Heliyon 9 (2023) e18438

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Performance shaping factors for future sustainable energy management: A new integrated approach

Ahmed Ali Ajmi [a,b], Noor Shakir Mahmood [a,b], Khairur Rijal Jamaludin [a,*], Hayati Habibah Abdul Talib [a], Shamsul Sarip [a], Hazilah Mad Kaidi [a]

[a] *Razak Faculty of Technology and Informatics, UTM, 54100, Kuala Lumpur, Malaysia*
[b] *University of Technology, Ministry of Electricity GCEP/Middle Region, Iraq*

A R T I C L E I N F O

Keywords:
Success factors
Decision-making
Integrated system
Power plants
Energy efficiency

A B S T R A C T

The current literature suggests that a lack of integration between engineering for performance shaping factors (PSFs) and workplace energy management (WEM) is a significant barrier to improving energy management practices (EMP) and power plant efficiency. The study identified three research objectives in response to this research gap: (1) conduct a systematic literature review to analyze current studies; (2) develop a novel integrative model capable of predicting EMP; and (3) test the novel model's validity and reliability through an empirical study in thermal power plants. In this study, a group of academic and energy experts designed research instruments to achieve the study's objectives, which were then pilot-tested. Partial least square structural equation modeling was utilized to analyze the data in this study. The study successfully developed a new model for future sustainable energy management in power plants and a new model integrating the PSFs and WEM to predict power plant energy performance, aiming to enhance communication between operators and EMP in power plants. The model exhibited exceptional explanatory and predictive abilities, yielding a strong fit. Furthermore, the incorporation of success factors associated with PSFs positively influenced the EMP. The data set followed a normal distribution, confirming the model's reliability and validity. Significantly, this study achieved a breakthrough by being the first to integrate success factors for PSFs and WEM in thermal power plants, thus effectively addressing an unexplored area of research. However, the inconsistencies in the current studies emphasize the necessity for additional investigations into the strategy of PSFs in EMP within power plants.

1. Introduction

Performance in power plants is becoming an important issue, especially in maintenance and operation, as it significantly impact future sustainable energy management practices (EMP) [1]. Performance shaping factors (PSFs) play a crucial role in the maintenance of power plants, making them valuable indicators for improving EMP [2,3]. Additionally, PSFs are used to assess human factors, whose negligence can lead to increased human errors, diminished human reliability, and heightened human risk within power plant operations [4]. Consequently, further studies and investigations are imperative to enhance human factors and minimize human errors in power plant environments [5]. PSFs could be used as success factors to improve performance reliability, improve power plants'

* Corresponding author.
E-mail address: khairur.kl@utm.my (K.R. Jamaludin).

https://doi.org/10.1016/j.heliyon.2023.e18438
Received 26 March 2023; Received in revised form 11 July 2023; Accepted 18 July 2023
Available online 23 July 2023
2405-8440/

Nomenclature

WEM	Workplace energy management
PSFs	Performance shaping factors
EMP	Energy management practices
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
HTMT	Heterotrait–monotrait ratio
EMS	Energy management sustainable
TMS	Top management support
TE	Teamwork
EP	Energy policy
EE	Energy efficiency
CO	Commitment
MO	Motivation
WO	Work overload
SF	Skill flexibility
RM	Risks management
TW	Teamwork
AW	Awareness
TP	Time pressure
CI	Continuous improvement
NOS	Newcastle Ottawa Scale
COM	Communication

performance, and reduce human errors [6] it also could be use it as failure factors such as NPP fields. Accordingly, PSFs, especially human factors, can improve the personnel's behavior performance toward EMP in power plants [7]. The poor performance of PSFs in power plants has resulted in increased human errors, which can have long-term negative effects [8–13]. Furthermore, unlike nuclear power generation systems that require high levels of automation, thermal power plants typically operate with lower levels of automation.

EMP refers to the systematic approach and set of strategies employed to optimize energy use and improve energy efficiency within a given context, such as an organization or facility. EMP involves the planning, implementation, monitoring, and evaluation of energy-related activities, including energy conservation, energy procurement, energy audits, and the adoption of energy-efficient technologies and practices. It focuses on reducing energy consumption, minimizing waste, and maximizing the overall energy performance of a system or operation. WEM, on the other hand, specifically pertains to the management of energy use and efficiency within a workplace or work environment. WEM involves the application of energy management practices within the organizational setting, aiming to optimize energy consumption and promote sustainable energy practices among employees and stakeholders. This includes activities such as energy awareness campaigns, employee engagement, energy-efficient equipment and lighting, and the implementation of energy-saving policies and procedures. While both EMP and WEM share the goal of improving energy efficiency, they differ in scope. EMP encompasses a broader perspective, considering energy management across various contexts, sectors, and operations. WEM, on the other hand, narrows the focus specifically to energy management within the workplace setting, addressing energy-related issues and practices relevant to employees and operations within an organization.

Consequently, human errors, energy wastage, and insufficient attention to PSFs are more likely to occur in these settings [14]. Addressing issues related to EMP is a global priority, as they are directly related to enhancing organizational and personnel performance. To accomplish this, we must integrate EMP principles into decision-making processes, thus promoting improved sustainable energy management [15]. Therefore, additional research is required to investigate the use of PSFs, including individual factors, in enhancing energy management practices. Existing research has primarily examined the role of personal performance in providing energy for homes, but there is a dearth of research in industrial sectors. In addition, few studies and projects have implemented strategies to modify personnel behavior to conserve energy and enhance EMP [16]. Despite the importance of PSFs in improving sustainable energy management, the systematic literature review (SLR) indicated a lack of literature that used PSFs to improve EMP.

Future research should prioritize exploring the impact of PSFs on sustainable energy management. Consequently, efforts to improve personnel energy conservation behavior and enhance EMP must be prioritized [17–20]. A lack of interest in PSFs can be disastrous, directly impacting EMP [21]. Future research in the field of EMP in power plants should identify PSFs [22]. Accordingly, the integration between the success factors of PSFs and EMP is considered an optimal solution to improve behavior in sustainable energy management [23]. Furthermore, the focus on integrating PSFs is regarded as one of the most prominent future works required to improve energy performance [24]. Academic literature currently lacks an integrative conceptual framework to integrate the success factors of PSFs and WEMin power plants. Therefore, this study addresses the current research gap by developing a novel integrative conceptual framework that integrates the success factors of PSFs and WEM in power plants through three approaches: conducting an SLR to analyze current studies, developing a novel integrative model capable of predicting EMP, and testing the validity and reliability of the novel model through an empirical study in thermal power plants. These steps are followed by discussions with arbitrators and energy experts to construct a comprehensive and integrated smart framework.

This study makes a significant contribution to the literature on sustainability in energy management by introducing a groundbreaking integrated framework for future trends in sustainable energy management, specifically tailored for power plants. The framework is designed to be easily applicable. It offers a fresh approach by conducting a logical literature analysis based on success factors for PSFs and derived from previous studies across different industries. To ensure its validity, the framework is further verified by experts in the technical and energy fields who work in power plants. Additionally, the proposed methodology within this integrated framework holds the potential to effectively evaluate and enhance EMP in various industrial systems within related fields. In summary, the key contributions of this paper can be summarized as follows:

- It established a coherent research classification, uniquely identifying the appropriate performance shaping factors for thermal power plants. This classification represents a significant advancement in the field.
- This study is the first of its kind to integrate success factors for each performance shaping factor and success factors for energy management in the workplace. By doing so, it provides future trends and insights for sustainable energy management.
- By considering social factors, the study presents modern and sustainable solutions to address an industrial problem, ensuring the long-term sustainability of energy management. It achieves this through the integration of performance shaping factors and success factors for sustainable energy management.
- The study identifies and addresses various open issues related to sustainable energy management, specifically within thermal power plants, contributing to the existing body of knowledge in the field.
- This research presented innovative solutions to an industrial problem by developing a novel approach to energy management via performance shaping factors in power plants.
- The proposed study model demonstrates high flexibility, making it readily applicable within thermal power plants and across different industrial sectors. This adaptability enhances its potential for practical implementation and impact.

2. Research methodology

The research methodology employed in this study encompasses two main directions. The first direction involves a systematic theoretical investigation of the existing literature to establish a cohesive academic taxonomy. This is achieved through an SLR, which aims to identify the research problem and address existing gaps. Of the total 535 papers, 90 were selected for an in-depth examination of the performance architecture. The ultimate goal of this phase is to construct an integrated conceptual framework that can enhance power plant performance. Researchers followed the recommended procedures to ensure transparency and rigor, as outlined by Ref. [25]. This involved careful planning, conducting the SLR, and reporting the analysis results. The authors also made efforts to overcome any data limitations and developed a strategic framework based on the SLR's findings to enhance power plants' performance and profitability. To increase the reliability of their approach, they adopted a dual strategy that incorporated the perspectives of energy experts and power plants. The second step of the research methodology is to validate the proposed model through empirical investigation. The collected data were then analyzed using two advanced stages of analysis. The overall research methodology process is explained in Fig. 1.

