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Strategies to Optimise Project Management Implementation in the Delivery of Renewable Energy Projects in Indonesia

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Abstract: One of Indonesia's sustainability targets is achieving full energy transitions and net zero emissions by 2060 or sooner. Thus, significant strides and massive investments are being made to revolutionise the development and delivery of infrastructure projects, particularly in the energy sector. The State Electricity Company is driving these advances, targeting a surge in renewable energy usage to 23% by 2025 and 31% by 2050. Despite these efforts, progress remains critically low, highlighting the urgent need for more effective strategies and execution. A comprehensive understanding of the critical success factors (CSFs) and barriers—and how they influence these projects—is essential to ensuring their successful delivery. This study aims to identify and model the influences of various CSFs and barriers to renewable energy projects' success in Indonesia. Using a questionnaire survey with 182 respondents, this study explored the critical success factors, key challenges, and applicable strategies. The data were analysed using exploratory factor analysis and structural equation modelling. The analysis revealed four critical success factors, including stakeholders' collaboration and project supervision, and 10 key challenges, including insufficient planning, poor stakeholder communication, and unrealistic cost and time estimation. The strategies involved a cross-functional framework for effective collaboration, early consultation for integrating collaboration and supervision, and frequent reporting for enhanced supervision. These strategies are crucial to addressing emerging challenges in renewable energy projects and achieving sustainable development goals in Indonesia.

Keywords: challenges; critical success factors; Indonesia; project management; renewable energy; strategies

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1. Introduction

Indonesia's energy consumption is mainly from fossil fuels, with nearly 100% electricity access and renewable energy making up 14.5% of the mix [1]. Energy demand is expected to rise by 80% by 2030, with targets of 17–19% renewable energy by 2025 and 44% by 2030 [1]. The country has significant renewable energy potential. Transitioning to renewable energy is crucial for reducing emissions and ensuring sustainability [1,2]. Indonesia has committed to achieving net zero emissions (NZEs) and sustainable development goals (SDGs) by 2060 or sooner [3]. According to the electricity supply business

plan (RUPTL) 2021–2030, the State Electricity Company (PLN) is planning to boost the utilisation of renewable energy to 23% or higher in 2025 and 31% or higher in 2050 of electricity provision throughout the country [4]. However, PLN mainly relies on fossil fuel energy for electricity provision in Indonesia, where approximately 80% of the generated energy is from coal firing [5]. It shows that renewable energy projects (REPs) are unpopular in Indonesia's SDGs.

It is challenging for developing countries to transition to renewable energy [6]. Several projects involving renewable energy technologies in developing countries have failed [7]. Indonesia—one of the developing countries in Asia—is likely to face similar challenges in achieving its renewable energy development goals if appropriate project management (PM) strategies are not in place [8]. The nature of power plant projects often influences their implementation and demands unique solutions throughout their execution [9]. Projects have an embedded characteristic of being unique; various projects encounter different challenges in reaching their objectives [10]. Different levels of complexity across the projects produce various levels of uncertainty, which leads to distinct challenges in their execution [11].

Furthermore, the uniqueness of the project creates various dimensions for project success—project success has different criteria depending on its uniqueness [12]. Critical success factors (CSFs) are essential to effective project management (PM) and have a direct relationship with project success [13]. While Indonesia is committed to achieving ambitious SDGs, it is anticipated that the country will face significant challenges in executing complex renewable energy projects. This underscores the crucial role of CSFs in the development of renewable energy in Indonesia, providing essential guidance for effective PM implementation. Therefore, identifying CSFs for REPs could help improve PM practice in delivering renewable energy projects in Indonesia.

PLN monopolises the energy sector in Indonesia, and it is mandated by the government to achieve the target of 23% renewable energy in 2025, according to RUPTL 2021–2030 [4]. This implies that the implementation of PM in PLN and their related organisations has a vital role in REPs in Indonesia. Therefore, identifying the key challenges and CSFs from the perspective of PLN and their vendors is vital to determining the PM enhancement strategies in REPs in Indonesia. Specifically, this research aims to (1) identify the CSFs for Indonesia's renewable energy projects, (2) identify the key challenges in Indonesia's energy sector development, and (3) identify applicable project management strategies to deliver renewable energy projects in Indonesia.

The outcome of this study is a set of strategies to optimise PM implementation by addressing CSFs and challenges specific to Indonesia's renewable energy projects. This research offers both practical implications, by identifying effective strategies for enhancing PM in the delivery of renewable energy projects, and empirical implications, by demonstrating the benefits of incorporating diverse perspectives to identify key CSFs and challenges. This approach helps determine the appropriate management style based on the project's type and the organisation's characteristics.

1.1. Critical Success Factors (CSFs)

Many studies have explored the definition of project success in various aspects and how it is measured. For instance, Kerzner [14–16] discovered that project success is determined by the ability to satisfy technical goals involving cost, time, and quality, the benefits and values gained by the stakeholders, and how the project is performed. However, Boyd [17] categorises five maxims of project satisfaction, including delivering the products for customers' needs, delivering quality while maintaining costs, delivering the project consistent with the customers' timeframe, delivering the desired degree of feedback for cus-

tomers' desires, and having a fair conflict resolution system for both the customers and the team. This clarifies that a wide range of definitions for project success differ regarding the individual's perspectives. Nonetheless, Rockart [18] suggested that CSFs are variables in PM whose fulfilment will ensure successful delivery for stakeholders. Moreover, Ofori [19] defines CSFs as a set of project areas that must be managed effectively based on the project's environment to achieve project success. These studies show that CSF can boost project performance to achieve its success. Thus, exploring CSF is essential to understand which key areas in PM can contribute effectively to project success.

According to Pinto and Slevin [20], understanding CSF can give a guideline to execute better and monitor the PM approach for achieving project success. Moreover, Rockart [21] suggested that CSF identification provides significant information to prioritise several areas aligned with the expected success. CSF can also align resource allocation towards favourable criteria in the project to enhance its value with minimum resource utilisation [22]. In addition, Shenhar and Dvir [23] implied that CSF is highlighted as a strategic plan to achieve strategic objectives with effective planning. In summary, identifying CSF helps deliver the project and strategic objectives in various dimensions, such as effective control and monitoring, resource utilisation, and strategic goals.

Meanwhile, studies believed that the determination of CSFs in the projects is influenced by various factors, such as the context of the industry [24], specific stakeholders [25], and the project's concept and complexity [12]. This shows that multiple aspects influence the required CSFs in the project. For instance, Pinto and Slevin [26] emphasised that clear objectives, competent teams, realistic cost and time estimates, and adequate resources are part of CSFs in a more general study. However, a more recent study in a developing country in South America argued that a competent project team and adequate resources are not involved in CSFs [27]. Meanwhile, a study in Thailand, which is more similar to Indonesia, clarified that a competent team and adequate resources should be prioritised as CSF, excluding realistic cost and time estimates. These studies explain that various project contexts result in different priorities, which should be considered in CSF selection. Therefore, a detailed evaluation of the project, such as its context and stakeholders' perspectives, is required to identify CSFs correctly. This study has collected and established a breakdown list of several relevant success factors (SFs) (Table 1) based on various studies from 1987 to 2024.

Table 1. List of success factors based on the literature.

Success Factor	Reference													
	[20,26]	[14–16]	[17]	[28]	[29]	[30]	[31]	[25,32]	[33]	[19]	[27]	[34]	[35]	[36]
Clear project management objectives (SF1)	√			√	√	√			√		√	√		√
Top management support (SF2)	√			√	√	√	√	√	√	√	√	√	√	
Information/communication (SF3)	√		√		√	√	√			√			√	√
Clear involvement (SF4)	√	√	√			√	√		√	√	√	√		√
Competent project team (SF5)	√						√	√	√	√		√	√	√
Authority of project manager/leader (SF6)	√					√				√				√
Realistic cost and time estimates (SF7)	√	√	√	√						√	√		√	
Adequate project control (SF8)	√				√	√						√	√	√
Problem-solving abilities (SF9)	√						√				√			√
Project performance and quality (SF10)		√	√							√	√	√	√	
Adequate resources (SF11)	√	√				√	√		√	√				√
Planning and controlling (SF12)	√	√		√	√	√		√	√		√	√		√
Monitor performance and feedback (SF13)	√		√	√			√	√		√				√
Project mission/common goals (SF14)	√					√	√			√	√	√	√	
Project ownership (SF15)	√	√			√			√	√			√		

1.2. Project Management (PM) Challenges in Developing Countries

Based on Kerzner's [37] study, PM has experienced significant evolution over the years and has become a strategic necessity to create business value using technology to

ensure its effectiveness. However, PM in developing countries has encountered several drawbacks over the years [38–40]. Furthermore, studies have found that PM maturity levels in developing countries have fallen from 2010 [41] to 2020 [42]. However, as the author mentioned, this research is conducted in South Africa, which may have a specific situation that needs to be clarified. Thus, PM implementation in developing countries needs improvement strategies for project challenges.

