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# Evaluation of Green Investment in Renewable Energy Power Plants Using Analytical Hierarchy Process in Archipelago

**Ferdy Hidayatullah[1], Rizki Julia Utama[2], Muksalmina[3], Ahmad Syahyana[4], Sari Raudhatul Jannah SI[5], Safura Rusydi[6], Lukman Nul Hakim[7], Mairezaton[8], Ismi Ridha Mulyana[9]**

[1,3,4,5,6,7*)] Department of Management, Universitas Ubudiyah Indonesia, Banda Aceh, Aceh

[2,8,9)]Department of Computer Education, Universitas Ubudiyah Indonesia, Banda Aceh, Aceh

* Correspondence e-mail; ferdyhidayatullah@uui.ac.id

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**Abstract**

This study evaluates green investment in solar photovoltaic (PV) power plants in Indonesia's archipelagic regions using the Analytical Hierarchy Process (AHP). Despite the country's renewable energy target, solar and wind development remains constrained by investment risks, inadequate infrastructure, and policy uncertainty. The study aims to identify and prioritize the key determinants influencing green investment decisions for solar PV projects in island areas. Data were collected through questionnaires and interviews with 75 government representatives, researchers, and practitioners, with 35 responses meeting the AHP consistency requirement. The results indicate that policy factors are the most influential dimension (0.4825), followed by economic (0.3120) and technical factors (0.2055). At the sub-criteria level, profitability (0.7724), renewables obligation (0.6055), and technological maturity (0.6020) received the highest priorities. The findings show differences among stakeholder perspectives regarding subsidies, regulatory certainty, and financial accessibility. The study contributes a structured multi-stakeholder decision-making model and recommends combining fiscal incentives, long-term regulatory frameworks, and risk-mitigation mechanisms to accelerate solar PV investment.

**Keywords** Solar Power Plant; Green Investment; Renewable Energy; Archipelago; Analytical Hierarchy Process



## INTRODUCTION

Photovoltaic (PV) solar power plants are the fastest-growing source of renewable energy, contributing more than 38% of global renewable capacity expansion between 2018 and 2025 (EIA, 2024). PV solar energy is more modular compared to other renewable energy sources, enabling greater grid connectivity while lowering the critical mass of construction costs, thus offering relatively high investment scalability (Hasibuan et al., 2024). According to the International Energy Agency, PV solar in Asia will account for more than 50% of the increase in total renewable energy over the next five years, with over 60% of new PV capacity expected to be installed in Asia (EIA, 2024). Policy factors in major Asian countries have created a conducive environment for PV solar expansion. All major Asian countries, including Indonesia, Vietnam, Japan, and South Korea, are promoting various supportive policies (B. Kim et al., 2019). Although China has terminated its feed-in-tariff (FIT) scheme, the country is expected to maintain its current PV expansion pace due to existing infrastructure investments. China's PV capacity is projected to nearly triple, from 131 GW in 2017 to 386 GW by 2025 (Rystad Energy, 2025). PV expansion in India is also accelerating due to its economic attractiveness and sustained policy support. India is expected to become the world's third-largest PV capacity holder, adding 63 GW between 2018 and 2024 (PIB, 2025). In South Korea, rapid PV expansion is anticipated in response to the government's Renewable Energy 3020 policy (MOTIE, 2018). Overall, renewable energy projects in Asia dominate with strong prospects for significant growth in solar energy deployment.

Indonesia itself has set a renewable energy (RE) target of 23% by 2025, including 3.6 GW from wind power plants (WPP) under the mandatory National Energy Master Plan 2020–2025. However, actual WPP development reached only 1.13 GW or 31% of the target by 2024, falling short of national energy goals (IESR, 2024). As an archipelagic country, Indonesia should be able to optimize its vast renewable energy potential, particularly in remote and outer islands. Solar energy in these regions remains underutilized, especially in the so-called "3T" (frontier, outermost, and disadvantaged) areas. The average solar radiation in archipelagic regions is 4.5 kWh/m$^2$/day with monthly fluctuations of about 10%, which falls into the stable solar category (Hidayatullah et al., 2025). The stalled growth of WPP risks creating inequality in electricity distribution across regions. In the archipelago, grid integration is critical for inter-island distribution, yet faces significant challenges due to high investment costs and inadequate infrastructure. Moreover, most island regions still rely on fossil-fuel-based diesel generation, which is environmentally unsustainable (Siregar et al., 2024).

According to Sustainable Finance Indonesia (2024), renewable energy investment growth has been alarming, recorded at –37%, with wind power investment representing only 6% of the total energy mix. This reflects a disproportionate allocation of investments toward other energy sources, leaving WPP development lagging behind other renewables. If this trend continues, Indonesia's vast WPP potential will remain underutilized, jeopardizing national renewable energy targets. The lack of investment is influenced by several factors, including limited transmission infrastructure, poor grid integration in archipelagic regions, regulatory uncertainty, unattractive tariff schemes, fossil fuel subsidies, and restricted access to financing due to high project risk. These challenges make achieving Indonesia's Net Zero Emission 2060 target increasingly difficult (SFI, 2024).

Within this context, the financial sector plays a strategic role in advancing green finance. Banks, financial institutions, and capital markets function as providers of capital for renewable energy projects as well as managers of investment risk. Their role is crucial for a successful transition, as instruments such as green bonds, sustainability-linked loans, and blended finance can reduce reliance on government subsidies while attracting private sector participation. However, the low share of WPP investment suggests that Indonesia's financial sector remains cautious due to limited risk-mitigation instruments and insufficient fiscal incentives. Financing through combined foreign direct investment (FDI) and domestic direct investment (DDI) has also been suboptimal in terms of downstream integration. Therefore, the financial sector’s role in establishing clear regulations, risk guarantees, and investment incentives will be key to accelerating green project financing, which requires a comprehensive evaluation framework for green finance decision-making (East Asia Forum, 2025).

The rapid growth of the PV market underscores the need for decision-making tools to design and evaluate efficient investment strategies. Previous studies have mostly focused on technical aspects such as site selection (Ahadi et al., 2023; Colak et al., 2020 and Ahadi et al., 2023), sustainability assessment (Londoño-Pineda et al., 2021; Alimohammadlou & Khoshsepehr, 2022 and Hasibuan et al., 2025), and PV technology selection (Eyuboglu et al., 2025; Arıkan Kargı & Cesur, 2024 and Shayani Mehr et al., 2022). Research on investment and policy aspects (Günen, 2021; Mustafa et al., 2024 and Macchiaroli et al., 2023), feasibility studies (Hamad et al., 2024; Asare-Addo, 2022 and Bandaru et al., 2021), and investment indicator development (Koirala et al., 2021 and Keeley & Matsumoto, 2018) has largely been limited to econometric analyses of macroeconomic parameters affecting renewable energy expansion. Consequently, these findings cannot be directly applied to project-level investment strategy formulation and evaluation, which limits their usefulness for financial investors in evaluating individual projects and their relevance to social communities and green finance implementation.