The SLR process was based on three factors: (i) keywords, (ii) databases, and (iii) time frame. To minimize bias and ensure a comprehensive search, the study selected search keywords based on the primary research questions and assessed their accuracy. Five digital scientific databases were utilized: Science Direct, Scopus, IEEE Xplorer, Web of Science, and Springer. The study analyzed and reviewed the filtered articles published between 2014 and 2023 and were limited to those published in English. To ensure the quality of the SLR and reduce potential biases, the selected articles underwent three reduplication steps. Using the Newcastle Ottawa Scale (NOS), three authors independently assessed the quality of the literature that met the criteria, and a fourth reviewer resolved any disagreements. The rigorous and thorough filtering process resulted in the selection of 90 pertinent articles from an initial pool of 535. The SLR findings were then utilized to conduct a case study, in which energy experts identified and evaluated critical success factors. The validity of the model was evaluated using PLS SMART and SPSS software.

SLR protocol was based on five reputable databases, yielding a total of 535 scientific papers on the research topic. The SLR criteria focused on selecting research published within the last ten years, resulting in 331 papers directly relevant to the study. After excluding 103 duplicate research papers found in multiple databases, the remaining count was 228. Since the study protocol emphasized publications in related fields, 33 scientific research papers that were book chapters were also excluded, leaving a total of 195 articles. Next, a title and abstract examination eliminated 45 articles that did not closely address the study's subject, resulting in a total of 150 articles. Due to restricted access, five articles were not accessible for reading, resulting in a final count of 145 articles. In the final step, all papers were thoroughly reviewed, and 55 articles were excluded due to content and scope issues. The SLR covered a total of 90 scientific articles. Fig. 2 illustrates the filtering steps implemented to select relevant articles based on the established criteria.

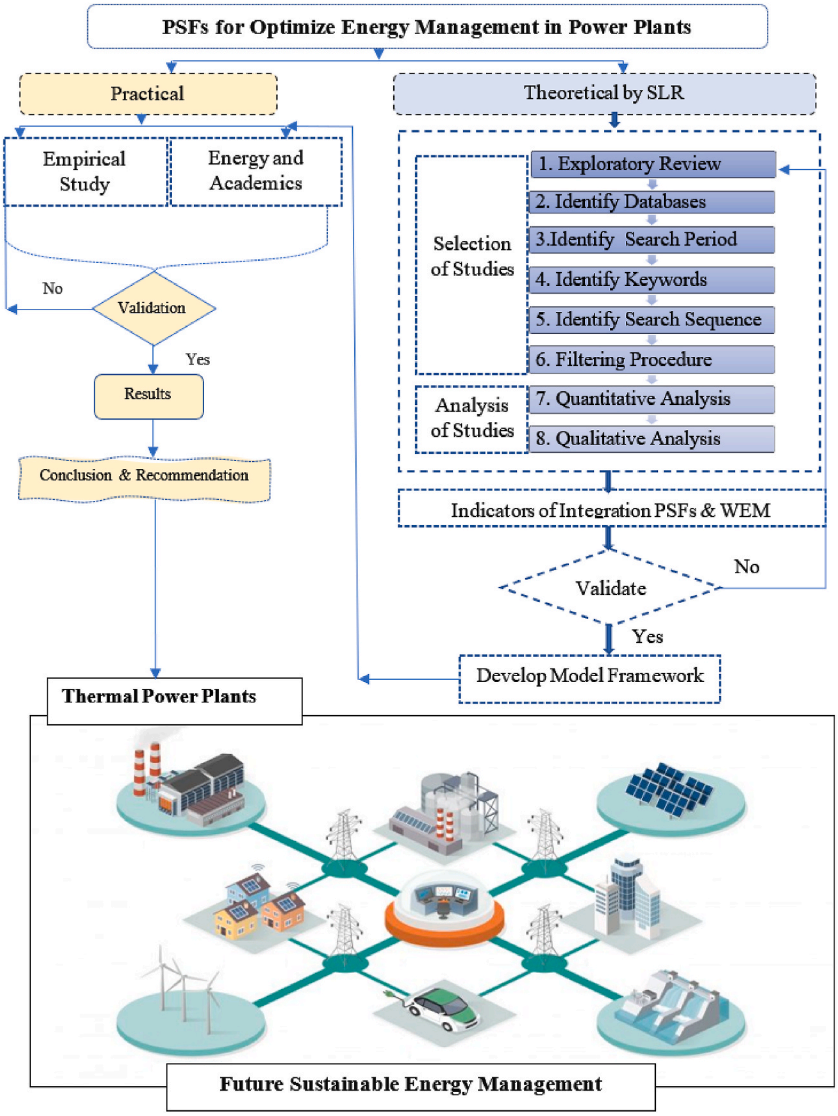

Fig. 1. Research methodology process.

2.1. *Exploring common performance shaping factors in thermal power plants*

Identifying and understanding success factors play a crucial role in diagnosing errors and driving better performance in the workplace [26]. Success factors for PSFs play an important role in the manufacturing and contribute to enhancing the managerial planning and action that must be practiced to achieve effective performance; further investigation of the success factors, such as motivation, skill flexibility, commitment, teamwork, communication, and leadership, in other industry sectors is needed [27,28]. However, in such studies, the PSFs' success factors were never prioritized, as technological factors remained the primary focus. Consequently, it is considered a research gap that requires additional studies. Hence, we must identify the success factors related to the PSFs [29]. The success factors for human performance PSFs are no less important than other critical factors, such as technology success factors and supply chains, but in the literature, no study has thoroughly discussed them [30–32]. The researchers developed measurement tools to assess performance and recommended their use to understand critical factors better. They have identified various success factors that contribute to enhanced workplace performance. These factors include competence, dedication, motivation, the availability of resources, work overload, and time constraints. Table 1 provides a comprehensive overview of the scientific evidence and rationale supporting the utilization of these success factors. It also highlights the practical contributions of these factors in enhancing performance reliability across various industrial sectors, including thermal power plants.

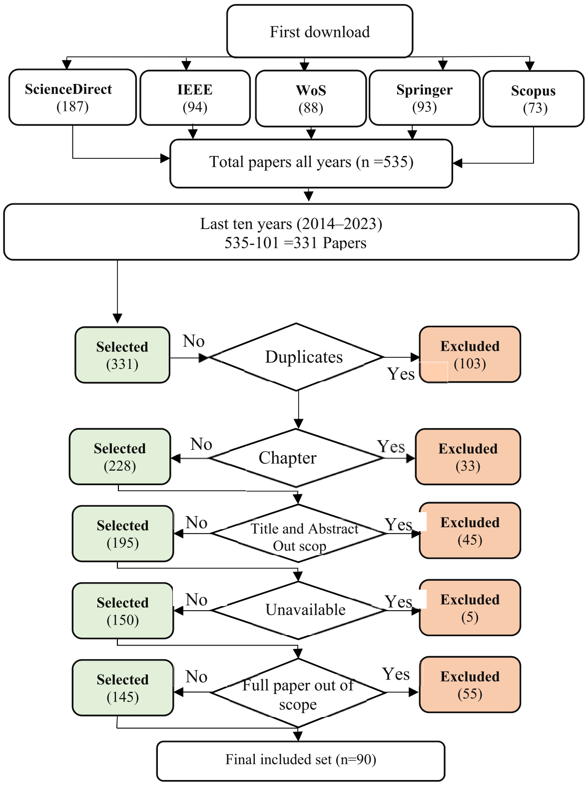

Fig. 2. Study selection flowchart.

2.2. Exploring common factors of workplace energy management in thermal power plants

Workplace energy management refers to systematically optimizing energy consumption within a workplace or organizational setting. It involves implementing strategies, practices, and technologies to monitor, control, and reduce energy usage while maintaining operational efficiency and promoting sustainability. Enhancing workplace energy management reduces human errors, improves human factors, and mitigates maintenance and operational risks [65]. The existing literature indicates a strong correlation between the success of EMP in the energy sector and particular success factors. Identifying and comprehending these factors permits the establishment of meaningful relationships between them and the recognition of their interdependence. Ultimately, such knowledge contributes to improving the overall EMP [66]. The influence of personnel performance factors on EMP and energy conservation, particularly in the context of maintenance activities, has been the subject of an extensive body of research. One key aspect involves raising awareness among personnel and establishing clear energy policies that can effectively enhance energy utilization within the workplace [67]. Previous literature [68–71] has investigated the role of workers in raising energy efficiency in the workplace. The results show that interest in energy management concepts can be used to increase energy efficiency in factory operations, as energy efficiency increases by 20% if it is related to training and raising the workers' awareness to optimize energy use.

Table 1
Success factors of PSFs proposed by previous studies in power plants.

Performance Shaping Factors	Supporting References
Teamwork	[4,24,26,28,32–53]
Skills Flexibility	[4,24,28,32–36,40–42,45,47–50,54–58]
Commitment	[4,26,28,32,33,40–43,45,47–49,55,58,59]
Motivation	[4,28,33,41–43,45,47,54,55,60]
Work overload	[4,32,33,35–39,44,46,48,55,61–63]
Time pressure	[4,24,26,33,34,36,37,39,40,44,46–50,62,63],
Fatigue	[52,55,64],
Creativity	[52,59,62]
Awareness	[28,60,64]
Cognitive	[36,47,58,59]
Intimidation	[28,43,62,64]
Communication	[28,40,45,56–58]
Stress	[4,43,64]

Table 2
Success factors of WEM proposed by previous studies in power plants.