Meanwhile, studies discovered that challenges produce adversarial impacts on the project, such as defects and incomplete deliverables [43] and dynamic changes that require responsive management practice [44]. Specifically in infrastructure megaprojects, Flyvbjerg et al. [45] mentioned that challenges make projects suffer from cost overruns and scope changes. These studies indicate that challenges in PM result in various negative impacts on delivering project objectives. Pinto and Slevin [26] also believe that identifying challenges in PM practice becomes the key to improving project success. Other studies found that the identification of challenges provides a few benefits, including clarifying potential risks and their mitigation [46,47], generating an enhanced management approach [48], and determining improved stakeholder collaboration [49]. Hence, identifying challenges is important to address emerging challenges and minimise their impacts on project results.

Also, studies found several sources for challenges that arise in the project, such as organisational factors [10,26], environmental factors [45,50], technical factors [51,52], and the human factor [53,54]. Nonetheless, Flyvbjerg et al. [45] suggested that PM challenges are likely context-specific. For instance, research and development projects are struggling to manage innovation and transfer knowledge [55], while information technology projects encounter rapid changes and customer involvement issues [56], and construction projects regularly deal with strict budgets and timelines and team integration issues [10]. Specifically for developing countries, Ofori [24] found that construction projects have common challenges, including resource limitations, regulatory barriers, and inadequate stakeholder communication. Yanwen [40] added that there are several challenges in PM in developing countries, such as a lack of PM infrastructure and PM awareness at the top management level. However, Munns and Bjermi [57] believe that challenges in developing countries emerge between medium- and large-scale projects. Meanwhile, Flyvbjerg et al. [45] suggested megaprojects in construction tend to face challenges such as underestimation of cost, optimism bias, and stakeholders' complexity. Hence, it is inevitable for REPs in Indonesia to encounter challenges since REPs are mostly large projects that require an advanced management approach. In summary, the literature indicates that many factors influence the various challenges arising from the project. Therefore, collecting perspectives from professionals and practitioners with relevant experience can help evaluate specific challenges in this study.

While tailoring this literature review, distinct challenges are identified in PM practice in infrastructure projects in developing countries, namely insufficient planning [58–60], design and cost changes [61–63], and lack of appropriate skilled workers [64,65]. Moreover, the recent studies by McDermot et al. [27] and Welde and Bukkestein [66] found similar challenges, such as poor communication, unclear scopes, and insufficient performance and quality control. This literature review shows a wide variety of PM challenges. Thus, a thorough assessment must determine which challenges suit specific projects. To summarise, the list of collected PM challenges relevant to the context of REPs in developing countries is provided in this literature review (Table 2).

According to Boonstra and Reezigt [67], adopting appropriate strategies relevant to the specific project involves the combination of overviewing PM strategies and understanding the project's complexity. Although the project's complexity may differ for each project, the energy sector's projects in developing countries tend to have higher complexity [40,57]. This

leads to the urgency of improving strategies in PM practice to deliver successful execution in REPs in Indonesia. Nonetheless, despite several studies examining PM strategies [68–70], it is essential to examine the appropriate PM strategies by addressing the project goals and the issues for reaching those goals [67]. Furthermore, finding the relationship between CSFs and challenges is essential to minimise the adversarial impacts of the challenges [22,26] and enable effective management in the project [46]. Hence, the generation of PM strategies is influenced by the relevant CSFs, key challenges and the relationship of both to ensure its alignment with the project's requirements.

Table 2. List of challenges based on the literature.

Challenges	Reference													
	[38]	[39]	[71]	[22]	[64]	[72]	[62]	[65]	[59]	[27]	[66]	[73]	[34]	[36]
Insufficient planning (C1)	√			√	√	√			√		√		√	√
Lack of skilled workers (C2)	√			√	√	√	√	√	√	√	√	√		
Poor stakeholders' communication (C3)	√		√		√	√	√			√		√	√	√
Unrealistic cost and time estimation (C4)	√	√	√		√		√		√	√	√			√
Unclear project scope (C5)	√						√	√	√	√		√	√	
Underestimation of risk control and management (C6)	√				√					√		√	√	√
Insufficient resources (C7)	√	√	√	√						√	√	√		
Inadequate project delivery system (C8)	√				√	√							√	√
Lack of technology knowledge (C9)	√						√				√	√	√	
Poor top management support (C10)		√	√							√	√			√
Insufficient cash flow (C11)	√	√			√		√		√	√		√		√
Inappropriate analysis and design (C12)	√	√		√	√	√		√	√		√	√	√	√
Inadequate performance and quality control (C13)	√		√	√			√	√		√		√	√	√
Lack of accountability in decision-making (C14)	√				√		√			√	√		√	√
Inefficient bureaucracy system (C15)	√	√				√		√	√			√		

2. Research Methods

To observe social reality for objective findings, positivism philosophy is beneficial in measuring phenomena amidst distinct perspectives [74]. Further, the literature explains that positivist research involves a deductive approach by collecting facts for hypothesis testing. Moreover, Cresswell [75] suggested that positivism philosophy is a quantitative study exploring the research's aim through identification, measurement, and assessment. The quantitative study also allows the validation of the preliminary assumptions through numeric analysis to produce the data results for attaining research objectives [76]. In other studies about the construction projects, this method enables an in-depth knowledge of infrastructure projects, which can provide valuable objective opinions on the project's complexities [77,78]. Therefore, a conceptual model for quantitative study is established with a positivism philosophy and a deductive approach utilising theories exploration in the literature review and professionals' perspectives collection for analysis (Figure 1).

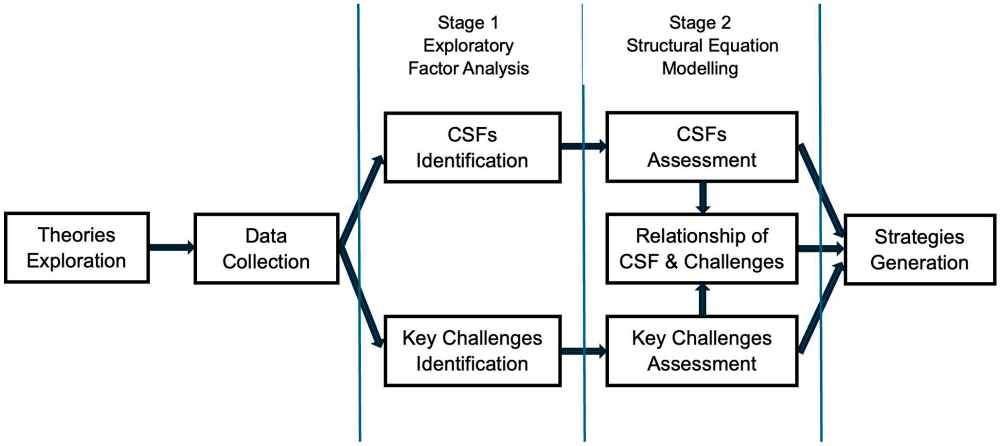

Figure 1. Conceptual model of the research.

2.1. Data Collection

The population of this research comprised practitioners and professionals who contributed to renewable energy projects in Indonesia—including the client, contractor, and consultant. These different roles are important to produce multiple perspectives to achieve the aim of this research. Although PLN [79] recorded 820 renewable energy projects in Indonesia in 2023, there was no reliable central database for practitioners and professionals who contributed to these renewable energy projects (sampling frame). Therefore, nonprobability, purposive sampling, and snowball sampling techniques were used to select relevant participants for this study. In purposive sampling, the selection of participants is based on a specific purpose [80], focusing on individuals who possess relevant knowledge and experience regarding the topic being studied. Snowball sampling entails identifying initial participants who then assist in locating additional participants in the target population [81]. Given the challenges associated with recruiting a large and diverse pool of experts in the construction field, purposive and snowball sampling have frequently been employed in construction research [82–84]. The questionnaire was disseminated through personalised emails, which included a Microsoft Word file attachment and a web link generated to facilitate online responses. The total number of distributions is indeterminate because potential respondents were kindly requested to forward the questionnaire to other practitioners and professionals deemed appropriate. As a result of various limitations, including the demanding schedules of experts, a total of 182 responses were collected all around Indonesia. This sample size could be considered both representative and acceptable. Moreover, the response rate is comparable to those of similar surveys in the field of construction [83–85]. Similarly, this meets the central limit theorem's requirement of a minimum sample size of 30 for any group, as recommended by Sproull [86] and Ott and Longnecker [87]. A sample of the questionnaire is provided in Appendix A to have a better understanding of the survey. This study was reviewed and approved by the University of Leeds Research Ethics Committee (Approval Code: MEEC 22-005).

2.2. Data Analysis Stage 1 (EFA)

First, this study tested the accuracy of the data by calculating Cronbach's coefficient alpha to measure the correlation between two parallel tests, those in the initial tests [88]. The coefficient alpha was calculated as follows [88]:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_i S_i^2}{S_t^2}\right)$$

where

α = Cronbach's coefficient alpha.
k = the number of items.
S_i^2 = the variance of scores on the item.
S_t^2 = the variance of total test scores.

Cronbach and Shavelson [88] classified the coefficient alpha value proceeding analysis.

