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Research paper

Modeling energy management sustainability: Smart integrated framework for future trends

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ABSTRACT

The sustainability issues of energy management are among the open challenges that lack an integrative sustainable framework and need urgent solutions in the power plants. Extant literature has neither defined energy management sustainability adequately, nor developed any sustainable framework in the power plants. In light of this, the study responds to this research gap through achieving four objectives: (1) To create a coherent research taxonomy with a new scope, (2) To systematically analyze current challenges and future trends, (3) To identify the critical success factors (CSFs) of the energy management system (EMs) in the power plants, and (4) Develop a smart integrated framework to ensure the success and sustainability of EMs in power plants. The methodology is based on two approaches: the theoretical approach through comprehensively systematic literature review (SLR) and establishing a coherent research taxonomy to extract the CSFs. In contrast, the second approach is based on the judgment of technicians and energy experts working in power plants to develop a sustainable framework via a case study in the power plant. The SLR finding was employed with expert judgment to develop a smart model. The IBM-SPSS and PLS-SEM software were utilized to analyze data in the case study. The study was validated using three methods: first, content validity test through the SLR and expert arbitration. Secondly, the construct validity test via composite reliability (CR), Cronbach's alpha (CA), and average variance extracted (AVE). Thirdly discriminant validity test through Fornell and Larcker Criterion. The normality assessment by Skewness and Kurtosis has also been checked. All the results proved the validity and reliability of the integrated framework for sustainable EMs in power plants. The results for CA and CR were above 0.7. and the results of AVE were more than 0.5. The data normality value of skewness and Kurtosis are +/-2. Thus, the case study results indicate that it was acceptable and confirmed the literature results. Also, it confirmed the success of the proposed sustainable framework. The results fulfilled the normative requirements for validity and reliability. This study succeeded in developing a smart and sustainable framework for the future directions of energy management in power plants, which is a novel outcome of this study.

1. Introduction

The energy management methodologies in manufacturing are rapidly growing, but the power plant sectors are still quite fragmented (Ahmed et al., 2022). Nevertheless, the energy sector has more concerns about energy production costs and sustainability (McIlvennie et al., 2020). For that, imperative to conserve energy by adopting sustainable systems using energy management systems EMs. The top management and policymakers should facilitate the adoption of energy management to increase energy efficiency in power plants (Ali et al., 2021a). In the power plants context, EMs are used to optimize the processes and are closely related to environmental management. Similar to other industries, it is not impossible to enhance energy production by EMs; hence from the beginning would help lower the occurrence of unfavorable issues (Bai et al., 2019). EMs ISO 50001 presents a framework for energy to be managed systematically; as ISO50001's framework aids in building the capacity to manage energy, it is an ideal approach to be adopted by power plants (Pelser et al., 2018). On the other hand, continuous energy losses in power plants require further studies to strengthen EMs and conserve energy using the energy policy to lower energy costs and enhance EMs (Williams and Short, 2020).

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Nomenclature

CSFs	Critical Success Factors
EMs	Energy Management System
SLR	Systematic Literature Review
PLS-SEM	Partial Least Squares Structural Equation Modeling
IBM-SPSS	Statistical Package for the Social Sciences
CR	Composite Reliability
CA	Cronbach's Alpha
AVE	Average Variance Extracted
NOS	Newcastle Ottawa Scale
EMS	Energy Management Sustainable
TMS	Top Management Support
EMP	Energy Management Performance
EP	Energy Policy
EE	Energy Efficiency
A	Awareness
E	Environment
OS	Operational Strategies
HR	Human Resources
T	Teamwork
ECP	Economic Performances
QS	Quality Service
CI	Continuous Improvement
IA	Internal Audit
OC	Organizational Culture

Power plants suffer from weak sustainable energy management systems, as most of the previous literature focused on energy management in industrial sectors. Analysis of the literature confirmed that 92.3% of the implementation of energy management programs was in various industries, while only 7.6% were implemented in power plants (Ahmed et al., 2022; Mahmood et al., 2022). Therefore, this study opted to perform a comprehensive systematic literature review (SLR) on scientific articles on EMs areas to obtain more input on the subject matter. In addition, SLR is more transparent and reliable than the conventional literature review as researchers review selected papers based on specific inclusion and exclusion criteria. Most importantly, SLR helps in reducing researchers' biases (Xiao and Watson, 2019). This SLR highlights the taxonomy, current challenges, and future trends in EMs. Previous literature confirms the lack of CSFs for EMs in power plants; this study analyzed the literature carefully and identified CSFs with an intelligent conceptual framework for sustainability and facilitating the adoption of EMs in power plants (Mahmood et al., 2020; Fuchs et al., 2020). ScienceDirect, IEEE Xplore, and Web of Science databases were checked to choose 166 from 600 articles to analyze current challenges, CSFs, and future energy management trends in power plants. The articles are then scrutinized to focus on the area of interest and listed based on the publication year, database, and research location. To allow research gaps to be identified, problems associated with the research topic are explained. The literature is classified into three main trends energy policy by 22%, energy efficiency by 48%, and ISO 50001 by 30% of the total literature. The future research gaps were highlighted in this study. The analysis confirmed that the literature on CSFs to enable and succeed EMs in power plants lacks balance and consistency. This study proposes an integrated framework for successful EMs in one smart management system. This research seeks to answer three specific research questions related to the study objectives goal of this research aim: (RQ1) what are the research taxonomy, current challenges, and future trends of EMs architecture in the power plants? (RQ2) Has the literature identified CSFs that facilitate the implementation and sustainability of EMs in power plants? (RQ3) What is a sustainable smart framework that integrates CSFs for EMs into one management system?. The energy management methodologies in manufacturing are rapidly growing, but in the power plant sectors are still quite fragmented. For that, the smart framework in this study is derived inductively based on a comprehensive and systematic analysis of the literature to describe the dynamic process of energy management in power plants.

Our work contributes to the green energy management literature by proposing a smart integrated framework for future trends of sustainable energy management easily applicable to the power plants. The proposed integrated framework consists of a novelty logical analysis of the literature according to the CSFs for energy management recommended by previous literature in various industries and verified by technical and energy experts working in power plants. This integrated framework can be regarded as a prelude or the first step toward experimental deduction and validation of the framework. Furthermore, the proposed methodology through the integrated framework may also be instrumental in delineating the overall energy management performance in any industrial system in the related fields. The main contributions of this paper are summarized as follows:

- Based on the best research knowledge, no noteworthy studies have identified the EMs Architecture critical success factors, current challenges, taxonomy, and future trends. Therefore, this work is the first effort that proposes and combines the CSFs in one smart system to ensure sustainable energy management and achieve high energy efficiency of power plants in real-time.
- This study succeeded in creating a comprehensive research taxonomy with a new research scope presented for the first time for the sustainability of energy management in power plants.
- Provide a modern vision for sustainable energy management in the power plant through an integrated smart framework that has been verified through the previous literature and technicians with energy experts' judgment working in power plants.
- Identify open issues and research gaps that need further investigation to overcome the current challenges facing improving energy management performance in power plants.
- This study contributes to strengthening the literature and raising the efficiency of power plants through two dimensions, academic and practical. The first dimension reveals the challenges and directions of future research and the imbalance in the literature related to EMs. It guides the researchers and future studies of energy management issues in power plants. In contrast, the practical dimension reveals the case study to explore energy experts' judgment based on the CSFs to establish and test the novel integrative energy management framework in the power plants.
- The work is considered a guide based on scientific evidence for providing the necessary theoretical and practical approach to assist researchers and power plants by providing modern and sustainable energy management processes.