Workplace Energy Management	Supporting References
Teamwork, Energy team	[29,34–36,50,75–79]
Skills, Experience	[29,34–36,50,66,76,79–83]
Commitment	[29,76–78,80,80,82,84,85]
Motivation	[29,71,75–77,86,87]
Awareness	[17,66,67,71,75–77,79,80,82,83,88–91]
Risks Management	[75,79,82,90,92]
Top Management Support	[29,66,75,77–79,82,86,88,90]
Continuous improvement	[17,67,71,75,79,80,83,90,92]
Policies	[66,80,83,86,89,91,92]
Communication	[75,76,79,80,87–89,91]

The results show that energy savings are achieved by switching on or off the machines according to system states [72]. Energy management activities must be successful within the electricity sector to gain top management's clear and official commitment. However, the literature lacks quantitative studies on energy management [73].

Enhancing EMP by leveraging success factors and overcoming barriers has emerged as a crucial and pertinent topic. Moreover, identifying and implementing these success factors is essential to achieve success in energy management efforts [74]. Performance-Shaping Factors (PSFs) are elements that influence the performance of individuals, teams, or organizations in achieving their goals. In the context of workplace energy management, PSFs are the factors that shape energy-related behaviors, practices, and decision-making processes within the workplace. The relationship between WEM and PSFs is crucial. Effective workplace energy management requires addressing and integrating the relevant PSFs into energy management strategies and initiatives. For example, establishing a culture of energy efficiency and sustainability, providing leadership support and resources, engaging employees in energy-saving practices, and providing training and incentives can all positively influence energy-related behaviors and performance. As shown in Table 2, previous studies have helped researchers identify success factors for EMP that can be integrated with personnel performance to improve overall performance.

2.3. Integration of the success factors for PSFs and WMP in a novel model

In this study, we aim to explore integrating PSFs and WEM into a management system called IPSFEM. The goal is to improve the performance of energy management in power plants. Table 3 provides a comprehensive overview of multiple studies examining success factors for PSFs and WEM. The table contains an analysis of 24 research papers (numbers 1 through 24) focusing on PSFs and 25 articles (numbers 25 through 49) investigating WEM success factors. The study identified success-producing factors in industries and power plants through this analysis. For example, one of the success factors identified is the frequency (F) of (TW), which appeared in 26 of the 49 studies. This factor is equally important in both energy management studies and shaping factors. In addition, a 53% alignment rate demonstrates its suitability for integration. By analyzing the selected studies, the present study identifies and presents the success factors demonstrated to be effective in relevant industries and power plant contexts. These findings contribute to a greater comprehension of the success factors in PSFs and WEM. Table 3 compares the integrated PSFs and WEM to determine the factors that the studies agree on for use in the present study.

Table 3 provides an overview of the evaluation metrics utilized to manage PSFs in the workplace. The findings reveal that teamwork TW was the most frequently employed metric (53%). Other metrics, including skill flexibility (51%), commitment (49%), motivation (39%), time pressure (29%), work overload (27%), top management support (33%), awareness (18%), policy (16%), communication (16%), continuous improvement (16%), risk management (12%), cognitive (10%), stress (4%), creativity (2%), and fatigue (2%), were also utilized. However, the usage of these metrics varied among the reviewed studies, with some conflicting sub-metrics. Notably, no known studies have used these metrics collectively, indicating a lack of standardized guidelines for evaluating different metrics. Each study adopted metrics that aligned best with their specific objectives.

This variation presents a challenge in establishing specific metrics for evaluating and benchmarking performance detection and classification. Empirical studies proved useful in providing a deeper understanding of the research community, particularly in areas that have not been extensively explored. Consequently, the identified success factors are summarized in Fig. 3.

2.4. Differences in PSFs between thermal and nuclear power plants

Extensive analysis of the previous literature reveals a lack of consensus regarding the specific number of Performance-Shaping Factors (PSFs). The varying nature of these factors is attributed to the diversity of work environments and conditions. On the other hand, the literature investigated the important and effective role of PSFs in nuclear power plants such as [93–95]. This literature indicated PSFs play a crucial role in nuclear power plants as they significantly influence human performance and energy management practices. These factors encompass a wide range of aspects, including workload, fatigue, stress, situational awareness, and teamwork, which can have a substantial impact on operator performance and contribute to either error or success. Furthermore, organizational factors are of utmost importance within nuclear power plants. These factors encompass the management systems, processes, and culture within the plant, directly affecting overall performance and WEM. Elements such as leadership, communication, training,

Table 3
Comparison of success factors with the integration of PSFs and WEM

PSFs	*Performance Shaping Factors (PSFs)																								**Workplace Energy Management (WEM)																									F	%
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49		
TE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X									X	X	X	X	X	X	X	X	X	X	X																26	53
SF	X	X		X					X		X	X	X	X	X	X	X	X	X					X	X	X	X	X	X	X	X	X			X	X	X													25	51
CO	X	X	X	X					X	X	X	X	X	X	X		X		X	X				X		X					X	X	X	X		X		X	X	X										24	49
MO		X		X					X	X	X	X			X		X		X		X					X		X			X	X	X				X		X		X	X								19	39
TMS	X											X														X	X	X	X	X	X		X	X		X	X	X					X	X					X	16	33
TP			X		X	X		X			X	X	X						X			X	X	X		X	X	X																						14	29
WO	X				X	X	X	X				X							X			X	X	X	X	X		X																						13	27
A																					X								X				X		X		X		X			X			X		X			9	18
P																													X		X				X		X		X	X				X				X		8	16
C																X													X			X							X		X		X	X			X			8	16
CI																													X	X								X	X			X			X	X		X		8	16
RM																													X	X						X		X	X									X		6	12
C											X						X			X				X											X															5	10
S										X			X																																					2	4
I										X													X																											2	4
CR																				X			X																											2	4
F														X																																				1	2

*Performance Shaping Factors (PSFs)

1- [32]
2- [42]
3- [26]
4- [28]
5- [44]
6- [37]
7- [38]
8- [39]
9- [45]
10- [43]
11- [47]
12- [48]
13- [49]
14- [40]
15- [41]
16- [56]
17- [58]
18- [57]
19- [55]
20- [59]
21- [60]
22- [63]
23- [64]
24- [36]

**Workplace Energy Management

25- [35]
26- [4]
27- [34]
28- [50]
29- [75]
30- [79]
31- [85]
32- [76]
33- [77]
34- [78]
35- [83]
36- [82]
37- [66]
38- [90]
39- [80]
40- [24]
41- [87]
42- [71]
43- [88]
44- [89]
45- [67]
46- [17]
47- [91]
48- [92]
49- [86]

Note: Details and sequencing of the literature are presented in Table 3.

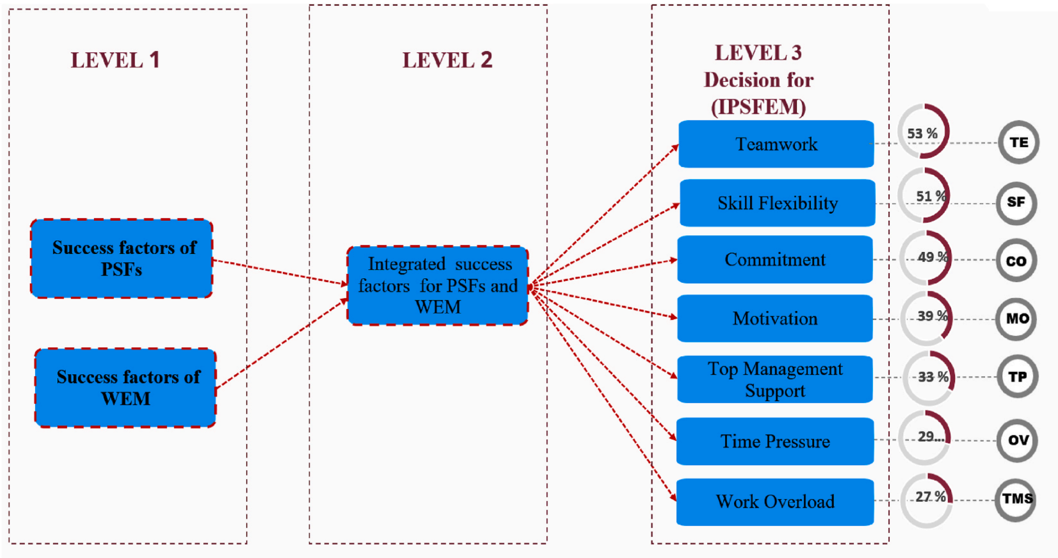

Fig. 3. Summary of identified success factors.

procedures, and safety culture have a profound influence on the effectiveness of energy management practices and the overall functioning of the plant. By recognizing and addressing these PSFs, nuclear power plants can identify potential performance challenges and implement strategies to enhance safety, efficiency, and the effective management of energy. This may involve optimizing training programs, improving communication and procedures, fostering a strong safety culture, and incorporating efficient energy management practices into the organizational framework. The integration of these PSFs ensures that the plant operates at its best, minimizing risks and maximizing performance in terms of energy management and overall operations.