Further, the data are analysed using EFA with the Principal Component Analysis (PCA) method and the varimax rotation method at two levels utilising IBM SPSS Statistics 29 to select which indicators of CSFs and challenges fit the PM implementation. EFA with PCA and varimax rotation provides several benefits for research, including dimension reduction to focus on the most important options [89], identification of underlying constructs as unobserved latent variables [90], and a factor solution with higher accuracy to represent the true structure of the data [91]. These benefits of EFA allow for effective factor reduction and structure development from the collected elements to ensure the validity of the research. Several studies describe the required thresholds in EFA with PCA and varimax rotation method analysis, including the value of Kaiser–Meyer–Olkin (KMO) above 0.700 [92], p-value in Bartlett's test below 0.050 [91], factor loadings in communalities greater than 0.500, and cumulative loadings greater than 60% [93]. Additionally, in evaluating the variable's group, the factor loading for each indicator should be greater than 0.500 in EFA varimax to ensure the significance among indicators [93]. Also, Hair [93] suggested that the cumulative loadings should be above 60% to ensure that the factor solution captures a substantial portion of the data's variability. Hence, the EFA analysis in this study complied with these requirements to generate an accurate factor solution and unobserved latent variables with relevant underlying constructs.

2.3. Data Analysis Stage 2 (SEM)

The second analysis in this research involves SEM with Maximum Likelihood Estimation (MLE) as an integrated analysis from EFA. Based on Hoyle [94], SEM with MLE has a strong capability to model the relevancy of the latent variables as the unobserved constructs from the observed indicators, which allows the transfer of the analysis from the indicators to constructs. This method can also facilitate the analysis of new unobserved constructs and generate the correlations between variables as a relationship assessment [95]. SEM with MLE can provide several benefits, such as reliable correlation estimates and an accurate relationship model [95], a more holistic approach to model exploration and a description of significant correlations [96], and accurate assessment and model refinement through the calculation of various model fit indices [97]. This results in using SEM with MLE in this research to evaluate established model fitness and calculate the variables' estimates and their correlation.

In the first stage of SEM with MLE, it is necessary to assess the normality of the data with kurtosis and skewness measurement [95]. The normality of the data should be obtained with the skewness value less than absolute $|2.000|$ and kurtosis less than absolute $|7.000|$ [98,99]. Furthermore, Barret [100] clarified that the evaluation of model fit could utilise the comparison of chi-square over the degree of freedom $\left(x^2/df\right)$, and the value should be below 5.000 to be acceptable [95]. Nonetheless, the assessment using chi-square is highly sensitive to sample size, which often causes the larger size with the appropriate model to become unfit [95]. To avoid this inaccurate indication, evaluating the model fit in SEM with other parameters such as the second stage of SEM is recommended. Several studies discovered additional parameters can be used to confirm the model fit, such as SRMR should be below 0.080 to be an acceptable fit [97], TLI is above 0.900 to be acceptable [97,101]. Moreover, CFI is required to be over 0.900 [101,102], and RMSEA should be less than 0.080 to be accepted [97,103]. Finally, the impact of the independent

variables on the dependent variable is evaluated with the requirement of a *p*-value below 0.050 and a t-value greater than absolute |1.960| for a *p*-value of 0.050 [95]. The author added that the standardised estimates in SEM indicate the interpretation and the strength of the relationship between two variables [95]. Therefore, these stages were carried out in the analysis of SEM with the MLE method to provide a full description of the model sufficiency and the relationship between the variables in this study.

This research integrates EFA and SEM to facilitate an in-depth analysis of indicators identified in the previous literature. EFA is advantageous for filtering indicators, enabling the identification of key indicators within variables and the formation of indicator groups within each variable that share a common construct as latent variables. Conversely, SEM examines the relationships among all variables to elucidate their mutual impacts. This combination yields a more comprehensive assessment of existing data by concentrating on significant factors and revealing their interrelationships in PM practices to achieve project success. Consequently, SEM analysis complements EFA by generating more accurate strategies in this research, illustrating the connections between key CSFs and challenges previously identified by EFA.

3. Results and Findings

This study's questionnaire survey collected 182 responses from various professionals and practitioners contributing to Indonesia's energy sector development. The survey results contain categories, including respondents' backgrounds, awareness of Indonesia's SDG commitment, and perspectives about CSFs and challenges in REPs in Indonesia.

3.1. Respondents' Background

The result indicates that most participants have 5–10 years of experience (Figure 2a). The result for the working environment is approximately equal between the two groups, with 51% of respondents working on-site and 49% working in the office (Figure 2b). Most participants work in non-managerial positions within their organisation (Figure 2c). Most participants have an owner/client role in the project (Figure 2d). These results imply that all participants have distinct experiences in energy sector development. Thus, this diversity enables the data collection to represent the target population for this research.

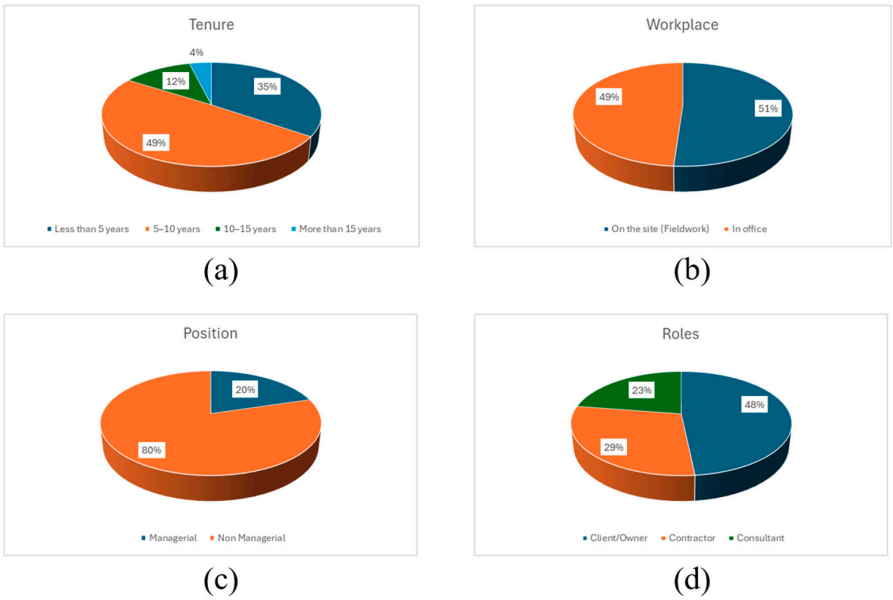

Figure 2. Respondents' background: (**a**) level formatting of experience result, (**b**) respondents' workplace result, (**c**) organisational position result, and (**d**) project roles result.

3.2. Respondents' Awareness

First, most participants know Indonesia's SDG commitment, with 54% agreeing and 25% strongly agreeing that they were aware (Figure 3a). Second, out of 182 participants, most believe Indonesia will encounter potential issues in performing REPs, with approximately 55% agreeing and 18% strongly agreeing (Figure 3b). Lastly, most participants agree that Indonesia can achieve the SDG in 2060 (Figure 3c). This leads to the description of the respondents' level of awareness in this research and their distinct opinions in this case.

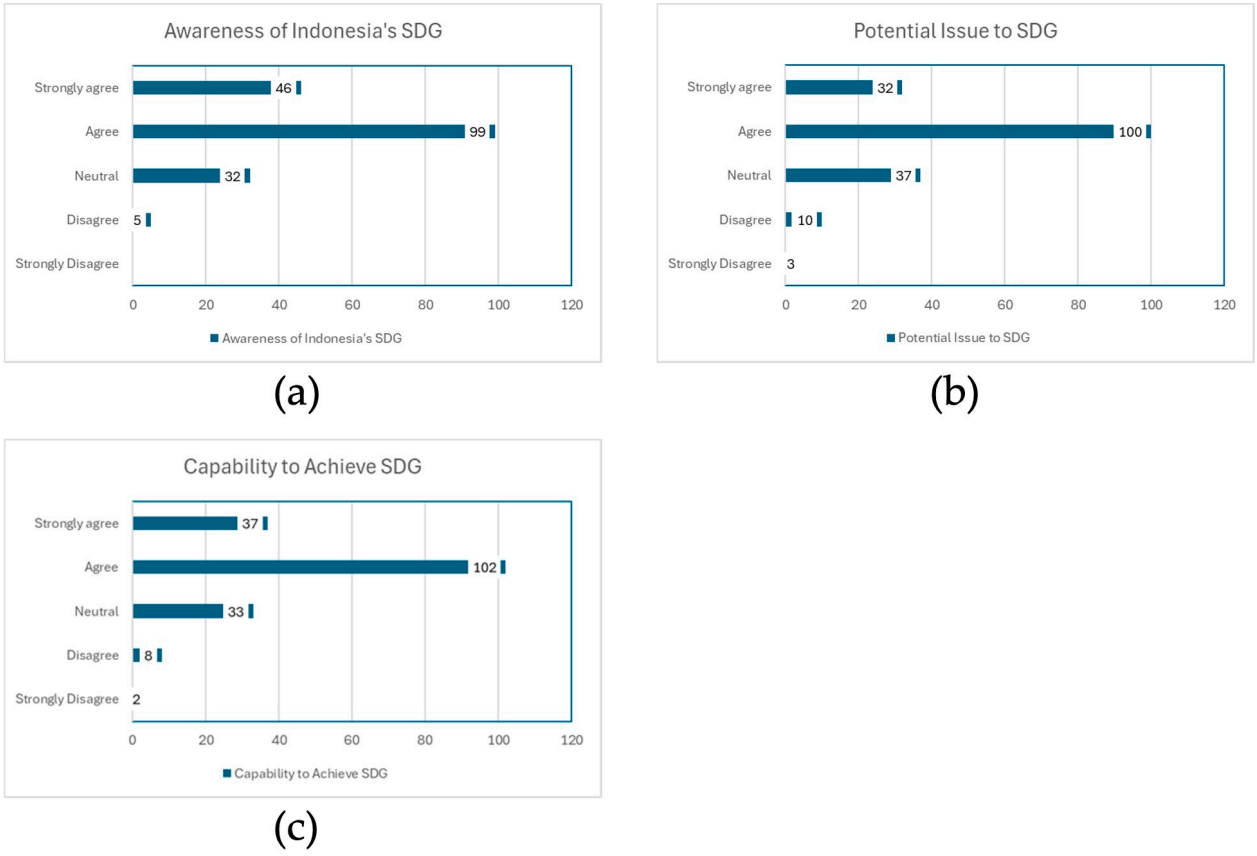

Figure 3. Respondents' awareness: (**a**) awareness of SDG result, (**b**) awareness of issue result, and (**c**) awareness of capability result.