The academic literature currently lacks an integrative conceptual framework for CSFs of energy management in power plants. Therefore, this study responds to this research gap by conducting a systematic analysis of literature in energy management and then discussing the literature results with arbitrators and energy

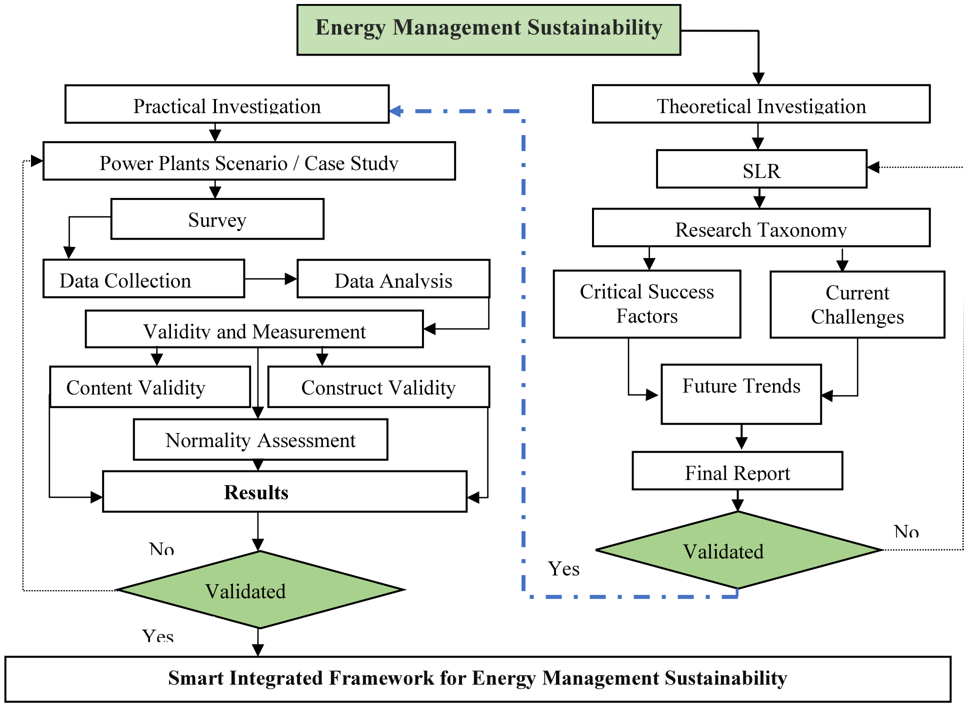

Fig. 1. Research methodology map.

experts in power plants to build a comprehensive and integrated smart framework. The study purposely maintains a view focused on energy management and service quality in the power plants. In this regard, we avoid discussing different areas details that are out of the scope of this study. At the end of the work, future research recommendations will guide upcoming researchers, energy providers, and consumers with methods to enhance power plants' power management system reliability.

2. Methodology

The methodology was established based on employing the outputs of the SLR for the last eleven years and establishing a coherent research taxonomy to develop a framework for sustainable energy management in power plants by conducting a questionnaire for technicians and energy experts. Extensive efforts have been made to address the scarcity of data available in power plants to enhance SLR. The power plants were selected as a case study by considering an ideal and successful topic for applying the model and creating a new sustainable concept for successful integration. The case study adopted a positivism philosophy and a deductive approach. The questionnaire consists of closed questions detailed in the case study section. Fig. 1 illustrates the study methodology map, including the steps of SLR.

2.1. Systematic review protocol

SLR helps explicitly and rigorously identify, analyze, and interpret evidence critically without biases. As SLR synthesizes findings from reviewed papers, a specific protocol is carried out to ensure its quality (Xiao and Watson, 2019). The following sub-sections will explain this study's SLR protocol for this study.

2.2. Scope

This article has been covered the key areas that dealt with EMs in the electricity sector through keywords, using specified keywords, namely "Energy management", "ISO50001", and "Power plant" other keywords used to extract more articles related to the area of interest were "Energy efficiency", "Energy conservation", "Energy consumption", "Energy Policy", "Energy Security" and "Energy Economics" combined with the OR and AND operators followed by "Energy management" and combined with the OR and AND operators followed by "ISO50001". The explicit query text is shown on top of Fig. 2.

2.3. Eligibility criteria

The specific eligibility criteria were prepared for this SLR. The search began by mapping the title into a general listing comprising three groupings obtained from previous literature. After removing duplicates, the articles were scrutinized further using pre-determined exclusion criteria, where the remaining articles were filtered and screened three times. Articles were excluded when they did not meet the following conditions; namely, (i) not written in English, (ii) focused only on a specific element of EMs practices, and (iii) targeted solely on general EMs practices such as home energy, cloud energy system and energy communication.

2.4. Quality assessment

The study used the Newcastle Ottawa Scale (NOS) to evaluate the quality of the articles that met the requirements. Four independent authors conducted the quality assessment, and a fifth author resolved disputes between the four authors. The articles were classified using three rigorous steps and the three-pass theory. The first step was to conduct a general survey through the titles of articles from 2011-to 2022. At the same time, the second step was classifying and ensuring that all studies fit the study criteria, excluding studies that did not meet the search criteria. The third step was by analyzing the final articles that match the research criteria and simulating the authors' work. The above quality standards allow for meeting the study criteria (Peterson et al., 2011).

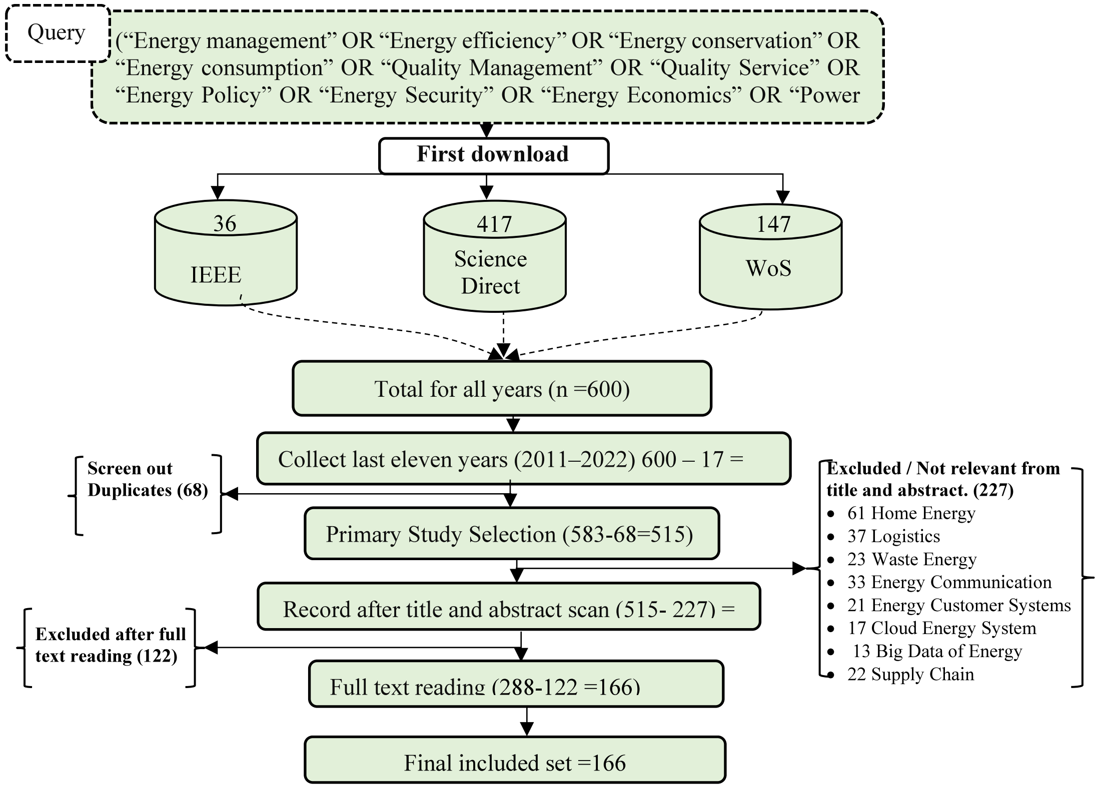

Fig. 2. Mapping of SLR search.

3. Research taxonomy

The research taxonomy aims to analyze the latest findings of previous literature and extract critical success factors for energy management. The search results led to the retrieval of 600 articles published within the designated period (2011–2022). Out of the 600 articles, 417 were taken from ScienceDirect, 147 articles were from WoS, and 36 were from IEEE Xplore. Due to accessibility issues, three articles from WoS could not be downloaded. The remaining articles were filtered using the protocol. The first filtration process removed (17) articles as they were not published between 2011 and 2022, and the other (68) were duplicates. The first round of exclusion left the researcher with 515 papers. The next stage saw 227 articles excluded based on their titles and abstracts. In the third stage, where the papers were read thoroughly, 122 papers were removed from the final list, leaving the researcher with 166 articles for the SLR. The 166 articles were again read and examined carefully to determine the map for the research. The researcher came up with three key groups based on the examination: (i) energy efficacy, (ii) energy policy, and (iii) ISO 50001. The taxonomy analysis revealed a particular set of patterns and classifications unique to areas of energy management. The Energy management mapping the green mapping represents the present research's scope and domains. The research literature taxonomy is illustrated in Fig. 3.

To generate a complete visualization of the literature map and research taxonomy, it is necessary to know the statistics of literature distribution according to databases, years of publication, and methodologies commonly used in such studies. Fig. 4refers to the distribution statistics results of articles. While Fig. 5 shows the distribution results of articles based on their publication year from 2011 to 2022. Fig. 6 explains the most widely used methodologies in such studies. The distribution results show that 69.2% (115 of 166) articles implemented the approach as a case study and questionnaire according to the methodologies used. Therefore, the case study, and survey are the most popular and effective approaches for this type of research.