The differences between PSFs for thermal power plants and traditional PSFs in nuclear power plants can be attributed to the unique characteristics and operational requirements of each type of power generation facility. Here are some reasons why the PSFs for thermal power plants may differ from those in nuclear power plants:

i. Operational Environment: Thermal power plants primarily rely on the combustion of fossil fuels, such as coal or natural gas, to generate electricity. In contrast, nuclear power plants utilize nuclear reactions to generate heat. The operational environments, safety considerations, and associated challenges in each type of plant differ significantly. As a result, the factors influencing human performance and energy management practices may also vary.
ii. Risk Factors: Nuclear power plants are associated with inherent risks due to the presence of radioactive materials and potential for catastrophic events. Consequently, PSFs in nuclear plants often emphasize factors such as radiation safety, strict adherence to procedures, and specialized training to ensure the safe operation of nuclear reactors. Thermal power plants, while still requiring safety protocols, may place relatively greater emphasis on factors such as fire safety, emissions control, and equipment maintenance.
iii. Technological Complexity: The technical aspects and complexity of the systems and equipment used in thermal power plants and nuclear power plants differ significantly. This disparity can lead to variations in the PSFs relevant to each type of plant. For example, nuclear power plants may focus on factors related to reactor control, radiation protection, and emergency response, while thermal power plants may prioritize factors related to heat management, turbine operations, and fuel efficiency.
iv. Regulatory Framework: The regulatory frameworks governing nuclear power plants and thermal power plants often differ due to the distinct risks and considerations associated with each type of plant. These regulatory variations can influence the emphasis and requirements placed on different PSFs, tailored to the specific industry regulations and guidelines.

It is essential to recognize and address these differences when studying and implementing PSFs in thermal power plants. Tailoring PSFs to the unique characteristics and challenges of thermal power generation helps ensure the safe and efficient operation of these facilities while promoting effective energy management practices.

3. Empirical study

The systematic review of the literature served as the foundation for developing a model focused on the sustainable integration of energy management in thermal power plants. This model was formulated based on the identified factors contributing to success and was subsequently validated by a group of energy experts and academic professionals. To evaluate the effectiveness of the proposed study model, an experimental study was carried out specifically in thermal power plants located in Iraq. The authors obtained official permissions from the electricity ministry to collect reliable data. Considering Iraq's numerous ongoing obstacles in supplying sufficient energy to its expanding population and the prevalent performance issues in Iraqi power plants, we deemed them an ideal subject for this study. In accordance with ethical standards, the instruments of the study were reviewed and approved by the academic and energy experts from various power plants, including the head engineers Yasser Abbas Hammadi and Ahmed Rasim Mahammed from Iraqi power plants, as well as Professor Syed Ali Raza Shah, the Dean of the Faculty of Engineering at Pakistan UET, and Professor Nik Hasnaa Mahmood from Universiti Teknologi Malaysia (UTM). Prior to participating in the experiments, informed consent was obtained from all participants, ensuring their voluntary participation, and understanding of the study's objectives and potential risks involved.

3.1. Data collection

Data collection was carried out at four thermal power plants in Iraq, involving multiple sources such as engineering staff, managers, technicians, and operators. These individuals provided the necessary information and insights crucial for the study. This study's unit of analysis was the organizational level exemplified by thermal power plants. The questionnaires used in this study were adapted from a previous study [1,24] and developed as closed-ended questions. The descriptive research design was chosen because it facilitates immediate comparative analysis. As a result, we conducted a series of meetings with relevant personnel to gain deeper insights into the problem at hand. These meetings proved instrumental in validating and cross-checking the issues and success factors identified for our study's model. In addition, they ensured that the factors outlined in the literature were aligned with the experiences and EMP of experts working in thermal power plants in Iraq. We conducted an empirical study to better understand the actual challenges faced by EMP in Iraqi thermal power plants. These steps allowed us to observe and comprehend the real issues firsthand, fostering a more comprehensive understanding of the subject matter.

3.2. Sample size

The sample size was drawn from four thermal power plants, representing 186 individuals out of a total population of 360, according to the equation developed by Ref. [96]. The study employed a 5-point Likert scale and a cross-sectional design, as recommended by Ref. [97]. The current investigation employed a simple random sampling technique: the respondents were randomly selected from the target population.

3.3. Data analysis

The study was carried out through two stages of analysis. In the first stage, preliminary data analysis was performed using IBM-SPSS. The preliminary test results proved that the study constructs do not have a problem in terms of outliers, skewness, kurtosis and common bias method. This stage aimed to thoroughly examine the data for potential issues and ensure its readiness for advanced analysis by the Partial least squares structural equation modeling (PLS-SEM).

4. Results and discussion

4.1. Measurement model analysis

To accomplish research objectives, this study follows the PLS-SEM guidelines proposed by Ref. [95] to investigate the causal relationship between the exogenous (independent) variable and the endogenous (dependent) variable. This involves thoroughly examining the measurement model to assess the reliability and validity of the measurements. In partial least squares structural equation modeling (PLS-SEM), the measurement model is crucial for assessing the reliability and validity of the measurement instruments used to represent the latent constructs or variables in the research model. This model includes the following essential steps:

4.1.1. Examining model reliability

Previous studies have outlined the initial step in assessing the reflective measurement model by examining indicators through factor loadings. The existing literature has provided guidelines for calculating factor loadings, suggesting that values above 0.6 are desirable [98]. All items within the indicator exhibit satisfactory reliability. The results of the factor loadings and detailed results of the model testing are presented in Fig. 4.

In the context of Smart-PLS, load factor values refer to the strength of the relationships between the observed variables (indicators) and the latent construct in a structural equation model. Good load factor values indicate a strong and reliable connection between the indicators and the underlying construct. Based on Fig. 4, it is evident that all loading values for the construct meet the criteria established by previous studies. The experimental test results further demonstrate that the study model exhibits exceptional load factors, surpassing the threshold of 0.6 set by previous research for each indicator, as shown in Table 4.

4.1.2. Examining internal consistency reliability of model

Internal consistency reliability analysis is a statistical technique that is employed to evaluate the reliability and consistency of measurement items within a scale or instrument. It helps researchers determine to what extent the items consistently measure the same construct or concept. By evaluating internal consistency, researchers can establish the dependability and coherence of the instrument's

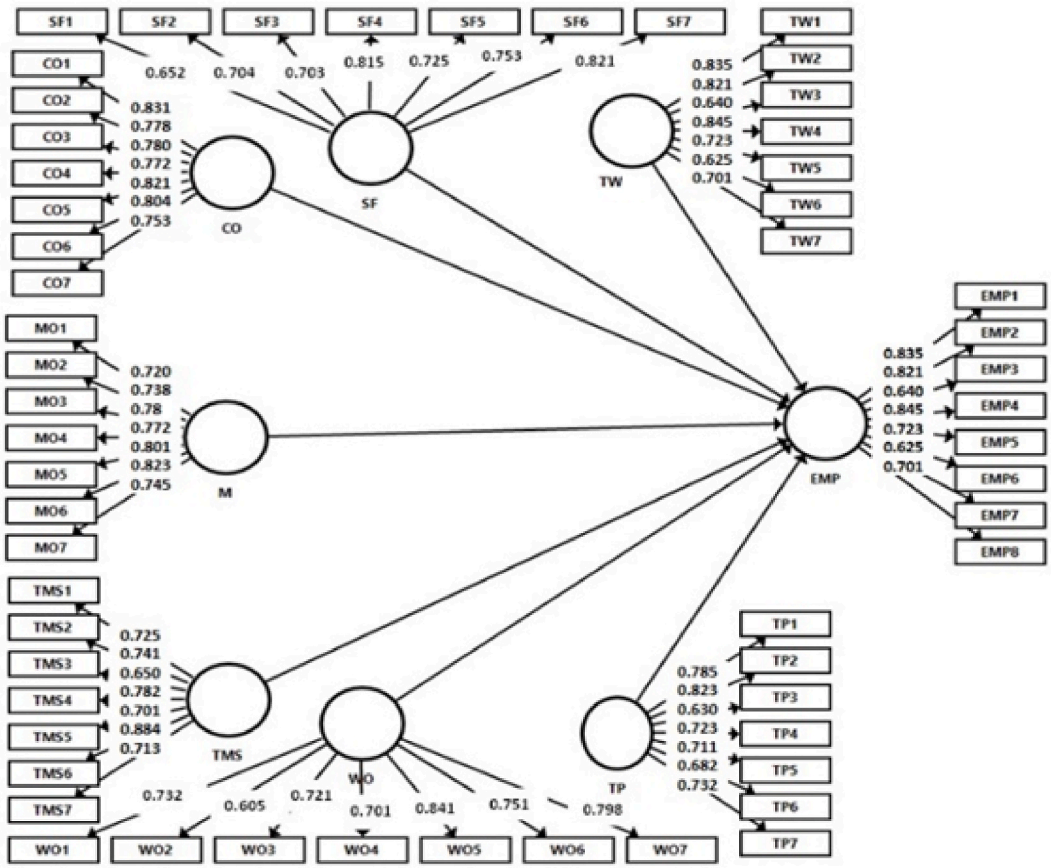

Fig. 4. Measurement model via the PLS smart algorithm.

measurements, thereby enhancing the validity and reliability of the collected data. Composite reliability (CR) and Cronbach's alpha (CA) are commonly used metrics to evaluate internal consistency. Acceptable values for these metrics typically range from 0.60 to 0.70, with values above 0.70 considered good [98]. In assessing the reliability of the constructs model, the CR measure should ideally exceed 0.7 [99]. In this study, the CA value surpasses the recommended threshold of 0.70 [100], and the CR value is higher than the cutoff of 0.7 [101]. The CR and CA can be observed in Figs. 5 and 6, respectively.

