems and Technologies	• Book chapter under "Handbook of Climate Change Mitigation and Adaptation" • Spanning/review of historic data, current levels, and future trends of energy efficiency under different sectors like production, energy transmission and storage, transportation, industry, buildings, and appliances.	• Energy use efficiency is the cheapest and easiest source of energy. • up to 1/3 of the worldwide energy demand in 2050 can be saved by energy efficiency measures. • Energy-Intensive Industries to include cement, steel, aluminum ores pulp & paper. • These industries have a strong effect on global	• countless areas for hidden or for indirect energy efficiency improvements not yet maximized. • Advanced packaging, for instance, can save substantial amounts of materials • green computing • Electronic banking, video telephony, and teleconferencing • fleet management that economizes travelling energy. • Constrained shifting of employment and economic

			energy consumption, because they are not only energy intensive as such but because they produce high amounts of materials per year. • The IEA predicts big improvements in energy efficiency in industry, which are expected to be more than offset by higher output of steel and cement (IEA 2009), especially in the developing world, to which countries like Brazil, Russia, India, China (BRIC), Mexico, and South Korea belong.	activity/transition from manufacturing to the service sector saves energy and cuts greenhouse gas emissions, because the service sector is much lower in energy intensity. • energy efficiency not yet extended to water resources, eco-system, de materialization, ephemeralization, etc.
Mandel et al. (2022)	Conceptualizing the energy efficiency first principle (EE1st): Insights from theory and practice	Exploratory review of the literature a compelling theoretical to obtain a background that can help inform the design of effective policy interventions in order to move from	EE1st is thus theorised as a decision principle that prioritises demand-side resources and supply-side energy efficiency over default supply side resources whenever they	• practical constraints, traditional energy efficiency policies like standards and subsidies must remain a critical element of the policy framework at EU and Member State levels.

		principle to practice.	provide greater value to society in meeting decision objectives. it is embedded in the EU's unbundled and liberalised energy markets, it relies on a multitude of decision-makers and addresses not only electricity but also all energy vectors. • its focus on the societal perspective, making it a principle of public policy rather than only regulated utility business.	• some of its key aspects and implications for policymaking remain unclear, with the associated risk that EE1st remains merely a slogan without tangible impact on energy-related investment, planning, and policymaking. • Study limited to EU member states.
Rusydian a. et al. (2021)	Energy Efficiency in OIC Countries: SDG 7 Output	• Efficiency measurements were done using the Data Envelopment Analysis (DEA) method. • Productivity measurement was done by using the Malmquist	• there are differences in the level of efficiency regionally, whereby Muslim countries in the European continent are then followed by the countries of the West Asian region in the second position and the	• The study was limited to only members of Association of Islamic Cooperation Organisations (OIC). • Hence efficiency yardsticks may not be applicable to non-Islamic countries.

		Productivity Index (MPI).	third position is the central African region which is superior to the region Other Africa.	
Jurgita et al. (2020)	Energy efficiency in the industrial sector in the EU, Slovenia, and Spain		• the most cost effective way to reduce emissions, improving energy security, enhancing competitiveness and making energy consumption more affordable for all consumers • Both countries analysed in this paper have high domestic dependence on imported energy sources, therefore, showing a great potential for energy efficiency. • All EU Member States had to present their integrated NECPs, which, inter alia, must outline how they intend to meet the energy efficiency targets for	• The study was limited to only two EU countries. • Efficiency studies needed in heating and cooling requiring the Member States to conduct a comprehensive assessment of the cost effective potential for energy efficiency in heating and cooling, principally through the use of cogeneration, efficient district heating and cooling and the recovery of industrial waste heat .

			2030 and what measures will be employed to secure them. • the EED has more coercive measures, such as audit obligations on all large enterprises (including businesses operating in the industrial sector).	
Saurav et al. (2016)	Minimizing energy costs of commercial buildings in developing countries.	Novel to schedule supply resources and optimize temperature set points by leveraging the inherent thermal storage potential of a building. Use of a computationally fast algorithm which can be used as a substitute for optimization.	• savings can be enhanced substantially by integrating pre-cooling with supply-side strategies. • savings from pre-cooling and set point optimization are more for offices because of their greater pre-cooling potential, as large buildings have higher thermal capacity. grid connected cell towers, pre-cooling is effective when other loads in the building could be served	• include levelized cost of energy for battery and solar into savings calculation challenge here is. • to obtain right market prices of batteries and solar PVs. • assumption in the proposed framework that forecast for outages, occupancy, solar power and ambient temperature are known.