To address these limitations, this study develops a project-level investment evaluation model for PV solar power plants and derives the relative weights of each indicator. Structured interviews with energy industry experts and power plant operators were conducted, complemented by the Analytical Hierarchy Process (AHP) method. Expert questionnaires were used to propose investment evaluation indicators that should be considered for efficient PV investments from a financial investor perspective. AHP was also applied to account for uncertainty in decision-making (J. Kim et al., 2019 and B. Kim et al., 2019). 9). The AHP method was then used to determine the weight of each indicator.

This research contributes significantly by developing a green investment evaluation model for photovoltaic solar power plants at the project level using the AHP approach. Unlike previous studies that focused primarily on technological, policy, or macroeconomic aspects, this research formulates relevant indicators by incorporating financial and risk factors, while also quantifying the relative importance of each. Indicators were derived through literature review and expert interviews involving financial investors, project developers, academics, and power plant practitioners, making them universal and applicable in various contexts, including Indonesia’s archipelagic regions. Furthermore, this study emphasizes the differing perceptions among key stakeholders of power companies, financial investors, and practitioners and identifies their distinct investment priorities. As a result, the proposed model is expected to provide a more rational, quantitative, and comprehensive foundation for supporting investment decisions and accelerating solar PV development in Indonesia. This research also represents one of the first studies to prioritize the investment dimension of PV projects by highlighting the quantification of stakeholder differences and their implications for investment strategies.

**METHODS**

This study was conducted in the Banyak Islands, Aceh Singkil, using two research sites: Baguk Island, located at coordinates (2°18′12.6″N, 97°24′32.2″E), and Panjang Island, located at coordinates (2°20′04.9″N, 97°23′22.9″E), as shown in Fig. 1. The selection of these sites was based on their suitability with the research objectives, particularly considering the inadequate electricity supply, which still relies on diesel power plants, and the limited accessibility of inter-island grid integration. The method employed in this study is a systematic approach to investigating a series of activities aimed at uncovering new knowledge and insights. The research process typically begins with problem identification, a review of existing literature, and an examination of previous research perspectives. After developing hypotheses, data are collected, analyzed, and processed (Sahir, 2021). This research model applies a five-level hierarchy to evaluate solar PV for green investment decision-making: Level 1 (Goal), Level 2 (Indicators/Dimensions), Level 3 (Criteria), and Level 4 (Sub-Criteria/Factors). The sample consisted of three respondent groups with qualifications and credibility relevant to the energy sector in Aceh (B. Kim et al., 2019). These groups included energy finance experts, government representatives (Aceh Energy and Mineral Resources Office), academics (lecturers in renewable energy and management), and practitioners (National Electricity Company (PLN) and investors), with 25 respondents in each group, totaling 75 respondents.

The Analytical Hierarchy Process (AHP) is a decision-making method developed by Saaty, proven effective in addressing complex problems. AHP is particularly useful for problems involving branching criteria and multiple sub-criteria (Saaty 1988). Essentially, AHP is a decision-making framework designed to overcome limitations of previous approaches, with its main tool being a functional hierarchy that uses human perception as its primary input. Through hierarchical structuring, complex and unstructured issues can be decomposed into groups and organized systematically (Dos Santos et al., 2019). In practice, AHP applies pairwise comparisons among criteria, sub-criteria, and alternatives within a hierarchical structure. In this study, the dimensions include policy, economic, and technical factors (B. Kim et al., 2019). The fundamental principles of AHP applied here include Decomposition, Comparative Judgment, Synthesis of Priority, and Logical Consistency. For the analysis, this study employs the Spice Logic software as the main AHP tool.

1. Decomposition

Defining the problem, by breaking down the complete problem into its elements and describing it in hierarchical form, as follows:

2. Comparative Judgment

Comparative judgment is a crucial step in the AHP (Analytic Hierarchy Process) method, involving the assessment of the relative importance between two elements at a particular level. These judgments are represented in a matrix format using a priority scale. For a given set of *n* elements, the pairwise comparison matrix (comparison matrix) will be of size *n* x *n*, and the total number of pairwise comparisons required is $n(n-1)/2$. A distinctive characteristic of the comparison matrix employed in the AHP method is that its diagonal elements, from top left to bottom right, are all equal to one. This is because the elements being compared are essentially the same (Saaty, 1988).

**Table 1. Comparison Matrix**

| | A1 | A2 | A3 | A4 |
|---|---|---|---|---|
| A1 | 1 | | | |
| A2 | | 1 | | |
| A3 | | | 1 | |
| A4 | | | | 1 |

3. Synthesis of Priority

The comparison matrix for a group of elements has been formed, so the next step is to measure the priority weight of each element. The final result of calculating the priority weight is a decimal number below one (for example 0.01 to 0.99) with the total priority for elements in one group equal to one. The priority weights of each matrix can determine local priorities and by synthesizing local priorities, global priorities can be obtained. Determining the priority of criteria elements can be seen as the weight/contribution of these elements to decision making objectives. This priority is determined based on the views of experts and parties with an interest in decision making, both directly (discussion) and indirectly (questionnaire) (Saaty, 1988).

4. Logical Consistency

One of the main assumptions of the AHP method that differentiates it from other methods is the absence of absolute consistency requirements. With the AHP method which uses human perception as input, inconsistencies can occur because humans have limitations in expressing their perceptions consistently, especially when comparing many elements. Based on these conditions, humans can express their perceptions freely without having to think about whether their perceptions will be consistent in the future or not. Perceptions that are 100% consistent do not necessarily provide optimal or correct results and conversely perceptions that are not completely consistent may provide the true or best picture of the situation. Determining preference values between elements must be logically consistent, which can be measured using the Consistency Ratio (CR) (Saaty, 1988). The CR criteria in calculating element/variable equations are as follows:

a. If $CR < 0.1$, it means that the data in the comparison matrix is consistent and the eigenvector values are acceptable.
b. If $CR > 0.1$, it means that the data in the comparison matrix is inconsistent and the eigenvector value is unacceptable.

The data collection for this research is conducted by distributing questionnaires. The questionnaire technique is one of the data collection methods involving the submission of written questions through a pre-prepared list of questions that respondents must fill out (Triani, 2017). The measurement scale in research using Analytical Hierarchy Process (AHP) utilizes a scale for paired comparison assessment, as shown in the following table 2.