4.2. Examining model validity

Assessing the validity of the model is of utmost importance when evaluating the quality and reliability of a measurement model. The convergent and discriminant validity tests are two widely used tests to evaluate the model's validity. The convergent validity test focuses on determining the extent to which different indicators within a construct converge or agree. Typically, this is evaluated using the average variance extracted (AVE) metric, which measures the amount of variance captured by the indicators. The higher the AVE, the greater the convergent validity, indicating that the indicators measure the same construct effectively. On the contrary, the discriminant validity test aims to examine the uniqueness of the measurement model's various constructs. It involves analyzing the correlations between indicators of distinct constructs to ensure that these correlations are lower than those between indicators of the same construct. The heterotrait–monotrait (HTMT) ratio of correlations is commonly employed to quantitatively assess discriminant validity. A value below 1 suggests sufficient distinctiveness between the constructs. By conducting these tests, researchers can thoroughly evaluate the validity of the measurement model.

The findings and conclusions derived from the subsequent data analysis are bolstered by establishing a strong model validity, providing a solid foundation for research results [98]. According to the literature, each construct within itself should be higher than others in the same column. For example, the results in Table 5 show the indicator CO with CO = 0.722 which it higher than others in the same column, and so on. The results show that each variable's AVE exceeded 0.5 (50%) on average. This suggests that each item within the construct explains more than 50% of the variance within the respective construct. Table 5 demonstrates that the square root of AVE for each construct should be greater than its correlation with other constructs.

The second criterion utilized to evaluate the discriminant validity is the HTMT, which provides more precise results according to previous studies. According to Ref. [95], an HTMT threshold value must be less than 0.85 to be acceptable. The HTMT results presented

Table 4
Results of factor loading for indicators.

Indicators	Factors loading >0.6	Average	Indicators	Factors loading >0.6	Average
SF 1	0.652	0.739	CO1	0.831	0.791
SF 2	0.704		CO2	0.778	
SF 3	0.703		CO3	0.78	
SF 4	0.815		CO4	0.772	
SF 5	0.725		CO5	0.821	
SF 6	0.753		CO6	0.804	
SF 7	0.821		CO7	0.753	
MO1	0.72	0.768	TMS1	0.725	0.742
MO2	0.738		TMS2	0.741	
MO3	0.78		TMS3	0.65	
MO4	0.772		TMS4	0.782	
MO5	0.801		TMS5	0.701	
MO6	0.825		TMS6	0.884	
MO7	0.745		TMS7	0.713	
WO1	0.732	0.735	TP1	0.785	0.726
WO2	0.605		TP2	0.823	
WO3	0.721		TP3	0.63	
WO4	0.701		TP4	0.723	
WO5	0.841		TP5	0.711	
WO6	0.751		TP6	0.682	
WO7	0.798		TP7	0.732	
TW1	0.835	0.741	EMP1	0.835	0.749
TW2	0.821		EMP2	0.821	
TW3	0.64		EMP3	0.64	
TW4	0.845		EMP4	0.845	
TW5	0.723		EMP5	0.723	
TW6	0.625		EMP6	0.625	
TW7	0.701		EMP7	0.701	
			EMP8	0.804	

in Table 6 demonstrate that this study met the criteria and threshold established by previous research. Accordingly, the results of Table 6 were higher than 0.85, which is the threshold set by theories for an acceptable model.

In summary, the measurement model results demonstrate that the constructs included in the model exhibit high reliability, validity, and strong internal consistency. The analysis confirms that the model meets the criteria established in previous studies and surpasses the specified thresholds for these measures. In particular, the results indicate that all constructs possess discriminant validity.

4.3. Normality test

To enhance reliability and ensure the normal distribution of the data, this study examined the regression standardized residual histograms and normal probability P–P plots. These visual tools are commonly used to assess normality. Regression standardized residual histograms are frequency distribution graphs where the rectangles' widths are proportional to the class intervals, and their

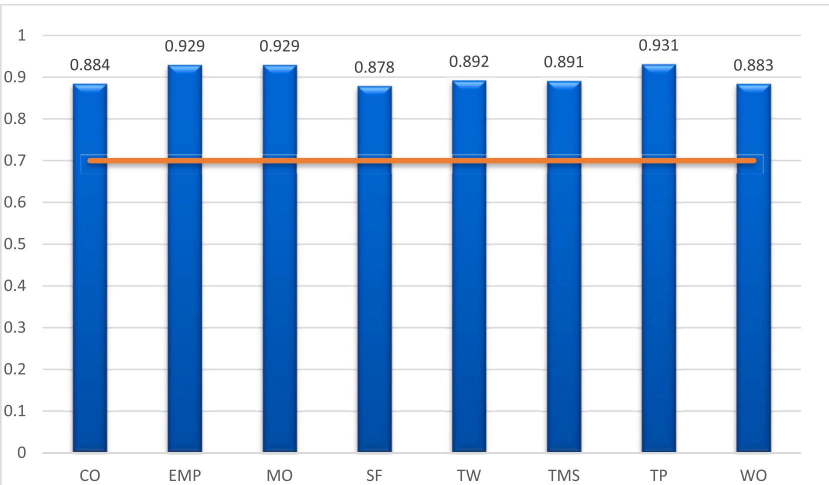

Fig. 5. Composite reliability results.

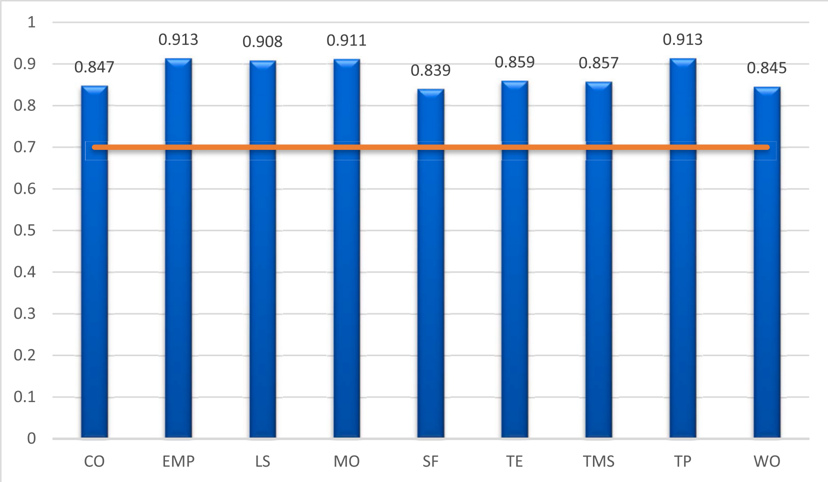

Fig. 6. Cronbach's alpha results.

Table 5
Validity of the measurement model.

	CO	EMP	MO	SF	TE	TMS	TP	WO
CO	**0.722**							
EMP	0.712	**0.788**						
MO	0.545	0.717	**0.808**					
SF	0.405	0.562	0.434	**0.713**				
TW	0.450	0.664	0.563	0.345	**0.736**			
TMS	0.560	0.690	0.521	0.396	0.569	**0.734**		
TP	0.597	0.778	0.606	0.500	0.563	0.606	**0.811**	
WO	0.519	0.658	0.513	0.417	0.494	0.525	0.568	**0.720**

Table 6
Results of discriminant validity by HTMT criterion.

	CO	EMP	MO	SF	TE	TMS	TP	WO
CO								
EMP	0.809							
MO	0.619	0.784						
SF	0.473	0.636	0.492					
TE	0.524	0.748	0.632	0.396				
TMS	0.656	0.778	0.587	0.460	0.661			
TP	0.677	0.849	0.662	0.566	0.633	0.682		
WO	0.610	0.747	0.584	0.489	0.573	0.607	0.647	

heights represent the corresponding frequencies [102]. The objective of inspecting these histograms is to ensure that the curve is centered on the line, indicating that the tails on either side of the curve are symmetrical mirror images of one another. This symmetry indicates that the data have a perfect normal distribution.

In addition, P–P plots of normal probability were utilized to assess normality. These graphs compare the observed cumulative probabilities of the data with the cumulative probabilities expected from a normal distribution. If the points on the plot align closely with the diagonal line, it indicates that the data closely follow a normal distribution. By analyzing the regression standardized residual histograms and normal probability P–P plots, researchers can ensure the normal distribution of the data, thereby increasing the reliability of subsequent analyses and interpretations. The examination results confirm the normal distribution of the data.

Fig. 7 depicts the regression standardized residual histogram, whereas Fig. 8 displays the normal P–P plot. Both figures display symmetric bell-shaped curves with no significant deviations from the norm. These results provide solid evidence that the relationship between the set of independent variables and the dependent variable is significant and normally distributed [103].