3.3. Results and Findings of CSFs

This survey involved 15 SFs from the literature review, and respondents were asked using a Likert scale from 1 to 5 (from strongly disagree to strongly agree) to measure their level of agreement. Based on the survey, Clear stakeholders' involvement (SF 4) obtained the most responses for strongly agreeing with 99 responses, and Leader's authority (SF6) obtained the most responses for agreeing with 114. Despite these SFs collected from the literature, several respondents disagree with some factors. For instance, project ownership (SF 15) obtained the most disagreement from the respondents, with six responses, and two respondents selected "strongly disagree" for information/communication (SF 2). However, most respondents believed that these factors significantly influence PM implementation, which implies the validity of these factors since they are collected from the previous literature. The graphical description of the results of CSF can be seen in Figure 4.

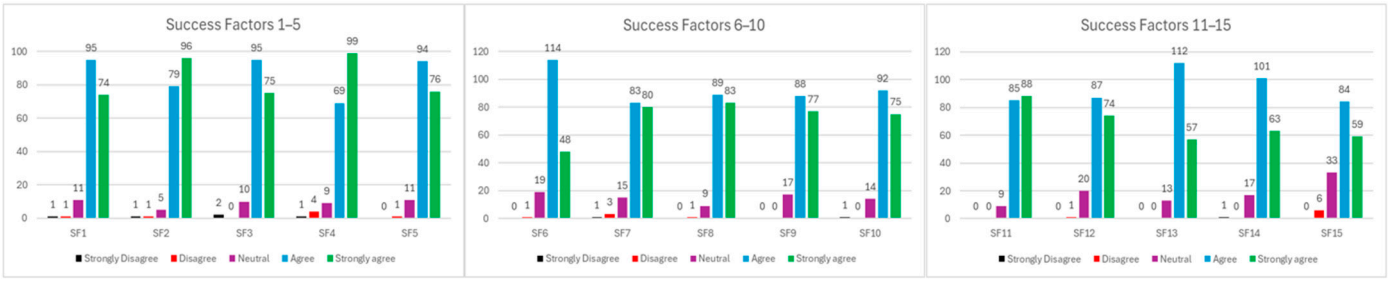

Figure 4. Respondents' perspectives on SFs.

3.4. Results and Findings of Challenges

This survey also utilised a Likert scale similar to CSFs to capture the significant challenges for this research. According to the results, insufficient planning (C1) obtained the most strongly agreed responses from 109 respondents, while inadequate project system (C8) had the most agreed responses from 94 respondents. Although the number is relatively low, some respondents had different perspectives on particular challenges. For instance, insufficient bureaucracy (C2) obtained the highest number of 7 responses with disagree, while there were no strongly disagree responses from the respondents in the challenges questions. In summary, the respondents showed diversity in their responses in this survey for the significant challenges in PM implementation. The interpretation of this result is that the challenges collected from the literature are relevant and valid to the recent situation in Indonesia. The graphical description of the results of the challenges is shown in Figure 5.

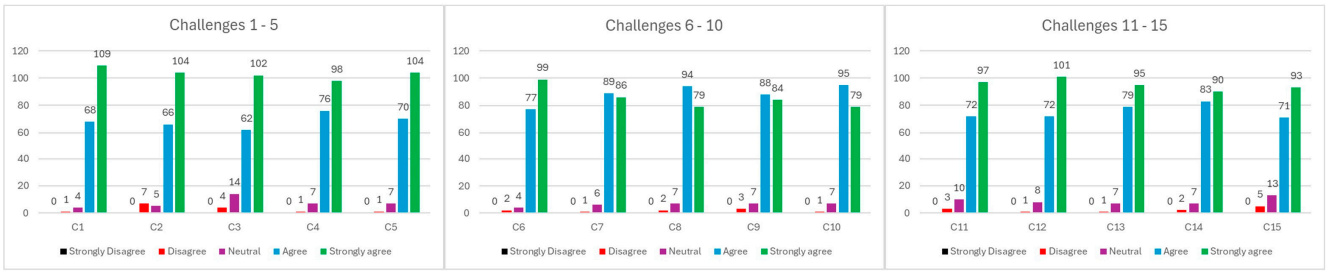

Figure 5. Respondents' perspectives on challenges.

4. Discussion

4.1. Identification of CSFs

First, the collected data of SFs was analysed with SPSS to find Cronbach's coefficient alpha. The calculation resulted in a value of 0.863, which is indicated as very good [88]. This leads to a strong covariance between the observed score and the true score in the data since the reliability test evaluates random measurement error [88], which is only less than 14% in this case.

Second, survey data regarding SF was analysed using EFA with PCA and the varimax rotation method at two levels to identify appropriate CSFs for this research. In the first level of the EFA analysis, the overall calculations yielded acceptable values, with a KMO statistic of 0.852 and Bartlett's *p*-value less than 0.010. However, the analysis of all SFs resulted in varied factor loadings ranging from 0.419 to 0.767 (Table 3), encompassing four latent variables with cumulative loadings of 57%. Consequently, the SFs with factor loading values below 0.500 were removed from consideration, including SF9 (problem-solving ability) and SF11 (adequate resources). According to Pinto and Slevin [26], CSFs in projects differ based on several contexts, including specifications, environment, and objectives. Furthermore, multiple studies support the notion that the diversity of CSFs is influenced by specific factors, such as project context [19], stakeholder expectations [25],

and levels of complexity and strategic concepts [12]. Additionally, de Wit [104] noted that the determination of project success depends on various perspectives, which can impact the relevant CSFs for the project. This indicates that the SFs eliminated in this study are not deemed significant, as the experienced respondents did not regard them as relevant factors for Indonesia's REPs.

Table 3. Detailed results of communalities' extraction for CSFs in the first EFA analysis.

Indicators	Extraction 1	Description
SF1	0.767	Significant
SF2	0.613	Significant
SF3	0.541	Significant
SF4	0.614	Significant
SF5	0.578	Significant
SF6	0.536	Significant
SF7	0.539	Significant
SF8	0.510	Significant
SF9	0.475	Non-significant
SF10	0.537	Significant
SF11	0.419	Non-significant
SF12	0.683	Significant
SF13	0.585	Significant
SF14	0.572	Significant
SF15	0.621	Significant

Finally, the second EFA analysis, similar to the previous method, was undertaken with 13 indicators of SF by excluding SF9 and SF11. This analysis resulted in four unobserved variables and higher cumulative covariance (61%) than the first analysis. The factor loading value for all SFs also increased compared to the previous analysis, ranging from 0.605 to 0.826; the detailed breakdown can be seen in Table 4. These results lead to the model description for further analysis in SEM as latent variables in CSFs.

Table 4. Detailed result of variance loading and component matrix for CSFs in EFA.

Indicators	Factor CSF 1	Factor CSF 2	Factor CSF 3	Factor CSF 4
SF5	0.765			
SF2	0.713			
SF4	0.707			
SF6	0.650			
SF3	0.635			
SF7		0.682		
SF10		0.665		
SF14		0.605		
SF13			0.762	
SF15			0.689	
SF1			0.585	
SF12				0.826
SF8				0.637
Rotation total	2.945	1.766	1.704	1.533
Sums of squared loadings % of variance (cumulative %)				
	22.7 (22.7)	13.6 (36.2)	13.1 (49.3)	11.8 (61.1)

4.1.1. CSF1 (Stakeholder Collaboration)

Based on the analysis, group 1 (CSF1) consists of five indicators, namely, SF5 (team competency), SF2 (top management support), SF4 (clear stakeholder involvement), SF6 (leader authority), and SF3 (information and communication). According to Mitchell et al. [105], several areas are connected to building effective collaboration with the stakeholders, including the leader's authority, management support, stakeholder involvement, sufficient team competency, and proper communication. Moreover, PMI [52] emphasises that stakeholder management, as a key framework, is established by some essential aspects such as identifying the competencies and proper communication within the project team, and the leader's authority and management support play a vital role in enabling stakeholder management. There is a dynamic process where stakeholders interact and engage within the project team as stakeholders collaborate, which allows building the relationship and maintaining communication to align stakeholders' involvement with project objectives [106]. This leads to the construct of all indicators in group 1 interpreting stakeholder collaboration for its latent variable.