**Table 2. Pairwise Comparison Rating Scale**

| Priority | Clasification | Information |
|---|---|---|
| 1 | Both elements are equally important | Two elements have the same influence on goals |
| 3 | One element is slightly more important than the others | Experience and judgment slightly favor one element over the other |
| 5 | One element is more important than the other elements | Experience and judgment strongly favor one element over another |
| 7 | One element is clearly more important than the others | One element that is strongly supported and dominant is seen in practice |
| 9 | One element is absolutely more important than the others | Evidence supporting one element over another has the highest possible level of corroboration |
| 2,4,6,8 | Values between two adjacent consideration values | A compromise is required between two considerations |

Source: Saaty, (1988)

By instinct, humans can estimate simple quantities through their senses. The simplest process is comparing two things where the accuracy of the comparison can be justified. Therefore, a quantitative scale from 1 to 9 is established to assess the importance level of one element compared to another (Saaty, 1988). In this study, we explore the evaluation of tourism destinations using the AHP approach by examining the dimensions of policy, economic, and technical factors in relation to solar PV for green investment decision-making (B. Kim et al., 2019). To realize the direction of this research, a conceptual framework is required to provide an overview of the research stages up to the conclusion. The following is the conceptual framework for the hierarchical structure applied in this study, as illustrated in Fig. 1 below:

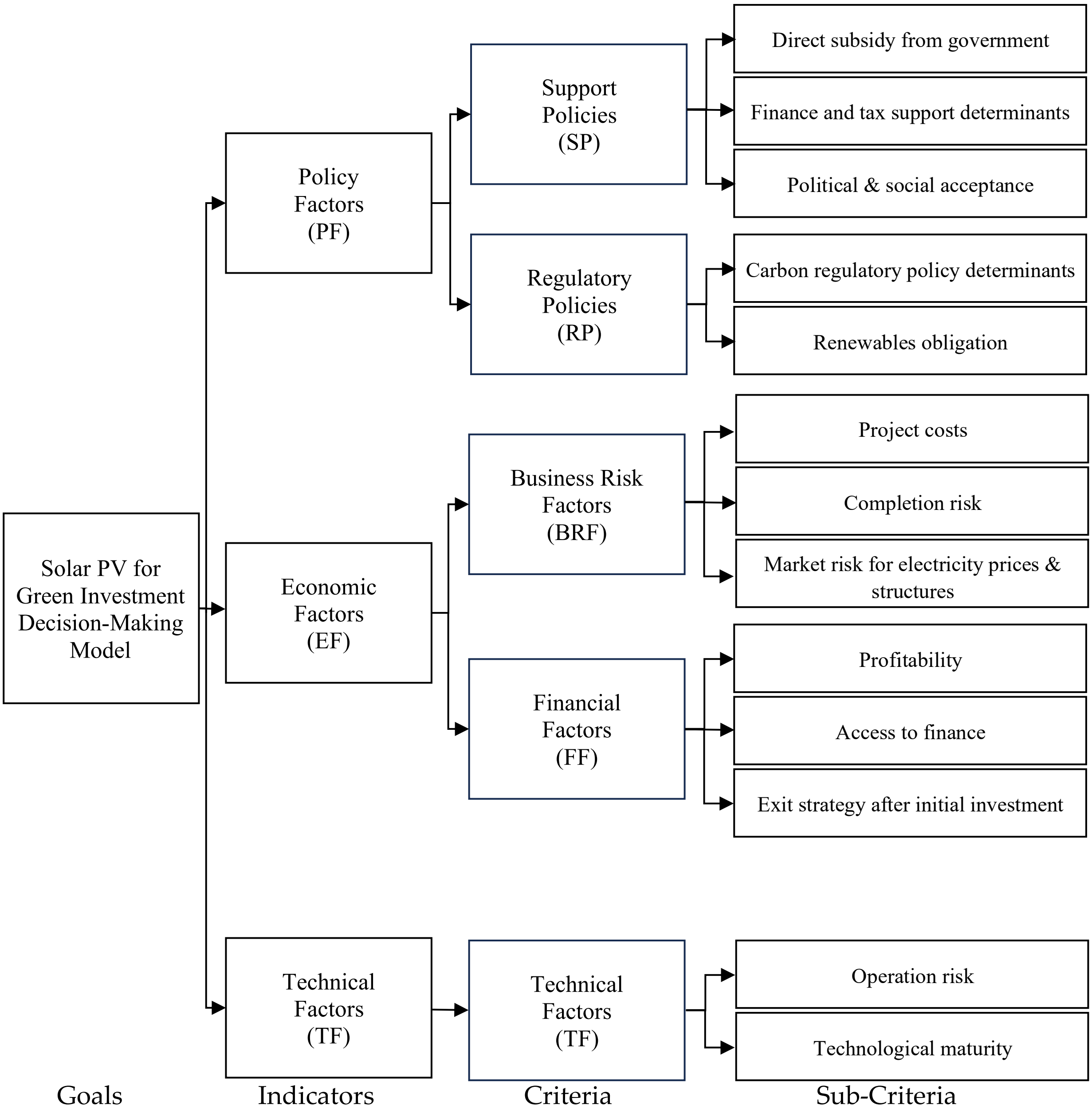


**Fig 1. Structural Hierarchy Diagram of Solar PV for Green Investment Evaluation**

Based on Figure 1 above, it can be seen that at Level 1 (Goal) lies the model for evaluating solar PV for green investment decision-making. At Level 2 (Indicators/Dimensions), the factors include policy, economic, and technical aspects. At Level 3 (Criteria), the elements consist of support and regulatory policies, business risk and financial factors, as well as technical factors. At Level 4 (Sub-Criteria/Factors), various determinants from these three dimensions are included. The relationships among these variables will be examined as an alternative framework for evaluating solar PV for green investment through a hierarchical structure using the Analytical Hierarchy Process (AHP) method.

Analytical Hierarchy Process (AHP) is a multi-criteria decision-making method developed by Thomas L. Saaty. It structures a complex decision problem with multiple factors or criteria into a hierarchy. This hierarchy is a representation of the problem in a multi-level structure where the top level is the goal, followed by levels of factors, criteria, sub-criteria, and so on down to the bottom level of alternatives. With a hierarchy, a complex problem can be broken down into its components and then arranged into a hierarchical form so that the problem appears more structured and systematic (Saaty, 1988). AHP is a decision-making method that essentially tries to overcome all the shortcomings of previous methods. The main tool of the AHP method is a functional hierarchy with the main input being human perception. With a hierarchy, something complex and unstructured is broken down into groups and then these groups are arranged into a hierarchical structure (Dos Santos et al., 2019).

A striking difference between the AHP method and other decision-making methods lies in the type of input. Existing methods generally use quantitative input. Automatically, these methods can only process quantitative things as well (Siwiec & Pacana, 2021). The AHP method uses human perception, which is considered to be "expert" as the main input. The criteria, "expert" here does not mean that the person must be a genius, smart, have a doctorate degree, and so on, but rather refers to someone who really understands the problem at hand, feels the consequences of a problem or has an interest in the problem (Leal, 2020). The Analytical Hierarchy Process (AHP) method is multicriteria because it uses many criteria in determining the priority of a decision support system. In addition to its multicriteria nature, the AHP method is also based on a logical and structured process, because the prioritization is carried out using a logical and structured procedure (Karakaş & Yıldıran, 2019).