This study is in line with previous studies, such as [104] and the study by Ref. [105]. This confirmed that the integration of PSFs and WEM contributes clearly to enhancing the sustainable EMP. Upon comparing our novel model, which integrates PSFs and WEM, with previous studies, several key aspects of similarities, differences, and advancements emerge. In terms of similarities, our model aligns with previous research in recognizing the significance of both PSFs and WEM in achieving sustainable energy management practices.

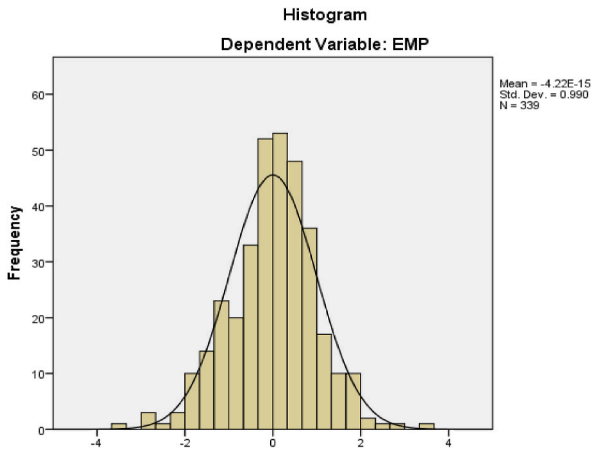

Fig. 7. Regression standardized residual.

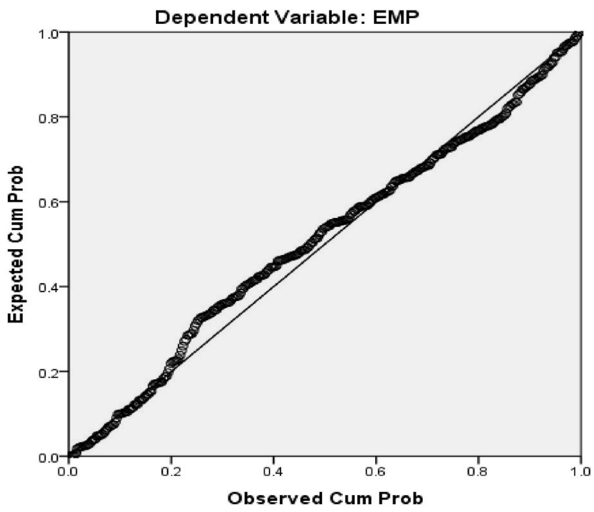

Fig. 8. Normal P–P plots plot of regression standard residual.

Several studies have acknowledged the importance of individual factors, such as teamwork, skill flexibility, commitment, and motivation, in enhancing energy management performance [106]. However, our model distinguishes itself through the integration of these factors, aiming to overcome the challenges of sustainable energy management. While previous studies have examined individual factors separately, our model combines them to form a comprehensive framework that considers the interplay and synergistic effects of PSFs and WEM on energy management sustainability. This integration contributes to the advancement of existing research by providing a holistic perspective and addressing the limitations of previous studies. By considering the combined influence of PSFs and WEM, our model offers a more comprehensive understanding of the complex dynamics involved in sustainable energy management in power plants.

5. Conclusions, limitations, and future work

Integrating PSFs and WEM is the optimal solution for future sustainable EMP in power plants. Previous literature suggests that the lack of integration between these factors results in poor energy performance. This study systematically reviewed 90 articles to identify PSF and WEM success factors. Five databases were examined between 2013 and 2023 as part of the review. Based on our findings, the study developed a novel model to improve and integrate power plant performance. To test the model's effectiveness, we established research hypotheses by integrating the success factors of PSFs and EMP into a single system, as shown in Table 3. In conclusion, this research paper has successfully built a rigorous and tight model for predicting energy management in thermal power plants. The model considers the various factors that contribute to PSFs and EMP in thermal power plants and has been shown to accurately predict energy management. The model provides engineers and energy managers with a valuable tool for making informed decisions regarding energy management in thermal power plants, and it has the potential to significantly impact the energy sector.

The research presented a groundbreaking model that outlines future directions for sustainable energy management in power plants. One of the key strengths lies in its introduction of a novel methodology that integrates performance-shaping factors with energy management in the workplace. This unique approach acknowledges the multifaceted nature of energy management and recognizes the influence of various factors on overall performance. By considering performance-shaping factors such as human behavior, organizational culture, and technological advancements, the research offers a comprehensive framework for effective and sustainable energy management. This holistic perspective enables power plants to address not only technical aspects but also human and organizational aspects that impact energy efficiency.

Furthermore, the model provides a roadmap for decision-makers to implement practical strategies and interventions. It empowers them to optimize energy management practices, identify areas for improvement, and foster a culture of energy efficiency within power plants. This research serves as a valuable resource for industry professionals, policymakers, and researchers seeking innovative solutions to promote sustainability and enhance energy management practices in power plants.

While the study utilizing questionnaires to collect data from thermal power plants and analyzing the data using the PLS-SMART method has several strengths, it is important to acknowledge its limitations as well. The following are potential limitations associated with this approach:

5.1. Limitations

The study has the following limitations:

i. The effectiveness of the study is dependent on a high response rate from the targeted thermal power plants. However, low response rates can introduce a selection bias and affect the generalizability of the findings. It is important to consider the representativeness of the sample and potential biases that may arise from non-response.
ii. Relying on questionnaires introduces the possibility of self-report bias, where respondents may provide inaccurate or biased information. This bias can arise from memory limitations, social desirability, or subjective interpretations of the questions. It is crucial to consider the potential impact of this bias on the validity and reliability of the collected data.
iii. The scope of the study was limited to thermal power plants in the energy sectors.
iv. The study's sample size could be expanded to include more thermal power plants for a more comprehensive analysis.
v. The SLR revealed that most studies on improving the energy and PSF performance were focused on industrial sectors and nuclear power plants, with a scarcity of research on thermal and gas power plants.
vi. The study may not have captured all relevant factors affecting the integration of PSFs and WEM in thermal power plants.
vii. The findings of the study may be context-specific to thermal power plants and may not be easily generalized to other industries or settings. Factors such as organizational culture, technological infrastructure, or regulatory frameworks specific to thermal power plants may limit the transferability of the findings.

Acknowledging these limitations allows for a comprehensive understanding of the potential constraints and considerations associated with the study's methodology, theory, and data analysis. Researchers should address these limitations transparently and take them into account when drawing conclusions and making recommendations based on the study's findings.

5.2. Future work

The following are directions for future research:

i. The SLR revealed that most studies on improving energy and PSF performance were focused on industrial sectors and nuclear power plants, with a scarcity of research on thermal and gas power plants. Therefore, further research is recommended to enhance the performance of thermal and gas power plants.
ii. Further research must also extend the study's findings to other power plants and industry scenarios, validate the integrated model in real-world situations, and improve performance in thermal and gas power plants.
iii. Future studies can also explore the potential to integrate other energy management programs, such as ISO 50001, into the energy management process in thermal power plants.
iv. Finally, the impact of leadership style on the success of the integration of PSFs and EMP must be investigated.

Funding statement

This work was supported / funded by the Ministry of Higher Education Malaysia/ University of Technology Malaysia under the Fundamental Research Grant Scheme (FRGS/1/2021/TK0/UTM/02/45).

Author contribution statement

Ahmed Ali Ajmi, Khairur Rijal Jamaludin: Wrote the paper and performed the experiments.
Noor Shakir Mahmood: Conceived and designed the experiments.
Hayati Habibah Abdul Talib: Analyzed and interpreted the data.

Shamsul Sarip, Hazilah Mad Kaidi: Contributed reagents, materials, analysis tools or data.

Data availability statement

Data will be made available on request.

Declaration of competing interest

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

Acknowledgment

The authors express their sincere gratitude to Universiti Teknologi Malaysia (UTM)/Razak Faculty of Technology and Informatics for providing financial support. Furthermore, the authors are incredibly grateful to the Iraqi Ministry of Electricity for providing the necessary data.