3.1. Current trends of energy management (state-of-the-art)

The overview allows the researcher to understand better the subject explored. Moreover, the process helps justify which areas of EMs are understudied or discounted. Of the 166 articles, thirty-three (36 or 21.7%) classified the research domains and literature trends. The current trends for these articles shown in Table 1 need further investigation and contribute to the success of the energy management architecture as critical success factors. According to the surveyed literature, the CSFs include organizational culture (OC), top management support (TMS), energy policy (EP), energy efficiency (EE), awareness (A), environment (E), operational strategies (OS), energy management performance (EMP), human resources (HR), teamwork (T), economic performances (ECP), quality service (QS), continuous improvement (CI), internal audit (IA). Table 1 and Fig. 7 indicate the research domains on which previous studies focused. Technical articles were 130 by (78.3%).

A review literature taxonomy of EMs applications showed that it could extract critical success factors from three main trends to achieve energy management sustainability: energy efficiency, energy policy, and ISO50001 see Fig. 3. Each category is explained further in the following sub-sections:-

3.2. Critical success factors of energy efficiency

According to Tan et al. (2015), energy efficiency is part of EMs strategies. It enhances a country's economic feasibility and effectiveness, reduces greenhouse effects and reliance on energy while increasing supply security, and creates employment. For a review on energy efficiency in this SLR, 62 out of 166 37.3% articles were reviewed. The identified traits were categorized into

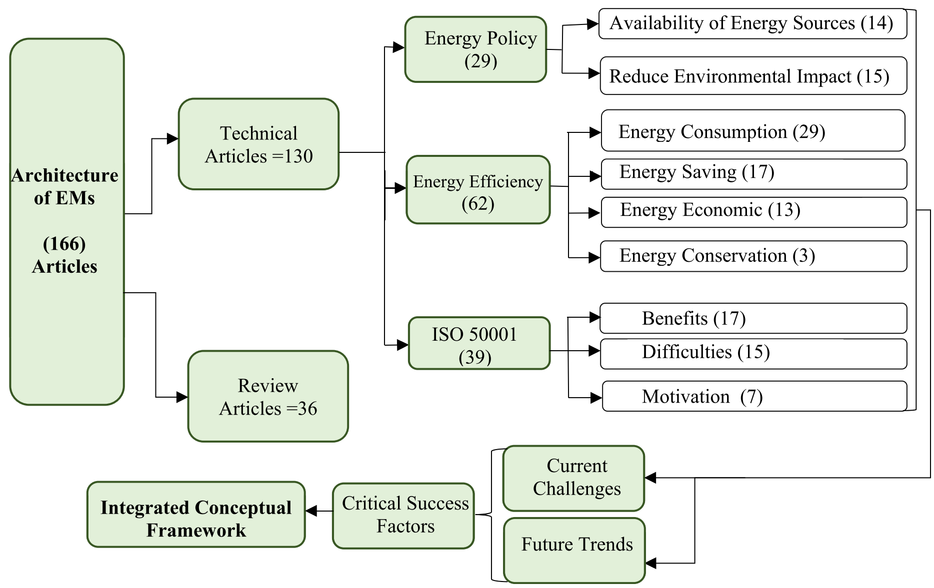

Fig. 3. Research literature taxonomy. . (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

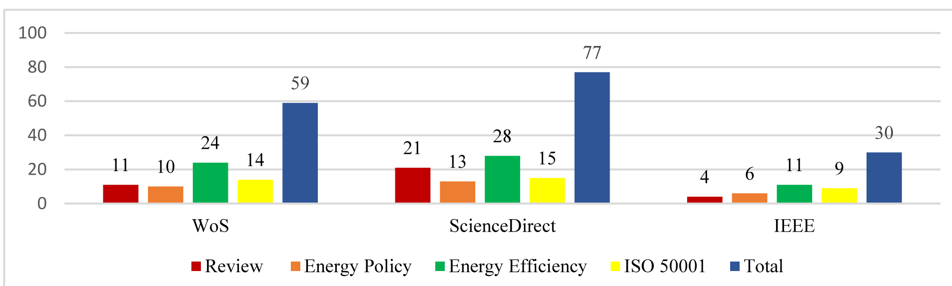

Fig. 4. Distribution statistics of papers by database.

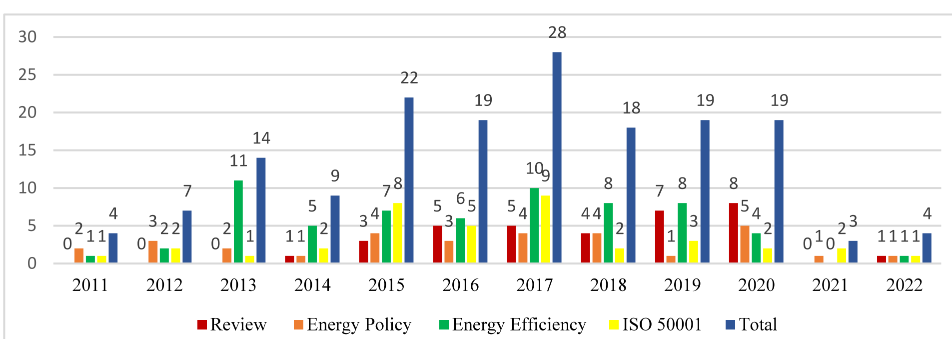

Fig. 5. Distribution papers by publication years.

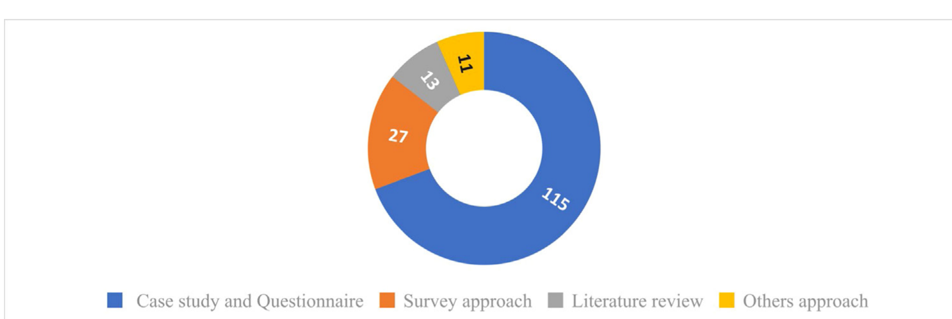

Fig. 6. Distribution papers by methodologies.

Table 1
Current trends of previous studies (Zaman et al., 2022; Rasool et al., 2022; AlMethn and AlFawzan, 2022; Mahmood et al., 2022; Andersson et al., 2021; Zhao et al., 2021; Mahmood et al., 2021; Iris and Lam, 2019; Menghi et al., 2019; Piacentino et al., 2019; Narciso and Martins, 2020; Wohlfarth et al., 2020; Cooremans and Schönenberger, 2019; Simsek and Urmee, 2020; Choong et al., 2014; Bayram and Ustun, 2017; Bonacina et al., 2015; Lawrence et al., 2019; Fernando and Hor, 2017; Zuberi et al., 2020; Ang et al., 2016; Sola and Mota, 2020; Pradhan et al., 2017; Clairand et al., 2020; Kamat et al., 2016b; Srivastava et al., 2019; Hossain et al., 2020; Fiorini and Aiello, 2019; Jovanovic et al., 2017; Carreiro et al., 2017; Roth et al., 2020; Bottcher and Muller, 2016; Paravantis et al., 2018; Luong, 2015; Pradella et al., 2019; Finnerty et al., 2018; Jabbour et al., 2017; Schulze et al., 2016; Pusnik et al., 2016; Tan et al., 2015).

Study	Year	Current Trends													
		OC	TMS	EP	EE	A	E	OS	EMP	HR	T	ECP	QS	CI	IA
[12]	2022		●	●		●			●						●
[13]	2022		●		●				●				●		●
[14]	2022	●		●		●			●				●	●	
[7]	2022	●	●			●			●				●		●
[15]	2021		●						●		●		●		●
[16]	2021			●					●						
[17]	2021	●	●		●	●			●				●		●
[18]	2019		●	●	●	●		●	●		●				
[19]	2019			●					●				●		
[20]	2019						●					●		●	
[21]	2020	●			●				●						●
[22]	2020			●		●									
[23]	2019			●				●	●	●			●		●
[24]	2020	●					●					●		●	
[25]	2014		●				●					●			
[26]	2017	●	●							●					
[27]	2015	●	●			●			●		●				
[28]	2019				●								●		
[29]	2017				●	●	●								●
[30]	2020	●	●					●		●				●	
[31]	2016			●			●				●				
[32]	2020							●							
[33]	2017	●				●					●		●		●
[34]	2020				●					●				●	
[35]	2016							●							
[36]	2019									●	●				
[37]	2020		●											●	●
[38]	2019	●			●					●	●				
[39]	2017	●	●	●		●								●	●
[40]	2017								●		●				
[41]	2020		●	●						●			●		
[42]	2016							●				●			●
[43]	2018	●			●	●								●	●
[44]	2015	●		●							●		●		
[45]	2019														●
[46]	2018	●		●		●					●		●		
[47]	2017	●	●	●	●		●	●	●					●	
[48]	2016								●		●				
[49]	2016							●						●	●
[50]	2015							●	●		●		●		
Score		15	14	14	11	12	6	9	16	7	12	4	13	10	15
%		37.5	35	35	27.5	30	15	22.5	40	17.5	30	10	32.5	25	37.5