Pairwise comparison matrix analysis is a method for each criterion based on the AHP (Analytical Hierarchy Process) scale. The pairwise comparison matrix illustrates the relative distribution or influence of each element on each objective or criterion at the same level above it. From each pairwise comparison matrix, the eigenvector of each pairwise comparison matrix is then calculated to obtain the local priority because there is a pairwise comparison matrix at each level, then synthesis must be carried out between the local priority to obtain the global priority. The procedure for performing synthesis differs according to the hierarchy. Ranking the elements according to relative importance through the synthesis procedure is called priority setting. Global priority is the priority/weight of subcriteria or alternatives to the overall/highest level hierarchy goal. The way to get this global priority is to multiply the local priority of subcriteria or alternatives by the priority of the parent criterion (the criterion at the level above it) (Saaty, 1988).

## RESULTS AND DISCUSSION

### Consistency of Responses

The number of samples and the ratio of each respondent category to the total samples are summarized in Table 3. This table also presents the consistency test results of the 75 respondents. We applied a CR criterion of 0.15, which is consistent with many previous studies (J. Kim et al., 2019; B. Kim et al., 2019 and Koirala et al., 2021).

**Table 3. Consistency of Responses Analysis**

| Classification of AHP Respondents by Groups | | | | |
|---|---|---|---|---|
| | **Government** | **Reserchers** | **Practitioners** | **Total** |
| Number of respondents | 25 | 25 | 25 | 75 |
| CR < 0,15 | 13 | 12 | 10 | 35 |
| Consistency passing ratio | 52% | 48% | 40% | 46,7% |

The consistency test in the Analytical Hierarchy Process (AHP) was conducted on 75 respondents, equally divided into three groups government, researchers, and practitioners with 25 respondents in each group. The test applied a Consistency Ratio (CR) threshold of 0.15, in line with standards widely adopted in previous AHP studies. The results indicate that only 35 respondents (46,7%) achieved a CR value below 0.15 and were thus categorized as consistent. More specifically, the government group demonstrated the highest level of consistency, with 13 out of 25 respondents (52%) meeting the threshold. The researcher group followed with 12 out of 25 respondents (48%) consistent, while the practitioner group showed the lowest consistency, with only 10 out of 25 respondents (40%). These findings suggest variations in consistency levels among groups, potentially influenced by differences in experience, knowledge background, and familiarity with pairwise comparison assessments. Therefore, the subsequent analysis relied only on data from the 35 consistent respondents to ensure the validity of the AHP weighting results.

**Pairwise Comparison**

The priority scale rankings at Levels 2, 3, and 4 in the evaluation of solar PV for green investment decision-making in island regions were determined by global weights calculated through CI and eigenvalues. The alternative priority scale is presented in Table 4.

**Table 4. Global weight of Pairwise Comparison**

| **Level/Category** | **Global Weight** | **Rating** |
|---|---|---|
| **Level 1 (Indicators)** | | |
| Policy factors | 0.4825 | 1 |
| Economic factors | 0.3120 | 2 |
| Technical factors | 0.2055 | 3 |
| **Level 2 (Criteria)** | | |
| Support policies | 0.1872 | 4 |
| Regulatory policies | 0.1248 | 5 |
| Business risk factors | 0.1930 | 3 |
| Financial factors | 0.2895 | 1 |
| Technical factors | 0.2055 | 2 |
| **Level 3 (Sub-Criteria)** | | |
| Direct subsidy from government (SP-1) | 0.5536 | 5 |

| | | |
|---|---|---|
| Finance and tax support determinants (SP-2) | 0.2520 | 8 |
| Political & social acceptance (SP-3) | 0.1953 | 11 |
| Carbon regulatory policy determinants (RP-1) | 0.3951 | 7 |
| Renewables obligation (RP-2) | 0.6055 | 2 |
| Project costs (BRF-1) | 0.5873 | 4 |
| Completion risk (BRF-2) | 0.2122 | 9 |
| Market risk for electricity prices & structures (BRF-3) | 0.2016 | 10 |
| Profitability (FF-1) | 0.7724 | 1 |
| Access to finance (FF-2) | 0.1311 | 12 |
| Exit strategy after initial investment (FF-3) | 0.1078 | 13 |
| Operation risk (TF-1) | 0.3982 | 6 |
| Technological maturity (TF-2) | 0.6020 | 3 |

The AHP results show that at Level 1 (Indicators), policy factors (0.4825) rank first, followed by economic factors (0.3120) and technical factors (0.2055). This finding highlights that the success of renewable energy investment in island regions strongly depends on government support through regulations and incentive instruments. In the context of green investment, policy priorities are crucial because they create an attractive investment ecosystem for private investors to finance Solar PV projects.

At Level 2 (Criteria), financial factors (0.2895) and business risk (0.1930) emerge as the main economic considerations, while within the policy dimension, support policies (0.1872) hold significant importance. This indicates that although technical factors determine system sustainability, investment decisions are more strongly influenced by financial certainty and supportive regulations. Therefore, fiscal policies and incentive instruments such as subsidies, tax reductions, and green financing schemes are the key determinants of Solar PV investment attractiveness in island regions. At Level 3 (Sub-criteria), the three highest priorities are profitability (0.7724), renewables obligation (0.6055), and technological maturity (0.6020). Profitability demonstrates that investors primarily assess investment feasibility through long-term profit projections. Meanwhile, renewable energy obligations and technological maturity serve as drivers of investor confidence by minimizing project risks. Other technical sub-criteria, such as operation risk (0.3982), are also relevant but carry lower weights compared to financial and policy aspects.

With this composition of weights, it can be concluded that Solar PV investment decisions in island regions are largely influenced by profitability certainty, the presence of mandatory renewable energy policies, and proven technological readiness. Thus, policy strategies emphasizing financial incentives, regulatory certainty, and technical support will be key to attracting green investment for sustainable electrification in island areas. Figure 4 illustrates the relative importance at the third layer, where profitability (53.64%) is considered the most critical factor. Since economic factors showed the highest importance at the first layer, profitability emerges as the main determinant. Furthermore, renewable obligation (42.05%), project costs (40.78%), and technological maturity (41.81%) are regarded as more significant than other indicators. These results imply that direct future profits, cost factors affecting profitability, and the acquisition of renewable obligation certificates are considered more critical than risk factors, which are easier to predict in the early stages of a solar PV project. Alongside renewable obligation (42.05%), project costs (40.78%) also demonstrate higher importance than other factors, as exit strategies in financial investment can reduce project risks and increase returns (Akusta et al., 2025).

