

Conceptualization and antecedents of productive use of electricity: A systematic literature review

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ARTICLE INFO

Keywords:

Productive use
Electricity
Conceptualization
Antecedents
Theory
Methods

ABSTRACT

Productive use of energy is recognized as a pathway to economic and sustainable development. Indeed, there has been deliberate effort to promote productive use of energy, particularly, electricity by policy makers and international organizations. However, limited understanding of what constitutes productive use and factors that potentially influence uptake of productive uses at micro level continue to undermine existing efforts to promote productive use of energy in developing countries. Using a systematic literature review approach, a total of 54 out of 997 articles were selected following the criteria for inclusion and exclusion for further analysis. We find that majority of studies define productive use of electricity as application of electricity energy services to activities that generate income or enhance productivity. Regarding conceptualization, we found that productive use of electricity is conceptualized along three dimensions, which are (1) improved performance of existing income generating activities, (2) use of modern electrical productive use appliances and (3) creation of new enterprises and job opportunities after electrification. Furthermore, the review found that majority of studies identify electricity related factors as important drivers of productive use of electricity. However, these should be bundled with other non-electricity related variables including financial, technological, human capabilities, institutional, infrastructural, social, demographic characteristics. The paper has also identified various research gaps that may inform future studies in productive use of electricity.

1. Introduction

Energy and electricity in particular is recognized as a crucial factor in promoting sustainable development and economic progress (Lee et al., 2020). Electricity unlocks various energy services (such as lighting, digital technologies and communication, product cooling and mechanization) that improve end users' capacity to engage in productive uses (Blimpo and Cosgrove-Davies, 2019). In addition, Attigah et al. (2015) observe that the use of electricity services in productive activities not only serves as a means of translating energy access into poverty reduction through increased job creation and income, but also contributes to ensuring sustainability of electrification programs.

Thus, electricity can directly contribute to economic development through various productive use applications. Research has shown that, productive uses of electricity (PUE) stimulate business growth, creation

of new enterprise and jobs, and hence improved income. For example, Ngowi et al. (2019) demonstrate that new entrepreneurial activities such as mobile phone charging, welding centers, hair dressing, photocopying, and lighting business centers emerged in Bulongwa-Tanzania as a result of off-grid rural electrification. Similarly, Pueyo & DeMartino (2018) show that many new businesses started while old ones improved performance in terms of opening hours and increased sales following the introduction of electricity in several rural communities in Kenya. In addition, Peters and Sievert (2016) document instances in the African setting where households were able to use electrical appliances to generate income by providing goods and services that cater to the local community, such as mobile phone charging, television cinemas, or mills. Furthermore, Ganguly et al. (2020) note that PUE makes electrification initiatives more financially viable since it boosts demand and create capacity to pay for more energy services. Despite the benefits,

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<https://doi.org/10.1016/j.clet.2024.100747>

Received 27 September 2023; Received in revised form 16 March 2024; Accepted 1 April 2024

Available online 3 April 2024

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available evidence suggests that productive use of electricity is relatively limited in developing countries particularly in rural regions (Blimpo and Cosgrove-Davies, 2019; Lee et al., 2020).

Productive use of energy and electricity in particular, has been defined differently by various scholars. Some researchers have defined it in a broader sense, encompassing the utilization of both electric and non-electric energy for activities that improve income and welfare outcomes, including gender equality, health, and education (Anil Cabraal et al., 2005; Kapadia, 2004; Terrapon-Pfaff et al., 2018). Others have a narrower interpretation of productive use, defining it as any activities that directly utilize electricity or energy services to increase income or value (Benjamin Attigah and L, 2015; Brüderle, 2011; Pueyo and DeMartino, 2018). While, others consider productive use as an extension of households' capacity to generate income from non-farm activities, rather than establishing a distinct business like a micro-enterprise (Aklin et al., 2017; Ngowi et al., 2019). As of now, there is no universally agreed upon definition for the productive use of energy.

Although access to electricity is recognized as a key antecedent for productive use, recent studies argue that access to electricity alone is insufficient to drive productive use activities rather, effective productive use requires a combination of electricity and non-electricity related factors (Pelz et al., 2021; Pelz et al., 2023; Pueyo and DeMartino, 2018). Nonetheless, prior studies synthesizing literature on productive use of electricity though comprehensive, have concentrated on specific aspects with limited scope with less attention given to understanding the conceptualization, antecedents, and theories of PUE at micro-level are limited. For example, Pueyo and Maestre (2019) reviewed literature productive uses of energy focusing on the benefits, gendered constraints and possible interventions to achieve gender equity in the PUE. Morrissey (2019) synthesized literature on electrification and productive use with a narrow focus on unleashing the economic benefits and impacts of productive uses of electricity. Terrapon-Pfaff et al. (2018) conducted a systematic literature review on productive use of energy as a pathway to development with focus on the outcomes and impacts. Riva et al. (2018) undertook a comprehensive review and extensive analysis of the literature on electricity access and its impact on rural socio-economic development, and vice versa.

While we acknowledge the contribution of these authors in the area of productive use of electricity, their studies are limited to either the benefits, constraints, existing policy interventions or outcomes and impacts of productive use of electricity. A comprehensive review of factors that hinder or drive productive uses of electricity has received limited attention. Furthermore, none of the reviewed studies considered exploring theories employed and how productive use of electricity is conceptualized over time. As guided by Sequeira (2014), conceptualization entails the establishment of a clear and succinct definitions for the concept under study. This is vital because it facilitates clarity in understanding, measurement and analysis of the concept. In that regard, the purpose of this study is to provide a comprehensive review of literature with a focus on unearthing the conceptualization, theories employed, and the factors that hinder or drive productive uses of energy.

The contribution of this study is twofold. First, it utilizes a systematic review methodology to evaluate the available evidence from both published and grey literature on productive use of electricity worldwide. This approach is unique because it is scientific and synthesizes existing literature in a more progressive and logical manner useful enough to draw conclusions on productive use of electricity. Second, by drawing from diverse and comprehensive sources of information, the study provides useful insights on crucial determinants of PUE that researchers, policy makers and electrification practitioners - to make informed decisions. In the same vein, the findings of this study inform a framework of analysis and proposes areas for future research.

2. Materials and methods

2.1. Review approach

The study utilized a systematic literature review (SLR) approach to analyze existing evidence on productive use of electricity for a period of over 20 years (from 2000). This approach was preferred because it is structured, rigorous and enables detailed review of all high quality and relevant literature to address pre-formulated research questions (Litte et al., 2008). Aveyard and Bradbury-Jones (2019) emphasize the importance of researchers carefully selecting and justifying the approaches they choose for conducting a literature review, and meticulously adhere its methodology. A systematic review method employs explicit and reproducible methodology in searching, assessing, and synthesizing existing literature with a high level of objectivity (Litte et al., 2008). Furthermore, this approach follows clearly laid out process that encompasses the formulation of review protocol, clear and robust literature search strategy as well as well-defined eligibility criterion to guide inclusion and exclusion of the study materials. Eligible studies are subjected to subsequent screening and objective assessment to ensure relevance and quality (Bowler et al., 2010). Accordingly, our study employed standard guidelines and formats for systematic literature review proposed by Tranfield et al. (2003). The guideline (protocol) includes, question formulation, material collection, selection and evaluation, analysis and evaluation, reporting of the results.

2.2. Question formulation

To comprehensively gain understanding and knowledge of productive use of electricity, the study therefore sought to find answers to the following questions.

- i. How is productive use of electricity conceptualized?
- ii. What factors influence productive use of electricity?
- iii. What theories and methodologies are applied to study productive use of electricity?
- iv. What are the likely research gaps that need to be addressed in the future?