In addition, Ofori [24] suggested that stakeholder collaboration involving capacity building and stakeholder involvement in infrastructure projects in developing countries is beneficial to ensure sustainable development. Müller and Turner [32] also highlighted that stakeholder collaboration can effectively navigate the project environment in developing countries by providing clear direction and facilitating good communication. Therefore, stakeholder collaboration, as the construct in group 1, is appropriate to be one of the CSFs in REPs in Indonesia to support the achievement of project success.

4.1.2. CSF2 (Delivery Management)

The second group (CSF2) is composed of three indicators, including SF7 (time and cost estimation), SF10 (performance and quality), and SF14 (project mission/common goals). This group focuses on delivery management since it is a process to ensure that the project deliverables are performed in the specified requirements according to the designed schedule and budget plan to achieve its goals [44]. Furthermore, Baccarini [11] states that delivery management involves cost and time estimation to properly plan the schedule and financial resources for completing the project. de Wit [104] also highlighted that performance and quality management are integrated into the delivery management to meet the project goals expected by stakeholders. Furthermore, clear project goals can guide delivery management, such as providing direction in decision-making and ensuring the project contributes to strategic values [23]. In addition, Kerzner [16] also implied that the determination of project delivery requires a holistic approach involving cost and time estimation, performance and quality management, and project goals. This indicates that the interaction among indicators in group CSF2 is aligned with delivery management.

Additionally, delivery management is critical in projects in developing countries to identify the timeline and schedule to meet the requirements and avoid potential negative consequences since they tend to be cost- and time-sensitive [107]. Moreover, delivery management provides a more adaptive and flexible project, essential to cope with changes and maintain the quality of complex projects [108]. Thus, delivery management is recommended as the relevant CSF in this case study since REPs in Indonesia tend to be megaprojects with high complexities.

4.1.3. CSF3 (Project Supervision)

Meanwhile, group 3 (CSF3) is also formed from three indicators, which are SF13 (monitor and feedback), SF15 (ownership), and SF1 (clear objective). Monitoring involves continuous assessment, and feedback involves timely information, which is crucial in

project supervision to maintain alignment with project objectives [46]. Ownership refers to project supervision, which drives accountability and influences the project's governance to meet the objectives [22]. Moreover, Lock [109] emphasised that well-defined objectives are a foundation for successful project supervision to enable a shared understanding of the expected outcomes among stakeholders and utilise them to evaluate the project efforts. Kerzner [46] also defined project supervision as an aspect of the PM that involves monitoring and guidance provision for the project aligned with its governance and objectives. These studies imply that the indicators in CSF3 work together to develop effective project supervision to describe the stakeholder's responsibility and proper inspection measured with clear expected objectives.

Furthermore, effective supervision can ensure accountability and adherence to its objectives while reducing the potential corruption as a key concern in developing countries [110]. Project supervision can enhance project performance and outcomes with regular monitoring and feedback as guidelines to meet the objectives by facilitating timely decisions to address changes and emerging issues often encountered in developing countries [107]. Hence, project supervision can positively impact REPs in Indonesia as a relevant CSF in this research.

4.1.4. CSF4 (Integration Management)

Lastly, the fourth group (CSF4) comprises the rest of the indicators, which are SF12 (planning and controlling) and SF8 (project control). Planning and controlling are continuous cycles in integration management to allow plan updates and realignment of the progress to stay on track [44]. Another study found that project control is essential in integration management to provide adjustment plans and actions related to the impact of changes in the project [48]. Based on PMI [47], integration management is a key aspect of PM that coordinates planning and controlling to manage conflicts and interdependencies effectively. These studies indicate that integration management involves coordinating planning and control processes, adjusting plans based on changes, and maintaining the project aligned with its goals.

According to Turner and Müller [54], projects in developing countries often have multiple interlinked components, making integration management essential for aligning various project elements and adjusting appropriate actions for each process. In addition, Kerzner [46] implied that integration management provides alignment between project activities and strategic goals, which are more important in developing countries where projects have strategic initiatives related to broader issues. Therefore, integration management can be suggested as part of the CSFs to provide more aligned processes in REPs to ensure the achievement of broader strategic objectives in Indonesia.

4.2. Identification of Key Challenges

Studies found that identifying challenges in PM can contribute to the project's success in various aspects [26,47,48]. This identification of challenges was similar to SF's analysis. Cronbach's coefficient alpha was calculated, resulting in an excellent value of 0.938. This means the survey data are valid and reliable for further quantitative analysis in this study.

While carrying a similar EFA test with SFs, 'challenges' data achieved an excellent KMO value of 0.946. For Barlett's test, the resulting value is lower than 0.010, which means that the data in the variable is correlated and acceptable for EFA. These results show the reliability of the research, which proves the validity of the collected data. However, the variable group result generated lower indicator values, ranging from 0.370 to 0.676 (Table 5). Hence, some indicators with factor loading below 0.500 are eliminated, which are C2 (lack of skilled workers), C7 (insufficient resources), C9 (lack of technology knowledge), C10

(poor management support), and C11 (insufficient cash flow). PM challenges may vary in specific projects since they are context-specific and affected by several factors [45]. Several studies also discussed the various emerging challenges in the project influenced by distinct factors such as project type [10,56] and industry and environment [24]. Also, other studies suggested that existing challenges are affected by specific factors in the project, such as its scope and complexity [111], organisational and cultural context [45], and stakeholders [112]. These studies imply that the identification of challenges requires the details of the project since it can be affected by various factors, especially for REPs in Indonesia, which may have specific characteristics.

Table 5. Detailed results of communalities' extraction for challenges in the first EFA analysis.

Indicators	Extraction 1	Description
C1	0.649	Significant
C2	0.452	Non-significant
C3	0.567	Significant
C4	0.639	Significant
C5	0.627	Significant
C6	0.602	Significant
C7	0.481	Non-significant
C8	0.571	Significant
C9	0.370	Non-significant
C10	0.445	Non-significant
C11	0.478	Non-significant
C12	0.511	Significant
C13	0.676	Significant
C14	0.606	Significant
C15	0.526	Significant

The second EFA analysis was undertaken with 10 remaining indicators to enhance their correlation. This analysis resulted in a greater cumulative loadings value of 61%, with factor loadings ranging from 0.725 to 0.840, with the breakdown results, as shown in Table 6. Tabachnick and Fidell [89] suggested that EFA may extract a single component in the variable when the elements are highly intercorrelated, which leads to an inability to distinguish between factors. Nonetheless, a single-factor solution may result from an unseparated homogeneous dataset across multiple elements [91]. Moreover, the elements collected from the previous literature contain different aspects of challenges, such as poor communication from human aspects [53], inadequate project delivery system from technical aspects [47], and unclear project scopes from organisational aspects [10]. Hence, the dataset in challenges can have a high correlation rather than homogeneous elements. This can also be seen from the high values of Cronbach's coefficient alpha [113] and factor loadings [114].

The challenge with the highest factor loading, C13 (inadequate project control), is aligned with a study by Sovacool and Cooper [115], who found that megaprojects in the energy sector involve higher complexity, which leads to difficulties in their control. Furthermore, Sambasivan and Soon [116] mentioned that poor control is indicated as a key challenge in developing countries, resulting in ineffective PM. In addition, inadequate control is also found in Vietnam, which leads to delays and cost overruns [62]. Therefore, C13 is supported by similar studies to be an acceptable key challenge in this research.

Meanwhile, C5 (unclear project scopes) is also supported by Pinto and Slevin [26], who mentioned that unclear scopes result in misaligned objectives and failure to meet stakeholders' expectations. Moreover, McDermot et al. [27] believed that ill-defined scope is one of the most common challenges in developing countries, manifesting in errors and changes. Additionally, Vindi et al. [34] found that REP in Indonesia required contractual

renegotiation due to design and scope changes. These studies indicate that C5 is often encountered by projects in developing countries, particularly in Indonesia's REPs. Therefore, the analysis of C5 is proven to be a significant challenge that adversely impacts the project's success.

Table 6. Detailed result of variance loading and component matrix for key challenges in EFA.

Indicators	Factor Challenges
C13	0.840
C5	0.815
C14	0.802
C4	0.800
C1	0.796
C6	0.780
C3	0.762
C8	0.760
C15	0.754
C12	0.725
Rotation total	1.001
Sums of squared loadings % of variance (cumulative %)	
	6.148 (61.477)

For C14 (lack of accountability in decision-making), Yanwen [40] found that lack of accountability happened in the form of bribery and corruption in complex project management in developing countries. Poor accountability in developing countries is influenced by distinct cultural habits not established with structured management [117]. Sustainable development projects in Indonesia need to adopt legal frameworks to enhance accountability in decision-making [118]. Thus, specific cultures in developing countries may lead to C14, including in sustainable development projects in Indonesia, which can influence the achievement of project success.