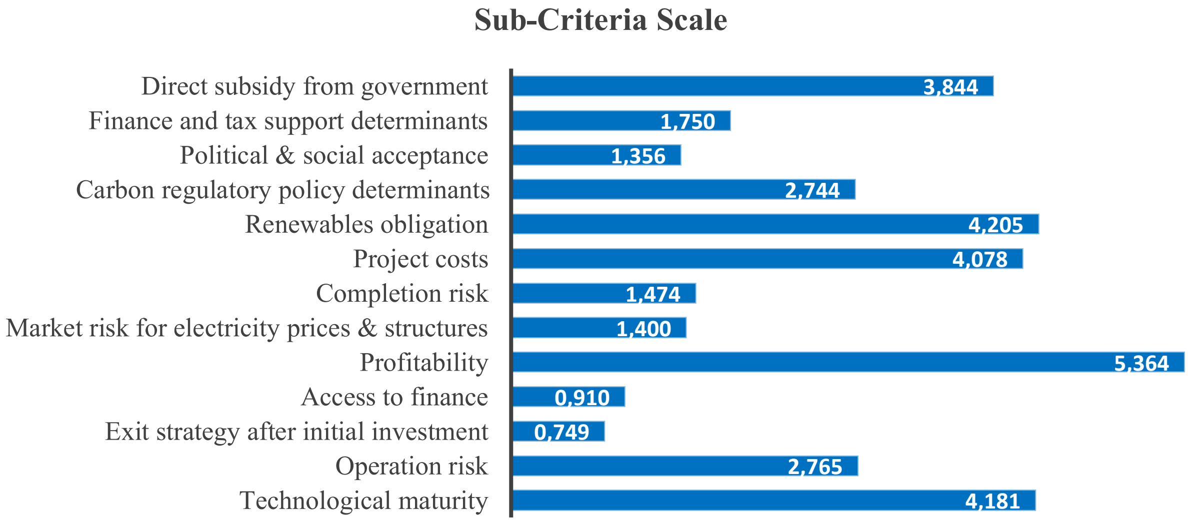


**Fig 2. Analysis results for the fourth layer**

The AHP analysis results indicate that the three sub-criteria with the highest weights are technological maturity (0.1237), profitability (0.1072), and operation risk (0.0818). This confirms that the adoption of proven and mature technologies, clear financial profit potential, and the ability to minimize operational risks are dominant factors in Solar PV investment decision-making in island regions. Therefore, the successful implementation of projects largely depends on technological readiness and business models capable of ensuring sustainable returns.

The next influential sub-criteria are direct subsidy (0.0641) and project costs (0.0457), both of which emphasize the importance of fiscal policy interventions and project cost efficiency in supporting investment sustainability. Direct subsidies and reduced initial costs can enhance project attractiveness for investors, particularly in remote areas with higher financial risks. These findings further reinforce the argument that proactive public policies can accelerate renewable energy adoption in island regions. Meanwhile, factors such as finance & tax support (0.0283), renewables obligation (0.0239), access to finance (0.0227), and political & social acceptance (0.0216) carry medium weights. Although less significant than technical and economic factors, these aspects remain important for long-term sustainability. Regulatory support, the availability of green financing instruments, and local community acceptance can serve as catalysts to strengthen investment competitiveness, especially when combined with de-risking strategies from governments or financial institutions.

The sub-criteria with the lowest weights exit strategy (0.0169), completion risk (0.0165), market risk (0.0155), and carbon regulatory policy (0.0155), exert relatively minor influence in the island context. This suggests that investors and stakeholders focus more on technical issues and profitability than on market risks or carbon regulations. Nevertheless, despite their lower weights, these factors remain relevant at the macro level and should still be considered in the design of comprehensive national energy policies.

First, the dominance of policy factors (0.4825) indicates that investment decisions for solar PV projects in island regions depend strongly on supportive policy frameworks. Fiscal incentives, regulatory certainty, subsidies, and power purchase agreements are essential because remote areas face market, infrastructure, and logistics constraints. Second, economic (0.3120) and technical (0.2055) factors remain important. Economic factors determine profitability through reliable cost and cash-flow projections, while technical factors influence technological maturity, operational readiness, maintenance, and long-term project sustainability. Thus, policy creates investment opportunities, economic factors assess feasibility, and technical factors support implementation. Third, policymakers should prioritize de-risking measures, including capital subsidies, concessional financing, project aggregation, purchase guarantees, and blended finance schemes. AHP weights can also support site-ranking models by combining sub-criteria performance with their global priorities. Finally, the findings are context-specific, and future studies should conduct consistency-ratio checks and sensitivity analyses to test the robustness of investment priorities across different island conditions.

**Detailed Analysis Results by Group**

There are various stakeholders in the solar photovoltaic (PV) power market, consisting of financial investors and power generation companies that operate the plants. It is important to analyze the differing perspectives of stakeholders participating in the solar PV market, given its rapid growth and the diversity of actors involved. Although they share the same objective investment or solar PV power supply each stakeholder may perceive the relative importance of each factor differently. Therefore, this study analyzes the differences in perspectives among academic experts in fields directly or indirectly related to policy formulation and investment, as well as financial investors and representatives of power generation companies, who are the main actors in the solar PV market. The survey was conducted separately for each stakeholder group. The differences in perceptions among these groups were then quantified to support the formulation of future policies and investment indicators related to solar PV. Figure 3 shows the relative importance at the first layer for each stakeholder group.

