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Walking Towards the Energy Transition: An Approach to an International Cooperation Management Model for the Development of Renewable Energies in Cuba

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Abstract

Cuba is driving its sustainable energy transition with renewables as the central axis, although the Cuban government estimates that substantial investments will be necessary to achieve this goal. This work presents a proposal for a Management Model of International Cooperation for the Development of Renewable Energies, aimed at mobilizing the required funds. The model was designed through a structured questionnaire with 7 dimensions, 22 activities, and 5 subprocesses to guide the collaborative management of projects. The methodological approach was quantitative, descriptive, and psychometric, ensuring content validity through expert evaluation and statistical analysis. Reliability was established through internal consistency measures, while construct validity was supported by an exploratory factor analysis, confirming its feasibility and coherence. The validated questionnaire confirms its methodological rigor and practical utility, favoring the subsequent implementation of the model for Cuba's transition toward green energy.

Keywords: green energy transition; international cooperation; management model; renewable energies

1. Introduction

1.1. Contextualization

The United Nations Industrial Development Organization (UNIDO) promotes access to clean energy through projects with governments, organizations, and the private sector, stressing that the energy transition requires international cooperation in investment, technology transfer, and common standards, since no country can achieve this alone. Global partnerships combine climate financing, technical cooperation, and knowledge transfer. The UNIDO Annual Report 2024 highlights the strength of technical cooperation and multisectoral collaboration, noting that in 2024 funds reached 663.6 million USD and technical cooperation activities increased by 29%, surpassing proposed targets [1]. UNIDO defines international cooperation comprehensively as a mechanism that: (a) mobilizes extensive voluntary financial resources; (b) increases technical cooperation that supports sustainable productive transformation; (c) establishes partnerships with multiple actors, including the private sector and international organizations; (d) prioritizes industrial innovation,



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adaptation to climate change, social inclusion and sustainable development in line with the 2030 Agenda [1].

The United Nations Development Programme (UNDP) views cooperation as a strategic and multidimensional approach. It provides countries with knowledge, resources, and expertise. The goal is to improve well-being, resilience, and equality. Cooperation is based on inclusive partnerships and multi-stakeholder coordination. It strengthens national capacities and supports sustainable development [2]. The UNDP Strategic Plan 2022–2025 emphasizes collaboration inside and outside the UN system. It promotes systemic approaches that use innovation, creativity, and global expertise [3]. The European Parliament reaffirms the European Union (EU)'s commitment to peaceful cooperation, dialogue, and international law. It highlights collaboration on climate change, human rights, and sustainable development [4]. The International Renewable Energy Agency (IRENA) stresses global cooperation to accelerate renewable energy. It calls for financing, alliances, fair transition, and collective action [5]. BRICS includes civil society as a dynamic partner [6]. The Organisation for Economic Co-operation and Development (OECD) defines technical cooperation as strengthening capacities through services and training [7]. In Cuba, Decree-Law 16 of 2020 defines cooperation as relations based on solidarity, mutual benefit, and sovereignty. It aims to support economic, social, and scientific-technical development [8].

Cuba's integration into international cooperation mechanisms requires analyzing different perspectives. Romero [9] argues that although Cuba can access external financing, this depends on meeting debt obligations, which demands productive reforms including decentralization, greater business autonomy, and diversification of ownership structures. Cabrera [10] adds that local development in Cuba has followed a distinct model compared to Latin America, where priorities and resource allocation align with national strategies. However, persistent limitations remain, such as centralized decision-making, vertical productive structures, weak local development culture, and the absence of a national innovation system based on territorial needs. Korkeakoski and Filgueiras [11] estimate that Cuba needs between 3.5 and 4 billion USD in investments to reach renewable energy goals by 2030, including 24% renewable penetration, reduced electricity costs, and significant CO₂ mitigation. Most investments are expected in wind and solar energy, with foreign capital playing a key role. Yet, Arias et al. [12] highlight that weak policies and institutions in the electricity sector create barriers to technology adoption, making stable policies, legal frameworks, and regulatory schemes essential to support renewable energy integration.

Various approaches in the management and organizational literature [13–16] have emphasized the importance of establishing robust models to confront scenarios of change and uncertainty. Cameron and Green [13] highlight the need to apply change management methodologies to facilitate organizational adaptation, while Daft [14] underscores the role of organizational design in aligning resources and processes. Navarro Claro and Bayona Soto [15] propose the evolution toward advanced quality paradigms, and Mendoza-Saltos et al. [16] emphasize the relevance of continuous evaluation of service and production quality to strengthen operational performance.