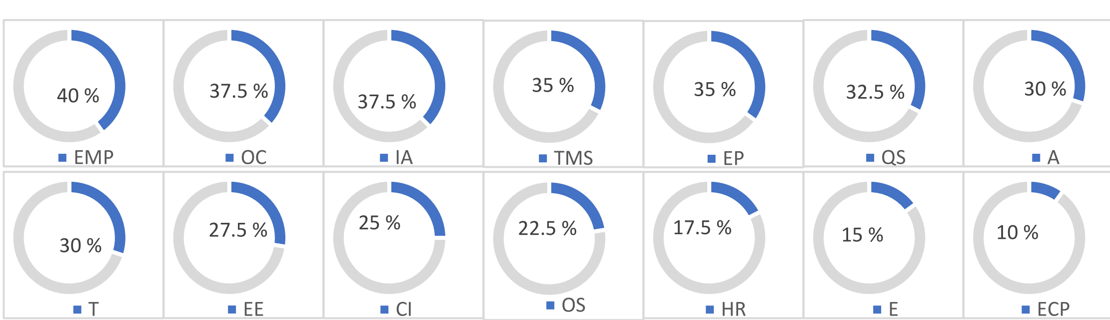

Fig. 7. Literature trends.

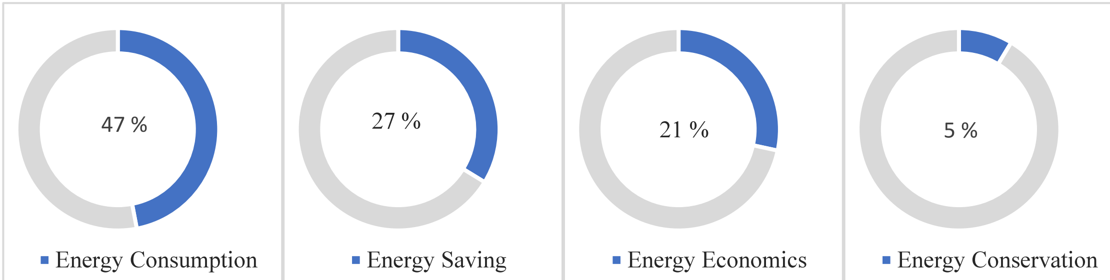

Fig. 8. Energy efficiency indicators for sustainable energy management.

the following four sub-sections as CSFs/indicators of successful and sustainable energy management. (i) energy consumption that consisted of 29 out of 62 articles focused on the energy consumption within EMs. (ii) energy-saving consisted of 17 out of 62 articles that dealt with the energy-saving aspects, which is part of energy management's energy efficiency. (iii) energy economics consisted of 13 out of 62 articles covering papers related to energy economics, including cost reduction as a success factor for energy management. (iv) energy conservation subsection consisted of 3 out of 62 articles and focused on energy efficiency and energy conservation. Fig. 8 refers to the energy efficiency indicators to successfully achieve energy management proposed by previous studies and trends of current research 47% of the literature confirmed that energy consumption plays an important role in successful energy management, and 27% of the literature focused on the energy saving. 21% of the current literature refers to the energy economy as CSFs for energy efficiency. Only 5% of the literature has linked energy conversion with energy efficiency as figure in Fig. 8.

The main domine of energy efficiency with the context of the critical success factors to ensure sustainable energy management consisted of 29 out of 62 articles. The CSFs proposed by previous studies and implemented in many industries and countries succeeded in energy consumption, composed of 29 out of 62 articles. Energy-saving has 17 out of 62 articles, while energy economics consists of 13 out of 62 articles. Conversely, the energy conservation by 3 out of 62, as shown in Table 2.

3.3. Critical success factors of energy policy

This section describes and summarizes energy policy issues, benefits, motivation, and relation to other industry factors. 29 out of the 166 articles were reviewed and categorized according to the identified issues. Energy security is apportioned into two subsections according to energy policy issues. The sub-sections as indicators of successful energy management. (i) Reduce environmental impact, consisting of 13 out of 29 articles. (ii) Availability of energy sources 16 out of 29 articles. Fig. 9 refers to 45% of the literature that confirmed that reducing environmental impact can be considered as an essential indicator in energy policy to achieve sustainable EMs in the industry. In comparison, 55% of previous studies refer to the availability of energy sources as a vital indicator of energy policy success within energy management in any industrial sector.

The research domine of energy policy with the context of the CSFs to ensure success and sustainable energy management consisted of 29 out of 166 articles. The CSFs proposed by previous studies have been implemented in many industries and countries. The domine of energy policy is composed of reducing the environmental impact in 14 out of 29 articles, and availability of energy sources consisted of 15 out of 29 articles as shown in Table 3.

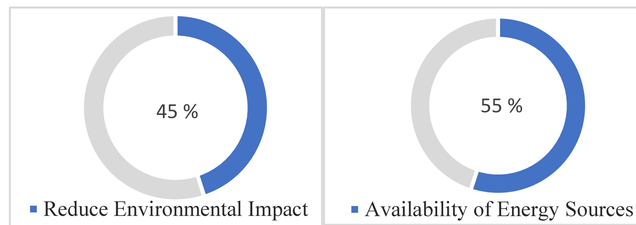

Fig. 9. Energy policy indicators to sustainable energy management.

3.4. Critical success factors of ISO 50001

The third section of EMs taxonomy is ISO 50001. The standards ensure that organizations optimize their energy performance by systematically managing it. Besides providing guidelines for these companies, it also helps improve energy management. As the EMs standards represent good industrial practices, 39 out of 166 articles were reviewed and discussed in this section, as shown in Table 4.

4. Development of an integrative energy management framework in the power plants

The integrated management system allows the integration of different groups according to unified concepts to improve processes and systems in one integrated system that helps the organization achieve its sustainable goals (Ahmed et al., 2022). The SLR and the judgment of energy experts helped establish the components of an integrated framework for sustainable energy management in power plants. The objective of the integrated framework is to provide a modern vision for sustainable energy management and to overcome the current challenges. Careful study and analysis of the previous literature helped the researchers in this study identify the CSFs needed by the conceptual framework to ensure the success of EMs in power plants.

The first strategy of the integrated framework for EMs is to analyze current information of energy performance data to conduct a preliminary assessment. The first strategy aims s to identify the current challenges that impede the sustainability of energy management in the power plant. While the second strategy involves implementing and enabling the critical success factors (CSFs) for energy management that have been extracted by systematic analysis of the previous literature. The CSFs have been used in various industries and have already succeeded, but they were not used in power plants. Therefore, this study presented CSFs as an essential part of the integrated framework for sustainable energy management in power plants. The CSFs that achieved the highest score were selected in the CSFs comparison tables such as Tables 1–4 and Fig. 7, which include organizational culture (OC) by 37.5%, internal audit (IA) by 37.5%, top management support (TMS) 35%, energy policy (EP) 35%, quality

Table 2
Research trends domains of energy efficiency.

Energy efficiency Indicators to successful and Sustainable EMs	Key References	Contexts and Critical success factors
Energy consumption It consisted of 29 articles	Fernando and Hor (2017), Rudberg et al. (2013), Drumm et al. (2013), Prashar (2017b), Menghi et al. (2020), Ashraf et al. (2019), Seow et al. (2016), Nikas et al. (2019), Vikhorev et al. (2013), May et al. (2016), Gutierrez et al. (2018), Nouri et al. (2013), Li et al. (2019), Finnerty et al. (2017), Orgerie et al. (2014), Introna et al. (2014), Tarhan et al. (2016), Pelser et al. (2017), Wahren et al. (2015), Javied et al. (2018), Velázquez et al. (2013), Ali and Jaiswal (2019), Kluczek and Olszewski (2017), Giacone and Manco (2012), Shrouf and Miragliotta (2015), Ejaz et al. (2017), Tan et al. (2017), Javied et al. (2016) and Rackow et al. (2015)	Operational strategy to successful energy management, environmental performance, awareness, teamwork, organizational, continuous improvement, risk management, transparency on energy consumption, top management support, leadership, energy audit, real-time and sustainable process.
Energy saving It consisted of 17 articles	Sola and Mota (2012), Gamede et al. (2019), Prashar (2017a), Sucic et al. (2017), Thollander et al. (2013), Lawrence et al. (2018), Locmelis et al. (2018), Forouli et al. (2019), Moraes et al. (2019), Galata et al. (2015), Morales et al. (2018), Dehning et al. (2019), Zuberi et al. (2017), Richert (2017), López-López et al. (2014), Blass et al. (2014) and Kumar et al. (2021)	Decision making, top management support, awareness, controlling energy use, integration technical energy management and others system as CSFs to adoption EMs system, experiences, energy policy's implementation, top management support, leadership, conduct energy audit continue evaluating energy efficiency program and improve quality systems
Energy economics It consisted of 13 articles	Lawrence et al. (2019), Jayaseelan et al. (2013), Liebl et al. (2018), Papetti et al. (2016), Müller et al. (2013), May et al. (2015), Bergmann et al. (2017), Therkelsen and McKane (2013), Swanepoel et al. (2014), Beck et al. (2016), Chai and Baudelaire (2015), Batista et al. (2013) and Rodrigues et al. (2019)	Framework to integration how energy management with other systems, assessment of the energy information economically, identify the factors EMs drivers, barriers, and successful implementation of EMs, leadership, conduct an energy audit,
Energy conservation It consisted of 3 articles	Weranga et al. (2012), Faghihi et al. (2015) and Wongsapai (2016)	Smart metering to ensure the coming generations effort to conserve and use energy effectively to enable energy efficiency, leadership, conduct an energy audit, policy's roles, top management support, organization culture