2.3. Material collection

2.3.1. Data sources

The study materials were identified using databases of scientific journal publishers, internet search engines, and websites of different academic and development organizations. During database selection, emphasis was put on those databases that provide metadata and abstracts: Metadata captures information on; year of publication, journal title, volume, issue (article identification number) and Digital Objective Identifier (DOI) number. The reason being that the search for the materials ought to be sufficiently broad yet specific enough to capture all high-quality and relevant studies. Thus, for this study, several databases were considered including ScienceDirect, Elsevier, Springer, and web of science. These databases were considered because they contain majority of papers on energy studies and they are extensively used databases in literature search as shown by the bibliometric analyses (Aghaei Chahdegani et al., 2013; Mongeon and Paul-Hus, 2016). Other search engines, especially Google scholar, was used during the search process since it has a wide reach to many databases.

2.3.2. Selection of the journals

The study focused mainly on the major leading journals that publish scientific papers in the area of energy generally and particularly productive use of energy. Such journals were identified using the Clarivate Analytics journal ranking alongside their impact and cite factors (da Silva and Al-Khatib, 2021). Specifically, the journals classified and ranked under A, B, and C categories were considered as credible journals

and these informed our content collection. Furthermore, where the Clarivate Analytics classification was not applicable, journal impact and cite factors were used to identify credible journals from which the articles and records were extracted. The paper also considered some studies by reputable and credible organizations, like World Bank, Energy Sector Management Assistance Program (ESMAP) and the German Agency for International Cooperation (GIZ) were considered.

2.3.3. Search strategy

Published articles and other relevant literature were searched and accessed between 07 January and 20 May (2022) through various databases and websites of e-journals. The material collection process commenced with defining the key search (Boolean) words and expressions. The Boolean expressions or search terms included in the search algorithm were: “energy use”, “productive use of energy”, “productive use of electricity”, “productive use of solar energy”, “productive use of renewable energy”, “energy and income generation”, “Productive use of energy AND households”. The search included “Allintext” and “Allintitle” search operators to capture a wider number of articles and records in productive use of energy.

Following the comprehensive literature search, 997 potentially eligible records were identified and retrieved. First stage screening for Initial screening of title, abstract and time period led to the exclusion of 833 records. In the second stage, the studies were screened for duplicates and a total of 86 studies were excluded and 78 were retained for further screening. Subsequently, full-text evaluation was conducted for the remaining 78 records, of which 24 more were excluded on the grounds of limited relevance, poor quality and unreliability of data. Finally, 54 studies (46 articles and 8 reports) were selected for the systematic review. Fig. 1: Provides the outcome of the search strategy by May 20, 2022.

2.4. Selection and evaluation

This review specifically focuses on peer reviewed papers and selected grey literature on productive use of electricity published between 2000 and May 2022.

Inclusion criteria: All articles published within that period were

considered and included for synthesis in this study. Articles still under press but accepted for publication and accessible to the researchers were also considered for review in this study. Studies that primarily dealt with productive use of energy, productive use of renewable energy, productive energy use impacts, economic impacts of electrification, impact of electrification on income, productivity, employment, and enterprise development were largely eligible for inclusion. Studies that primarily dealt with productive use of electricity including grid electricity, mini-grids, and off-grid solar PV (such as Solar Home Systems) were eligible for inclusion. Methodologically, literature reviewed varies according to the research question posed. Thus, studies that used either cross-section and or panel data were considered. Studies that used quantitative, qualitative, or combined both approaches were considered. Studies that used descriptive, correlation, regression, and quasi-experimental approaches (such as use of instrumental variables, difference-in-differences estimations, fixed effects, and propensity score matching) were considered for inclusion. thus, we delineate the review to socio-economic dimensions where the cumulative evidence is quite substantive (Riva et al., 2018). Given that English is the official language, and the researchers are more familiar with it, all articles written in English were specifically considered.

Exclusion criteria: In line with Brass et al. (2012) the review excluded technical reports and working papers from non-reputable institutions as we believe their active role in electrification projects and programmes might have biased the reporting of findings. Conference papers and book chapters were also excluded from this review (these were eliminated in the preliminary filtering from the data bases) because this type of literature may not provide empirical evidence. Studies published earlier than 2000 and beyond May 20, 2022 were not considered. Mendeley software was used to eliminate duplicates from the data set.

2.5. Full paper text review and analysis

All the 54 papers included in this study were fully reviewed, data extracted and coded in excel file. The review captures and characterizes details in each paper in line with the study objectives. The main data extracted from the studies considered were summarized in categories as presented in Table 1.

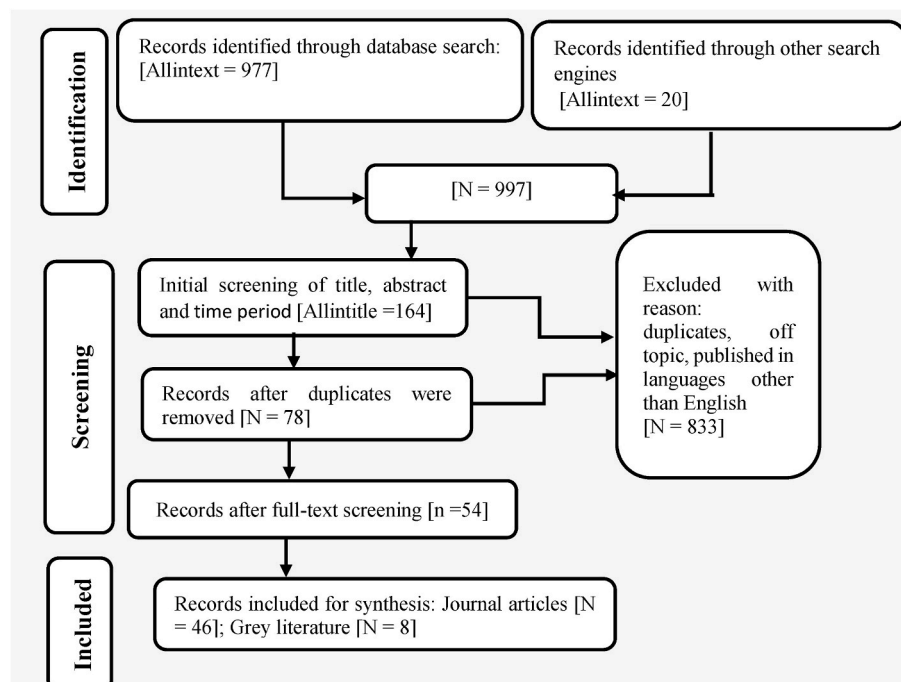


Fig. 1. Flowchart for studies selection.

Table 1
Analysis categories used to synthesize papers.

Analysis categories	Category definition
Publication Year	This is the year in which the document was published.
Journal	Specifies the journal or organization where the document was published and the number of articles published per journal
Paper origin	the region and the country from which the reviewed paper originated
Methodology data collection	Research methodologies employed in the reviewed papers data sources and data collection methods used in different papers (e.g., case studies, surveys, interviews etc)
Analytical techniques	Data analysis methods used in the reviewed papers (e.g., Differences-in-Differences (DiD) techniques, Fixed-effects panel models etc)
Theories	Entails different theories, frameworks and approaches adopted by scholars in their studies
Conceptualization	The different ways scholars define PUE and the main dimensions employed to capture/measure PUE.
Antecedents	These are drivers of PUE categorised as energy related factors, financial related factors, technological factors, human capital factors, infrastructural related factors, institutional factors and demographic factors

3. Synthesis of reviewed literature

This section analyses and synthesizes 54 papers and the findings are presented under two subsections. Sub-section one summarizes the descriptive analysis and sub-section two presents thematic analysis.

3.1. Descriptive analysis

3.1.1. Research publications over time

Fig. 2 displays the distribution of articles published on productive use of energy from 2000 to May 2022. While the results show that some articles were published as early as 2000, it can be observed that the highest number of articles were published between 2010 and 2020 with a sharp drop in 2014. Overall, the analysis indicates that, research and publication in the area of productive use of energy increased in the year 2011–2020 (about 35 studies) contributing around 63% of the total articles reviewed in the current study.