			using a battery, thus eliminating the use of DGs for certain periods of time. off-grid cell towers, majority of the savings arise by ensuring that DGs run at the right efficiency levels, for example by charging the battery in parallel while serving the loads.	
Siitonen et al. (2010)	Variables affecting energy efficiency and CO2 emissions in the steel industry	Analysis of energy consumption figures using Partial least square (PLS) analysis to derive energy efficiency indices.	• Challenges of energy efficiency can be avoided by clear definition of the system boundaries. • consideration of on-site energy conversion and energy consumption of intermediate products crucial.	• Difficulty in definition of system boundaries, and calorific values used when collecting energy consumption data. • Changes in the operating conditions of a steel mill, such as the production rate, affect the specific energy consumption, and then make it difficult to separate the effect of energy efficiency improvement actions from the effects of other changes.
Saddam (2015)	The efficacy of energy production and economic growth in	• Pearson correlation tests • Co-integration tests	• There is a large positive strength (*) between the aggregate	• Relating energy consumption to economic growth/output in relation to

	aggregate energy consumption:	• Regression of an empirical model for the logarithmic annual stationary data of selected OIC countries.	energy consumption and the production of crude oil, electricity generation, and natural gas production, which amounted to be 0.91, 0.79 and 0.85 respectively. • The economic growth of EA sample has led to achieving an efficiency in term of using energy sources. However, this result could be attributed to the role of advanced technologies used in the manufacturing sectors of these economies (Lall, 1998)	only three energy resources i.e. crude oil, electricity and natural gas.
Kimuli. et al. (2022)	A sustainable energy portfolio for	• TIMES-VEDA platform.	• the primary supply energy should be	• TIMES-VEDA modeling framework is a partial

	Greater Kampala Metropolitan Area towards the mid-century	• A represents the energy system in form of a reference energy system (RES). It consists of VEDA Front-End (VFE) and VEDA Back-End (VBE) as management platforms of the model generator. VFE is for data handling and VBE is for results handling via dynamic users defined pivot tables.	optimized and comprises biofuels (64.9%), charcoal (14.8%), fossil fuels (19.9%), and renewables (0.4%) for sustainability. • The share of electricity should be increased by 53.68% in the final demand by fuel type, to become the major contributor to fuel consumption for Kimuli et al. (2022) • 100% dependency on imported refined fossil oils mostly via Kenya from the middle east • The analysis also suggests that energy demand by	equilibrium model. • The model only considers majorly the energy management system, while ignoring the economy-wide effects. • the model exhibits drawbacks such as ignoring the policymaking behavior of various economic proxies, especially private households, • underestimate of the elasticity of the energy system to respond to price signals or policy shocks leading to an overestimated cost of CO2 emissions abatement strategy. • They are data-intensive, often at a level of detail that is impractical in some economies. • The cost of implementing

			sector would increase from 139.6 PJ to 497.42 PJ and CO2 emissions would increase from 4.6m tons to 7 m tons. The cost of implementing the sustainable energy portfolio appears to be reasonable. • Management should invest optimally in low-carbon electrical power production, transportation, industrial and residential sectors if sustainability is to be achieved by 2050	the sustainable energy portfolio appears to be reasonable.
Proskuryakova and Kovalev (2015)	Measuring energy efficiency: is energy intensity a good	• Use of engineering thermodynamic indicators and	• Energy intensity measure reflects consumptio	• Using energy intensity measure as an indicator of energy efficiency is

	evidence base?	economic measures of energy efficiency based on energy intensity	n not efficiency. • Thermodynamic indicators should describe energy efficiency at all levels.	problematic as it does not indicate what exactly is inefficient. • It may indirectly point to a general state of affairs in an industry or economy, but it does not provide a basis for specific recommendations on energy efficiency development.
Ganda and Ngwakwe (2014).	Problems of Sustainable Energy in sub-Saharan Africa and Possible Solutions	Systematic literature review of previous studies.	• sustainable energy refers to renewable energy sources like hydro and technologies that enhance energy efficiency • the major problems identified are: continued employment of fossil fuel subsidies; the presence of monopoly structures in the energy sectors; regulatory and macroeconomic	• inefficient policies and frameworks in the governance so that sustainable energy development priorities are attained.

			risks in sustainable energy schemes; large capital required to fund sustainable schemes; high transaction costs; low carbon risk and negative social factors.	
Patterson (1996).	What is energy efficiency?: Concepts, indicators and methodological issues.	Use of six advanced indicators i.e. • Energy efficiency index to measure EE improvements at sector level. • Energy savings to quantify the amount of energy saved over a period or for given year. • Financial indicators to show the financial benefit of energy savings for households. • Benchmarking indicators to assess how each country performs compared	Energy efficiency has different meaning and frontiers i.e; • Economic efficiency; Energy intensities provide for instance an assessment of energy efficiency from an economic point of view versus • Technical efficiency); Here unit consumption are more focused on technical energy efficiency. SEC.3.1.1 Indicates the energy intensity of industry, of manufacturing or of an industrial branch as the ratio between	• Does not specify the actual indicators of energy intensity of the stated manufacturing industries.