Furthermore, C4 (unrealistic cost and time estimation) is clarified by Welde and Bukkestein [66], who mentioned that inaccurate cost and time estimation influenced large government project delays. The estimation issue involves optimism bias and prospect theory, leading to underestimating uncertainties and errors in the project [119]. This is common in megaprojects since they are driven by inadequate information but higher ambition [45], especially in public facility projects that involve social values [120]. Therefore, C4 is considered an important challenge in REPs in Indonesia since REPs are not very common and are associated with more social ambition.

Meanwhile, C1 (insufficient planning) is supported by Zidane and Andersen [121], who found that poor planning is the most frequent issue in construction projects in Norway. Also, a study in Malaysia found that improper planning is the most impactful issue in construction projects, leading to delays [116]. Moreover, Ofori [122] believed that inadequate planning is often encountered in construction projects in developing countries and is associated with high complexity. Megaprojects in the energy sector are complex, especially because they often interfere with political uncertainties, regulatory matters, and environmental concerns [115]. Hence, the characteristics of REPs enhance the impact of C1 on project management practice, especially in developing countries, including Indonesia.

For C6 (underestimation of risk management and control), large construction projects are exposed to risks embedded with several issues [123]. The common mistake in risk management practice in megaprojects is that it is often reactive rather than proactive, resulting in poor mitigation [124]. Moreover, a study found that insufficient risk management

often happens in developing countries, which leads to delays and demands for changes in infrastructure projects [27]. Especially for megaprojects, higher complexity and uncertainty require robust risk management and control to ensure that project objectives are met [45]. Therefore, C6 is a key challenge in REPs in Indonesia since developing countries fail to deal with the scale of the complexity and uncertainty in megaprojects.

Furthermore, C8 (inadequate project delivery system) is supported by Duy Nguyen et al. [72], clarifying that improper project delivery systems are a common phenomenon in large construction projects in Vietnam, resulting in inefficient execution. The degree of project delivery shows a significant relationship with project management maturity, which is decreasing in developing countries [42,125]. The poor delivery system in REP in Indonesia leads to its failure to meet its objectives [34]. Therefore, C8 is a significant challenge for this research, especially when project management maturity in developing countries has fallen recently.

For C15 (insufficient bureaucracy), Merrow [126] believed that megaprojects often encounter bureaucracy issues involving poor administrative capacity to manage their complexities. Insufficient bureaucracy is an issue in large governance-related projects in the form of ineffective coordination with superior bodies [66]. For instance, large construction companies in Vietnam also encounter poor bureaucracy associated with bribery, which escalates the cost [72]. Governance structures influence the bureaucracy issue, leading to inefficiencies in the project [127]. Additionally, Ahsan and Gunawan [128] implied that bureaucratic problems caused policy changes and slow decision-making processes in developing countries. Therefore, C15 is proven to significantly impact megaprojects and developing countries, which is relevant to this research.

Finally, C12 (inappropriate analysis and design) is aligned with research by McDermot et al. [27], which suggested that the design process for infrastructure projects in developing countries includes technical difficulties and complexities requiring involvement from all parties. For example, large projects in Vietnam often encounter design changes caused by poor analysis [62]. In addition, REP in Indonesia encountered issues in analysis and design related to its compliance with technical standards [34]. Thus, the significance of C12 in this research is evident—REPs in Indonesia involve high complexities, which increases the possibility of encountering such issues.

4.3. CSFs and Key Challenges Assessment and Relationship

This research established a structured model based on the variables from previous analysis, including five independent variables (Figure 6), four latent variables for CSFs, one variable for key challenges, and one dependent variable for project success. Afterwards, the normality requirements are evaluated to check if the model fits for SEM with the MLE method. This analysis produced acceptable values ranging from −1.547 to 0.182 for skewness and −0.629 to 4.545 for kurtosis. In summary, SEM with the MLE method can be carried out with the data collection using the model. Further, the model's fitness was analysed by assessing several requirements for SEM with MLE. Based on the calculation, the generated model for this research was fit since all resulting values met the requirements (Table 7). Therefore, using SEM with the MLE method, this study had sufficient data and an appropriate model to investigate the covariance for all variables.

Table 7. Comparison of the results and the requirements for model fit in SEM.

	(x^2/df)	SRMR	TLI	CFI	RMSEA
Result value	1.674	0.023	0.909	0.921	0.061
Requirement	<5.000	<0.080	>0.900	>0.900	<0.080

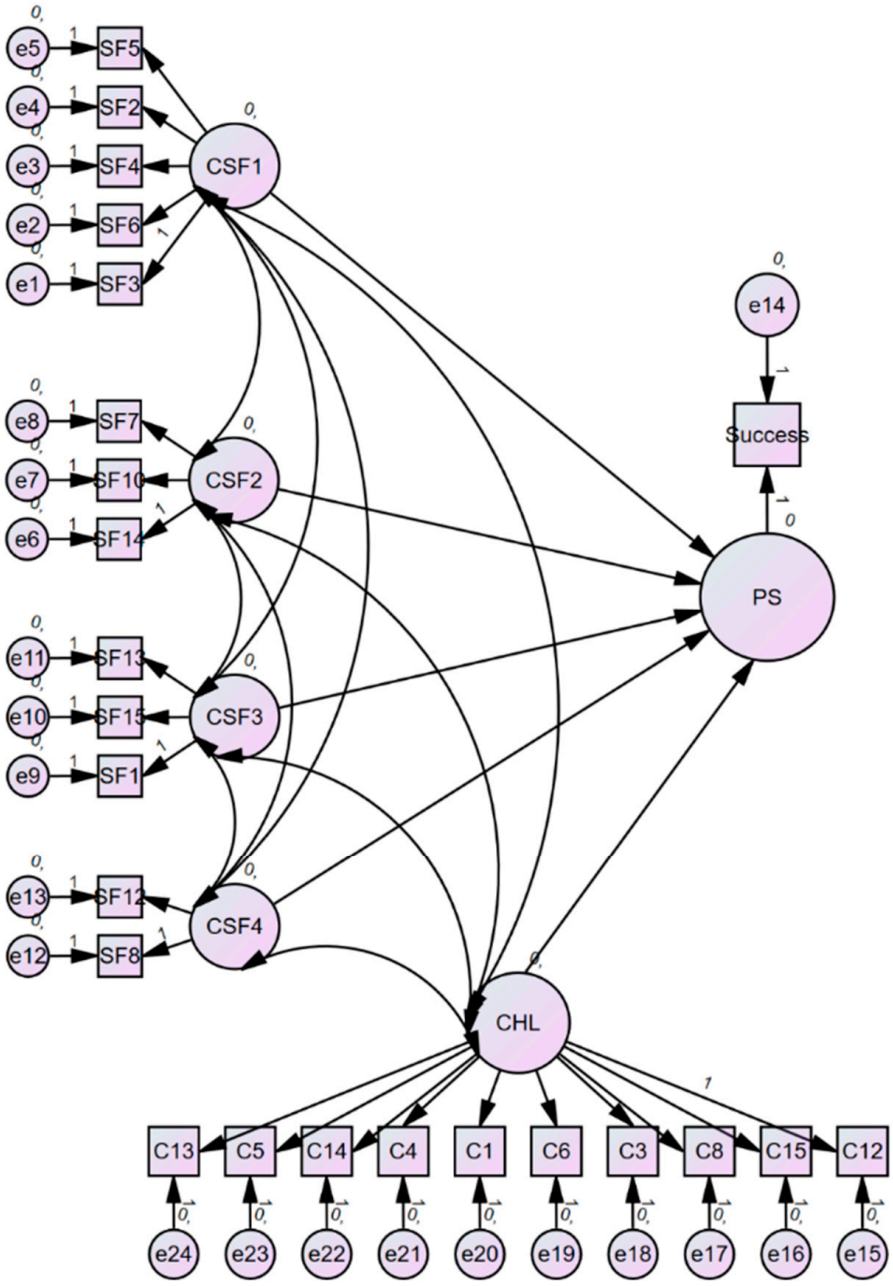

Figure 6. Research covariance model for SEM.

This analysis showed that the established model can capture the relationship between CSFs and challenges and their impact on project success. Based on Jugdev and Muller [129], managing CSF allows effective mitigation for the impact of challenges, leading to a higher chance of reaching project success. Also, CSFs are interdependent with challenges since addressing challenges can enhance the effectiveness of CSF implementation to achieve project success [22]. Thus, the established model provides fitness and significant relationships between variables supported by the SEM analysis and the previous literature.

Furthermore, SEM was conducted to find the correlation of all variables in the model at the following stage of evaluation. For the covariances of CSF1, CSF3, and challenges to project success, the resulting values were indicated to meet the requirement with *p*-values of 0.002 and 0.01, respectively, and t-values of 3.059, 3.597, and 2.568, respectively, leading to their significant impact on project success. However, CSF2 and CSF4 indicated higher *p*-values of 0.433 and 0.202 and lower t-values of 0.784 and 1.275, implying their insignifi-

cant correlation to the project's success. This means that both CSF2 and CSF4 have failed to show their significant correlation to project success. Hence, this analysis indicated that only three variables, CSF1, CSF3, and key challenges, are accepted for further analysis to respond to the research aim. Nonetheless, all independent variables indicate various values for standardised estimates from −2.70 to 0.966 in the analysis model, which measures the correlation between each independent and dependent variable (Figure 6). Therefore, the strategy generation will involve standardised estimates, *p*-values, and t-values for all variables in the summary result (Table 8) to direct its consideration.