3.1.2. Sources of data

Table 2 presents the journals and reputable organizations that published papers reviewed in this study. Notably, majority of the papers (13 of 54) were published in the journal of *Energy for Sustainable Development*, followed by *Energy Policy* (5). These were followed by journal of *Renewable and Sustainable Energy Reviews*, *World Development*, *World Bank* and *GIZ and ESMAP* with 4 publications each. Furthermore, journal of *Energy* published 3 articles while *Energy Economics* and *Journal of Development Effectiveness* published 2 articles each. Overall, we observe that nearly 75% of the articles reviewed were published by the high ranking journals and reputable organizations. Furthermore, our analysis indicates that, there are 3 reputable organizations including World

Table 2
Number of articles published per journal as of May 2022.

Journals	Frequency	Percentage	Impact Factor
Energy for Sustainable Development	13	24.1	5.22
Energy Policy	5	9.3	6.14
Renewable and Sustainable Energy Reviews	4	7.4	14.98
World Bank	4	7.4	
World Development	4	7.4	5.28
Energy	3	5.6	7.15
GIZ & ESMAP	4	7.4	
Energy Economics	2	3.7	7.04
Journal of Development Effectiveness	2	3.7	1.05
IZA Journal of Labour & Development	1	1.9	1.64
American Economic Review	1	1.9	10.54
Annual Review of Energy and Environment	1	1.9	11.11
Annual Review of Environment and Resources	1	1.9	17.91
Economic Development and Cultural Change	1	1.9	1.19
Energy and Environment Research	1	1.9	2.95
European Journal of Development Research	1	1.9	2.526
International Journal of Environmental Sustainability	1	1.9	1.28
International Journal of Managing Value & Supply Chains	1	1.9	3.7
Renewable Energy	1	1.9	8.00
Science Advances	1	1.9	14.14
The Energy Journal	1	1.9	7.14
World Bank Economic Review.	1	1.9	2.23
Total	54	100.0	

Bank, GIZ and Energy Sector Management Assistance Program (ESMAP) that published work on productive use of energy.

The highest number of papers reviewed on productive use of electricity were published in *Energy for Sustainable Development* journal. This may be because of the journal scope of work and focus. Unlike most of the journals that have technical focus, *Energy for Sustainable Development* journal focuses on publishing original research and reviews about energy in developing countries, sustainable development, energy resources, technologies, policies, and interactions. Hence, research in productive use of energy fits well within the scope of this journal.

3.1.3. Regional distribution of published papers on productive use of energy

Fig. 3 presents the distribution of research papers published or reviewed by region. As shown in this figure, the analysis reveals that the highest number of research papers were from Africa (46.3%) and followed by Asia (27.8%). The two regions dominated research on productive use of energy. This observation could be attributed to the fact that African and Asian regions constitute the highest proportion of the less developed and developing economies in the world. Thus, majority of

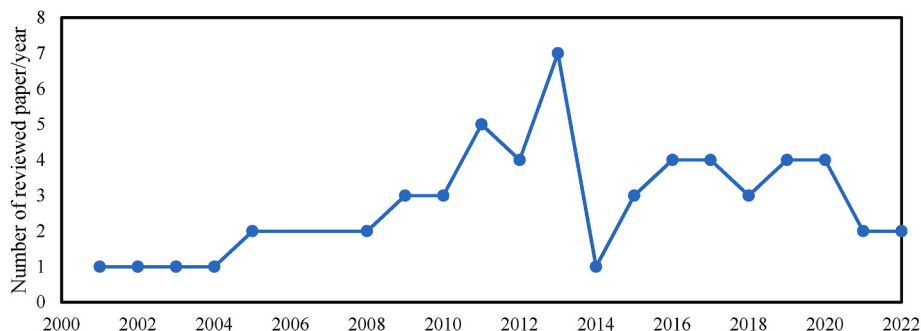


Fig. 2. Spread of the reviewed articles according to publication year.

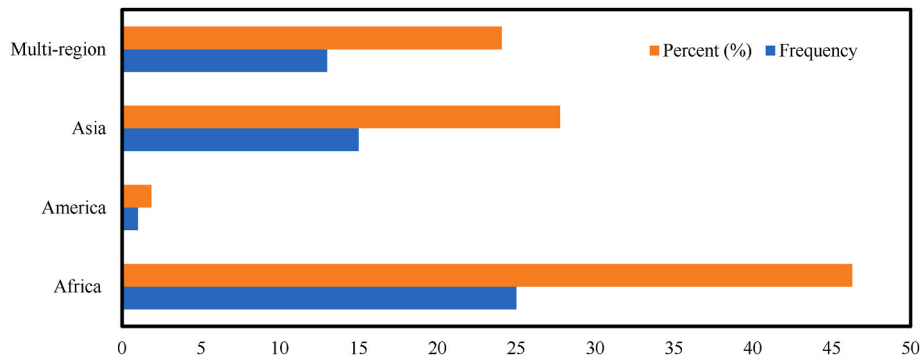


Fig. 3. Number of publications by region.

productive use interventions and studies target less developed and developing countries. The analysis further shows that around 24.1 % of the reviewed studies were undertaken in more than one region while 1.9% of the studies were undertaken in America. America had the least number of the articles published in the period between 2000 and 2022 perhaps because the region is highly developed hence, productive use of energy may not be a key priority in the development agenda.

Regarding country’s origin of study, our analysis reveals that a majority published studies are multi-country contributing about (33.3%) as shown in Fig. 4. This was followed by studies carried out in India (18.5%). Kenya, Bangladesh, and Tanzania contributed 5.6 % respectively. Apart from being part of the Asian region, it is interesting to note that India has implemented numerous productive uses of energy projects; hence research on productive use of electricity is of great relevance to policy makers and energy practitioners in India. Five countries (including Ghana, Rwanda, South Africa, Uganda and Vietnam) had at least two articles published within the period of study contributing 3.7% each while the rest had at least one paper published contributing around 1.9% of publications each during the same period.

3.1.4. Research methodologies employed in the reviewed papers

Fig. 5 shows the data collection methods used in different papers. Our analysis reveals that 43% of the studies used survey method for data collection, 33% used structures interviews for data collection while 17% used case study approach. It is observed that mixed methods were least used methods for data collection especially in exploratory studies translating to around 7%. Thus, the analysis suggests that available studies have largely used survey methods for data collection, and this is closely followed by structured interviews. However, use of mixed methods is limited. The increased reliance on survey data could be because these datasets are often readily available in statistical institutions and the observations are nationally representative.

With respect to data analysis techniques, Table 3 indicates that

descriptive analysis is the most popular data analysis technique used by the studies reviewed translating to around 22 papers (40.7%). This is followed by Difference-in-Difference analytical approaches with 10 papers (18.5%). The analysis further shows that linear and non-linear regressions models as well as fixed effects and pooled OLS approaches were frequently used for analysis. It is worth noting that, a significant number of papers employed two or more analytical approaches for their analysis.

Table 4 displays the theories used by different papers reviewed in the study. Analysis shows that approximately 18 out of 57 papers employed a theory to study productive use of energy, while the rest of the reviewed papers does not employ any theory. Specifically, 9 out of these 18 papers (50%) employed theory of change framework, 3 papers (17%) adopted the Livelihoods framework based on the capability theory while 2 papers (11%) mention the energy plus approach. The other theories utilized include Energy plus approach which follows from ToC (2), Agricultural household model (1), Resource based theory (1) Theory of production (1) among others.

3.2. Thematic analysis

3.2.1. Conceptualization of productive use of electricity

The concept of productive use of electricity has been defined by several scholars as shown in Table 5. Despite divergence in definitions, one common thread across all the definitions used in these studies is the issue of the involving use of electricity for income generation. From synthesized studies, there is unanimous consensus to view productive use of electricity as any activities that use electricity energy services to increase income and or value of the end user.

