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Framework for Project Sustainability for Power Installations Using Business Intelligence Approach: A Systematic Literature Review

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Abstract

The growing concerns about environmental sustainability and energy conservation have led to increased interest in optimizing electricity consumption and billing processes in various projects. This research article presents a comprehensive study on the development and application of Business Intelligence (BI) frameworks for enhancing project sustainability through data-driven energy management. Through the integration of BI tools and techniques, this research investigates the analysis of electricity consumption patterns, billing accuracy, and cost-effectiveness in diverse project contexts. The article emphasizes the significance of data preprocessing, statistical analysis, and predictive modelling in uncovering valuable insights to support informed decision-making. Additionally, the review examines the concept of project sustaibility, emphasizing its significance in achieving desired outcomes, meeting stakeholder expectations, and ensuring the project's viability in an ever-changing environment. Traditional project management approaches often fail to adequately address sustainability concerns, leading to project failures or limited long-term impact. Hence, the review highlights the growing importance of leveraging BI-driven frameworks to enhance project sustainability in various sectors, including in Information and Communication Technology (ICT) domain. The Systematic literature review (SLR) method was used involving the scooping of 230 articles from over 8 global academic databases. With the use of exclusion criteria, only 61 articles were used in the study. The analysis of the articles shows that 57% were journal articles, 39% were conference proceedings, 2% were thesis/dissertations and 2% were generic. Within the scope of this literature review, key terms and keywords were identified to provide insights into the development of a novel BI-driven framework for project sustainability. Consequently, future research directions are identified to further explore the integration of renewable energy sources, AI and machine learning applications, and behaviour-based energy management strategies within BI frameworks for sustainable project outcomes. This review lays the foundation for future research endeavours in developing innovative BI-driven frameworks that foster sustainable practices and contribute to a greener and more resilient future across diverse industries and projects.

A. Introduction

In today's rapidly evolving business landscape, organizations are increasingly focusing on project sustainability as a key driver for long-term success particularly in the power sector [1]. Project sustainability encompasses the ability to achieve desired outcomes, meet stakeholder expectations, and ensure the project's long-term viability in a changing environment [2]. Traditional project management approaches often fall short in adequately addressing sustainability concerns, leading to project failures, or limited long-term impact. Project sustainability refers to the ability of a project to achieve its objectives and deliver long-term benefits while minimizing negative environmental, social, and economic impacts [3, 4]. It encompasses the concept of balancing the needs of the present without compromising the ability of future generations to meet their own needs. Consequently, every Information and Communication Technology (ICT) project to be sustainable must consider the lifecycle environmental impacts, prioritize data security and privacy, foster digital inclusion, and ensure ongoing maintenance and support for the technology infrastructure [1, 3]. Consequently, numerous companies and organizations have made substantial investments in ICT to sustain competitiveness and ensure long-term viability [1, 5, 6]. Overall, ICT has become an indispensable tool for enhancing efficiency, productivity, and sustainability across diverse sectors [2]. By enhancing processes, automating tasks, and diminishing waste and defects in construction operations, ICT has prompted an augmented focus on project sustainability within ICT projects, consequently fostering the emergence of a new research avenue referred to as "The application of project sustainability in ICT using business intelligence (BI)" [1, 3]. This approach involves leveraging BI to effectively govern and manage business processes, thereby facilitating sustainable production and consumption through ICT. Nevertheless, there is a scarcity of studies that provide comprehensive insights into the successful execution of this method. The concept of business intelligence encompasses a range of tactics, technologies, and data systems utilized by enterprises to derive valuable insights from extensive and heterogeneous datasets. These insights aid in making diverse business decisions across different organizational levels [2, 4].

Project sustainability is currently being applied across various platforms, including project management, institutions, individuals, programs, and other entities necessitating efficient and effective production, distribution, marketing, and delivery of products and services. For successful project sustainability, it is imperative to engage both organizational and individual responsibility to ensure the continuity of all outcomes and benefits. Furthermore, the establishment of specific standards and metrics during project identification, feasibility studies, design, implementation, evaluation, formulation, appraisal, monitoring, and funding assumes crucial significance [3, 6]. Sustainable development, as defined by Porras *et al.*, [2] pertains to development that adequately meets present needs while safeguarding the ability of future generations to meet their own requirements. Extensive research has demonstrated that the lack of an appropriate sustainability plan often leads to project failures and financial losses for businesses [1, 8]. Successful sustainability performance occurs when projects and sustainability initiatives are fully integrated into the corporate business strategy

and management system [1-4]. There is no single document or article where project sustainability research has been analysed and detailed into various research focus and their applicability. Researchers over the years have used the concepts of BI to attempt incorporating elements of project sustainability into a frameork but no articles has captured all researches that deals with the issues of projects sustainability. This papers seeks to present a survey of all the research that has been conducted using BI frameworks for project sustainability over the 20 years with the goal of revealing future research directions and providing an easily accessible documents for researchers to explore. Among the objectives of this survey research is to focus on specific research that deals with the use of BI in the development of sustainable dashboards for monitoring users electricity consumption with the aim of elevating the hardship associated with the blackbox approach to electricity billing system by consumers of electricity.
The paper is organized as follows: Section 2, provide background information on the concept of BI and project sustaibility, BI and sustainability in power management, and cover comprehensive reviews in ICT frameworks and dashboard tools for power consumption. Section 3 provides various research methods based on search strategy approach, paper relevance and selection, conduct quality assessment process, data extraction and data synthesis. Section 4 provides research results, Validation in section 5, Limitation discussion in section 6, Future focus in section 7 and section 8 is Conclusion.