Table 8. Summary covariance for independent variables to dependent variable.

Hypothesised Relationship	Standardised Estimates	T-Value	*p*-Value	Decision
CSF 1 to project success	0.499	3.059	0.002	Accepted
CSF 2 to project success	−0.179	−0.784	0.433	Rejected
CSF 3 to project success	0.966	3.597	<0.001	Accepted
CSF 4 to project success	0.236	1.275	0.202	Rejected
Challenges to project success	−0.27	−2.568	0.01	Accepted

Specific CSFs can enhance the opportunity to successfully deliver specific megaprojects in developing countries [24]. Strong stakeholder collaboration and effective supervision in megaprojects help deal with their complexities, improving project outcomes [119]. Hence, focusing the strategies on CSF1 and CSF3 can contribute to advancing PM implementation in Indonesia's REPs. Meanwhile, Flyvbjerg et al. [45] specified the challenges for megaprojects that failed to reach success and suffered from cost escalation and scope changes. Moreover, similar studies in developing countries have revealed adverse impacts of the key challenges on project success, such as C1, C3 [116], C4, C6, C15 [27], C5, C8 [34], C12, C13, and C14 [62]. Thus, the relationship between key challenges and project success in this research is supported by the previous literature.

Moreover, this research also seeks the correlation between CSFs and key challenges with correlation estimates, which can describe the strength and direction of the relationship across variables [95]. The analysis showed various values of correlation estimates between all latent variables of CSFs and the challenges from 0.546 to 0.590. Nonetheless, the correlation estimates were focused on the relationships between CSF 1 and CSF 3 with the challenges. Note that CSF 2 and 4 were rejected in the previous discussion. The correlation estimates showed a positive linear relationship between the variables, resulting in an estimated value above 0.56 for all accepted variables, as seen in Table 9. Therefore, SEM analysis proved the correlation between key CSF and challenges in this research from the main variables significant to the project's success.

Table 9. Summary result of the correlation between independent variables.

Variable Correlation	Estimates Value	Decision
CSF 1 to challenges	0.590	Accepted
CSF 2 to challenges	0.587	Rejected
CSF 3 to challenges	0.569	Accepted
CSF 4 to challenges	0.546	Rejected
CSF 1 to CSF 3	0.673	Accepted

Zwikael and Ahn [130] found the relationship between CSFs and challenges that navigate the determination of CSFs to tackle emerging challenges in the project. Especially for CSF1, studies indicated that stakeholders' collaboration plays a significant role in

addressing specific challenges such as building communication [131], ensuring the alignment of project scopes, enhancing overall accountability in decision-making [112], and minimising complicated bureaucracy [72]. For CSF3, studies found that effective supervision has an important influence on several challenges, for instance, enforcing detailed planning [46], validating accurate schedule and cost estimation [132], ensuring effective risk management [130], improving delivery system [133], developing detailed analysis and design [112], and enhancing quality control process [32]. Turner and Müller [54] also highlighted that project supervision can facilitate team communication and involvement rather than just monitoring process, which enhances stakeholders' collaboration. Also, Karlsen [134] mentioned that project supervision helps to reduce conflicts and align the involvement of stakeholders, resulting in better collaboration. Hence, CSF1, CSF3, and key challenges in this research provided a strong relationship between each other, which is proven by existing knowledge.

4.4. PM Strategies

4.4.1. Cross-Functional Framework (S1)

REPs involve stakeholders with various expectations for the project, especially when the expectation is associated with social values. This leads to interdisciplinary requirements in project execution simultaneously, which could result in conflicts. Utilising S1 can facilitate relationship building and extensive consideration to determine project scopes and stakeholders' involvement. S1 enables a more detailed assessment of the decision-making process by gathering input from all stakeholders. This assessment can navigate management support and the leader's authority to ensure that the decision is aligned with the strategic objectives. Therefore, this framework helps to develop effective coordination among various backgrounds to enhance the bureaucratic system and accountability in the decision-making process.

Literature evidence: According to Yang and Shen [135], a framework involving various stakeholders fosters better collaboration in diverse environments where conflicts may emerge. The cross-functional team also enables the integration of different disciplines in the decision-making process to ensure comprehensive problem-solving, which promotes accountability [136]. Other studies also mentioned that cross-functional teams can simplify bureaucratic processes to avoid delays [137] and provide rich learning spaces to develop team competency [138]. Hence, S1 allows the management of CSF1 by integrating stakeholders' multidisciplinary approaches to optimise their involvement in achieving project success.

4.4.2. Early Consultation (S2)

The potential impact of early consultation should be considered in PM implementation, particularly in projects associated with high complexity. The impact of the challenges in complex projects can be minimised and mitigated properly with S2. Another impact of this strategy is associated with the team's diversity in REPs. The consultation process is essential for information distribution about diverse aspects to ensure that everyone keeps track of project updates. Also, it can increase their involvement to provide effective monitoring for the project. Therefore, early consultation can contribute to managing stakeholders' collaboration and project supervision as key CSFs to overcome a project's complexity.

Literature evidence: Intensive consultation encourages stakeholders to develop a greater sense of ownership, foster strong collaboration, and increase supervision throughout the project [106]. According to Rowlinson and Cheung [139], consulting with stakeholders creates a platform for knowledge sharing when facing challenges. It empowers them to become more involved, resulting in a shared perspective on project implementation.

Furthermore, Jepsen and Eskerod [140] suggested that early consultation provides effective control and guidance in the decision-making process, aligning with project objectives. Thus, these studies illustrate how the correlation between CSF1 and CS2 manifests in S2, allowing for effective resolution to address the key challenges.

4.4.3. Frequent Reporting (S3)

S3 allows detailed supervision associated with effective monitoring to ensure that the project meets its objectives. It can resolve issues in various project phases, such as improper planning and poor project delivery. Furthermore, regular reporting can support risk management implementation by providing early warnings to stakeholders to promptly mitigate the risk's impact. In addition, S3 helps to reinforce the clarity of the project's objectives among stakeholders, ensuring mutual understanding within the team. Afterwards, the stakeholders can feel more involved with the regular updates, increasing their sense of belonging and level of contribution. Therefore, this strategy can effectively manage CSF2, leading to a more responsible environment among stakeholders and maintaining control to achieve project success.

Literature evidence: A study mentioned that routine reporting enables continuous monitoring to support timely corrective actions, improving control [46]. Hillson [141] emphasised that regular reporting is a proactive approach to risk management to prevent the escalation of adverse impacts from the issues and maintain project stability. Based on Locke and Latham [142], project reports can provide constant clarification about project objectives for the project team and support aligning planning and delivery with the expected outcomes. Lastly, an increased sense of ownership can be obtained by consistently reminding relevant stakeholders, which encourages them to meet their commitments for their role in the project [131]. Hence, the implementation of S2 is aligned with CSF2 by allowing immediate signals for necessary adjustments and ensuring the project team's contribution to meeting project objectives.

Based on the discussion of PM strategies in this research, the integration arrangement of PM strategies with the key CSF, challenges, and their correlations are summarised in Table 10.

Table 10. Integration of PM strategies and key CSFs, challenges, and their correlations.

Key CSF	PM Strategies	Key Challenges
CSF 1	Cross-functional framework (S1)	C3, C5, C14, and C15
	Early consultation (S2)	C1, C3, C4, C5, C6, C8, C12, C13, C14, and C15
CSF 2	Frequent reporting (S3)	C1, C4, C6, C8, C12, and C13

5. Conclusions

This research aims to identify applicable project management strategies to deliver renewable energy projects in Indonesia. To achieve this aim, the research (1) identified the CSFs for Indonesia's renewable energy projects, (2) identified the key challenges in Indonesia's energy sector development, and (3) the identified CSFs and challenges were used to inform project management strategies to deliver renewable energy projects in Indonesia. A questionnaire survey collected data from 182 respondents involved in Indonesia's energy sector development. The data were analysed using exploratory factor analysis and structural equation modelling. The result revealed 13 CSFs grouped into stakeholder collaboration, delivery management, project supervision, and integration management. The analysis identified 10 key challenges in Indonesia's energy sector development. These

challenges included insufficient planning, poor stakeholder communication, and unrealistic cost and time estimation. Three main strategies were recommended to address emerging challenges in renewable energy projects and achieve sustainable development goals in Indonesia. The strategies included a cross-functional framework for effective collaboration, early consultation for integrating collaboration and supervision, and frequent reporting for enhanced supervision. Given Indonesia's well-documented issues with corruption, collusion, and nepotism (KKN), these strategies can also address these concerns by ensuring regulatory compliance and enhancing the monitoring system throughout the process.