Further scrutiny of the literature reveals that productive use of electricity is conceptualized as a multidimensional construct that entails three main dimensions. Notably, (i) the improvement in the operations and performance of existing enterprises due to direct application of

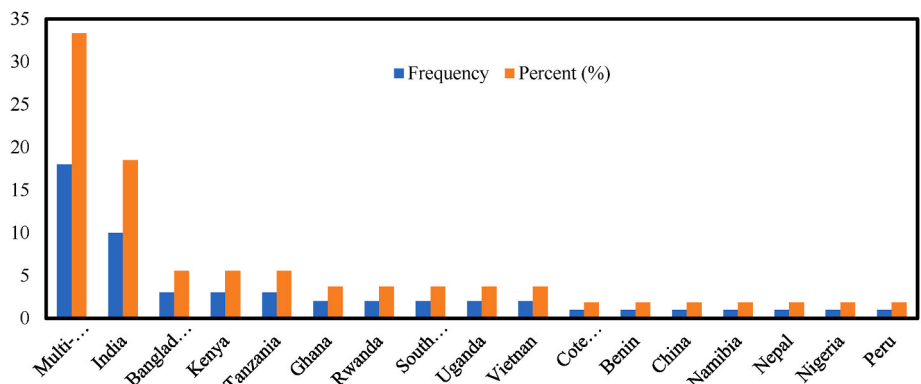


Fig. 4. Distribution of publications by country of origin.

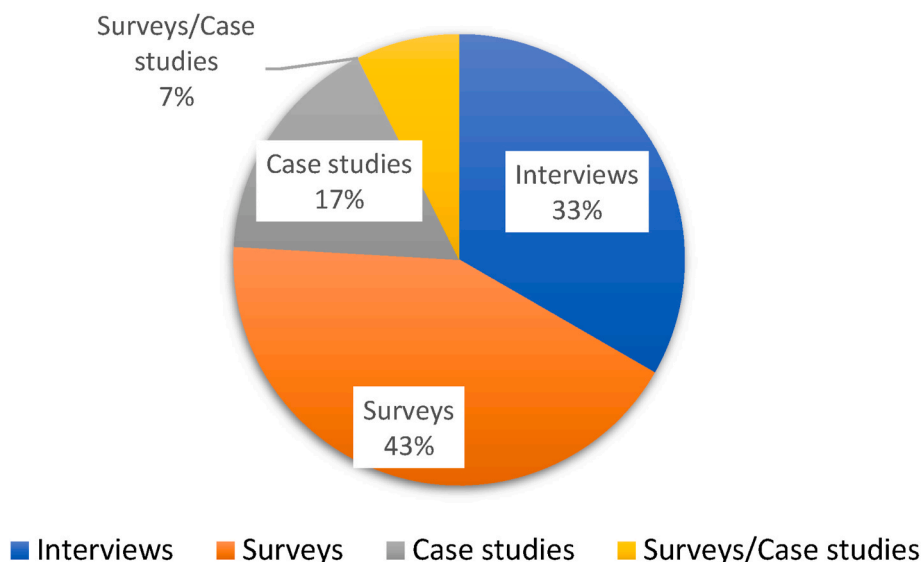


Fig. 5. Percentage distribution of data collection methods used.

Table 3
Data analysis methods.

Data Analysis Methods	Frequency	Percentage
Before-after comparison and regression analysis.	3	5.6
Contribution analysis	1	1.9
Descriptive	22	40.7
Differences-in-Differences (DiD) approach	10	18.5
Endogenous treatment approach.	1	1.9
Fixed effects model + Instrumental variable (IV) method	2	3.7
Fixed-effects panel models	4	7.4
Linear and non-linear regression models	4	7.4
Linear probability model	1	1.9
OLS regressions	2	3.7
Structural and the functional analysis	1	1.9
Two Stage Probit Least Squares (2SPLS) model	2	3.7
Variance analysis (means/SDs)	1	1.9
Total	54	100.0

Table 4
Different theories, frameworks and approaches adopted by scholars.

Theory	Frequency	Percent (%)
Agricultural household model	1	6
Theory of production	1	6
Theory of consumer surplus.	1	6
Resource-based theory	1	6
Energy Plus Approach	2	11
Livelihoods framework	3	17
Theory of Change	9	50
Total	18	100

electricity energy services as indicated by Akpan et al. (2013), Ngowi et al. (2019), Pueyo and DeMartino (2018) and Pelz et al. (2021) among others; (ii) increased productivity due to utilization of electrical appliances as applied by Kooijman-van Dijk (2012), Bridge et al. (2016), and Sharma et al. (2020) and, (iii) creation or emergence of new enterprises and jobs due to electrification as used in Dinkelman (2011), Peters & Sievert (2016) and Vernet et al. (2019). Analysis in Fig. 6 shows that nearly 61.1% of the reviewed papers identify improvement in the performance of existing enterprises as productive use outcome. 29.6% identify creation of new enterprises and jobs while 9.3% indicate increase in productivity as an outcome of productive use of electricity.

Furthermore, Table 6 displays how productive use of energy has been operationalized in literature. The analysis reveals that several indicators

Table 5
Definitions of PUE in literature.

Definition	References
income-generating activities that depend on electricity as an input, such as manufacturing, industrial activities, and services	Blimpo and Cosgrove-Davies (2019)
agricultural, commercial, and industrial activities involving energy services as a direct input to the production of goods or provision of services to increase income or value	Attigah et al. (2015); Brüderle (2011); Pueyo and DeMartino (2018)
using electricity in activities that enhance opportunities for income generation	Kooijman-van Dijk (2012); Vernet et al. (2019)
one that involves the application of energy derived mainly from renewable resources to create goods and/or services either directly or indirectly for the production of income or value"	Bensch et al. (2012); Hartvigsson et al. (2021)
those that increase income or productivity as utilization of both electric, and non-electric energy for activities that enhance income and welfare	Pueyo et al. (2020)
activities that increase people's incomes from existing activities or that create new opportunities for people to generate incomes	Anil Cabraal et al. (2005); Kirubi et al. (2009); Terrapon-Pfaff et al. (2018)
extension of households' ability to generate non-farm income	Morrissey (2019)
using electricity in non -farm activities or micro-enterprises to generate income	Ngowi et al. (2019); Peters and Sievert (2016)
	Domegni and Azouma (2022); Pelz (2020); Pelz et al. (2021)

such as changes in profit, revenue, number of employees, number of customers served, hours of work, product variety after electrification to operationalize economic performance of productive use of electricity. Regarding use of electrical appliances, studies have used electric lights, refrigerators, electric milling machines, electric sewing machines, electric hair driers and cutters, electric welding machine, mobile phone charger, computers, printers and copiers, electric cooking devices, electric carpentry machines and electric water pumps to operationalize productive use of energy. For the case of availability of energy services or emergence of new enterprises after electrification, studies use increase in the number of enterprises created and availability of electricity reliant services such as milk cooling, milling services, welding services, mobile phone charging and repair services, bars, restaurants, private medical services, internet cafes, computer and printing services, and

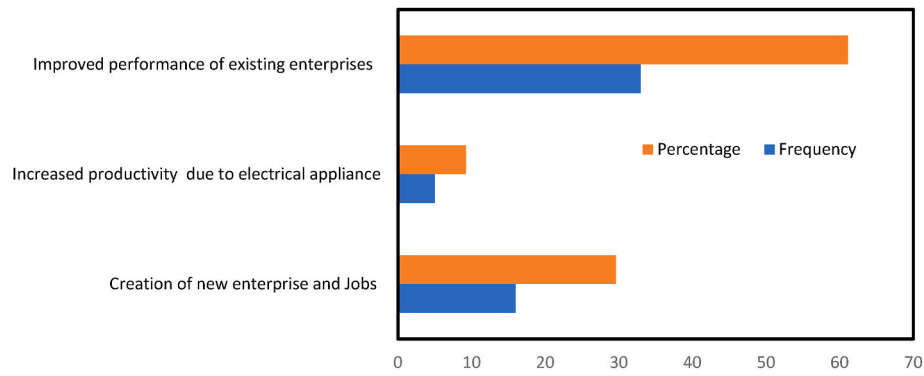


Fig. 6. Conceptualization of productive use of energy.