Concept of Business Intelligence and project sustainability in context
Business intelligence (BI) is becoming increasingly important approach for many companies and organizations across the world because of its tool's capabilities and techniques, companies can gain insights into customer behaviour, market trends, and operational performance among other things. Simultaneously, the growing concerns about environmental impact and resource depletion have necessitated the integration of sustainability principles into projects management. As stated in [2-4], BI frameworks are effectively supporting decision-making processes in diverse business settings. Enhancing business performance is achievable through the pillars of the framework, namely business analysis, enterprise reporting, and performance management. At present, there is a utilization of business analytics (BA) frameworks to define BI frameworks that enable comprehensive analytical processing and reporting. Likewise, companies are demonstrating a keen interest in harnessing the potential of big data by exploring vast amounts of data and extracting valuable insights from it [2]. Moreover, businesses equipped with BI systems exhibit superior resource alignment, leading to improved operational capabilities and performance outcomes [4]. Firms face operational risks that include disruptions in production and supply chain, shortages of innovations, and crises related to quality, all of which contribute to profit fluctuations [10]. Higher levels of risk expose firms to increased vulnerability and uncertainty in cash flow [13]. The study Lee and Park [14], present an easily implementable, efficient, and practical alternative approach for segmenting profitability customers, employing a customer satisfaction survey as its foundation. In the highly competitive business landscape, the ability to identify profitable customer segments, foster long-term loyalty, and expand existing relationships is crucial for maintaining a competitive

edge [13-15]. To address this need, companies across various industries have adopted Customer Relationship Management (CRM) as a prominent business strategy, integrating sales, marketing, and service functions across multiple business units and customer touchpoints [14]. CRM empowers organizations to gain valuable insights into customer value, effectively target the most profitable customer segments, nurture high-quality relationships, and ensure long-term loyalty and profitability.

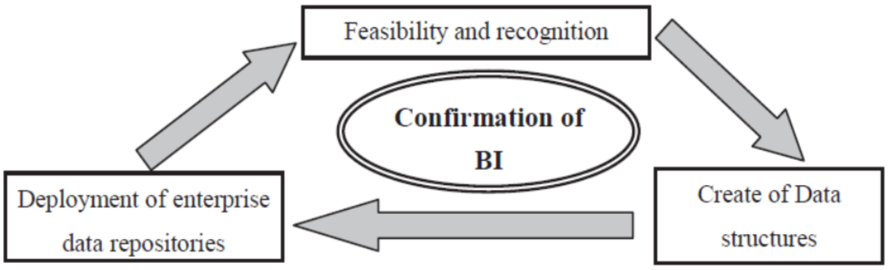

Figure 1: Cycle of implementing Business Intelligence [16]

According to figure 1 which shows the cycle around the confirmation of successful implementation of Business Intelligence within any organization, all firms must be able to establish repositories to store and manage relevant data for analysis and reporting [16]. Consequently, the cycle proceeds to where every organization must assess the feasibility of implementing BI and recognizes the potential benefits of it especially for evaluating the organization's existing systems, infrastructure and resources while also identifying the specific objectives and needs than can be addressed through BI. Lastly on the next stage the organization then designs and develops a sustainable data structure to support BI implementations which involves defining the data model, establishing data integration processes, and ensuring data quality and integrity. The utilization of computer tools for risk-based decision-making has been extensively studied in the information systems field, especially as decision support systems for credit risk assessment [15, 17].

Key performance indicators (KPIs) are utilized to assess the progress and impact of sustainability projects within an organization [4]. Nevertheless, attaining robust sustainability performance relies on the integration of sustainability initiatives and projects into the wider corporate business strategy [2].

In detail, the concept of green project management primarily entails incorporating "green thinking" into existing project management methodologies. Consequently, agile practices can enhance flexibility, speed, learning, and responsiveness to change [1, 2, 14].

In their study, Hosseini *et al.*, [1] examined the relationship between sustainability and Information and Communication Technology (SICT) in construction projects. They argued that ICT has the potential to enhance various aspects of construction projects, including management functionalities, decision-making processes, resource optimization, and workers' efficiency through improved communication and cooperation.

Furthermore, technological innovation has emerged as a key approach for addressing environmental challenges, promoting sustainable business practices, and stimulating economic growth by reducing reliance on non-renewable resources and curbing emissions [23]. The findings of the study made by Villanthenkodath *et al.,* [24] underscore the positive long-term impact of ICT on reducing CO2 emissions. They strongly indicated that ICT contributes to economic growth, job creation, industrial development, and overall facilitation of business activities.

Business Intelligence and sustainability in power management

The energy sector plays a critical role in driving economic growth and achieving sustainable development goals [15]. However, it faces the challenge of meeting increasing demands while striving for improved energy efficiency [4, 15, 27]. Smart grid technologies have emerged as crucial in optimizing energy efficiency, but their deployment poses challenges in addressing evolving consumer needs. Business Intelligence (BI) in smart grids is recognized as a fundamental tool for maximizing grid intelligence and effectiveness [9, 12]. It transforms the grid into an information-rich environment, enabling informed decision-making based on actionable intelligence [12-15].

Power outages have diverse causes, stemming from various factors such as the increasing complexity of system operation and control, unforeseen equipment failures, errors in the operation of protective relays, and occasional cyber threats. These factors contribute to the vulnerability of the electric power infrastructure, leading to interruptions in power supply. In the event of a power outage, the transport infrastructure, including road and rail networks, can be severely affected, disrupting the movement of people and goods [27, 28]. Additionally, this disruption can lead to significant challenges, such as people being stranded on roads while trying to return from work, schools, or offices [9].