While this study successfully achieved its aim, it is essential to acknowledge certain limitations and propose future research directions. The relatively low number of responses may impact the generalisability of the findings. The adopted methodology is cross-sectional, concentrating data collection on a specific moment in time. Future research could benefit from larger sample sizes to validate the findings. Moreover, employing a multiple-case design using secondary data from the existing literature could enhance both the internal and external validity of the research. This study is specifically limited to renewable energy projects in Indonesia, as the considerations for these projects are influenced by the surrounding context and the various types of projects. Further studies are recommended to verify how the strategies impact projects with typical characteristics. This study focused on renewable energy projects in Indonesia within the framework of committing to SDGs, recognising that different project types can generate distinct considerations for CSFs and challenges. Additionally, this study recommended innovative strategies, necessitating further research to verify the impact of these strategies on projects with typical characteristics. Given the high scale and complexity of renewable energy projects, a more detailed study is required to assess the implementation of these strategies for enhancing PM practices in managing uncertainties. A broader range of case studies from various industries and developing countries should further clarify the specific indicators and their relevance to project success in their contexts.

This study develops both practical and empirical implications for the industry. Regarding practical implications, the method of identifying CSFs and challenges can provide valuable lessons and help determine appropriate strategies for projects. These strategies can be integrated into the project delivery system at PLN to ensure comprehensive consideration in the decision-making process, utilising a cross-functional framework. This approach facilitates proper management of changes through early consultation and frequent reporting while maintaining project performance. As for empirical implications, this research highlights the benefits of incorporating diverse perspectives to gain extensive insights into the project. Since project managers must determine the appropriate PM style based on the project and the organisation, identifying distinct expectations from multiple stakeholders can enhance PM performance by addressing their requirements effectively.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

CFA	confirmatory factor analysis
CFI	comparative fit index
CSF	critical success factor
EFA	exploratory factor analysis
ENDC	Enhanced Nationally Determined Contribution
KKN	corruption, collusion, and nepotism
KMO	Kaiser–Meyer–Okin
MLE	maximum likelihood estimation
NZE	net zero emission
PCA	principal component analysis
PLN	State Electric Company
PM	project management
PMI	project management institute
REP	renewable energy project
RMSEA	root mean squared error of approximation
RUPTL	electricity supply business plan
SDG	sustainable development goals
SEM	structural equation modelling
SF	success factor
SRMR	standardised root mean square residual
TLI	Tucker–Lewis index
UN	United Nations

Appendix A. Sample of the Survey Questionnaire

You are being invited to take part in a research project. Before you decide, you need to understand why the research is being performed and what it will involve. Please take time to read the following information carefully. Ask us if anything could be clarified or if you want more information. Take time to decide whether you wish to take part.

This research study aims to explore the most suitable project management strategies to deliver renewable energy projects in Indonesia. The participants in this research study are professionals and practitioners who are participating in energy sector development in Indonesia. If you meet this criterion, we invite you to participate in the survey. For those who do not meet this specific category, we sincerely appreciate the time you have taken to read this questionnaire.

What is this document? This document serves as an information sheet for this research study. It explains the nature of this study, your rights, and what will be performed with your data.

Nature of this study. This research study involves completing the questionnaire, which consists of statements. You will be asked to choose one of the answers from the options provided based on your experiences and perceptions. Before you start, we may have questions about you (e.g., tenures, positions, and role in the project). You need to answer every question in the questionnaire. It will take you approximately 10–15 min to complete the questionnaire. You will be given full instructions shortly.

Risks and benefits. There are no known risks associated with this study. While there is no direct benefit to participants, your participation will contribute to our knowledge. The results of this study are expected to provide valuable insights that can be used to enhance the effectiveness of future delivery performance in renewable energy projects in Indonesia.

Confidentiality and use of data. To safeguard your privacy, we will never share personal information with anyone outside the researcher, his supervisor, and assessment staff at the University of Leeds as required for assessment purposes related to the researcher's

degree. The data will be securely stored in encrypted files to prevent unauthorised access. Responses will be made anonymous to protect your privacy, and any data will be presented in an aggregated form to prevent the identification of individuals.

Voluntary participation and right to withdraw. Your participation is voluntary, and you may withdraw from this study at any time and for any reason. If you have any questions or need further information, please contact the researcher by email. Please visit the University of Leeds Privacy Notice for more information regarding ethics and data protection. By completing and returning this questionnaire, you imply your consent to participate in this research study. We sincerely appreciate your time, effort, and valuable insights in this research study. Thank you for your participation.

You may continue to the next page to give consent for your participation.

Consent Form

Please give a checklist next to each statement if you agree:

- ___ I agree to participate in this study voluntarily, and I am free to withdraw at any time without giving any reason.
- ___ I confirm that I have read and understood the information explaining the research project and how my data will be stored and used.
- ___ I understand that my responses will be kept strictly confidential.
- ___ I understand that relevant sections of the data collected during this study may be reviewed by the researchers.

By clicking "I agree," you indicate your consent to participate in this research.
I agree (button to proceed)

Section 1

First, you will be asked some demographic information:

1. Have you participated in energy sector projects in Indonesia?
   - Yes.
   - No.
2. What is your gender?
   - Male.
   - Female.
   - Prefer not to say.
3. How long have you been participating in energy sector's projects?
   - Less than 5 years.
   - 5–10 years.
   - 10–15 years.
   - More than 15 years.
4. What is the environment of your daily job?
   - On site.
   - In the office.
5. What is your current position in the job?
   - Managerial.
   - Non-managerial.
6. What is the role of the organisation in the projects that you are working for?
   - Client.
   - Contractor.
   - Consultant.

Instructions

Please read the following instructions carefully before starting the questionnaire:

1. Please answer each question honestly based on your personal experiences and perceptions.
2. There are no right or wrong answers.
3. For the questions, you will be asked to indicate your level of agreement on a 5-point scale:

1 = Strongly Disagree.
2 = Disagree.
3 = Neutral.
4 = Agree.
5 = Strongly Agree.

After completing the questionnaire, please click the "Submit" button to send your responses.

Section 2

Table A1. Samples questions in Section 2.

No	Question	Answer (Please Select One)				
		1	**2**	**3**	**4**	**5**
1	Do you think you know about Indonesia's Sustainable Development Goals (SDGs) to reach Net Zero Emissions and Energy Transitions in 2060?					
2	Do you think Indonesia, as a developing country, has barriers to achieve SDG in 2060?					
3	Do you agree that Indonesia has the capability to achieve the SDG in 2060?					
	CRITICAL SUCCESS FACTORS (CSFs)					
4	Do you agree that Indonesia needs to prioritise several particular project management areas to reach project success in renewable energy projects for SDG?					
5	Do you agree that clear project management objectives can significantly determine project success while carrying out the renewable energy projects for SDG?					
6	Do you agree that top management support can significantly determine project success while carrying out the renewable energy projects for SDG?					
7	Do you agree that clear information and communication can significantly determine project success while carrying out the renewable energy projects for SDG?					
8	Do you agree that clear stakeholder involvement can significantly determine project success while carrying out the renewable energy projects for SDG?					
9	Do you agree that the competency of the project team can significantly determine project success while carrying out the renewable energy projects for SDG?					
10	Do you agree that the authority of project manager/leader can significantly determine project success while carrying out the renewable energy projects for SDG?					
11	Do you agree that problem-solving abilities can significantly determine project success while carrying out the renewable energy projects for SDG?					
12	Do you agree that project performance and quality can significantly determine project success while carrying out the renewable energy projects for SDG?					
13	Do you agree that realistic cost and time estimates can significantly determine project success while carrying out the renewable energy projects for SDG?					
14	Do you agree that adequate project control can significantly determine project success while carrying out the renewable energy projects for SDG?					
15	Do you agree that adequate resources can significantly determine project success while carrying out the renewable energy projects for SDG?					
16	Do you agree that planning and controlling can significantly determine project success while carrying out the renewable energy projects for SDG?					
17	Do you agree that performance monitoring and feedback can significantly determine project success while carrying out the renewable energy projects for SDG?					
18	Do you agree that clear project missions/common goals can significantly determine project success while carrying out the renewable energy projects for SDG?					
19	Do you agree that project ownership can significantly determine project success while carrying out the renewable energy projects for SDG?					

Table A1. *Cont.*

No	Question	Answer (Please Select One)				
		1	2	3	4	5
	CHALLENGES					
20	Do you think Indonesia will face challenges while carrying out the renewable energy projects for SDG?					
21	Do you agree that insufficient planning will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
22	Do you agree that lack of skilled workers will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
23	Do you agree that poor stakeholder communication will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
24	Do you agree that unrealistic cost and time estimation will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
25	Do you agree that unclear project scopes will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
26	Do you agree that underestimation of risk control and management will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
27	Do you agree that insufficient resources will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
28	Do you agree that an inadequate project delivery system will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
29	Do you agree that lack of technology knowledge will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
30	Do you agree that poor top management support will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
31	Do you agree that insufficient cash flow will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
32	Do you agree that inappropriate analysis and design will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
33	Do you agree that an inadequate project performance and quality control will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
34	Do you agree that lack of accountability in decision-making will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
35	Do you agree that insufficient bureaucracy system will have a strong impact on project performance while carrying out the renewable energy projects for SDG?					
	IMPACT OF CSF AND CHALLENGES ON PROJECT SUCCESS					
36	Do you agree that the critical success factors and challenges have a strong impact on Project Success in renewable energy projects for SDG?					

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