Table 6
Dimensions and respective indicators of productive use of electricity.

Dimensions/References	Operationalization (changes in specific indicators because of electrification)	Sources
Improved performance of existing enterprises	Increase in enterprise performance indicators such as profit, hours of work (opening and closing time), number of workers, number of customers served, sales revenue, range of products/ services produced and their quality	Obeng and Evers (2010); Akpan et al. (2013); Kanti Bose et al. (2013); Pueyo and DeMartino (2018); Ngowi et al. (2019); Vernet et al. (2019); Pueyo et al. (2020); Ganguly et al. (2020); Domegni and Azouma (2022)
Utilization of modern electrical PUE appliances	Use of modern electrical appliances such as lighting, milling machine, sewing machine, hair cutter, hair drier, welding machine, radio, television, mobile phone charger, computers, photocopiers, and printers, cooking devices/cooker, carpentry tool and water pumps.	Kooijman-van Dijk (2012); Sharma et al. (2020); Pelz et al. (2021); Bhatia and Angelou (2015)
Establishment of new enterprises or availability of energy reliant services in the community	Number of new enterprises created and, availability of electricity driven services in the community such as cooling, electrical grain milling, electrical welding, saloon/barber shops, Printing/Photocopying/ computer services, electrical water pumping, modern restaurants, video-halls/ betting, electrical repairs, agricultural processing, Internet cafes, photo studios, private medical services/ clinics among others	Peters and Sievert (2016); Lenz et al. (2017); Vernet et al. (2019)

video halls.

3.2.2. Antecedents for productive use of energy

Fig. 7 present the antecedents for productive use of electricity grouped into several broad categories, which includes energy related factors, financial related factors, technological factors, human capital factors, infrastructural related factors, institutional factors, enterprise characteristics and owner characteristics. From this analysis, it can be observed that energy related factors have been widely identified to influence productive use of energy.

Table 7 present breakdown of each category of antecedents of PUE. Further analysis reveals that access to, or availability of electricity

followed by reliability of electricity were the most reported factors under the energy category. In the category of financial factors, access to credit or finance topped the list of the antecedents. Under the category of technological factors, availability or access to electrical appliances followed by cost of the appliances were highly reported in literature. While in the category of human capital, possession of skills (business and entrepreneurial) was the most cited reported antecedent of productive electricity use. Many other antecedents of productive use were cited under different categories including access to markets (infrastructural factor), membership to an association (social factor), awareness (institutional factor), type of enterprise and location (enterprise characteristics) as well as age, education and gender (owner characteristics).

4. Discussion

The purpose of this paper was to provide systematic review of literature on productive use of electricity at micro-level with key focus on the conceptualization and the antecedents that catalyze and or impede productive use. More specifically, this study unearths what in literature constitutes productive use of electricity and the antecedents of productive use of energy.

4.1. Conceptualization of productive use of electricity

Generally, although not new, the concept of productive use of electricity is not yet well defined. A debate continues to surround what productive use of energy and electricity in particular means. The main point of contention is on whether productive use of electricity is limited to the direct use of electricity energy services for income generation as earlier put by Kittelson (1998). Or productive use of electricity should be extended to capture uses that directly enhance income and those that improve education, health and gender equality as advanced by Anil Cabraal et al. (2005). Nonetheless, some scholars (Benjamin Attigah and L, 2015; Brüderle, 2011) argue that such uses do not directly increase income but rather improve people’s welfare Based on these arguments, it is important to harmonize definition and conceptualization of productive use of electricity by identifying the common phrases used in previous literature.

Fifty-four papers that fulfilled the inclusion and exclusion criteria were reviewed and synthesized in that regard. Most papers reviewed with respect to the definition indicate that productive use of electricity refers to the direct use of electricity energy service in any activities to generate income or value. For example, scholars under the umbrella of produce (Brüderle, 2011; Mayer-Trasch et al., 2013) define productive use of energy as “agricultural, commercial, and industrial activities involving energy services as a direct input to the production of goods or provision of services to increase income or value”. Blimpo and Cosgrove-Davies (2019) define productive use as “income-generating activities that depend on electricity as an input”. Morrissey (2019)

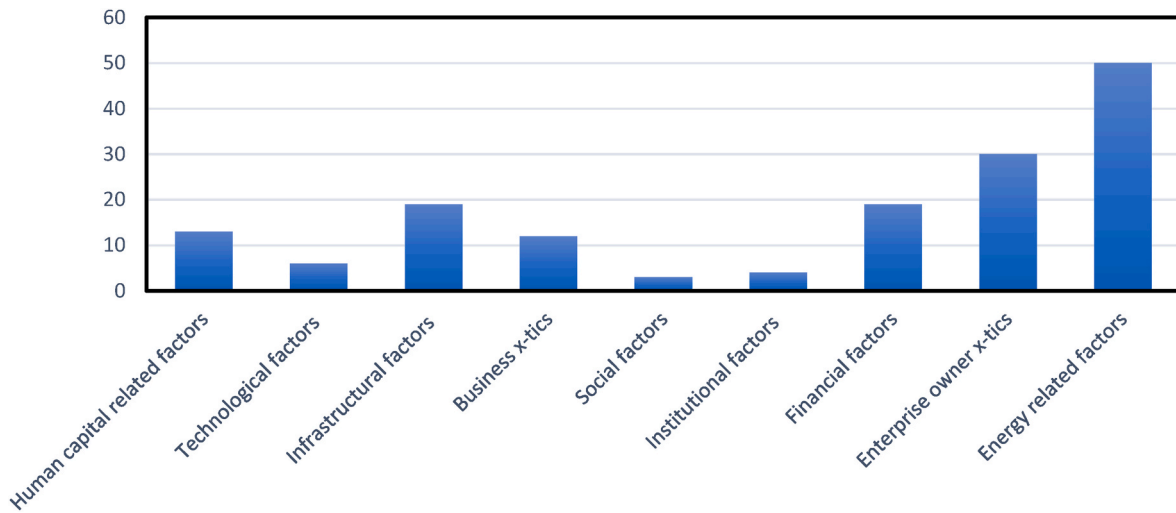


Fig. 7. Summary of antecedents of productive energy use.

Table 7
Antecedents of Productive energy use.

Antecedents	No. of paper	Antecedents	No. of paper
Energy related factors	47	Enterprise characteristics	14
Access to electricity	31	Type of business	4
Energy source	3	enterprise location	3
Cost of electricity/Tariffs	3	Years of business operation (age)	2
Reliable electricity supply	5	Business legal status	1
Energy intensity	4	capital endowment/assets	2
Solar PV adoption	1	Enterprise size	2
Financial factors	15	Infrastructural factors	16
Access to finance/financial capital	11	Access to business development services	1
Financial mgt Capacity	2	Access to markets	10
Innovative Payment mechanism	2	Access to road	4
Technological factors	8	Human capital related factors	9
Availability of productive use appliances	4	Owner experience& Knowledge	1
Cost of electrical appliances	3	skilled workers	8
Institutional factors	4	Social factors	3
Awareness/access to information	2	Political influence	1
policy and institutional environment	2	Membership to a network or association	2
Enterprise owner x-tics	30		
Age	10		
Education	9		
employment status	2		
Gender/sex	5		
Marital status	2		
Wealth of the owner	2		

describes productive use as activities that increase people’s incomes from existing activities or that create new opportunities for people to generate incomes or savings. Ngowi et al. (2019) define productive use as an extension of households’ capacity to generate non-farm income earnings after electrification. Others studies by Pueyo et al. (2020) and Pueyo and DeMartino (2018) define productive uses of electricity as those that use electricity in production of goods and services with a monetary value, hence enabling income generation. More recently, Domegni and Azouma (2022) define productive use of electricity as those that generate additional income for both the household and the electricity supplier.