The research conducted by Fan *et al.,* [29] centered around predicting the power consumption levels of residential buildings in a specific area using fundamental power consumption data. The authors highlighted the use of various methods to forecast building energy consumption, such as linear regression algorithms, decision tree algorithms, neural network algorithms, and support vector machines. Furthermore, the emergence of mobile application technology has opened new opportunities for enhancing enterprise energy management and promoting innovative approaches. Through the electric energy service management platform, enterprises can conveniently monitor their energy consumption and gain a comprehensive understanding of their power supply and distribution infrastructure [28, 30]. However, the effective management of a Net Zero Energy Building (NZEB) within the smart grid framework can sometimes face challenges due to discrepancies between demand and supply, influenced by consumer behaviour and weather conditions [25, 27, 31]. With the continuous growth of populations, technological advancements, and expanding economies, global energy consumption is escalating at an alarming rate.

For instance, if a high consumer demand for energy is anticipated, it may lead to unnecessary energy consumption due to excess power generated by photovoltaic systems [31]. For their evaluation protocol and after their regression model was trained, the author used common metrics such as Mean Squared Error (MSE), Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE) to calculate the efficiency of the model.

A smart grid encompasses various functionalities, including storage, demand response, and load management, while facilitating the seamless exchange of information between consumers and suppliers [25, 26]. Moreover, time series analysis is commonly employed for predicting future energy consumption, as real-time monitoring of buildings becomes increasingly prevalent [31]. The implementation of energy-saving strategies has transitioned from being a matter of prestige to a mandatory requirement for industrial companies, given the importance of enhancing the performance of industrial facilities [21, 26, 32]. Several countries have implemented effective regulations for electric energy management to foster energy efficiency [21]. Energy audits serve as diagnostic tools that assess the energy performance of industries, comprising three main components: evaluating the current energy state (preliminary audit), assessing energy performance (comprehensive audit), and formulating improvement measures [30-32].

Traditionally, AC-based power systems have been prevalent in the maritime industry. However, there is a growing trend towards the adoption of DC-based power systems. This shift is primarily driven by advancements in power electronic converters and power electronic-based breakers that are capable of efficiently managing high prospective DC currents. The emergence of these technologies has opened new possibilities for the implementation of DC power systems in maritime applications [26, 34].

A Comprehensive Reviews in ICT frameworks and Dashboard tools for power

In a study conducted by Farshchian, Darestani & Hamidi [40], the focus was on the development of a decision-making dashboard specifically designed to address power loss attributes within Iran's electricity distribution network. The researchers engaged with experts and managers from the Tehran Electricity Distribution Network to obtain further insights and data. The DEMATEL technique was employed as the primary decision-making method, allowing for the compilation of dashboard graphs, the creation of a visual structure model, and the formulation of informed solutions.

In a separate investigation by Norkus *et al.*, [42], the focus was on the development of a cloud-based contribution-making dashboard for the electricity trading domain. Employing an agile software development process, they iteratively engineered their solution. To enable usage-based billing, individual user usage was tracked using accounting components running on virtual machines (VMs). However, it should be noted that the graphical user interface (GUI) was primarily developed to support tablets, and thus its compatibility with certain mobile devices may be limited in terms of displaying all application details.

Furthermore, the study conducted by Ahdan, Susanto & Syambas [43] aimed to develop a remote-control device utilizing internet technology to enable the control of existing devices on an internet network through mobile systems. Their model design focused on building smart energy devices that could be applied to home features, employing sensor devices for remote control based on desired conditions and android applications. To facilitate the digital signal movement as an electrical circuit breaker, they connected their smart energy dashboard to the Firebase cloud. Electrical energy is a critical community need and an economic resource essential for various activities. Intelligent energy management in buildings has become a significant research area within the Internet of Things (IoT) domain.

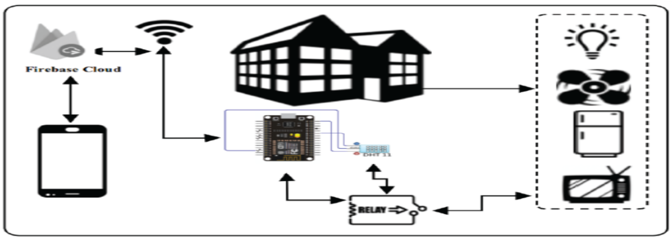

Figure 2: Smart energy Architecture [43]

With advancements in ICT, IoT enables efficient connections and communication, allowing places, objects, and individuals to be directly involved. Their study objective was to develop a system that could enhance electrical energy control, promoting more efficient electricity use while enabling building owners to manage electricity costs effectively as shown in Figure 3. The authors employed a smart energy architecture (Figure 3) to facilitate the transmission of information from sensor devices to the information processing system. This was achieved through the utilization of the network layer (or transmission layer). Additionally, this layer served as a means for managing services, as it possessed a connection to the database.

In their study, Matsui & Yamagata [47] focused on implementing an electricity consumption metering and online visualization system in 30 households with the aim of fostering behavioural change. Their system automatically collects data from sensor networks and websites to measure baselines and benchmark behavioural changes. Sensor networks are utilized for electricity data collection, while websites serve as information providers. Their system then stores information on how to act, and web access log data enables tracking of when individuals receive the provided information.

Billing and consumption monitoring

In a related study, Ighravwe & Mashao [50] present a framework that enhances the analysis of Renewable Energy Technology (RET) financing models under conditions of uncertainty. The proposed framework combines the best-worst (BW) method and the extended Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method, specifically chosen for their capability to enhance the optimality of decision-making. Given the scarcity of public resources in the current era, they indicated that governments often rely on partnerships with private investors to fund RET projects.