References

[1] A.-A. Ajmi, et al., Novel approach to energy management via performance shaping factors in power plants, Computers, Materials \& Continua 73 (3) (2022) 5025–5039.
[2] S. Kang, P.H. Seong, Performance shaping factor taxonomy for human reliability analysis on mitigating nuclear power plant accidents caused by extreme external hazards, Annals of Nuclear Energy 145 (2020), 107533.
[3] A.-M. Teperi, V. Puro, H. Ratilainen, Applying a new human factor tool in the nuclear energy industry, Safety science 95 (2017) 125–139.
[4] C.M. La Fata, et al., Human error contribution to accidents in the manufacturing sector: a structured approach to evaluate the interdependence among performance shaping factors, Safety Science 161 (2023), 106067.
[5] J. Park, W. Jung, J. Kim, Inter-relationships between performance shaping factors for human reliability analysis of nuclear power plants, Nuclear Engineering and Technology 52 (1) (2020) 87–100.
[6] N. Ade, S.C. Peres, A review of human reliability assessment methods for proposed application in quantitative risk analysis of offshore industries, International Journal of Industrial Ergonomics 87 (2022), 103238.
[7] C. Challis, et al., Human factors in dairy industry process control for energy reduction, Journal of Cleaner Production 168 (2017) 1319–1334.
[8] H. Diao, M. Ghorbani, Production risk caused by human factors: a multiple case study of thermal power plants, Frontiers of Business Research in China 12 (1) (2018) 15.
[9] Y. Liu, X. Hu, K. Feng, Economic and environmental implications of raising China's emission standard for thermal power plants: an environmentally extended CGE analysis, Resources, Conservation and Recycling 121 (2017) 64–72.
[10] S.S. Ofori-Parku, "Whale deaths" are unnatural: a local NGO's framing of offshore oil production risks in Ghana, Science Communication 38 (6) (2016) 746–775.
[11] M.N. Tanic, et al., Natural radionuclides in soil profiles surrounding the largest coal-fired power plant in Serbia, Nuclear technology and radiation protection 31 (3) (2016) 247–259.
[12] A. Rodriguez-Iruretagoiena, et al., Fate of hazardous elements in agricultural soils surrounding a coal power plant complex from Santa Catarina (Brazil), Science of the Total Environment 508 (2015) 374–382.
[13] M. Arab, et al., Characterization of pollution indices in soil surrounding a power plant by laser induced breakdown spectroscopy, Analytical Letters 48 (2) (2015) 360–370.
[14] E. Vollmer, D. Hermann, O. Mußhoff, Is the risk attitude measured with the Holt and Laury task reflected in farmers' production risk? European Review of Agricultural Economics 44 (3) (2017) 399–424.
[15] A. Mardani, et al., A review of multi-criteria decision-making applications to solve energy management problems: two decades from 1995 to 2015, Renewable and Sustainable Energy Reviews 71 (2017) 216–256.
[16] N.S. Mahmood, et al., Modeling energy management sustainability: smart integrated framework for future trends, Energy Reports 8 (2022) 8027–8045.
[17] J.R.N. Lopes, et al., A new model for assessing industrial worker behavior regarding energy saving considering the theory of planned behavior, norm activation model and human reliability, Resources, Conservation and Recycling 145 (2019) 268–278.
[18] E. Erell, B.A. Portnov, M. Assif, Modifying behaviour to save energy at home is harder than we think, Energy and Buildings 179 (2018) 384–398.
[19] C. Boomsma, et al., The feasibility of saving energy in challenging organisational contexts: testing energy visualisation in a social services office in the United Kingdom, Energy Research & Social Science 15 (2016) 58–74.
[20] M. Greaves, L.D. Zibarras, C. Stride, Using the theory of planned behavior to explore environmental behavioral intentions in the workplace, Journal of Environmental Psychology 34 (2013) 109–120.
[21] F. Igor, et al., Applied aspects of formation of facilitation-reflective methodology of personnel motivation management in the energy management system, in: International Conference on Business and Technology, Springer, 2020.
[22] B. Jovanović, J. Filipović, V. Bakić, Energy management system implementation in Serbian manufacturing–Plan-Do-Check-Act cycle approach, Journal of Cleaner Production 162 (2017) 1144–1156.
[23] M.T. Johansson, P. Thollander, A review of barriers to and driving forces for improved energy efficiency in Swedish industry–Recommendations for successful in-house energy management, Renewable and Sustainable Energy Reviews 82 (2018) 618–628.
[24] N.S. Mahmood, et al., Modeling the sustainable integration of quality and energy management in power plants, Sustainability 14 (4) (2022) 2460.
[25] A.K. Akobeng, Understanding systematic reviews and meta-analysis, Archives of disease in childhood 90 (8) (2005) 845–848.
[26] T. Jitpaiboon, S.M. Smith, Q. Gu, Critical success factors affecting project performance: an analysis of tools, practices, and managerial support, Project Management Journal 50 (3) (2019) 271–287.
[27] S.R. Kamat, A.A. Ajmi, N.S. Mahmood, Thermal comfort at the turbine room in the power station: a systematic review, Journal of Advanced Manufacturing Technology (JAMT) 10 (2) (2016) 79–90.
[28] J. Ahuja, et al., Do human critical success factors matter in adoption of sustainable manufacturing practices? An influential mapping analysis of multi-company perspective, Journal of Cleaner Production 239 (2019), 117981.
[29] N.S. Mahmood, et al., From literature to integrated intelligent framework for energy management success in power plants, in: 2021 IEEE 19th Student Conference on Research and Development, SCOReD), 2021.
[30] H.A. Masri, A.A.M. Jaaron, Assessing green human resources management practices in Palestinian manufacturing context: an empirical study, Journal of Cleaner Production 143 (2017) 474–489.

[31] A. Kumar, et al., Evaluating the human resource related soft dimensions in green supply chain management implementation, Production Planning & Control 30 (9) (2019) 699–715.
[32] A.B.L. de Sousa Jabbour, et al., When titans meet–Can industry 4.0 revolutionise the environmentally-sustainable manufacturing wave? The role of critical success factors, Technological Forecasting and Social Change 132 (2018) 18–25.
[33] J. Liu, et al., A Bayesian belief network framework for nuclear power plant human reliability analysis accounting for dependencies among performance shaping factors, Reliability Engineering & System Safety 228 (2022), 108766.
[34] S.F. Rasool, et al., Exploring the role of organizational support, and critical success factors on renewable energy projects of Pakistan, Energy 243 (2022), 122765.
[35] L. Wang, et al., Performance Shaping Factors Dependence Assessment through Moderating and Mediating Effect Analysis, vol. 202, Reliability Engineering & System Safety, 2020, 107034.
[36] C. Franciosi, et al., A taxonomy of performance shaping factors for human reliability analysis in industrial maintenance, Journal of Industrial Engineering and Management-Jiem 12 (1) (2019) 115–132.
[37] R.J. Johari, N.S. Ridzoan, A. Zarefar, The influence of work overload, time pressure and social influence pressure on auditors' job performance, International Journal of Financial Research 10 (3) (2019).
[38] E. Kissi, et al., Ascertaining the interaction effects among organisational citizenship behaviour, work overload and employees' performance in the Ghanaian construction industry, International Journal of Productivity and Performance Management 68 (7) (2019) 1235–1249.
[39] Q. Ye, D. Wang, W. Guo, Inclusive leadership and team innovation: the role of team voice and performance pressure, European Management Journal 37 (4) (2019) 468–480.
[40] M.A. Mahzan, A.N.A. b Ahmad, A. Bakri, A Review on Critical Success Factors for Total Productive Maintenance and Development of Research Framework, 2018.
[41] S. Seleem, E.-A. Attia, A. El-Assal, Identification of critical success factors for total productive maintenance, in: The International Conference on Applied Mechanics and Mechanical Engineering, Military Technical College, 2018.
[42] B. Aquilani, et al., A systematic literature review on total quality management critical success factors and the identification of new avenues of research, The TQM Journal 27 (8) (2017) 1076–1101.
[43] D. Seth, R. Shrivastava, S. Shrivastava, An empirical investigation of critical success factors and performance measures for green manufacturing in cement industry, Journal of Manufacturing Technology Management 27 (8) (2016) 1076–1101.
[44] A. Bruggen, An Empirical Investigation of the Relationship between Workload and Performance, Management Decision, 2015.
[45] A. Ahimbisibwe, R.Y. Cavana, U. Daellenbach, A contingency fit model of critical success factors for software development projects, Journal of Enterprise Information Management 28 (1) (2015) 7–33.
[46] S. Ali, Y.A. Farooqi, Effect of work overload on job satisfaction, effect of job satisfaction on employee performance and employee engagement (a case of public sector University of Gujranwala Division), International Journal of Multidisciplinary Sciences and Engineering 5 (8) (2014) 23–30.
[47] Z. Alias, et al., Determining critical success factors of project management practice: a conceptual framework, Procedia-Social and Behavioral Sciences 153 (2014) 61–69.
[48] J. Ram, D. Corkindale, M.-L. Wu, Implementation critical success factors (CSFs) for ERP: do they contribute to implementation success and post-implementation performance? International Journal of Production Economics 144 (1) (2013) 157–174.
[49] K.-C. Ng, G.G.G. Goh, U.C. Eze, Critical success factors of total productive maintenance implementation: a review, in: 2011 IEEE International Conference on Industrial Engineering and Engineering Management, IEEE, 2011.
[50] R.L. Boring, How Many Performance Shaping Factors Are Necessary for Human Reliability Analysis? Idaho National Laboratory (INL), 2010.
[51] J.A. Farris, et al., Critical success factors for human resource outcomes in Kaizen events: an empirical study, International Journal of Production Economics 117 (1) (2009) 42–65.
[52] T.V.N. Hoang, K. Lapumnuaypon, Critical Success Factors in Merger & Acquisition Projects: A Study from the Perspectives of Advisory Firms, Handelshögskolan vid Umeå universitet, 2008.
[53] H. Sun, W.C. Wing, Critical success factors for new product development in the Hong Kong toy industry, Technovation 25 (3) (2005) 293–303.
[54] A. Moeuf, et al., Identification of critical success factors, risks and opportunities of Industry 4.0 in SMEs, International Journal of Production Research 58 (5) (2020) 1384–1400.
[55] L. Clack, Employee Engagement: Keys to Organizational Success, The Palgrave Handbook of Workplace Well-Being, 2020, pp. 1–28.
[56] V. Kumar, R. Sharma, An Empirical Investigation of Critical Success Factors Influencing the Successful TQM Implementation for Firms with Different Strategic Orientation, International Journal of Quality & Reliability Management, 2017.
[57] E. Samimi, et al., Identifying and prioritizing critical success factors (CSFs) in retaining and developing knowledge workers in oil and gas project-based companies, Indian Journal of Science and Technology 8 (11) (2015) 1–10.
[58] A.C. Ogwueleka, The critical success factors influencing project performance in Nigeria, International Journal of Construction Project Management 4 (2) (2012) 159.
[59] D. Bangwal, P. Tiwari, Workplace Environment, Employee Satisfaction and Intent to Stay, International Journal of Contemporary Hospitality Management, 2019.
[60] A.P. Sarode, M. Shirsath, The factors affecting employee work environment & it's relation with employee productivity, International Journal of Science and Research 3 (11) (2014) 2735–2737.
[61] T.J. Kim, et al., An empirical study of the personality effects on diagnosis performance of human operators in unexpected plant conditions of NPPs, Annals of Nuclear Energy 145 (2020), 107557.
[62] P.A. Hancock, G. Matthews, Workload and performance: associations, insensitivities, and dissociations, Human factors 61 (3) (2019) 374–392.
[63] L. Hendry, Y. Huang, M. Stevenson, Workload Control, International Journal of Operations & Production Management, 2013.
[64] P.H. Mohseni, et al., Assessment of the living and workplace health and safety conditions of site-resident construction workers in Tehran, Iran, International journal of occupational safety and ergonomics 21 (4) (2015) 568–573.
[65] D. Andalib Ardakani, A. Soltanmohammadi, Investigating and analysing the factors affecting the development of sustainable supply chain model in the industrial sectors, Corporate Social Responsibility and Environmental Management 26 (1) (2019) 199–212.
[66] R.D. Raut, B. Narkhede, B.B. Gardas, To identify the critical success factors of sustainable supply chain management practices in the context of oil and gas industries: ISM approach, Renewable and Sustainable Energy Reviews 68 (2017) 33–47.
[67] W. Wu, W. Mao, Human factors in the role of energy efficiency, in: W. Cui, S. Fu, Z. Hu (Eds.), Encyclopedia of Ocean Engineering, Springer, 2020, pp. 1–7.
[68] X. Gong, et al., Integrating labor awareness to energy-efficient production scheduling under real-time electricity pricing: an empirical study, Journal of Cleaner Production 168 (2017) 239–253.
[69] G. Mert, S. Waltemode, J.C. Aurich, How services influence the energy efficiency of machine tools: a case study of a machine tool manufacturer, Procedia CIRP 29 (2015) 287–292.
[70] S.S. Shahzad, et al., Energy efficiency and user comfort in the workplace: Norwegian cellular vs. British open plan workplaces, Energy Procedia 75 (2015) 807–812.
[71] U. Dombrowski, S. Ernst, M. Evers, Employee participation for increasing energy efficiency in factory operations, in: Enabling Manufacturing Competitiveness and Economic Sustainability, Springer International Publishing, Cham, 2014.
[72] J. Huang, et al., A maintenance and energy saving joint control Scheme for sustainable manufacturing systems, Procedia CIRP 80 (2019) 263–268.
[73] R. Galvin, Humans and stuff: interweaving social and physical science in energy policy research, Energy Research & Social Science 26 (2017) 98–102.
[74] A.A. Saleh, A.H. Mohammed, M.N. Abdullah, Critical success factors for sustainable university: a framework from the energy management view, Procedia-Social and Behavioral Sciences 172 (2015) 503–510.