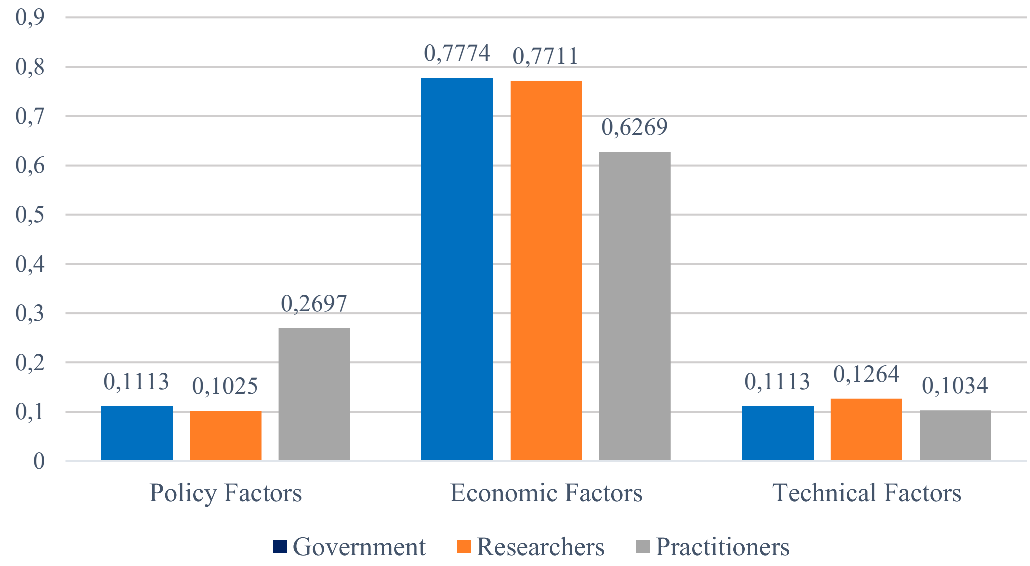


**Figure 3. Analysis Results for the Second Layer of each Stakeholder Group**

Similar to the integrated results Figure 3, economic factors show the highest weights across the three stakeholder groups. For power generation companies, the weights of policy, economic, and technical factors are 26.97%, 62.69%, and 10.34%, respectively. For financial investors, the values are 11.13%, 77.74%, and 11.13%, while for researchers, they are 10.25%, 77.11%, and 12.64%, respectively. These groups exhibit significant differences in relation to policy factors. Power generation companies place greater emphasis on policy factors and less emphasis on technical factors compared to the other groups, as they are most directly affected by policy interventions. For example, under renewable energy utilization programs in island regions, power generation companies are required to install and operate renewable energy facilities. In this context, policy factors are given greater weight by power generation companies, as they are more strongly influenced by regulatory measures than other stakeholders. Furthermore, policy factors may become more significant given the nature of the utility industry, where many companies are owned or supervised by the government. Figure 4 presents the analysis results of policy factors by stakeholder group.

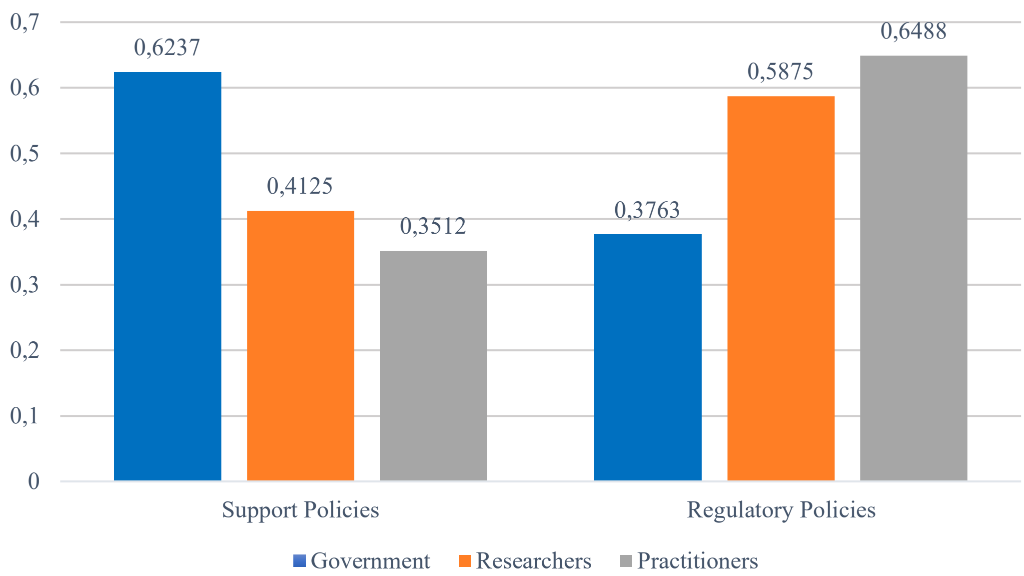


**Fig 4. Analysis Results for Policy Factors by Stakeholder Group**

The AHP results reveal significant differences in policy orientation among the three stakeholder groups regarding Policy Factors. The government places greater emphasis on Support Policies (0.6237) compared to Regulatory Policies (0.3763), indicating that fiscal interventions and incentives are considered the main drivers for reducing initial investment barriers in the archipelagic regions. This aligns with Kamdar & Liu (2025), who found that subsidies and fiscal incentives are critical catalysts for accelerating renewable energy adoption in high-investment-risk areas. By providing initial stimulus, the government can enhance the attractiveness of projects for investors who are generally reluctant to invest in remote areas.

In contrast, researchers consider Regulatory Policies (0.5875) more important than Support Policies (0.4125). This preference reflects the academic view that the sustainability of energy transition relies on a consistent long-term regulatory framework. Recent studies emphasize that renewable energy mandates, technical standards, and carbon regulations are more effective in creating a stable energy market than short-term incentives (Abdul & Wenqi 2024). This perspective underscores the importance of regulation as an institutional foundation to reduce uncertainty and ensure the achievement of national energy targets.

Practitioners exhibit a pattern similar to researchers, with the weight of Regulatory Policies (0.6488) significantly higher than Support Policies (0.3512). The dominance of regulatory factors for practitioners indicates that legal certainty, clear electricity tariffs, and interconnection mechanisms are more decisive for project feasibility than fiscal incentives. According to Gacu et al. (2023), regulatory clarity reduces project risks and increases financial institutions' confidence, which in turn facilitates private investment flows. This explains why business actors consider regulation far more important than direct financial support.

These differences in perspective have important implications for policy design. The government acts as a provider of initial incentives to reduce investment risk, while stable and consistent regulation is more valued by researchers and practitioners to ensure project sustainability. Therefore, an effective policy strategy should combine both approaches: short-term support policies to address initial investment barriers in the archipelagic regions, and long-term regulatory frameworks to maintain the stability of the renewable energy market. These findings are consistent with recent literature emphasizing the need for synergy between fiscal support and regulation to accelerate energy transition in developing countries (B. Kim et al., 2019).