Table 3
Research trends domains of energy policy.

Energy policy Indicators to Successful and Sustainable EMs	Key references	Contexts and Critical success factors
Reduce environmental impact It consisted of 13 articles	Paletto et al. (2019), Sovacool and Brown (2010), Martchamadol and Kumar (2012), Vivoda (2012), Elliot et al. (2020), Moon and Min (2017), Jafarzadeh and Utne (2014), Laskurain et al. (2017), Albalawi et al. (2020), Ates (2015), Malinauskaite et al. (2020), Ottermann (2011) and Locmelis et al. (2017)	Continuous assessment of environmental impact through EMs, human resources, organizational culture, awareness, training, teamwork, operation strategy, establish a framework to overcome barriers, monitoring, evaluating the energy policy, strategy development process, continuously improve requirements for energy performance, leadership, conduct an energy audit
Availability of energy sources It consisted of 16 articles	Vikhorev et al. (2013), Gill et al. (2015), Wang et al. (2021), Li et al. (2018), Fernando et al. (2018), Mangla et al. (2020), Colak et al. (2012), Nelwan et al. (2017), Laskurain et al. (2015), Javied et al. (2015), Tucker and Khanbaghi (2018), Dobes (2013), Teixeira et al. (2016), Bagdad and Mohammad (2016), Chrysikopoulos and Chountalas (2018) and Jaime et al. (2020)	Framework to monitor, energy security, developing energy policies, experts, policymakers, top management support, quality service, energy systems, leadership, energy audit, integrated energy, operation strategy, and assessment of energy performance

Table 4
Research trends domains of ISO 50001.

ISO 50001 Indicators to successful and Sustainable EMs	Key References	Contexts and Critical success factors
It consisted of 35 articles	Pelser et al. (2018), Fuchs et al. (2020), Javied et al. (2019), Paunescu and Blid (2016), Topić et al. (2015), Antunes et al. (2014), Gopalakrishnan et al. (2014), Haeri and Rezaie (2016), Fichera et al. (2020), Yao et al. (2016), Beihmanis and Rosa (2016), Dzene et al. (2015), Brand et al. (2015), Swiatek and Imbault (2017), Rizzon et al. (2015), Mkhaimer et al. (2017), du Plessis (2015), da Silva et al. (2019), Castro et al. (2017), Wessels (2011), Fiedler and Mircea (2012), Cascella et al. (2016), Chiu et al. (2012), Ikeyama et al. (2017), Jovanovic and Filipovic (2016), Dorr et al. (2013), Uriarte-Romero et al. (2017), McKane et al. (2017), Lira et al. (2019), Anisimova (2015), Marimon and Casadesus (2017), Rionda et al. (2015), Goncalves and dos Santos (2019), Rampasso et al. (2019) and Szajdzicki (2017b)	Defining normative needs and providing requirements, organizational culture, awareness, development process, evaluating implementation by municipalities as part of sustainable energy efforts, optimizing the entire process, Integration with other mature systems, improve the process, organizational culture, awareness, training, teamwork, operation strategy, monitoring, communication, leadership and energy audit.

service (QS) 32.5%, awareness (A) 30%, teamwork (T) 30%. The third strategy of the integrated framework is divided into sub-three stages: the operating strategy of preparing a clear energy policy for the power plant, the establishment of a unit to manage energy-related risks, and the continuity of internal audit (Ali et al., 2021b). The second sub-stages within the third strategy leads us to implement EMs and generate energy efficiency measures while ensuring continuous improvement according to success measures which include measures to follow up on energy efficiency and continuous improvement, good communication between the team and departments and the continuity of the internal audit process to ensure continuous improvement (Bhattacharjee, 2020). Third sub-stages within the third strategy refer to the role of top management in making decisions that support energy saving with continuous benchmarking and documenting procedures according to energy management performance standards (Ma et al., 2021; Ullah et al., 2021). The latest strategy in the framework clarifies the necessary measures to improve sustainable EMs. This strategy includes monitoring the performance and the barriers that hinder the performance of EMs on an ongoing basis through the main performance indicators and continually evaluating them and monitoring the implementation of energy policies with the different departments within the power plants. By studying previous literature and arbitration among energy experts, this integrated framework presents a methodology based on previous work to improve and succeed in energy management in power plants. Fig. 10 illustrates the sequential steps of an integrated sustainable EMs framework.

4.1. Case study

A case study is presented in this section aiming to demonstrate a practical application of the framework. To employ the outputs of the systematic literature review, the researchers decided to validate the integrated sustainable framework by conducting a case study in the Iraqi power plant. The importance of the case study site is because most of Iraqi power plants suffer from complex energy management performance and energy efficiency problems. Therefore, Iraqi power plants are suitable for applying the study's methodology in adopting the integrated conceptual framework for sustainable energy management.

4.2. Sample size of case study

The sample size is defined as a small section representing the larger whole (Gannon et al., 2019). The previous research has revealed that researchers have differing viewpoints on sample size and that no sample size is specified explicitly. Several other criteria are available in the literature for selecting an adequate sample size; nonetheless, selecting an appropriate sample size is tied to the method used for analysis (Hair, 2009). The sample sizes should be more than 30, and up to 500 are appropriate; however, the sample size is determined by the nature of the study. The research sample included in the study was made up of 98 technical experts and energy experts working in the power plants (Sekaran and Bougie, 2003). Thus, in this research, the focus has been placed on experts who directly contact the work environment in electrical power production plants.

4.3. Data collection

Data collection is a technique utilized to collect study information about specific elements (Sekaran, 2009). This study adopted a positivism philosophy and a deductive approach for data collection. A closed-question questionnaire was adapted from Ahmed et al. (2022) and Ajmi et al. (2016).

4.4. Data analysis

Data analysis is reviewing, purifying, transforming, and simulating data to discover valuable knowledge, information, and decision-making assistance (Thomson and Emery, 2014). The IBM-SPSS and PLS-SEM soft applications were utilized to analyze data in this study. Initially, questionnaire objects were coded and loaded into the SPSS Data. SPSS has already been picked since it is the most widely used data processing program globally (Verma, 2012).

4.5. Framework validity

The main criteria for evaluating a proposed integrated conceptual framework for sustainable energy management are reliability and validity, which proved successful in this study (Ramayah et al., 2011). Reliability and validity is term used to describe a particular model measurement consistency or dependability. Based on the items' inter-correlations, internal consistency is traditionally assessed using Cronbach's Alpha. According to Nunnally and Bernstein (1994), the value must be more than 0.7 to be accepted (Thollander et al., 2020). An instrument is deemed valid when precisely assessing the intended items (Heale and Twycross, 2015). The validity test can be divided into two types according to the Sekaran and Bougie (2016): content validity and construct validity (Sekaran and Bougie, 2016).

4.5.1. Content validity

Content validity is defined as a tool for measuring the strength and accuracy of a proposed model or framework (Heale and Twycross, 2015). The literature has suggested two approaches to verify the content of model or framework, namely: (i) through a comprehensive SLR by logical deduction comprehensive of literature according to the CSFs for energy management recommended by previous literature. (ii) Secondly, by the arbitration of energy experts through a questionnaire and interviews in power plants, then analysis of the data and check the reliability and validity of the framework. Experts' feedback was included to improve the proposed framework, then technical experts and energy experts agreed on the strategies of the proposed framework for sustainable energy management in power plants. This work-based analysis and the developed framework catalyze the object-oriented energy management in power plants, ensuring energy sustainable and cost-effective operation, guiding energy policy implementation, and future research in this field.