Additionally, Hashim [51] developed a novel index to assess the transition to renewable energy sources in various countries. The study evaluated the suitability of different variables for inclusion in the index. The authors pointed that shifting towards renewable energy sources is seen as a crucial step towards sustainable future growth, particularly for countries heavily dependent on coal, oil, and gas. Alternative sources such as solar, wind, and hydroelectric power can provide supplementary energy and eventually become the primary source in the future. Smart grid technologies have emerged as a promising solution to address the challenges of managing electricity distribution effectively. Advanced Metering

Infrastructure (AMI) is a crucial element of a smart grid as it facilitates bidirectional communication between utility companies and consumers [7]. Smart split metering refers to the division of electricity usage within a premise into various categories, such as residential, commercial, and industrial using metering technologies. This approach offers several advantages, including accurate measurement, real-time monitoring, and demand-side management capabilities. Figure 1 depicts the architectural framework of the smart metering system.

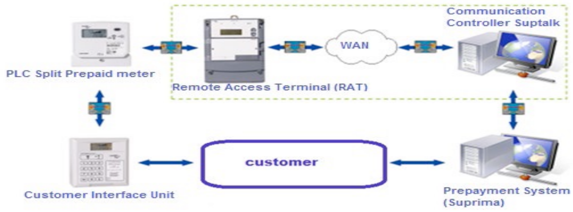

Figure 3: Architecture of Smart Metring System [9]

Smart split metering holds tremendous potential to revolutionize electricity distribution by providing granular insights into consumption patterns and facilitating efficient energy management. According to Ndaba [9], consumption-based pricing model operates under the principle that customers should be charged in proportion to the number (amount) of services they utilize, as recorded, and transmitted by smart meters capturing energy consumption.

$$Q_i = f\,(Y_i + P_i + X_i) + E_i \qquad \ldots\ldots\ldots\ldots\ldots (4)$$

They used equation 1 to calculate the quantity of energy every household used. Where Q_i is the quantity of energy demanded expressed as a function of a household's inputs, income Y_i, energy price P_i, and other household determinants of energy consumption X_i [9]. They indicated that the objectives of energy pricing are to enhance customer engagement in electricity demand by providing more accurate price signals that reflect energy costs. This enables power utilities to adopt a systematic approach to managing energy generation in alignment with prevailing demand, which is made visible through the data collected by these smart meters. Moreover, the real-time and accurate data acquired from smart meters can be leveraged by utilities to implement demand-response strategies, such as dynamic pricing or load shifting, which further contribute to the efficient management of electricity resources. By embracing this technology, both consumers and utilities can work collaboratively towards achieving a more sustainable and cost-effective energy ecosystem.

In their study, Adiono & Daud [56] designed a data communication system for an electricity smart meter to enable digital access to electricity credit payments, usage data reading, and meter control through internet connectivity for electricity operators and customers. Their system is based on Internet of Things (IoT) technology and incorporates a specialized server for connecting the digital electricity meter system with the payment gateway. The system includes a server, communication protocol, and dashboard system. Furthermore, an application is provided for electric operators to monitor all electricity meters.

In their study, Dai, Jing & Sun [58] conducted an analysis of the multiple causes of battery low-output-voltage failure in smart meters and developed a system reliability model for the clock battery circuit. The researchers computed the lifetime distribution of the clock battery circuit by integrating diverse forms of component data, including degradation data, lifetime distribution data, lifetime observation data, and failure rate data from datasheets. They indicated that the low-output-voltage failure of clock batteries is a critical issue in smart meters, and their study was aimed to investigate that problem comprehensively. They developed a method for determining the system's lifetime distribution by incorporating multi-source component data and estimating system lifetime and failure probability.

B. Research Method

The authors have followed Systematic Literature Review (SLR) methodology to aimed to identify the most effective approaches regarding the integration of business intelligence and project sustainability in the energy/electricity industries. To ensure a rigorous and reliable review process, the authors adhered to SLR guideline developed by Keele [61]. This guideline provides a comprehensive framework for conducting SLRs in the field of software engineering [60]. The SLR process involved an extensive examination of relevant studies focusing on electricity consumption and billing utilizing business intelligence. To ensure a comprehensive search, multiple databases were utilized such as Springer Link, IEEE Xplore, ResearchGate, Google Scholar, MDPI and Science Direct. The search was conducted using a standardized search string or query.

The following paragraphs provide a detailed description of the steps undertaken during the SLR process, highlighting the meticulousness and thoroughness of the study.

Search Strategy Approach

To initiate the search, the first phase involved the formulation of a search string. The subsequent steps were implemented to carry out the search:

- The authors derived the major terms from the focus of the research and study keywords namely: 1) Business intelligence, 2) Project sustainability, 3) Electricity consumption, 4) CASE Tool development and 5) Intelligence dashboard software development.
- Synonyms and alternative terms were identified for the major terms. Business Intelligence: (BI, intelligence meter, intelligence dashboard, smart meters, business decision, business process, business sustainability, business analysis, business strategy, business analytics, business applications), Sustainability: (project sustainability, corporate sustainability, computational sustainability, environmental sustainability, ecological sustainability, organizational sustainability, sustainable electricity, sustainable project management, sustainable business model, sustainable ICT),

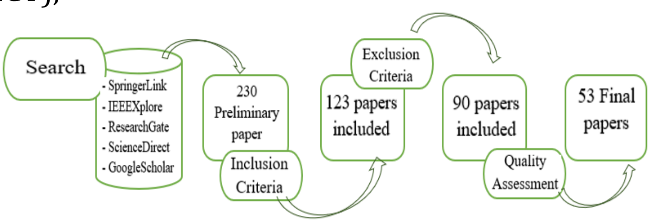

Figure 4: Process of performing quality assessment search.