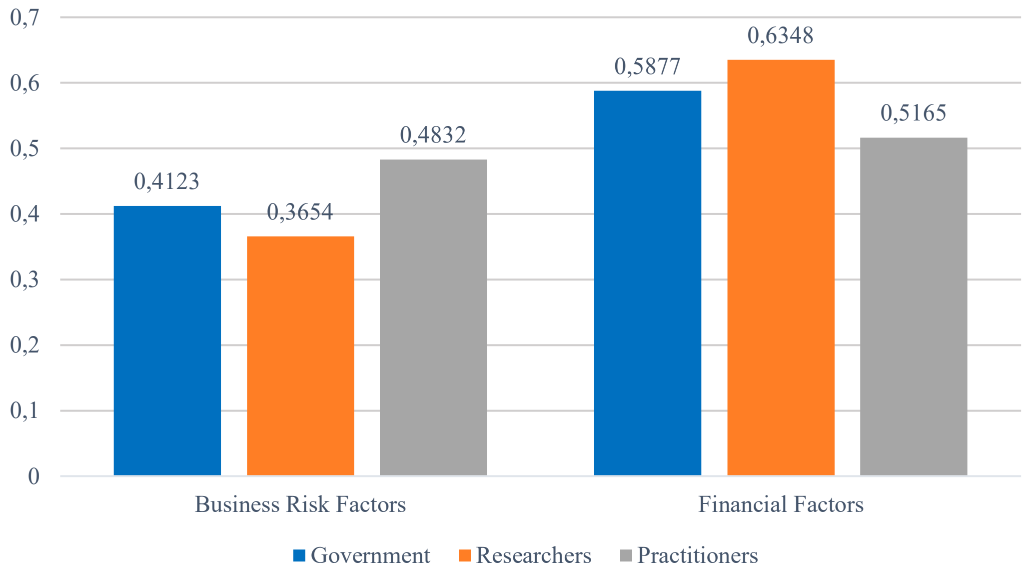


**Fig 5. Analysis Results for Economic Factors by Stakeholder Group**

The AHP analysis of the Economic Factors indicator reveals significant differences in priorities among the three stakeholder groups. The government assigns a higher weight to Financial Factors (0.5877) compared to Business Risk Factors (0.4123). This underscores the government's focus on creating funding mechanisms that can reduce the initial cost barriers for solar power plant development in archipelagic regions. Financial support through soft loan schemes, grants, or blended finance is considered more strategic in mobilizing investment. This finding is consistent with Kamdar & Liu (2025), who highlight the importance of government financial interventions in overcoming project financing constraints for renewable energy in remote areas. The Researcher group also gives greater weight to Financial Factors (0.6346) over Business Risk Factors (0.3654), arguing that access to capital and an appropriate financing structure are key to the long-term sustainability of projects. This perspective aligns with Gacu et al. (2023), who found that financial stability has a greater impact on renewable energy project feasibility than short-term market risks. For academics, innovations in green financing, such as green bonds and carbon credits, are critical instruments to accelerate solar energy penetration, particularly in developing countries with emerging energy markets. Unlike the previous two groups, Practitioners demonstrate a more balanced assessment between Financial Factors (0.5168) and Business Risk Factors (0.4832). This can be explained by the fact that practitioners deal directly with market risks, electricity price uncertainty, and on-the-ground project implementation challenges. This finding is consistent with Abdul & Wenqi (2024), who assert that industry actors consider operational risks among the primary obstacles to renewable energy project implementation. Therefore, practitioners view financial access as needing to go hand in hand with business risk mitigation to ensure projects proceed as planned.

Overall, these differing perspectives indicate that the government and researchers tend to emphasize financial aspects as determinants of project success, whereas practitioners recognize the importance of balancing business risk and financial feasibility. The policy implication of these findings is the need for a combination of instruments, namely innovative financing schemes accompanied by business risk mitigation mechanisms, such as project insurance or electricity price guarantees. This aligns with the recommendations of the International Renewable Energy Agency (IRENA, 2023), which emphasize that integrating financial instruments and risk mitigation can increase investor confidence and accelerate renewable energy adoption in remote areas.

The comparative results show that across all three stakeholder groups, Profitability ranks at the top: Government (0.1216), Researcher (0.1321), and Practitioners (0.1245). This indicates that financial return prospects remain the primary determinant in solar energy investment decisions in the archipelagic regions. For the government, profitability is important to attract private investors, while for researchers, it serves as evidence of long-term financial sustainability. Practitioners also emphasize this, as direct profits are closely linked to operational continuity.

The sub-criterion Project Costs also received high weights across all groups: Government (0.0942), Researcher (0.0896), Practitioners (0.0915). This reflects high sensitivity to initial investment costs, especially since hybrid solar-wind projects in the archipelago generally incur higher logistical and infrastructure expenses compared to mainland projects. Similarly, Access to Finance is prominent, particularly among researchers (0.1062), who regard financing access as a crucial element to ensure project feasibility. From a policy perspective, sub-criteria such as Renewables Obligation (0.0887–0.0925) and Direct Subsidy from Government (0.0735–0.0923) are relatively important, especially for the government, which relies on policy instruments to drive renewable energy penetration. Researchers view renewable energy obligations as a long-term policy instrument, whereas practitioners focus more on direct subsidies that can reduce initial operational costs.

Interestingly, risk-related aspects such as Completion Risk (0.0679–0.0732), Market Risk (0.0685–0.0758), and Operation Risk (0.0487–0.0524) tend to have medium-to-lower weights. This suggests that while risks are acknowledged, all three groups emphasize profit opportunities, cost feasibility, and policy support more heavily. Finally, Technological Maturity holds the lowest weight (0.0178–0.0320), indicating that stakeholders consider solar-wind technology sufficiently mature, and thus no longer a critical factor in investment decision-making.

The radar chart at the fourth level illustrates the distribution patterns of sub-criteria weights among the three stakeholder groups: Government, Researcher, and Practitioners. This visualization reveals factors that serve as points of convergence as well as factors that generate significant differences in assessment. Convergent factors are clearly seen in Profitability, where all three groups assign it as a top priority with relatively high weights. This consensus confirms that financial return prospects are regarded as key to the sustainability of solar energy investments in the archipelagic regions. Additionally, Project Costs also emerge as a relatively balanced factor across groups, indicating shared awareness of the high initial costs associated with developing hybrid solar-wind systems. In contrast, divergent factors appear in sub-criteria such as Direct Subsidy from Government and Access to Finance. The government assigns higher weight to Direct Subsidy due to its role as a regulator and provider of incentives, whereas researchers emphasize Access to Finance as the foundation for long-term project success. Practitioners place both sub-criteria at medium levels, giving greater focus to Market Risk and Completion Risk. These differences reflect distinct orientations: the government is policy-driven, researchers are academically-financially oriented, and practitioners are pragmatically operational.

Thus, the radar chart not only presents each group's priorities but also highlights potential points of synergy as well as areas of divergence. Points of synergy can serve as a basis for collaboration, while differences can provide critical input for formulating inclusive renewable energy policies. This visualization clarifies that implementation strategies should integrate policy incentives, financial access, and technical risk mitigation to gain acceptance across all stakeholders.