Although there appears to be no concrete definition of PUE, our

synthesized review of literature seems to confirm that productive use of electricity mainly refers to any direct application of electricity energy services (such as lighting, mechanical etc.) to activities that generate income or enhance value both for the supplier and end-user. Within this definition, it is important to note that the provision of electricity itself is not the end goal. Rather, electricity is an input for activities (new or existing) that generate income and enable economic development. Typically, such activities can be in agriculture (e.g. irrigation), agro-processing (e.g. grain milling, Juice blenders, coffee pulpers), manufacturing (e.g. carpentry, welding, tailoring, ice making for fish storage), and the service sector (e.g. in bars, hair dressing, restaurants that use electricity for lighting, sound systems and refrigeration, as well as for charging mobile phones).

Furthermore, the study looked at how productive use of electricity is conceptualized. Based on our synthesized review and analysis, there are several major expressions scholars have used while describing productive use of energy. These include changes in the economic performance of existing enterprises, creation, or emergency of new enterprises (mostly electricity reliant), and use of modern electrical appliances to increase productivity. This implies that productive use of electricity is a multidimensional concept conceptualized along three main dimensions. First, is the improvement in the performance of existing income generating activities after electrification. The second one, is increased use of modern electrical appliances after electrification and third one, is the establishment of new enterprises and jobs after electrification. However, majority of studies have used these conceptualizations in isolation which rather gives unclear picture of what constitutes productive use.

For example, Lenz et al. (2017) conceptualized productive use as increased usage of productive appliances, changes in the main occupation and firm creation after electrification. They note that although the occupation of most households in rural Africa is farming, some households used electrical appliances such as mobile phone charger, television ‘cinemas’, mills, electric carpentry equipment and electric sewing machine alongside farming to earn income. Sharma et al. (2020) conceptualized productive use of electricity as increased use of modern electrical appliances to enhance productivity, such as flour mills, welding machines, weighing machines, electrical bulbs, fans, refrigerators, and computers/printers after accessing electricity. Similar conceptual approach was used by Pelz et al. (2021). On the contrary, a significant number of studies (such as Akpan et al., 2013; Pueyo et al., 2020; Domegni and Azouma, 2022) conceptualize productive use of electricity in terms of improved performance of existing enterprises after electrification. Such improvements in performance are captured using indicators such as extended hours of work, increased customers base,

increased number and quality of products or services produced, increased number of employees hired, increased sales and enterprise profitability.

Furthermore, phrases such as establishment of new electricity reliant enterprises in the community are predominately employed in literature to depict productive use of electricity. Such enterprises may include, milling, cooling services, welding, hair dressing or barber shops, secretarial bureaus (printing and photocopying services), hauling/processing, water pumping, restaurants, repair shops, retail shops as well as internet cafes. For instance, Ngowi et al. (2019) used the number of new electricity reliant enterprises started or emerged after electrification. Similarly Peters and Sievert (2016) used a number of new enterprises created after electrification besides farming as the main occupation. Likewise, Vernet et al. (2019) conceptualized it the number of new enterprises that emerged in the experimental site than the control site after electrification. While most studies stress that majority of enterprises started after electrification were micro in nature dealing in informal activities such as selling vegetables, grains and fruits, general groceries, hair dressing, restaurants and cafes, bars, tailoring, mobile money services mobile phone charging, computer services, and video halls. It is important to note that, these studies conceptualize productive use of electricity as creation of new enterprises as a result of electrification.

From various conceptualizations reviewed in literature, this study, therefore, finds that productive use of electricity is a multidimensional construct that entails improvement of existing income generating activities, intensive use of modern electrical appliances and creation/emergence of new income generating activities after electrification. In other words, PUE involves application of electricity energy services to; improve the performance of the enterprise, intensify the utilization of modern electrical appliances to enhance productivity and establishment of electricity reliant enterprises which all lead to improved income and value. In turn, improved income, can enhance household's welfare, increase demand and the ability to pay for additional electricity energy services, and subsequently, increased energy demand and affordability sustain energy supply in the economy.

4.2. The antecedents for productive use of energy

Productive use of energy/electricity (PUE) is recognized worldwide as crucial for poverty alleviation, job creation, productivity and financial viability of electrification investments. Therefore, harnessing the potential of productive electricity use requires a clear understanding of precursor factors that drive or impede PUE at micro-level. This paper attempts to document different factors that potentially influence productive use of electricity in different study contexts as categorised under the following sub-sections.

4.2.1. Electricity related factors

Nearly all papers reviewed agree that electricity related factors are important drivers for productive use. Specifically, majority of authors identify access to electricity as a necessary condition for productive use. For example, Peters et al. (2011), Rao (2013) and Pueyo et al. (2020) argue that having access to electricity is a precondition for productive uses. This is because access to electricity unlocks various energy services such as electric lighting, electrical machines/tool, coolers/refrigerators as well as entertainment and communication appliances (Sharma et al., 2020; Pelz et al., 2021). Such electricity energy services enable businesses to operate for longer hours, attract new customers, produce quality goods and create new opportunities for income generating activities. They also enable individuals, households or communities to engage in new income generation (Vernet et al., 2019).

Although, electricity is generally regarded as a precondition for productive use, our synthesized analysis reveals that the role of electricity access in driving productive use is debatable. Particularly Ngowi et al. (2019) and Pueyo & Maestre (2019) argue that access to electricity is necessary but not sufficient condition for income generation. This

stream of literature suggests that besides having electricity connection, other electricity access attributes such as, cost, quality, reliability, and source equally play a significant role and should be considered when promoting productive uses. This is because end user, particularly, micro-enterprises decry of unreliability and high cost of electricity in many developing countries (Blimpo and Cosgrove-Davies, 2019). Therefore, in analysing electricity access as a driver of productive use, electricity aspects have received less attention. It's thus, important to think beyond having mere access and consider other aspects of access such as reliability, adequacy/capacity, and affordability.

4.2.2. Financial factors

The synthesized literature also identifies finance also known as financial capital as a key driver of productive use of electricity. Finance is specifically understood in terms of access to credit and supportive finance for PUE appliances, enterprise's financial management capabilities, availability of innovative payment mechanisms, and availability of formal financial services in communities. The lack of credit is considered a major barrier to productive use. Among poor populations, credit is important as it allows them to invest in actual connection to the grid or install solar PV systems (Neelsen and Peters, 2011). As emphasized by Pueyo et al. (2020) and Sharma et al. (2020), credit also enables micro-enterprises and households to purchase the appliances they need to benefit from electrification. In support earlier arguments, Pelz et al. (2021) strongly suggests that lack of access to working capital is a key barrier to productive use of electricity especially for smaller potentially unbanked rural MSEs that seek to expand operations. This is worsened by the unwillingness of microfinance institutions to accept purchased equipment as collateral for credit (Peters and Sievert, 2016). Besides lack of access to finance, synthesized literature suggests that even the microcredit commonly promoted as financial instrument for enterprise establishment and advancement, is insufficient for effective promotion of PUE because such small credit facility does not support entrepreneurs to invest in large-scale PUE appliances (Kooijman-van Dijk & Clancy, 2010; Pueyo and DeMartino, 2018).

4.2.3. Human capital

The synthesized studies cite limited human capital as a major barrier to productive use of electricity in rural Africa. Specifically, factors such as business skills (Terrapon-Pfaff et al., 2018), knowledge (Mayer-Trasch et al., 2013) and entrepreneurial abilities (Khandker et al., 2009) have been identified to play a complementary role towards realizing productive use of electricity. This suggests that both personality traits and cognitive abilities are crucial in enhancing productive use of electricity. For example, entrepreneurial skills in form of being able to identify new opportunities created by electricity and prepare sound investment plans were reported to be important for promoting productive uses of electricity in Uganda (Neelsen and Peters, 2011). Likewise, Pueyo et al. (2020) emphasized the importance of business skills and knowledge for the creation and growth of women owned businesses. Therefore, non-energy related antecedents such as business skills, experience and knowledge are crucial in driving productive use of electricity.