Electricity: (electricity consumption, electricity billing, electricity outage, electricity generation, electricity smart tool, electricity usage, electricity supply, electricity distribution network, electricity load), Dashboard: (electricity dashboard, energy dashboard, NILM dashboard)

- The authors used various methods and techniques to enhance their term search strategies such as wildcards, Boolean operators, phrase searching and truncation where needed.
- After applying those various search techniques, final search strings were formulated as follows: (“business app”, “Business intelligence) AND project sustainability”, “Electricity OR Energy consumption”, “intelligence dashboard AND smart dashboard”, “corporate sustainability”, “computational sustainability”, “smart meters”, “ecological sustainability”, “business strategy”) etc.

Paper Relevance and Selection

This paper selection procedure was performed to identify those primary studies that provide direct evidence based on their research questions and there are divided into few steps discussed below: After identifying related paper, initially 230 preliminary papers were selected from various database tools and 123 papers were included as shown in figure 4.

Table 1. Selected sources after applying the process of Inclusive/Exclusive criteria.

Criteria	Selected articles/source
Inclusive criteria	[1] [4] [7] [8] [9] [16] [18] [22] [25] [26] [27] [30] [31] [37] [41] [43] [47] [50]
Exclusive criteria	[2] [3] [5] [6] [10] [12] [13] [14] [15] [17] [20] [21] [51] [52]

Consequently 90 papers were excluded, then after performing quality assessment we were left with 53 papers. For enhancing rigor and validity the quality selection process was repeated, then the selection paper changed and goes as follows: The preliminary papers chosen this time was 61 papers. Thus 23 articles from Science direct, 26 from IEEEXplore, 2 from ResearchGate, 2 from MDPI, 2 from Springer Link, 6 from other different database as shown in figure 5 as well.

Inclusion criteria were applied on those secondary preliminary papers selected:

- Those papers are included in the search which either addressed business intelligence in general, project sustainability based on the development of electricity consumption and electricity billing dashboard software.
- Inclusion criteria was based on the availability of required keywords in paper title or keywords of the found articles, the language used on the article and its publication date.
- Thus table 1 shows some of papers selected after performing inclusive and exclusive criteria on the second preliminary papers.

The exclusion criteria were applied based on following parameters:

- Those papers were excluded which were not addressing any aspects of the research questions, research objectives and have nothing to do with developing application tool.
- Those papers whose title was in English but remaining content or full paper was in other language.

- Those papers were excluded that do not meet a certain threshold of quality or fail to adhere to rigorous research methods, including those that used various equations/formulas without adequate explanations of them.

Conducting quality assessment process

The study quality assessment procedure was carried out to assess if required outcomes (business intelligence and project sustainability concepts) are presented in the paper. The quality assessment was conducted as follows: All included papers were divided into two categories which are "qualitative checklist studies" and "quantitative checklist studies". The division played a significant role in identifying articles biasness and mitigations, consistency, and comparability, including helping us interpret the results of the included studies in a nuanced and informed manner. Thus, questions checklist on table 1 and table 2 were created based on that. Questions mentioned in the checklist were answered by us including some of our postgraduate researchers (colleagues) who were selected to read the papers for quality assessment. The questions were answered by identifying the article that correspond fully with it as indicated on both tables. All included articles were shared amongst two other postgraduate students including us to read and fill up those tables, then a brief discussion was held to finally discuss the results and compile quality checklist tables.

Table 2. Summary quality checklist for quantitative studies

Questions	Quantitative Empirical Studies	Correlation (observational studies)	Surveys	Experiments	Source
Design:					
Is the research question clearly stated and focused?	X		X	X	[1] [7] [8] [9] [18]
Is the study design appropriate for addressing the research question?		X		X	[1] [4] [7] [8] [9] [18]
Is the sample size sufficient to provide meaningful results?			X		[4] [7] [8] [9] [26]
Is the sampling method appropriate and representative of the target population?			X	X	[4] [7] [8] [9]
Conduct:					
Were data collection procedures adequately described and conducted?	X		X	X	[7] [9] [18] [26]
Are the measures used in the study valid and reliable?	X	X		X	[4] [9] [18] [26]
Were ethical considerations addressed and human subjects protected?		X		X	[6] [7] [8] [9]
Analysis:					
Were appropriate statistical methods used to analyze the data?	X	X		X	[4] [7] [9]
Were the statistical tests appropriate for the research question?		X			[7] [9] [18]
Conclusion:					
Do the conclusions align with the research question and findings?		X	X	X	[4] [7] [9] [18]
Were the limitations of the study			X	X	[6] [8] [9] [18]

addressed?					

Table 3. Summary quality checklist for qualitative studies

No.	Questions	Source
1	Is the research question/objective clearly defined?	[1] [4] [9] [22] [25] [27] [30] [31] [37] [43] [50]
2	Were the participants/sample appropriately selected for the study?	[4] [7] [8] [9] [15] [16] [30] [43] [47]
3	Is there a detailed description of the study design/methodology?	[4] [7] [9] [11] [16] [22] [37] [43] [47] [50]
4	Were adequate data collection techniques employed?	[1] [7] [9] [31] [37]
5	Are the data analysis procedures rigorous?	[9] [11] [22] [25] [37] [43] [47]
6	Are the findings/results clearly presented?	[4] [7] [9] [16] [30] [43] [47] [50]
7	Is there an adequate discussion and interpretation of the findings?	[4] [9] [27] [31] [37] [43]
8	Was reflexivity considered, and potential biases addressed?	[7] [9] [16] [30] [47]
9	Does the research demonstrate credibility?	[4] [7] [9] [25] [37]
10	Are the findings transferable or generalizable to other contexts?	[9] [15] [22] [27]
11	Are the sources comprehensively and accurately referenced?	[1] [9] [11] [30] [43] [47]
12	Were ethical considerations and participant protection addressed?	[7] [9] [16]
13	Does the study make a meaningful contribution to the existing literature?	[1] [4] [7] [9] [37] [43] [50]