**Table 5. Comparison of Stakeholder Group Distribution Patterns at the Fourth Level**

| Sub-Criteria | Stakeholder Group | | | Patterns | Interprestation |
|---|---|---|---|---|---|
| | Governmen | Researchers | Practitioners | | |
| SP-1 | 0,0923 | 0,0735 | 0,0812 | Divergent | Government places higher emphasis on direct subsidies, while researchers assign lower weight, focusing instead on long-term financing. |
| SP-2 | 0,0746 | 0,0824 | 0,0658 | Slightly divergent | Researchers stress fiscal support more strongly, while practitioners consider it less critical. |
| SP-3 | 0,0618 | 0,0702 | 0,0675 | Convergent | All groups recognize socio-political acceptance as important but not as a |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | top priority. |
| RP-1 | 0,0821 | 0,0773 | 0,0804 | Convergent | Similar weights indicate that carbon regulations are relevant but not dominant factors. |
| RP-2 | 0,0887 | 0,0925 | 0,0859 | Convergent | All stakeholders emphasize renewable obligations as essential for long-term sustainability. |
| BRF-1 | 0,0942 | 0,0896 | 0,0915 | Convergent | High upfront costs are a common concern across all groups. |
| BRF-2 | 0,0714 | 0,0679 | 0,0732 | Convergent | Small differences, with practitioners being slightly more sensitive to project completion risks. |
| BRF-3 | 0,0685 | 0,0720 | 0,0758 | Slightly divergent | Practitioners highlight market risks more strongly than the other groups. |
| FF-1 | 0,1216 | 0,1321 | 0,1245 | Convergent | All stakeholders consistently regard profitability as the most critical factor. |
| FF-2 | 0,0894 | 0,1062 | 0,0918 | Divergent | Researchers place stronger emphasis on financial accessibility, while others remain moderate. |
| FF-3 | 0,0769 | 0,0805 | 0,0781 | Convergent | All groups assign similar weights, recognizing exit strategy as a relevant financial safeguard. |
| TF-1 | 0,0487 | 0,0490 | 0,0524 | Convergent | Operational risks are considered relatively low across all stakeholders. |
| TF-2 | 0,0298 | 0,0178 | 0,0320 | Slightly divergent | Government and practitioners show greater confidence in technology maturity, while researchers assign lower weight, reflecting innovation concerns. |

The AHP analysis at the fourth level shows that several factors converge across all stakeholder groups, particularly profitability, which holds the highest weight in all three groups (Government 0.1216; Researcher 0.1321; Practitioners 0.1245). This consensus indicates that financial sustainability is a primary benchmark in solar energy investment decisions in the archipelagic regions. Additionally, project costs and renewables obligation also receive relatively balanced weights, emphasizing that high initial costs and renewable energy mandates are considered critical elements that cannot be overlooked. These findings are consistent with Wang et al. (2023), who found that profitability and cost structure are dominant factors influencing renewable energy investment decisions.

On the other hand, some factors exhibit considerable divergence. The government places greater emphasis on Direct Subsidy from Government (0.0923) as a policy instrument believed to accelerate renewable energy penetration. In contrast, researchers assign higher weight to Access to Finance (0.1062) compared to the government (0.0894) and practitioners (0.0918). This divergence reflects different orientations: the government focuses on short-term policy measures such as direct subsidies, while researchers emphasize long-term sustainability through access to green financing, including green bonds and concessional loans. This aligns with IRENA (2023), which highlights that a combination of policy incentives and financial access is key to accelerating the energy transition.

Practitioners, as field operators, exhibit a more pragmatic profile, placing greater attention on Market Risk (0.0758) and Completion Risk (0.0732) than other groups. This sensitivity can be explained by their direct exposure to electricity price uncertainty, power purchase agreements, and technical risks in project completion. Lee (2020) found that operational risks often have a stronger influence on practitioners' decisions than regulatory or financial factors, which explains their heightened focus on risk aspects. This indicates that although practitioners remain attentive to profitability, their primary concern is reducing operational uncertainties that could hinder project implementation success.

Overall, these findings suggest that solar energy development strategies in the archipelagic regions must integrate both convergent and divergent stakeholder priorities. Profitability, project costs, and renewable energy obligations can serve as convergence points to build synergy. However, differences in evaluating the importance of direct subsidies, access to finance, and market and operational risks highlight the need for a more inclusive policy approach. A combination of short-term policy incentives, innovative financing instruments, and operational risk mitigation mechanisms is believed to address the interests of all parties. Consequently, the direction of energy transition policy in the archipelagos would not only be financially viable but also resilient in facing technical and market challenges.

## FINDINGS AND DISCUSSION

The study findings indicate a combination of convergent and divergent factors in stakeholder assessments of solar energy investments in the archipelagic regions. Profitability emerges as the primary determinant agreed upon by the government, researchers, and practitioners, alongside project costs and renewables obligation, which are also collectively regarded as important. This consensus underscores that financial sustainability, initial cost efficiency, and renewable energy regulatory support form a shared foundation for decision-making. However, significant differences in orientation also exist. The government emphasizes direct subsidies as a short-term policy instrument, researchers highlight access to finance as key to long-term sustainability, while practitioners are more sensitive to market risk and completion risk associated with real-world project conditions. Thus, although there is alignment on fundamental factors, differing priorities must be bridged to ensure that policies and implementation strategies are inclusively accepted by all stakeholders.

Based on these findings, solar energy development strategies in the archipelagic regions should be built upon the identified convergence points profitability, cost control, and renewable energy obligations, while also accommodating divergent stakeholder orientations. Profitability can be enhanced through attractive investment instruments such as feed-in tariffs and long-term power purchase agreements that provide revenue certainty. Differences in views regarding subsidies and access to finance can be bridged using a hybrid approach, combining direct subsidies during the early development stage with long-term access to green financing instruments such as green bonds or blended finance. For practitioners, who place greater emphasis on risk aspects, policies should provide mitigation mechanisms such as project insurance, minimum electricity price guarantees, and milestone-based contract regulations to reduce market and technical uncertainties. By integrating these elements into inclusive policies, energy transition strategies in the archipelagos will be more effective not only financially, but also technically and sustainably, while contributing to the achievement of the Net Zero Emission 2060 target.

## CONCLUSION

The study findings indicate both convergent and divergent factors in how stakeholders assess solar energy investments in archipelagic regions. Profitability consistently emerges as the top priority across the government, researchers, and practitioners, accompanied by shared recognition of project costs and renewables obligation. This agreement suggests that decision-making rests on a common foundation: financial sustainability, cost efficiency, and supportive regulatory frameworks. At the same time, clear differences in orientation remain. The government places greater emphasis on direct subsidies as a short-term policy lever, researchers focus on access to finance to secure long-term feasibility, and practitioners give relatively more weight to market risk and completion risk that can affect real-world delivery. Bridging these perspectives is therefore essential to ensure policies and implementation strategies receive inclusive buy-in.

Strategically, solar development should build on the convergence points profitability enhancement, cost control, and renewable obligation mechanisms while also addressing divergence. Profitability can be strengthened through feed-in tariffs and long-term power purchase agreements that provide revenue certainty. To reconcile subsidy and financing concerns, a hybrid approach can combine early-stage direct subsidies with longer-term green finance tools such as blended finance or green bonds. For practitioners, risk mitigation should include insurance, minimum price guarantees, and milestone-based contract enforcement, supporting both financial and operational sustainability aligned with the Net Zero Emission 2060 goal.

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