4.2.4. Infrastructural related factors

Our analysis further identifies lack of access to supportive infrastructures as a common barrier to productive use of electricity. The most recurrently identified obstacles in this regard include lack of dynamic local market to sell additional products (Ganguly et al., 2020; Ngowi et al., 2019), poor road network and limited access to business development services (Blimpo and Cosgrove-Davies, 2019; Sharma et al., 2020). Availability of local markets and demand for locally produced goods and services is important for enterprise development and growth. However, Scarcity of vibrant markets increases crowding out effects and reduces the potential of rural micro-enterprises to expand their businesses through electrification (Pelz et al., 2021).

For productive use, the primary value of roads is to provide access to distant markets. Essentially, markets are a great determinant of whether electrification will result into productive use or not. Existing studies point out that in circumstances where electrification failed to drive the desired productive use, it was because villages are dispersed that the would-be entrepreneurs could not access markets to sell products (Kirubi et al., 2009; Blimpo and Cosgrove-Davies, 2019). Neelsen and Peters (2011) identify access to markets as one of the most powerful factors influencing productive use of electricity in Uganda. Similarly, Peters and Sievert (2016) note that the single resounding finding from their assessments of the impact of electrification on productive use in five countries was the role of market access to be the major determinant of whether people use energy for productive purposes. The scholars report that, although access to electricity stimulates productive electricity use, without a customer base or a possibility of reaching the market, then the likelihood of realizing productive use outcomes reduces. In addition, Lenz et al. (2017) report that in rural Rwanda, only rural communities located next to a main road and frequented by casual customers from outside experienced a net increase in income through sales of improved services and goods. Sharma et al. (2020) reiterates this point, noting that one way to promote electricity-based income-generating activities is to ensure access to market and good roads for transportation.

4.2.5. Institutional factors

Some papers have also identified the need for some form of awareness regarding the benefits of using electricity productively. For example, Brüderle (2011) stress that, the provision of electricity may be insufficient by itself to generate productive uses unless it is accompanied by parallel support measures such as raising awareness. Similarly, Attigah et al. (2015) note that awareness activities and active promotion on productive-use opportunities is important to encourage potential and existing businesses to connect to the grid and invest in modern electric appliances for productive use. Blimpo and Cosgrove-Davies (2019) point out that, electrification can play a crucial role in creating opportunities for income-generating activities, but electrification efforts should be accompanied by the provision of complementary factors such as awareness creation. Findings from analysed studies suggest that awareness helps newly connected and future entrepreneurs to take advantage of opportunities in the community, ensure proper investment decisions, optimally deploy productive machines, and avoid falling into 'electrification trap'. Electrification trap arises when the costs of production increase, but enterprise profits keep falling due to limited market or demand for products (Neelsen and Peters, 2011). Consequently, the need to prioritise awareness regarding the benefits of electrical appliances for productive use among end users should be top on the agenda of any PUE intervention (Morrissey, 2019). In other words, integrating electricity access with access to information and awareness is crucial in holistically driving productive use of electricity. Besides awareness and information access, literature highlights the need for conducive policies that support productive use of electricity by local citizens.

Scholars also suggest the need to consider conducive policies that support productive use of electricity by local citizens. Such policies could be on sustainable cost of connection or cost-sharing mechanisms for expensive off-grid solar PV systems for covering initial investments costs. The importance of appropriate tariffs built into sustainable payment plans will encourage local people to intensively use electricity. Also, well-regulated flexible payment mechanism that allow income constrained individuals or households to pay initial electrification costs in instalments, sometimes via their mobile phones is also highlighted in the literature. Such plans can favour the poor. Therefore, productive use needs of rural communities should be considered through a proper regulation on electricity pricing, taxes, market protection laws.

4.2.6. Technological factors

Availability of electrical appliances, their efficiency levels in

addition to their cost have been identified as important factors for productive use of electricity. Several studies reported that without access to efficient and affordable productive use appliances and equipment, realizing productive use outcomes is impossible. For example, Kooijman-van Dijk (2012) and Pelz et al. (2021) note that electricity brings various energy services such as lighting, motive power, communication, and refrigeration but these require use of appropriate electric appliances to generate income. Attigah et al. (2015) highlights the need for end users to have knowledge regarding the selection of appropriate high-quality efficient productive use equipment (e.g., energy-efficient electric mills, three-phase welding machines with low power factor, efficient light bulbs, well insulated and robust fridges suitable for bars). Lenz et al. (2017) and Pelz et al. (2021) note that low investment on electrical appliances that would be necessary to support productive use hinders income for end users. While Domegni and Azouma (2022) found that the introduction of electrical equipment on economic activity in rural Togo resulted into increase in farm productivity, sales, quality improvement and reduction in production cost. They concluded that use of electrical equipment (such as refrigerators, mills, graters, presses, grinders, dough mixers and shelling machines) is crucial for productive use activities and enhancement of household income.

4.2.7. Social factors

Under the social category, political influence, social network, or membership of an association, have been identified as important for productive use of electricity. For example, Kooijman-van Dijk et al. (2010), note that political leadership is important for productive use on grounds that politics influence how enterprises access and benefit from of electricity. In Bolivia, the authors found that local government officials, particularly mayors, played major role in bringing electricity to their communities. Such officials wield considerable power even to the extent of determining which businesses can open which in turn influences productive use of energy both at an individual and regional level. Kooijman-van Dijk (2012) recommends that productive use also depends on social skills and networks. The study identified social networks to be a key factor for productive use among small scale enterprises that rely on informal structures to access markets, information, and financial capital particularly from friends, family, and neighbours. On the other hand, lack of the right social network ties reduces productive use even if electricity supply infrastructure is available locally, due to lack of relevant information. Therefore, participation in diverse social groupings is important in building supportive social capital and this can go a long way in promoting productive use of electricity in local communities.

4.2.8. Enterprise related factors (characteristics)

The reviewed papers further identified enterprise related factors as important factors that may create a difference in productive use of electricity in different contexts. From the review, factors such as type of the enterprise (Akpan et al., 2013; Pueyo and DeMartino, 2018), geographical location of the enterprise (Vermet et al., 2019), years of business operation (Akpan et al., 2013), legal status of the enterprise and size of the enterprise (Pueyo et al., 2020) have been cited as determinants of productive use. In fact, many studies often include the enterprise related factors as control variables in the productive use regression models. But it might be interesting to explore their role in promoting adoption of productive use of electricity.

4.2.9. Personal/owner characteristics

Personal or individual related attributes have been identified to influence productive use outcomes among micro-enterprises. These personal attributes include age, education attainment, employment status or primary occupation, gender or sex and marital status of the owner (Pueyo et al., 2020). These characteristics have been extensively studied in literature as they limit the effectiveness of interventions to promote productive use of electricity, yet they are not easily addressed by policy

interventions. Thus, they form a category of potential factors that determine productive use of electricity. For example, gender issues have attracted a lot of research interest in the recent past and studies mentioned gender difference in their findings (Pueyo and DeMartino, 2018). Gender issues are aspects of culture and social norms, and they affect various facets of access, use and benefits of electricity and entrepreneurship.

4.3. Theories and methodologies applied to study productive use of energy

Furthermore, the study sought to identify theories and analytical methods used to study productive use of energy.

4.3.1. Theories

Regarding theories used, our analysis reveals that about a quarter of the studies mentioned theory, approach, or framework in their work. Implying that most of the papers never made a mention of any theoretical framework at all. Nonetheless, our analysis reveals that around eighteen studies mentioned either the theory, framework, or approach that the study was anchored on. Particularly, theory of change was increasingly utilized in the papers reviewed, followed by the Livelihoods framework and the energy plus approach. The other theories and frameworks utilized include Agricultural household model, Resource based theory of entrepreneurship and the production function.