Data extraction

Data from each selected paper was extracted based on data source (database), title, publication type (journal, conference, book chapter, thesis), conference/ journal/ book/thesis name, publication year, author's name, methodology applied in the paper, BI and project sustainability approaches. Figure 5 shows various databases used for the articles retrieval. Most of the articles were taken from IEEE Xplorer and Science Direct since many of them were more recent as shown in figure 6. Consequently, many papers selected was from 2015 until 2023 and most of them being journal and conference papers shown in figure 7.

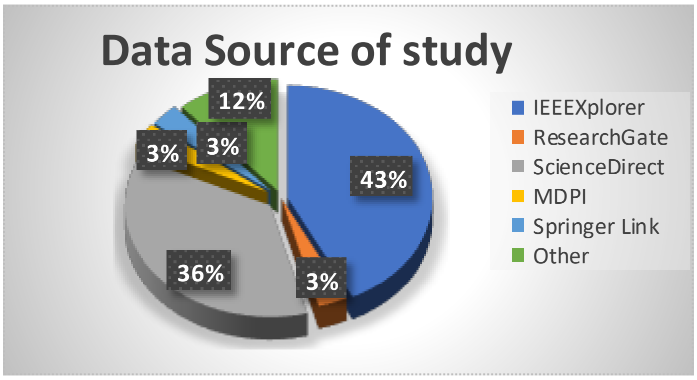

Figure 5. Percentage of papers taken from various databases.

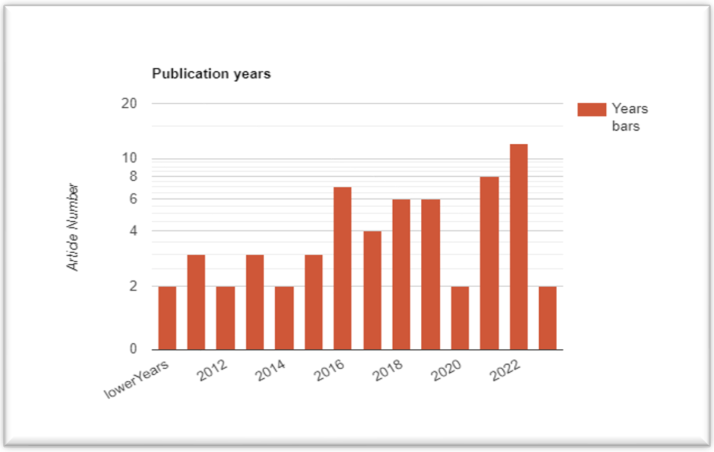

Figure 6. Publication years of studies.

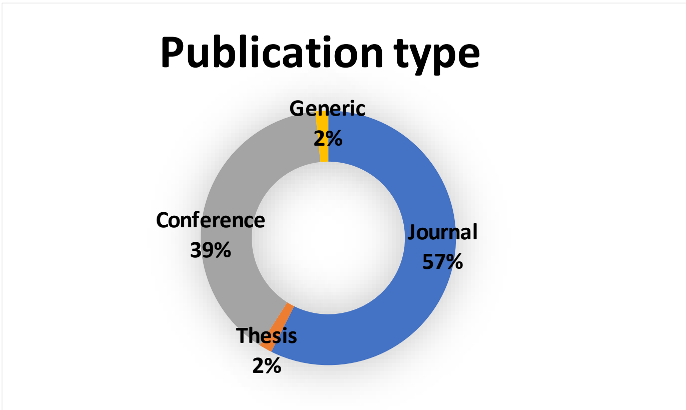

Figure 7. Publication type of studies.

Data synthesis

As describe above, the included papers were divided into qualitative and quantitative studies, but the method of meta-analysis was not used by any author. Table 4 shows all preliminary papers and how they cover related aspects. Furthermore, by looking at the table you can identify the research gap that most authors failed to cover. Results obtained from each paper based on their key findings and trend are discussed in section 4 (which is Result portion).

Adequate	Fair	Not adequate	Poor
(100% - 70%)	(69% - 50%)	(49% - 30%)	(Below 29%)

Table 4. Summary of articles analysis based on research question and research objectives of the reviewed papers.

SOURCE	Article focused keywords:					Tools used for:			Electricity application	%
	BI	PS	Electricity consumption	Electricity Billing	Intelligence dashboard Or Related Software	Graphs: Excel Tabula Power	survey	Other tools		