		to other countries. • Decomposition of energy consumption variation to show how energy efficiency improvements have impacted the energy consumption of the country. • Avoided CO_2 emissions to show what is the effect of energy efficiency improvement on CO_2 emissions.	the final energy consumption of the branch (measured in energy units: toe, Joule, etc) and the value added measured in constant monetary units. **Sec.3.1.4 indicates** 3 energy intensive branches to include steel, cement and pulp & paper.	
Giacone and Mancò, (2012)	Energy efficiency measurement in industrial processes.	• energy system of a site is represented using a single matrix equation, which expresses the relationship between imported energies and energy drivers • Mathematical process	• implementation in an energy management system standard (e.g. EN 16001, ISO 50001) or LCA standard (e.g. ISO 14044). • results are relevant for energy benchmarking,	• Difficulty of choosing an appropriate definition and specific measure of energy efficiency to best suit a given manufacturing set up from a range of many suggested options.

		modelling, through statistical analysis of energy consumption data, is used to quantify the specific energy consumption as a function of the output • regression analysis of historical data	budgeting and energy targeting.	

Other documents reviewed

- Other than articles presented in table .4 above, other documents to inform energy efficiency are as summarized below;

Table 5: Summary from other key documents reviewed

Document	Key findings/Insights
Advancing SDG.7: Implementation in support of the 2030 Agenda	• SDG 7 is a dedicated and stand-alone goal on energy that is to "ensure access to affordable, reliable, sustainable and modern energy for all". • The High-Level Political Forum (HLPF) Ministerial Declaration also commit to enhancing international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advances and cleaner fossil fuel technology, and to promoting investment in energy infrastructure and clean energy technology • By 2030, it projects a double the global rate of improvement in energy efficiency • Governments and other stakeholders are argued to accelerate the pace of transition towards renewable energy, especially in end-use sectors such as transport, buildings, agriculture and industry, as well as the pace of energy efficiency across all sectors of the economy, including cooling and district heating. • We reaffirm the commitment to rationalizing inefficient fossil fuel subsidies taking into account the specific needs and conditions of developing countries. It is also critical that we scale up capacity-building, research and development,

	including by sharing experiences and data and promoting innovation and investments in energy efficiency across all sectors of the economy, and that we support sustainable energy deployment, particularly in developing countries. • This agenda also re-affirms the commitment to rationalizing inefficient fossil fuel subsidies taking into account the specific needs and conditions of developing countries. It is also critical that we scale up capacity-building, research and development, including by sharing experiences and data and promoting innovation and investments in energy efficiency across all sectors of the economy, and that we support sustainable energy deployment, particularly in developing countries. • As part of the implementation program Scale up investments in energy efficiency across all sectors of the economy, supported by well-designed, evidence-based policies (e.g., building codes, minimum energy performance standards, energy performance labels, cost reflective energy tariffs, and fuel economy requirements), as well as by regional, national and local action plans (with effective enforcement and monitoring).
EESI Congressional Briefing series. Energy Efficiency Means Business (Thursday February 24, 2022).	• The Energy Efficiency and Renewable Energy (EERE) aims improving energy performance and efficiency in the US advanced manufacturing office by; • Innovative Research &development projects with public, private and academia, energy intensity reduction, industrial decarbonization, industrial assessment centers, technical partnerships • Energy Act of 2020 refocuses on attention on agency audits and their mandatory implementation.
Energy Sector Management Assistance Program. (2018), World Bank, *Policy Matters*	• Concerns about climate change have lent considerable momentum to the adoption of clean energy policies, with an evident surge in the uptake of targets for renewable energy and energy efficiency in the run-up to the 2015 Paris Climate Accord. • For example, Tunisia performs particularly well in energy efficiency planning and incentives and mandates for the public and industrial sectors, and Singapore performs exceptionally well in energy labeling schemes and financing mechanisms for energy efficiency. • three aspects of sustainable energy. By contrast, countries such as Bangladesh, Ghana, India, and Kenya have concentrated their efforts on policy frameworks for electricity access, even as they begin to catch-up on renewable energy and energy efficiency. • Among the world's largest energy-supply countries, Canada, China, Indonesia, Japan, and South Africa have improved energy productivity the most since 2010 (Figure 2.14). All five