The challenges of the energy transition span technical, economic, regulatory, and social dimensions. Technically, the intermittency of solar and wind complicates supply-demand balance, while fossil-fuel infrastructure requires modernization and storage technologies remain limited [17–19]. Economically, high upfront costs and restricted access to financing affect countries with low fiscal capacity, compounded by uncertainty in returns due to instability in strategic programs [20,21]. Politically and regulatory, fragmented policies, complex permitting, and unstable incentives undermine investor confidence and hinder implementation [22–25]. Socially, local resistance—driven by environmental concerns, misinformation, or unequal participation—can delay projects, underscoring the need for

inclusive mechanisms that foster acceptance and equitable benefit-sharing [22–25]. In emerging economies, inadequate infrastructure, weak legal certainty, and limited technical capacity highlight the necessity of deep political and structural reforms to advance the transition from fossil fuels to renewable energies [19–27].

Strategic planning, stakeholder articulation, technological innovation, capacity building, financing, training, institutional strengthening, and monitoring constitute interdependent dimensions that, according to various studies [22,28–43], enable the integration of sustainability, cooperation, and governance to advance viable and sustainable energy projects.

The reviewed literature [1–44] made it possible to identify gaps in international collaboration for Cuba’s energy transition, with a focus on the development of renewable energies, as shown in Table 1.

Table 1. Gaps in International Cooperation for Renewable Energies Development.

Dimension	Findings in Current Studies of International Organizations	Identified Gaps in the Literature	Key References
1. Strategic Planning	UNIDO and UNDP promote integrated planning aligned with Agenda 2030.	Absence of long-term strategic programs aligned with global cooperation standards; lack of sustainability criteria and operational tools.	[1–3,19,28–30,44]
2. Stakeholder Articulation	EU and BRICS highlight multisectoral partnerships and civil society involvement.	Limited coordination among government, private sector, and civil society; weak interinstitutional mechanisms and low social participation.	[4,6,17,18,22,33–35,44]
3. Innovation and Technology Transfer	IRENA and Belt and Road initiatives foster technology sharing.	Restricted access to advanced technologies; insufficient adaptation to local contexts; limited absorptive capacity in recipient countries.	[5–11,20,36–38,44]
4. Training and Capacity Building	UNDP emphasizes knowledge transfer and resilience building.	Weak local training systems; misalignment between training supply and labor demand; insufficient financial and managerial training.	[2,3,12,39,44]
5. Financing and Economic Sustainability	Global funds mobilized by UNIDO and IRENA; EU mechanisms for investment.	Barriers to international financing due to debt burdens and geopolitical restrictions; poor resource allocation and high risk perception.	[1,5,19,21,26,27,40,41,44]
6. Institutional Strengthening	EU resolutions and OECD promote governance reforms.	Highly centralized institutions; weak regulatory frameworks; institutional heterogeneity limiting stable environments for investment.	[4,7–9,42–44]
7. Monitoring and Evaluation	International models stress accountability and performance indicators.	Lack of robust monitoring systems tailored to renewable energy projects; absence of clear indicators and comparative analysis.	[15,16,22–25,44]

Source: Authors’ elaboration.

The selection of these seven dimensions emerges from the systematization of the reviewed literature, in which these categories recurrently appear as critical factors for the success of international collaboration in renewable energy [44]. The triangulation of sources—including documents from multilateral organizations, indexed academic articles, case studies, and national regulations—allows us to affirm that these dimensions constitute a valid and operational theoretical construct for analyzing international cooperation in the Cuban energy sector.

Based on a bibliographic review of the literature [1–44], the following scientific problem was identified: the absence of a systemic and intentional approach in the current management of international cooperation, which restricts access to funding and technology for the development of renewable energies. This limitation hinders the necessary acceleration of Cuba’s energy transition.

The purpose of this research is to design an International Cooperation Management Model for the Development of Renewable Energies in Cuba, enabling intentional and systemic access to sources of financing and technology. The model is adapted to the country's political, economic, and institutional context. It integrates climate financing, technology transfer, and multisectoral coordination to ensure a sustainable and resilient energy transition.

A literature review combined with expert criteria supported the design of a questionnaire with seven dimensions and twenty-two criteria aligned with the requirements of international cooperation (Refer to Supplementary Material S1 Informed Consent to Participate in Survey and Supplementary Material S2 Anonymous survey for the evaluation of the Management Model of international cooperation and the procedure for its implementation). This questionnaire is used to evaluate the content of the proposed International Cooperation Management Model (ICMM), which will serve as an operational tool for implementing renewable energy projects. At this stage, content validity will be assessed through Cronbach's alpha, while construct validity will be examined using Exploratory Factor Analysis. The expected results aim to demonstrate the hypothesis that greater access to financing and technology for renewable energy development in Cuba can be achieved through a systemic and intentional cooperation management model.