						BI				
[1]	✗	✓	✗	✗	✗	✓	✓	✓	✗	63%
[2]	✗	✓	✗	✗	✗	✓	✗	✓	✗	*35%*
[3]	✗	✓	✗	✗	✗	✓	✓	✓	✗	30%
[4]	✓	✓	✗	✗	✓	✓	✓	✓	✗	90%
[5]	✗	✗	✗	✗	✓	✓	✗	✓	✗	30%
[6]	✗	✗	✗	✗	✓	✓	✓	✓	✗	*45%*
[7]	✗	✗	✓		✓	✓	✓	✓	✓	*90%*
[8]	✗	✗	✓	✗	✓	✓	✓	✓	✓	*90%*
[9]	✓	✓	✓	✓	✓	✓	✓	✓	✓	*95%*
[10]	✗	✗	✓	✗	✓	✓	✓	✓	✗	*80%*
[11]	✗	✗	✓	✓	✓	✓	✓	✓	✓	*65%*
[12]	✗	✗	✓	✗	✓	✓	✓	✓	✓	*55%*
[13]	✓	✓	✗	✗	✗	✗	✗	✓	✗	*45%*
[14]	✓	✓	✗	✗	✗	✓	✓	✗	✗	*50%*
[15]	✓	✗	✓	✓	✗	✓	✓	✗	✗	*40%*
[16]	✓	✓	✗	✗	✗	✓	✓	✗	✗	*70%*
[17]	✓	✓	✗	✗	✗	✗	✗	✗	✗	*55%*
[18]	✓	✓	✗	✗	✓	✗	✓	✓	✗	*50%*
[19]	✓	✓	✗	✗	✓	✓	✗	✗	✗	*40%*
[20]	✗	✓	✗	✗	✗	✗	✗	✗	✗	*25%*
[21]	✗	✓	✗	✗	✓	✗	✗	✗	✗	*25%*
[22]	✗	✓	✗	✗	✗	✓	✗	✗	✗	*30%*
[23]	✗	✓	✗	✗	✗	✓	✗	✗	✗	*20%*
[24]	✗	✓	✗	✗	✗	✗	✗	✗	✗	*30%*
[25]	✗	✓	✓	✓	✓	✓	✗	✗	✓	*60%*
[26]	✗	✗	✓	✓	✓	✓	✓	✓	✓	*65%*
[27]	✗	✗	✓	✓	✓	✓	✗	✓	✓	*75%*
[28]	✗	✗	✓	✗	✓	✗	✗	✓	✗	*60%*
[29]	✗	✗	✓	✗	✗	✗	✗	✗	✗	*50%*
[30]	✓	✗	✓	✓	✗	✗	✗	✓	✗	*50%*
[31]	✗	✗	✓	✓	✗	✓	✗	✓	✓	*65%*
[32]	✗	✗	✓	✓	✗	✓	✗	✓	✗	*55%*
[33]	✗	✗	✓	✓	✗	✓	✗	✓	✓	*58%*
[34]	✗	✗	✓	✓	✗	✓	✗	✓	✗	*65%*
[35]	✗	✗	✓	✓	✗	✓	✓	✓	✓	*70%*
[36]	✗	✗	✓	✓	✓	✓	✓	✓	✓	*70%*
[37]	✗	✗	✓	✗	✓	✓	✓	✓	✓	*80%*
[38]	✗	✗	✓	✗	✓	✓	✗	✓	✗	*75%*
[39]	✗	✗	✓	✓	✗	✓	✗	✓	✗	*85%*
[40]	✗	✗	✓	✗	✗	✗	✗	✓	✗	*65%*
[41]	✗	✗	✓	✓	✓	✓	✓	✓	✓	*70%*
[42]	✗	✗	✓	✓	✗	✓	✗	✓	✗	*35%*
[43]	✗	✗	✓	✓	✓	✓	✗	✓	✓	*85%*

[44]	✗	✗	✓	✗	✓	✓	✗	✓	✗	*70%*
[45]	✗	✗	✓	✗	✗	✓	✗	✓	✗	*60%*
[46]	✗	✗	✓	✓	✗	✓	✗	✓	✓	*60%*
[47]	✗	✗	✓	✓	✗	✓	✓	✓	✓	*80%*
[48]	✗	✗	✓	✓	✗	✓	✓	✓	✓	*75%*
[49]	✗	✗	✓	✓	✗	✗	✓	✓	✗	*65%*
[50]	✗	✗	✓	✗	✓	✓	✗	✓	✓	*80%*
[51]	✗	✗	✓	✗	✗	✗	✗	✗	✗	*40%*
[52]	✗	✗	✓	✗	✗	✗	✗	✗	✗	*30%*
[53]	✗	✗	✓	✓	✗	✗	✗	✓	✗	*50%*
[54]	✗	✗	✓	✓	✗	✗	✗	✓	✗	*55%*
[55]	✗	✗	✓	✓	✗	✗	✗	✗	✗	*45%*
[56]	✗	✗	✓	✓	✗	✗	✓	✓	✓	*70%*
[57]	✗	✗	✓	✓	✗	✗	✗	✓	✓	*75%*
[58]	✗	✗	✓	✓	✗	✗	✗	✓	✓	*75%*
[59]	✗	✗	✓	✓	✗	✗	✗	✗	✗	*45%*
[60]	✗	✗	✓	✗	✗	✗	✗	✓	✗	*50%*
[61]	✗	✗	✗	✗	✗	✗	✗	✗	✗	*10%*

C. Result and Discussion

In this section, authors presented their key findings and insights obtained through the review process. The findings highlight the utilization of business intelligence techniques, the importance of real-time energy consumption monitoring, the incorporation of performance metrics and data visualization, the role of decision support and energy optimization, and the significance of stakeholder engagement. The discussion explores the implications of these findings in enhancing energy management practices and project sustainability.

i) Brief discussion of selected papers

The articles that are included on table 2 (quantitative studies) and table 3 (qualitative studies), are the main significant studies that this review paper is focussing on. Most of those studies adhere to the research questions and research objectives of this review. As shown in figure 5, most of selected articles are taken from IEEE Xplore and Science Direct because most of them years of their publications are recent. The oldest paper was published in 2007 (added for its significant content), while two newest articles were published in 2023. The selected papers were chosen based on their various approach of business intelligence and project sustainability context. Thus, most of their publication type was journal and conference papers as it clearly shown in figure 7.

ii) Brief articles results based on BI and project sustainability.

Table 5. Reviews results based on BI and project sustainability summary.