	countries have adopted best-practice policy measures for energy efficiency. • The biggest energy productivity improvements are in China and Indonesia, where policies like efficiency mandates for the largest industrial consumers have been instituted. • Tracking and enforcing energy efficiency is quite complex since most efficiency measures are typically driven by energy savings which involve hypothetical baseline calculations
The Uganda Vision 2040	• Section 4.2.3(205-206) indicates how government emphasis will be put on improving energy efficiency by promoting use of energy efficient technologies. Government will support upgrading of industrial technologies to less energy consuming technologies. • Moreso, a strategy by G.O.U to continuously review the energy sources with a view of using the most cost-effective source that will be ensured to provide a competitive tariff compared to other countries.
Energy Policy for Uganda 2023	• Among other objectives, this policy targets to promote the adoption of energy efficiency and conservation practices • Uganda subscribes to is the Paris Agreement, which pledges to reduce carbon dioxide (CO2) and other greenhouse gas emissions and adapt to climate change's impacts. • Energy intensity is a measure of the energy efficiency of a country's economy. It is the ratio of a nation's energy consumption to its GDP (gross domestic product). • Sec.4.4 indicates how energy efficiency& conservation are core elements of ending energy poverty and securing access to affordable, reliable, sustainable, and modern energy. • Implementing energy efficiency in parallel with expanding the electricity grid and new clean energy generation reduces energy demand. • It helps optimise energy supply to serve more customers reliably at minimum cost. • Adopting efficient technology and appliances and informed energy management practices allows rapid scaling up of energy efficiency to ease energy constraints and lower utility bills for both the public and private sectors while supporting a sustainable framework for long-term energy stability.
Uganda's Sustainable Energy For All (SE4ALL) Initiative Action Agenda, 2015	• It indicates the main 5 pillars of energy efficiency to include; Awareness & Information, Training & Education, Research and Development, Financing and incentives, Legislation & Framework • Implementation of Energy Audits in the Industrial sub sector by MEMD with the support from GIZ for high energy

	consuming facilities such as those in energy intensive manufacturing firms like Cement, steel, pulp & paper etc. • Existing gaps in energy efficiency are indicated under sub-section 4.3.3 to include like iincomplete Regulatory Framework such as Energy Efficiency and Conservation Bill, Insufficient awareness about energy efficient technologies, inadequate financing mechanisms, Inadequate technical capacity(certified personnel such as Energy Auditors, Managers, Inspectors, and Equipment testers. • Minimum Energy Performance Standards (MEPS) lack testing facilities, and implementation and oversight capabilities (monitoring and evaluation);

Conclusion

It can be seen that energy efficiency is a key driver to ensure access to affordable, reliable, sustainable and modern energy for all as per SDG 7 target of 2030. Various bodies like Paris Agreement, IEA, SE4ALL, EU, World Bank(HLPF), EERE, OIC, among others are on board to realize a continued improvement in energy performance and efficiency with its associated benefits. From the above review, it was further noted that a range of methods could be adopted to assess EE such as Data envelope Analysis (DEA), Malmquist Productivity Index (MPI), Novel, Pearsons correlation tests, EE index, regression, systematic literature review, exploratory reviews among others etc. EE was seen to be associated with a range of benefits such as adoption of energy efficiency and conservation practices, enhanced energy savings, improved innovations in energy efficient technologies, continuous improvement of minimum performance management standards, improved research & development, optimization of energy supply and to reliably serve more customers at minimum costs. Nevertheless, a number of gaps/challenges were encountered to still persist in conceptualizing, measuring and implementing energy efficiency at large. Such gaps/hiccaps included hidden/indirect avenues of energy efficiency improvements, energy efficiency not yet extended to water resources, eco-system & de materialization, unclear policies & regulatory frame-works, unclear indicators of energy intensity in manufacturing firms, difficulty of choosing specific measures of energy efficiency to best suit a given manufacturing set up/type, limited awareness & information, technical &financial limitations all still hold.

Recommendations

Since most previous studies have been conducted in OIC and EU countries dominated by developed & middle-income economies, their results do not befit a developing economy context and hence the need to more localize energy efficiency in economies that are trying to embrace industrialization like Uganda. Emphasis is further called for in implementation of energy audits especially in the industrial sub sector by responsible authorities & ministries within the high energy consuming industries such as those in energy intensive manufacturing firms like Cement, steel, pulp & paper etc. Investments in various capacity developments like technical skills, specialised renewable energy equipment, benchmarking, all directed towards a sustainable energy for all across the globe.

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Declaration of conflict of Interest
The author(s) declare no existing conflicts of interest with respect to the research, authorship and forth-coming publication of this article term paper.

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