4.5.2. Construct validity

Construct validity refers to the measures level that will test the model (Hair et al., 2020). Two types of construct validity testing, convergent validity test, and discriminant validity test, were used to determine the construct validity in this study, as detailed below:

Firstly, the convergent validity test uses composite reliability (CR), cronbach's alpha (CA), and average variance extracted (AVE). The composite reliability (CR) metric should be more than 0.7 to assess the constructions' dependability. The result of the algorithm showed that CR for all the constructs was above 0.7, as shown in Table 5. Average Variance Extracted (AVE) is another measure to check the validity model that should be more than 0.5 (Sarstedt et al., 2014). Table 6 presents CR values >0.7, AVE > 0.5, and Cronbach's Alpha > 0.7, which proves the validity and reliability of the integrated conceptual framework for sustainable energy management in power plants.

The second checking by discriminant validity test is helpful to check the measures of constructs and present the evidence to show whether the model is valid and related to each other

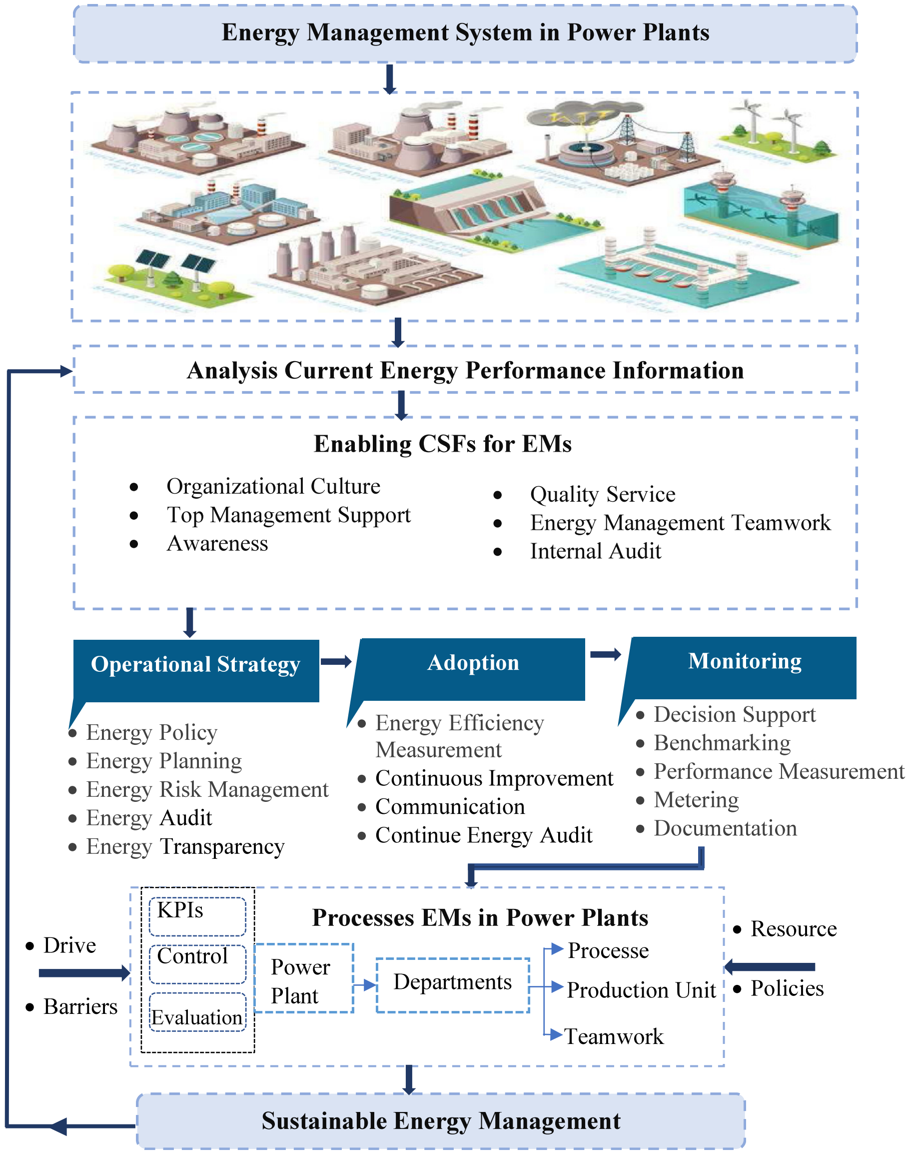

Fig. 10. Integrated conceptual framework for sustainable energy management.

Table 5
Internal consistency and convergence validity results.

Constructs	Composite reliability CR > 0.7	Cronbach's Alpha CA > 0.7	Average Variance Extracted AVE > 0.5
Organizational culture (OC)	0.91	0.90	0.59
Top management support (TMS)	0.88	0.75	0.62
Awareness (A)	0.92	0.91	0.61
Quality Service (QS)	0.87	0.89	0.60
Energy Management Teamwork (EMT)	0.90	0.90	0.58
Internal Audit (IA)	0.91	0.88	060
Energy Policy (EP)	0.89	0.92	0.63
Energy Efficiency (EE)	0.85	0.73	0.59
Energy Management Sustainable (EMS)	090	0.81	0.60

or not (Hair et al., 2017). One of the most substantial and most famous criteria used to verify discriminant validity is the Fornell and Larcker criterion test. The square root of the AVE of each latent construct should be greater than its correlation with other constructs (Fornell and Bookstein, 1982). The results in Table 6 show that the bolded values represent the square root of AVE, and plain values (off-diagonal) show a correlation among constructs. The results show that the square root of the AVE of each construct is greater than the off-diagonal values. Thus, all constructs meet Fornell and Larker criterion, representing that constructs have discriminant validity.

4.5.3. Normality assessment test

In regression analysis or SEM, examining model data normality is considered an essential check. Therefore, skewness and Kurtosis were carried out to identify the data normality. As a rule, skewness value outside ±2 and kurtosis value of ±2 indicate the non-normality of the data (Hair et al., 2017). The results of

Table 6
Discriminant validity — Fornell and Larcker criterion.

Constructs	OC	TMS	A	QS	EMT	AI	EP	EE	EMS
OC	0.714								
TMS	0.421	0.865							
A	0.528	0.780	0.782						
QS	0.431	0.467	0.622	0.786					
EMT	0.353	0.528	0.683	0.603	0.764				
AI	0.587	0.521	0.702	0.416	0.472	0.731			
EP	0.307	0.434	0.531	0.595	0.576	0.509	0.743		
EE	0.400	0.491	0.421	0.331	0.426	0.332	0.384	0.681	
EMS	0.518	0.603	0.372	0.543	0.667	0.343	0.509	0.505	0.881

Skewness and Kurtosis are presented in (Appendix A as supplementary data). The results proved all the values data were normally distributed as the skewness value for all the items was within ±2. Furthermore, the kurtosis values of all the items were within ±2, which did fulfill the requirement of Hair (2009).

5. Discussion

This article presents current and state-of-the-art information related to EMs and their critical success factors based on the energy policy, energy efficiency, and ISO 50001 (see Fig. 2). This study emphasizes research styles in this area of interest. What sets this survey apart from previous reviews focuses on optimizing energy management architecture through the literature and then use it to build a sustainable integrated framework through a case study in power plants. The proposed taxonomy has its advantages as it delves deeper into energy management by:- First, creating the research taxonomy tto organize selected articles. Second, the taxonomy would benefit new researchers investigating energy management sustainability, especially those exploring the critical success factors related to energy policy, energy efficiency, and ISO 50001 in various industries. Third, as many papers discuss energy management practices, the taxonomy will guide the researchers from overlooking key information due to the overwhelming number of sources. Finally, analyzing previous literature published in the last eleven years enabled us to identify the critical success factors for energy management sustainability in power plants. Researchers can adopt the taxonomy, especially those discussing similar works and interests in this study. Areas linked to energy management technologies are also mapped into specific groups to identify the research's weaknesses and strengths. This study's taxonomy highlights how the use of such technologies are researched extensively when exploring or reviewing areas of energy management sustainability and overlooking other key aspects such as solutions, techniques, and developmental endeavors. Apart from identifying areas that require more research, the taxonomy also points out that presently not many papers investigate ways to develop energy management sustainability in the power plants.

The current taxonomy calls attention to energy management technologies' key characteristics, namely critical success factors based on the energy efficiency, energy policy, and ISO50001 standards, as preferred by most researchers, hence neglecting the importance of traditional technologies. Works selected for the review are in the form of development papers, comparative studies, or overviews. The taxonomy uses statistical data for the individual categories to identify relevant areas of energy management technologies that can be adapted to current trends and make appropriate improvements to other areas. The researcher develops a common language to ease communication and discussion on related works like other taxonomies. The research taxonomy assisted the authors in establishing an integrated framework for energy management according to the CSFs for energy management recommended by previous literature in various industries and verified by energy experts working in power plants via a case study.