The theory of change illustrates pathways through which access to electricity results into productive use outcomes. For example, Peters and Sievert (2016) employed the theory of change to posit that electrification leads to higher incomes through three channels. The first mechanism is a shift from agricultural to non-agricultural activities that is associated with diversification of livelihood activities induced by availability of electric machinery, refrigeration, entertainment, and communication appliances. Moreover, new firms, which may demand additional non-agricultural labour, tend to emerge because of electrification. The second mechanism is a potential increase in total working hours because of higher quality lighting and an extension of the working day. The third channel is about increase in wages because of productivity increases. On the other hand, Lenz et al. (2017) employed the theory of change framework to demonstrate the causal link from electricity access to income generation in micro-enterprises. The study shows that electricity access triggers productive use through either emergence of new businesses or improvement of existing ones. This implies that, for already existing enterprise, access to electricity is expected to lead to decrease in input requirements and increase in quality of appliances which reduces cost of doing business and increases productivity, respectively. In addition, the availability of better lighting and entertainment devices enable longer operation hours or attract new customers, leading to higher profitability. Next to the availability of higher quality products, the most important expected impact on the community level is employment creation. Generally, the theory of change assumes that provision of electricity to the end user is sole determinant of productive.

The livelihood framework and the Energy plus approach extend the theory of change to capture non-energy related factors. The livelihood framework posits that the enterprise owner (entrepreneur) is central in making decisions about productive use of electricity, hence emphasizes aspects beyond electricity access (Kooijman-van Dijk et al., 2010). The livelihoods framework considers assets of the entrepreneur or household (including human, natural, financial, social, and physical) as starting points for the livelihood strategies that people undertake in addition to the influence of electricity access (Kooijman-van Dijk, 2012). Thus, the framework posits that productive use of electricity depends not only on energy related attributes but also to the decision-making capabilities and resource endowments of the entrepreneurs.

Similarly, the energy plus approach also known as Electrification Plus emphasizes complementing access to electricity (particularly the attributes of cost and reliable electricity services) with non-energy

inputs to enhance productive use of the electricity by the poor (Attigah et al., 2015; Garimella et al., 2015). The approach posits that if access to electricity is corroborated with a set of complementary factors such as access to supportive financial services, access to raw material, market linkages, infrastructure (such as roads and communications), availability of information and well skilled labour, then productive use of electricity will increase.

Synthesized literature suggests that access to electricity should be complemented with holistic livelihood and enterprise development initiatives such as access to information, markets, training, business development services and access to finance or credit. These will result into improved economic performance of rural enterprises (Kooijman-van Dijk, 2012; Mayer-Trasch et al., 2013), an approach emphasized under the Energy-plus framework.

4.3.2. Methods

Our analysis suggests that survey is the dominant data collection method employed by most reviewed papers, followed by structured interviews and case study approaches. Regarding data analysis, majority of the papers utilized descriptive analytical methods. This was followed by Difference in Difference (DiD) analytical approaches. The increased use of descriptive analysis could be because, most studies in productive use of electricity are largely anecdotal, hence may not necessarily indulge in empirical analysis. However, it is worth noting that, a significant number of papers employed two or more analytical approaches during analysis. In view of the common analytical methods used, the study found that, most of the findings reported by the studies were not robust due to methodological limitations. This means that, there is need for further empirical analysis (Lee et al., 2020).

5. Conclusion and recommendation for further work

5.1. Summary of findings

To conclude, this study finds that there has been an upward trend in the number of papers published on productive use of electricity with the highest number of articles published in 2013. This review also shows that most productive use studies were published in the Energy for Sustainable Development journal. Additionally, majority of studies were undertaken in the African continent, and they are multi-country in nature followed by those undertaken in India.

On the definition and conceptualization of productive use of electricity, the study found that majority of studies describe productive use of electricity as any application of electricity energy services in activities that increase income or enhance economic value. Furthermore, we found that productive use of electricity is conceptualized along three dimensions, which are (1) improved performance of existing enterprise (2) increased productivity and use of modern electrical appliances and (3) creation of new enterprises. On the antecedents of productive use, the review identified various antecedents and categorised them into electricity related factors, financial, technological, human capital, institutional, infrastructural, social, enterprise owner attributes and enterprise characteristics. In terms of the theories and methodologies used, we found that, the theory of change is commonly employed by PUE studies. The study further found that, majority of studies used descriptive analysis and difference-in-difference (DiD) approaches based on survey data.

Furthermore, the paper has uncovered some gaps in the existing literature. The review revealed that previous studies have tended to use a single dimension (mostly improvement in economic performance of an enterprise) to study productive use of electricity. However, to understand productive use of electricity necessitates operationalising all the three main dimensions in order to provide a holistic picture of productive use as well as useful insights for policy design. Additionally, the review showed that majority of studies have largely investigated access to electricity as sole driver of productive use. It could be interesting to

understand how other factors (such as financial access, awareness and access to information, skills, and experience as well as social networks) compliment electricity access to explain productive use of electricity. Perhaps future studies should consider testing the role of non-energy related antecedent alongside energy-related factors in a single study. Furthermore, while theories inform practice and likewise, we found that most studies (68.4%) barely used a theory to explain PUE. Even few studies that did anchor their work on a theory, the focus has been largely on the theory of change, which assumes that electrification alone can solely drive productive use of electricity. Hence, this framework leaves out other important antecedents that potentially influence productive use of electricity. Subsequent, studies should consider using theories, frameworks and approaches from other fields to develop a holistic theoretical model that explains productive use of electricity. Similarly, looking at the analytical approaches deployed, we observe that empirical studies are relatively limited in productive electricity use. Moreover, the focus has been mainly on grid access with less attention given to understanding the role electricity access through off-grid technologies (such as standalone solar PV system) which are currently dominating electrification landscape in rural Sub-Saharan Africa.

5.2. Further work

Drawing from the gaps identified in the literature, we make the following recommendations to guide future studies. There is need for future studies to empirically analyze productive use of electricity as multidimensional concept capturing three main dimensions suggested in this study rather than focusing on single dimension, which may mislead policy interventions. There is need to also corroborate theory of change with other theories or approaches such as energy plus approach, livelihood framework, capability theory or resource-based theory that capture other important aspects not explained by theory of change. This will provide more holistic approach to explaining productive use of electricity instead of using a single factor approach. Furthermore, previous studies have focused largely on understanding the impact of energy related factors on productive use (Piecemeal approach) while ignoring other crucial factors that drive productive use of electricity. It would be interesting to estimate the joint effect of electricity access and other factors such financial inclusion or financial access, human capital (skills and experience) and social factors (social networks) on productive use of electricity. Hence, future studies will address the issue of varying findings in previous studies. Future research should also focus on understanding the effect electricity access through off-grid solar PV solutions on productive use of electricity since these are predominant in most parts of rural Africa.

5.3. Limitation

This review applied a systematic literature review methodology which is synonymous with some form of biases most especially the use of limiters in form of time, language and criteria for inclusion and exclusion. As a result, some important articles may have been screened out and not included in this study. However, number of these biases have been handled by ensuring a larger scope in terms of publication period for the articles considered in the study.

CRediT authorship contribution statement

Sylvia M. Aarakit: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Joseph M. Ntayi:** Writing – review & editing, Supervision, Conceptualization. **Francis Wasswa:** Writing – review & editing, Supervision, Conceptualization. **Faisal Buyinza:** Writing – review & editing, Supervision, Conceptualization. **Muyiwa S. Adaramola:** Writing – review & editing, Supervision, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

Acknowledgements

We acknowledge the PhD scholarship support for Sylvia M Aarakit through the project titled: Capacity Building in Education and Research for Economic Governance in Uganda", a collaborative between the Norwegian University of Life Sciences Ås Norway and Makerere University Business School Kampala Uganda which is funded by the Norwegian Programme for Capacity-Building in Higher Education and Research for Development (NORHED) (Project number: QZA-0486-13/0017).

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