1.2. Explanation of the Management Model

Management refers to the set of actions or procedures that enable the execution of an activity or project. Lorino [45] defines processes as combinations of procedures that produce a material or immaterial result, while Zapata Murillo et al. [46] describe them as a set of activities that transform inputs into products or services. Bravo [47] offers a more comprehensive view by defining process management as a discipline that helps organizations identify, design, control, and improve processes to gain customer trust. In this sense, process management differs from the classical functional organization, as it prioritizes the customer's perspective over internal activities [48].

Gómez [49] conceptualizes process management as an organizational approach centered on creating added value for customers and stakeholders, while simultaneously addressing corporate interests. Pepper and Bergholz [50] define it as a methodology oriented toward continuous improvement through the systematic identification, documentation, and optimization of processes. Furthermore, other authors [51] emphasize innovation as a critical business resource that requires rigorous management, describing innovation management as the structured organization and direction of human, technical, and economic resources to generate new knowledge, products, processes, and services, or to enhance existing ones, ensuring their effective transfer into production and commercialization.

A management model is an organized structure that defines processes, strategies, and practices to direct and optimize organizational resources, with the aim of achieving objectives efficiently and sustainably [13]. These models integrate functions such as planning, organization, direction, and control, adapting to the specific characteristics of each institution [14]. Among the most common approaches are total quality management, competency-based management, and organizational agility, each with specific methodologies and tools [15]. The selection of the appropriate model depends on the organizational context, strategic objectives, and environmental demands [16]. From the preceding definitions, the following model has been constructed (Figure 1).

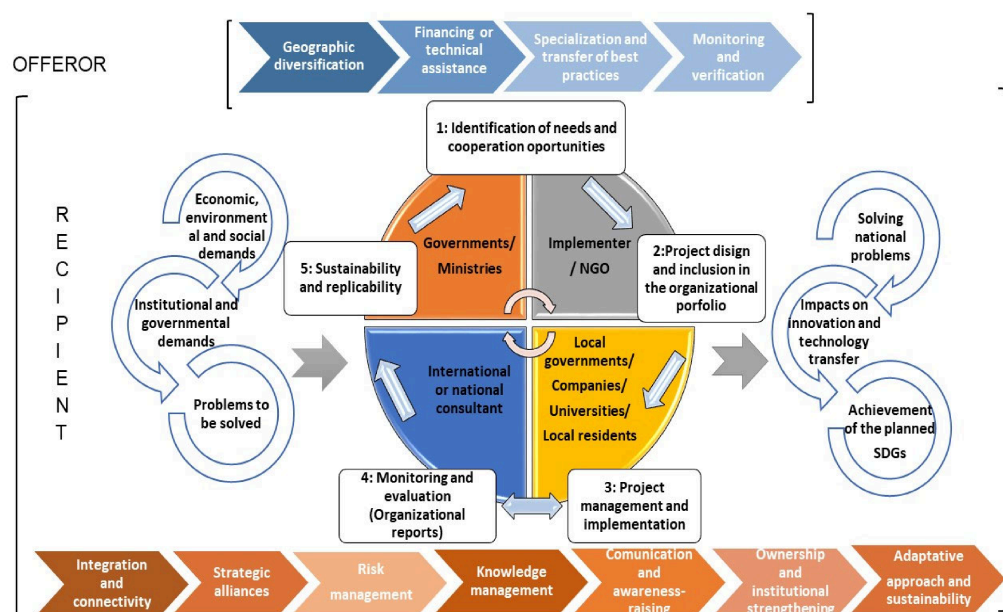


Figure 1. Schematic representation of the International Cooperation Management Model for the Development of Renewable Energies. Source: Authors' elaboration.

The following section presents the seven dimensions identified in international collaboration and their integration into a management model for sustainable energy projects. Strategic planning is integrated into the model as the axis that articulates sustainability, financial viability, and institutional coherence [28–30], while stakeholder articulation strengthens the framework through inter-institutional coordination and public–private partnerships that legitimize policies and mobilize resources [33–35]. Innovation and technology transfer are linked as mechanisms to acquire, adapt, and sustain energy technologies in local contexts [36–38], complemented by training and capacity building, which are incorporated as strategies to develop technical and financial human capital that drive the energy transition [39]. Financing and economic sustainability are integrated as drivers to mobilize international resources and design innovative mechanisms that ensure the long-term viability of projects [40,41]. Institutional strengthening is established as a condition to guarantee solid governance and organizational structures capable of attracting investment and responding to territorial needs [42,43]. Finally, monitoring and evaluation are embedded into the management model as tools to ensure transparency through indicators, accountability, and continuous improvement in energy policies [22,23,25]. These dimensions are embedded within the five subprocesses described in the model presented in Figure 1 [44].