The proposed framework was primarily validated through two approaches: (i) The first validation approach was via a theoretical investigation and comprehensive systematic analysis of previous literature to create a coherent research taxonomy to identify the CSFs, and current challenges and then present a modern vision for future trends of energy management sustainably in the power plants. (ii) The second validation approach was via a case study in the power plant. A survey and questionnaire were conducted for technical and energy experts working in power plants. The arbitration of energy experts strictly and transparently was very useful in guiding the proposed framework's paths by adopting the positivism philosophy and a deductive approach for data collection.

The study used reliability and validity as the main criteria for evaluating a proposed framework for sustainable energy management. The reliability of the framework and CSFs have been tested by Cronbach's alpha (CA). All the results for CA were above 0.7. The results of the CA test were (OC = 0.90) followed by (TMS = 0.75), (A = 0.91), (QS = 0.89), (EMT = 0.90), (IA = 0.88), (EP = 0.92), (EE = 0.73) and (EMS = 0.81), thus, it fulfilled the normative requirements for the validity of the framework according to Heale and Twycross (2015) as shown in Table 5. While the convergent validity and discriminant validity have tested the validity for framework and CSFs. The convergent validity test includes average variance extracted (AVE) and the composite reliability (CR), which should be more than 0.5 and 0.7, respectively. The results of the AVE test were (OC = 0.59) followed by (TMS = 0.62), (A = 0.61), (QS = 0.60), (EMT = 0.58), (IA = 0.60), (EP = 0.63), (EE = 0.59) and (EMS = 0.60), while the results of CR were (OC = 0.91) followed by (TMS = 0.88), (A = 0.92), (QS = 0.87), (EMT = 0.90), (IA = 0.91), (EP = 0.89), (EE = 0.85) and (EMS = 0.90) . Accordingly, the results of testing the framework of the study have fulfilled all the normative requirements legislated by the previous studies, which means that the framework was accepted for application in power plants (Sarstedt et al., 2014), as shown in Table 6. Also, the study used the discriminant validity test by Fornell and Larker criterion to check whether the model is valid and related to each other or not (Hair et al., 2017). The results in Table 6 show all constructs meet Fornell and Larker criterion, representing that constructs have discriminant validity (Fornell and Bookstein, 1982).

The data normality was also verified via the Skewness and Kurtosis test. As a rule, skewness value outside ±2 and kurtosis value of ±2 indicate the non-normality of the data (Hair et al., 2017). The results proved all the values data were normally distributed as the skewness and kurtosis values for all the items was within ±2, which did fulfill the requirement of Hair (2009). Based on literature analysis and the developed framework, this study catalyzes object-oriented energy management in power plants, ensuring energy sustainable and cost-effective operation, guiding energy policy implementation, and future research in this field. This paper can be regarded as a prelude or the first step

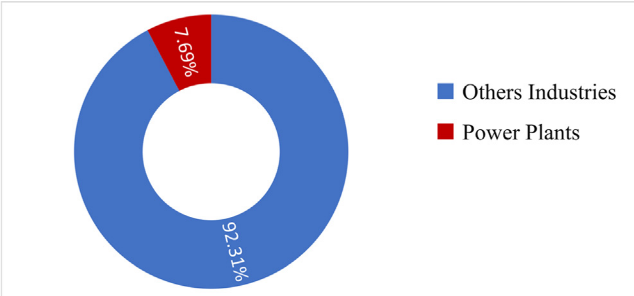

Fig. 11. Implementation rates of EMs in different industries.

toward experimental deduction and validation of the framework. The proposed methodology through the integrated framework may also be instrumental in delineating the overall energy management performance in any industrial system in the related fields.

5.1. Current challenges

Analysis of the previous literature confirmed that the current challenges of sustainable energy management still need further investigation and attention. For example, previous studies focused on energy security and efficiency as a criterion for the institution's success. Still, the omission of CSFs in power plants contributed to the complexity of the problem. 80% of the literature analyzed confirmed that organizational culture, top management support, internal audit, clear energy policies, awareness, and energy management team as CSFs need further investigation (Ahmed et al., 2022; Mahmood et al., 2022, 2021; Batlle et al., 2020). In comparison, 20% of the literature focused on institutions' obstacles in motivating workers to adhere to energy management standards. Analysis of the literature confirmed that 92.3% of the implementation of energy management programs was in various industries, while only 7.6% were implemented in power plants. Figs. 11 and 12 shows the energy management implementation rate.

Analysis of the previous literature identified a group of current challenges that still need further investigation, which can be summarized as follows:

i. Previous literature has investigated the role of TMS in sustainable EMs and concluded the need to strengthen the decision of higher management.
ii. Lack of EMs ISO 50001 case studies (Fuchs et al., 2020). There is a shortage and lack of transparency in the case studies presented and the lack of adoption CSFs of ISO 50001 in power plants (Fuchs et al., 2020; Thollander et al., 2020; Kanneganti et al., 2017; Szajdzicki, 2017a; António da Silva Gonçalves and Mil-Homens dos Santos, 2019).
iii. Lack of employees' awareness is essential when adopting energy management. Previous literature emphasized the need to enhance awareness among workers to implement EMs successfully.
iv. The case studies highlighted a lack of human resources, such as competencies, knowledge, cultures, and abilities for the employees who dealt with energy management ISO 50001 applications due to challenges and limitations linked to attempts to adopt ISO 5000 in various industries. The identified obstacles are technologies, infrastructure, finances, time, and inadequate management support.
v. The lack of top management support role for adopting energy management.
vi. There are no notable previous studies that have identified energy management's CSFs and have integrated energy management with service quality improvement in power plants with organizational culture as a mediator to facilitating and sustainable energy management.
vii. A shortage in studies providing a conceptual framework identifies CSFs for adopting EMs ISO 50001 and quality management in power plants.
viii. No worthwhile studies addressed the integration of performance shipping factors, including human factors, and human error, with EMs performance in power plants

5.2. Future trends

To alleviate obstacles faced by the decision-makers and top management personnel to create integration between the future trends and recommendations. This study summarized a set of future trends referred by previous studies that have not yet been well studied and need to be more developed. The future trends would contribute to the facilitation and sustainability of energy management programs in power plants, such as:

i. Future sustainable energy management by human-centric control: Enhancing human interaction must be considered for future energy management. Work settings can be modified to achieve positive interaction through a combination of energy management functions. Programs must make the human being an important axis that contributes to reducing energy consumption and promoting successful energy management concepts through training and awareness (Kamat et al., 2016a). In addition, there must be a clear role for humans in filling the gap between emerging technologies, artificial intelligence, sensors, and regulatory procedures, so the future of energy management will witness more interest in human resource technologies (Hammady et al., 2018).
ii. Future energy management by digitalization: Energy management programs are supposed to transform their procedures into digital processes, from internal auditing to accreditation, to avoid potential risks and human errors; so far, according to the literature, digitalization has not been used in energy management programs.
iii. Future energy management by integration: The integrated management system integrates two or more models into one intelligent system to achieve the organization's goals (Ikram et al., 2020). As the EMs standards align with international guidelines, they are also aligned with ISO 9001 Quality Management system (QMs), and ISO 14001 Environmental Management System (EMS). However, EMs focus on improving energy performance, whereas QMs are continually designed to improve service and product quality. Moreover, the critical success factors and success indicators between EMs and QMs are similar, making integrating them possible and easy to enhance energy management's overall performance (Ahmed et al., 2022; Petrescu et al., 2021).
iv. Future energy management by smart electricity grid: enhancing energy efficiency through EMs programs and integrating EMs with smart grid and storage energy system. Energy management programs help power plants generate stable electricity and increase efficiency. In addition, EMs programs help connect generation from turbine units to the smart grid through energy stores in each power plant to provide high flexibility in energy control and then contribute to a stable energy supply.

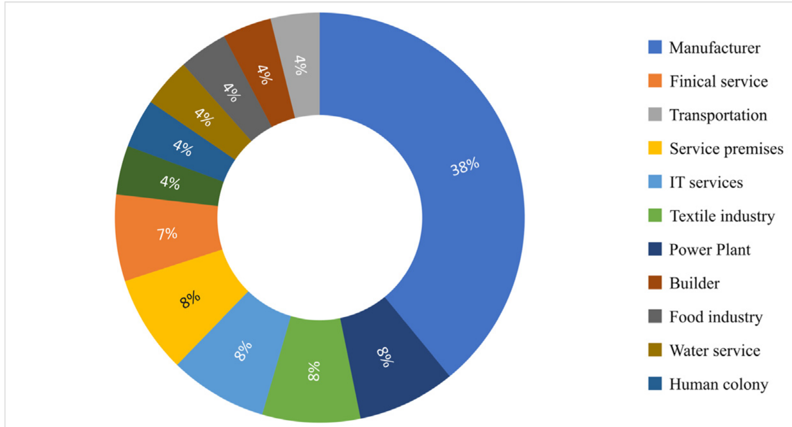

Fig. 12. EMS in power plants vs. other industries.