No.	Category	Field focus	Studies brief explanations
1.	Research coverage	Business intelligence	Various studies covered the aspects of BI based on data analysis, KPI, reporting and dashboards, intelligence tools, data governance and security, BI adaptation and challenges, Real-world BI case studies and future trends in BI.
		Project sustainability	Aspects that relate to project benefits and outcomes maintenance for long term were applied. Thus, components such as environmental, social, economic, institutional sustainability was discussed including policy and governance, monitoring and evaluation, stakeholder engagement, replicability, and scalability.
		Research questions	Studies identified current limitations and gaps of their research focus, then proposed various innovative and structured framework for project sustainability that leverage the capabilities of BI. For the facilitation and development of intelligence tools, studies used various approaches such as CASE Tools to enhance the clarity and precision of the framework development process. Additionally, articles discussed evaluation methodologies used to test the correctness, efficiency and reliability of their software tools including providing evidence supporting their feasibility and practicality.
2.	Design perspectives	Data accumulation	Many methods were used for data collections such as reading other research studies as discussed in "Research methods". Additionally, surveys and questionaries are popular approaches used to collect data either from individuals or organizations involved in their projects. Other approaches include interviews, case studies, getting data from existing BI tools, some researchers conducted direct observations and fieldwork for their data gathering.
		Software development	Studies covered software tools that are web-based such energy monitoring and management system (EMMS), and mobile applications (iOS/Android) based such as Dashboard Mobile Apps. Furthermore, other program types were developed like Desktop application (named: Energy billing and Analytics software), Web-based applications (named: Energy Efficiency Decision Support System), cloud-based platform (named: Cloud-Based Energy Data Platform). Researchers used different programming languages in developing their research software's.

<table>
<tr><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4">Software testing</td><td>i. Quality testing</td><td>Experts and project stakeholders were included to perform functional testing ensuring that BI features, data visualization and analytics capabilities work. Furthermore, testing such usability, performance and compatibility were also applied.</td></tr>
<tr><td>ii. Security testing</td><td>Vulnerability assessments were conducted to identify potential weaknesses in the software and ensuring compliances with data privacy and protection.</td></tr>
<tr><td>iii. Accuracy testing</td><td>Trusted sources for data were referenced and results were validated based on generating insights aligned with real-world observations and expectations.</td></tr>
<tr><td>iv. Human computation</td><td>Some studies recruited experts to identify anomalies and outliers in their software that requires further investigation.</td></tr>
<tr><td rowspan="3">3.</td><td rowspan="3">Research analysis</td><td colspan="2">Data visualizations</td><td>Studies used many different charts to identify patterns/trends, peak periods and potential areas for energy optimizations. Charts used include line charts to show electricity consumption trend over time, bar charts to compare variations in energy usage, pie charts or donut charts to illustrate the proportion of energy consumed from various sources, data table to present detailed billing information, dashboard visualization to display key sustainability metrics, Real-time dashboards to monitor consumption and billing data as generated, forecasting charts to predict future electricity consumption based on historical data and stacked bar to present the breakdown of electricity costs/overall billing.</td></tr>
<tr><td colspan="2">Data filtration</td><td>For ensuring that data used is aligned with research objectives, studies used various approaches like time-based filtrations by selecting data within specific timeframe relevant to their studies, data focusing specific project phase or locations, removing anomalies or outliers from the datasets, focusing on recent data generated.</td></tr>
<tr><td colspan="2">Data synthesize.</td><td>Studies collected data from multiple n sources such as smart meters, sensors, billing systems, other relevant databases. Data were then cleaned by removing duplicates, standardize units and perform data transformation. Consequently, other approaches were applied such as data aggregation, correlation, and causation analysis, and identifying energy optimization opportunities.</td></tr>
<tr><td>4.</td><td>Results significance and</td><td colspan="2">Study importance reflections</td><td>Studies addressed critical challenges faced by industries and projects in managing electricity consumption efficiency and achieving sustainability goals, promoting sustainable development practices and data-driven decision-making.</td></tr>
</table>

	implications	Contribution to existing knowledge	Many studies provided empirical evidence to support the effectiveness of BI-driven frameworks for electricity consumption and billing and validate the practical application in real-world scenarios.
5.	Privileges	Content access	Researchers used various platforms for accessing their research contents, many used open access journal which promotes wider dissemination and accessibility of research findings while other used subscriptions-based journals and their institutional repositories.

D. Conclusion

The authors have presented various studies that covers the electricity consumption and billing novel framework for project sustainability using business intelligence approach. Various libraries/databases such IEEE Xplore, Science Direct, Research Gate, MDPI, Springer Link and more were explored to accomplish this study. Most articles chosen from those databases ranges between the year 2015 and 2023, and many of them are journal and conference papers. Certain studies were excluded as discussed, while other studies were included particularly those that shed valuable light on the critical intersection of energy management, sustainability, and data-driven decision-making. Through the application of BI tools and techniques, these articles have explored innovative ways to optimize electricity consumption, enhance billing processes, and promote sustainable practices in various projects and industries. The findings of these research articles underscore the significance of BI-driven frameworks in transforming raw data into actionable insights for energy efficiency and cost savings. By leveraging real-time monitoring, predictive analytics, and data visualization, BI has emerged as a powerful tool for project stakeholders to make informed choices and drive positive changes in energy consumption patterns. The validation and peer review processes have bolstered the credibility and reliability of the research findings, ensuring that the proposed frameworks are well-grounded in rigorous analysis. Acknowledging the limitations and contextual variability has allowed for a balanced interpretation of the results, offering practical implications for real-world implementation. The insights gained from BI-based frameworks empower project stakeholders to optimize energy usage, reduce environmental impact, and foster financial savings.

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