[75] A.A. Saleh, et al., A partial least squares structural equation modeling (PLS-SEM) of energy management critical success factors to sustainable university in Malaysia, Journal of Critical Reviews 7 (8) (2020) 1330–1338.
[76] Y. Li, et al., Review of critical success factors (CSFs) for green building projects, Building and Environment 158 (2019) 182–191.
[77] S. Luthra, D. Garg, A. Haleem, The impacts of critical success factors for implementing green supply chain management towards sustainability: an empirical investigation of Indian automobile industry, Journal of Cleaner Production 121 (2016) 142–158.
[78] P. Karcher, R. Jochem, Success factors and organizational approaches for the implementation of energy management systems according to ISO 50001, The TQM journal 27 (4) (2015) 361–381.
[79] A. Mohammed Alia, M. Abdullah, Critical success factors for successful energy management implementation towards sustainability in Malaysian Universities, World Academy of Science, Engineering and Technology International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering 9 (3) (2015) 740–748.
[80] Y. Jin, et al., An energy management maturity model for China: linking ISO 50001: 2018 and domestic practices, Journal of Cleaner Production 290 (2021), 125168.
[81] P. Thollander, J. Maria, Energy management in industry-success factors and way forward, in: World Engineering Conference and Convention (WECC), 2015. Kyoto, Japan, 28 nov-4 dec 2015.
[82] J.-C. Brunke, M. Johansson, P. Thollander, Empirical investigation of barriers and drivers to the adoption of energy conservation measures, energy management practices and energy services in the Swedish iron and steel industry, Journal of Cleaner Production 84 (2014) 509–525.
[83] Y. Zhang, et al., Analysis for critical success factors of energy performance contracting (EPC) projects in China, in: 2008 IEEE International Conference on Industrial Engineering and Engineering Management, IEEE, 2008.
[84] A. Ahmed, et al., Intelligent integrated model for improving performance in power plants, CMC-COMPUTERS MATERIALS & CONTINUA 70 (3) (2022) 5783–5801.
[85] S.R. Kamat, N.S. Mahmood, A.A. Ajmi, Review and establishing framework model to adoption iso 50001 energy management system in power stations, Journal of Advanced Manufacturing Technology (JAMT) 10 (2) (2016) 67–78.
[86] Mahmood, et al., Energy management cultures assessment and its impact on the quality of service in power plants a research gap for future studies, PalArch's Journal of Archaeology of Egypt/Egyptology 17 (7) (2020) 11398–11412.
[87] L. Sivill, et al., Success factors of energy management in energy-intensive industries: development priority of energy performance measurement, International journal of energy research 37 (8) (2013) 936–951.
[88] G. Zhao, et al., Prioritizing critical success factors for sustainable energy sector in China: a DEMATEL approach, Energy Strategy Reviews (2021), 100635.
[89] A. Lawrence, et al., Drivers, barriers and success factors for energy management in the Swedish pulp and paper industry, Journal of Cleaner Production 223 (2019) 67–82.
[90] A. Abdullah, A.H. Mohammed, M.N. Abdullah, Critical success factors for sustainable university: a framework from the energy management view, Procedia-Social and Behavioral Sciences 172 (2015) 503–510.
[91] P. Xu, E.H.-W. Chan, Q.K. Qian, Success factors of energy performance contracting (EPC) for sustainable building energy efficiency retrofit (BEER) of hotel buildings in China, Energy policy 39 (11) (2011) 7389–7398.
[92] N. Firdaus, H.A. Samat, N. Mohamad, Maintenance for energy efficiency: a review, in: IOP Conference Series: Materials Science and Engineering, 2019.
[93] R. Wang, J. Wen, P. Li, A SEM-based research on influencing factors of team situation awareness in nuclear power plants, Frontiers in Energy Research 10 (2022), 982932.
[94] C.-S. Nam, B.-S. Lee, Development of an Integrated Human Error Simulation Model in Nuclear Power Plant Decommissioning Activities, Science and Technology of Nuclear Installations, 2023, p. 2023.
[95] M. Porthin, M. Liinasuo, T. Kling, Effects of Digitalization of Nuclear Power Plant Control Rooms on Human Reliability Analysis–A Review, vol. 194, Reliability Engineering & System Safety, 2020, 106415.
[96] U. Sekaran, R. Bougie, Research Methods for Business: A Skill Building Approach, John Wiley & Sons, 2016.
[97] J. Sekaran, Cronbachs Alpha: A Tool for Assessing the Reliability of Scales, 2009.
[98] J.F. Hair Jr., et al., A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM), Sage publications, 2021.
[99] J.F. Hair Jr., et al., Advanced Issues in Partial Least Squares Structural Equation Modeling, saGe publications, 2017.
[100] L.J. Cronbach, Coefficient alpha and the internal structure of tests, psychometrika 16 (3) (1951) 297–334.
[101] J.C. Nunnally, I.H. Bernstein, Psychometric Theory, third ed., McGraw-Hill, New York, 1994 [etc].
[102] J. Pallant, SPSS Survival Manual: A Step by Step Guide to Data Analysis Using IBM SPSS, Routledge, 2020.
[103] Ali, et al., Implications COVID-19 on performance and energy management in the production electricity, Computers, Materials & Continua 69 (1) (2021) 895–911.
[104] K.M. Smith, M.E. Hassall, Human factors for energy management: features, fit and field study, Eceee industrial 48 (3) (2020) 171–180.
[105] L. Hou, et al., Energy management for solar-hydrogen microgrids with vehicle-to-grid and power-to-gas transactions, International Journal of Hydrogen Energy 48 (5) (2023) 2013–2029.
[106] S. Gennitsaris, et al., Energy efficiency management in small and medium-sized enterprises: current situation, case studies and best practices, Sustainability 15 (4) (2023) 3727.