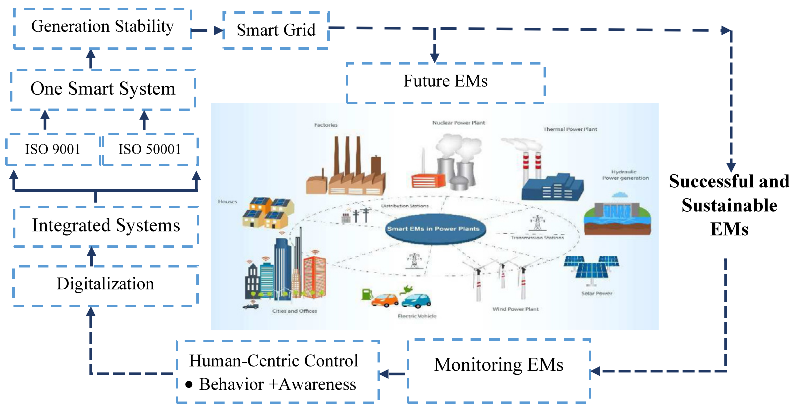

Fig. 13. Envisioning the future of energy management in the power plants.

v. Future energy management in real-time: to respond to this condition, energy management programs must be compatible with the new data and technologies used in the electricity sector and take advantage of industrial intelligence programs to enhance energy management programs' behavior.

The proposed points help in modeling the structure of future energy management in power plants. Fig. 13 shows the structure of the proposed energy tool system in the future. These proposals were developed based on the systematic review in this study. The energy management structure of the future contributes to providing a stable energy supply, creating a sustainable environment, and transforming power plants into sustainable smart plants.

6. Conclusion and recommendations

The smart framework presented in this study aims to enable sustainable energy management by considering CSFs impact on power plant features. To the best of research knowledge, very little studies have focused on EMSs in the power plants at the same level of detail as accomplished in this framework. Furthermore, there is no prior study that has highlighted the CSFs features of energy management sustainability in the power plants. Therefore, in this study, a comprehensive systematic literature review was conducted coupled with a case study to strengthen the understanding of various approaches to enabling sustainable energy management in power plants. This study systematically analyzed current challenges and future energy management trends in power plants. Although energy management grew increasingly popular among researchers, issues preventing smooth incorporation of the concept in organizations need to be addressed.

The academic literature currently lacks an integrative conceptual framework for CSFs of sustainable energy management in power plants. Therefore, this study responds to this research gap by conducting a comprehensive SLR from 2011 to 2022 to analyze challenges, identify CSFs for energy management, and then discuss the results of the literature with arbitrators energy experts in power plants via a case study to build a comprehensive and integrated smart framework. Analyzing previous literature showed that there are no noteworthy studies that succeeded in identifying CSFs for EMs in power plants and integrated with quality management (IEQM) and adopted the organization's culture as a mediator and predictor of the relationship between these factors and the success of energy management.

The validation of this study is based on two approaches. Firstly, theoretical investigation via comprehensive systematic analysis of previous literature to create a coherent research taxonomy to identify the CSFs, and current challenges and then present a modern vision for future energy management trends sustainably in the power plants. Secondly, practical investigation employs the results of a systematic review of the literature in a case study in the power plant. In addition, a survey and questionnaire were conducted for technical and energy experts working in power plants. As a result, the arbitration of technical and energy experts was strictly and transparent in guiding the proposed framework's paths.

The study used reliability and validity as the main criteria for evaluating a proposed framework for sustainable energy management. The reliability of the framework and CSFs have been tested by Cronbach's alpha (CA). All the results for CA were above 0.7 since were (OC = 0.90) followed by (TMS = 0.75), (A = 0.91), (QS = 0.89), (EMT = 0.90), (IA = 0.88), (EP = 0.92), (EE = 0.73) and (EMS = 0.81), thus, it fulfilled the normative requirements for the validity of the framework as shown in Table 5. While the convergent validity and discriminant validity have tested the validity for framework and CSFs. The convergent validity test includes average variance extracted (AVE) and the composite reliability (CR), which should be more than 0.5 and 0.7, respectively. The results of the AVE test were (OC = 0.59) followed by (TMS = 0.62), (A = 0.61), (QS = 0.60), (EMT = 0.58), (IA = 0.60), (EP = 0.63), (EE = 0.59) and (EMS = 0.60), while the results of CR were (OC = 0.91) followed by (TMS = 0.88), (A = 0.92), (QS = 0.87), (EMT = 0.90), (IA = 0.91), (EP = 0.89), (EE = 0.85) and (EMS = 0.90). Accordingly, the results of testing the framework of the study have fulfilled all the normative requirements legislated by the previous studies, which means that the framework was accepted for application in power plants, as shown in Table 5. Also, the study used the discriminant validity test by Fornell and Larker criterion to check whether the model is valid and related to each other or not. The results in Table 6 show all constructs meet Fornell and Larker criterion, representing that construct have discriminant validity. Finally, Skewness and Kurtosis test was used to check the data normality, all results between ± 2, which did fulfill the required standards.

The results of this systematic review have been compiled to build an integrated smart framework that addresses the CSFs of EMs and presents envisioning the future EMs in the power plants. The study indicated the most important challenges EMs programs face in the electricity sector and that the recent trends of future studies were detailed. These challenges are linked to top management support, organization culture, energy policy, cost reduction, quality improvement, reduced environmental impact, and energy saving. The review also recommended that upcoming research consider delving into issues linked to how the components ought to be handled and controlled and how energy industries' top management, personnel, and workers should incorporate the concept of EMs in their organizations.

In addition, it is appropriate to focus the future research on identifying methods to resolve barriers related to energy policy and ISO50001 standards in energy management in power plants context as a future gap. The purpose of identifying methods to resolve barriers related to energy policy and ISO50001 can be summarized as follows: (i) 80% of the case studies referred to real barriers that have not been systematically resolved, meaning that individual organizations discussed a narrower range of barriers than other categories. For example, most case studies in different industries that attained ISO 50001 certification focused on the achievement awards rather than identifying methods to resolve barriers related to energy policy and ISO50001 (Fuchs et al., 2020). (ii) As Fiedler and Mircea (2012) speculated, overcoming barriers contribute to cost-saving and energy sustainable (Fiedler and Mircea, 2012). (iii) Strengthening the company's image by contending for energy management leadership awards after resolving barriers. (iv) Most of the previous studies focused on the benefits and motivation of energy policy and ISO 50001 in various industries and the education sector, with the shortage of studies that dealt with overcoming barriers in the context of power plants. The SLR in this study confirmed weakness in the literature that dealt with methods to overcome barriers and sustainable energy management programs, including IOS 50001 and energy policy in the context of power plants, which is most important for people's lives, especially in the developing countries (Fuchs et al., 2020).

This research, like other studies, has a set of challenges and recommendations for future studies, which can be summarized as follows:

i. SLR noted that most literature on improving EMs performance focused on industrial sectors, with an apparent lack of literature on thermal and gas power plants. Therefore, this article recommends conducting more research to improve architecture EMs and facilitate their adoption in power plants.
ii. More case studies are recommended to facilitate the adoption of EMs ISO 50001 in the power plants.
iii. This study recommends comparing data on competition and motivation results for EMs programs with the same results for other groups without EMs programs to assess the development and adoption of EMs.
iv. It will be useful to use the CSFs of energy management ISO 50001and quality management, including; energy policy, service quality improvement, top management support, awareness, energy management team, and energy audit with organization culture as a mediator to sustainability and facilitate adoption of EMs ISO 50001 in the power plants.
v. It is recommended that more investigations on CSFs that affect the energy management performance represented by performance shaping factors such as teamwork, work overload, time pressure, motivation, commitment and skill flexibility, with the leadership practices as a mediator or moderator to improve overall performance.
vi. To enhance EMs, more studies on the human performance, performance shaping factors, including (human factors and human errors) and integration with EMs in the power plants.
vii. More integration of EMs ISO 50001 with quality management, specifically quality service, is required in power plants. In addition, integration of personnel performance, performance shaping factors, and EMs performance in maintenance power plants are also possible.
viii. The trends for future research of the various industrial sectors are established once the EMs are published in those sectors. Therefore, this study recommends analyzing the differences between the sectors adopting EMs and the non-adopting sectors.
ix. This study recommends digitizing the power plants' maintenance, operation, and examination procedures to ensure rapid and sustainable compliance with energy management programs.

Declaration of competing interest

All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version. (d) This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue.(e) The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript.

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Ethical approval

All procedures performed in this study were according to the institutional and/or national research committee's ethical standards and the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.egyr.2022.06.023.

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