1.3. Scope of the Management Model

In order to accurately interpret the model, the following terminologies must first be understood:

Offeror: Defined as any foreign state, organization, or institution that provides international cooperation to the country, whether in financial, material, technological, or training resources [8,44].

Recipient: The Cuban party, represented by the State, its institutions, organizations, or authorized entities, that receives and manages international cooperation for the country's economic and social development [8,44].

First, cooperation needs and opportunities are identified through gap analyses, geopolitical assessments, and alignment with priority plans [28–30]. Second, a project portfolio is formulated, including project design, partner negotiations, financing schemes, and submis-

sion for approval [31–35]. Third, projects are managed and executed through coordinated implementation, monitoring, training, and policy influence [36–38]. Fourth, monitoring and evaluation ensure continuous oversight, reporting, impact assessment, and documentation of lessons learned [39]. Finally, sustainability and replicability are addressed through knowledge management, financing mechanisms, documentation of good practices, exit strategies, and digital recordkeeping [40–42].

Completion of the five subprocesses contributes to the achievement of the SDGs, particularly those related to Affordable and Clean Energy (7) and Climate Action (13). In addition, the resolution of identified problems generates impacts in innovation (organizational or technological) and in technology transfer [43].

Strategic processes in international cooperation must align with providers and encompass geographic diversification of interventions, financing mechanisms or technical assistance, specialization, and the transfer of good practices, as well as monitoring and evaluation [28–30]. Complementarily, support processes are essential for successful project development, including integration with national and regional development plans, partnerships with institutions or universities, risk management, and knowledge management based on lessons learned [31–35]. They also involve communication and awareness with stakeholders, appropriation of technology and knowledge for institutional strengthening, and ensuring sustainability through financial and supportive mechanisms from the energy sector [36–42]. This contributes to the replication of large-scale pilot projects and the implementation of new initiatives [43].

2. Materials and Methods

For the development of the present research, works published in English and Spanish from 1999 up to the date of the search were requested. The authors selected those works that could serve as an analytical tool for decision-making, or whose content was valuable for the purposes of this article. Finally, 68 bibliographic references were selected for this study.

2.1. Expert Method

Rigorous expert selection is essential for validity and reliability in studies based on expert judgment [44]. Guerrero et al. [52] emphasize that experts should be heterogeneous, with recognized experience and willingness to participate, while the ideal number typically ranges between 7 and 15 [53–55]. Multi-criteria techniques considering professional experience, academic output, training, and recognition are recommended (Sigüenza et al. [56]; Maldonado et al. [57], complemented by self-assessments to standardize selection [45,51]. Although some sources suggest 15–30 experts as optimal [40–42], ranges from 2 to 20 are also accepted, with 10 experts often sufficient for reliable content validity. Balancing representativeness and feasibility is crucial, since very small groups may overestimate individual influence, while very large ones hinder consensus. Practically, the number should not exceed 30, as beyond this threshold the average error remains below 1, ensuring group reliability [58,59].

2.2. Questionnaire Development

To develop the questionnaire, a bibliographic review was conducted, analyzing the instruments used in studies with objectives similar to those of this research. A bibliographic mapping of the literature was conducted in five key international databases (Redalyc.org, Dialnet.net, Academia.edu, SciELO.org, and Google Scholar) to analyze the main methodological trends related to this field of research due to their quality criteria or international focus. An analysis of the instruments identified in the searches was then conducted [44,59].

2.3. Applied Procedure

The research technique employed was a survey, and the instrument used was an initial questionnaire comprising 22 activities, categorized into seven dimensions: 1—Strategic planning, 2—Stakeholder coordination, 3—Innovation and technology transfer, 4—Training and capacity building, 5—Financing and economic sustainability, 6—Institutional strengthening, and 7—Monitoring and evaluation. The clustering of the dimensions was performed on the basis of the gaps identified through the literature review and expert consultation [44].

The 22 items of the questionnaire were validated as relevant and applicable to the proposed model. This exploratory, descriptive, cross-sectional instrument validation study was conducted under a quantitative approach (Supplementary Material S1. Informed Consent to Participate in Survey and Supplementary Materials S1 and S2 Anonymous survey for the evaluation of the Management Model of international cooperation and the procedure for its implementation). Following the Delphi methodology, the questionnaire was administered to a panel of 12 experts, who completed both the first (May–June 2025) and second (June–July 2025) rounds of consensus. In the first round, responses were collected online, with open-text opinions allowed, and results presented using bar graphs for clarification; items without consensus were re-evaluated in the second round. The expert knowledge coefficient values used to determine the experts' position followed the criteria established in the reviewed literature [44,59]:

$0.8 \leq K \leq 1.0$, high expert competence coefficient.

$0.5 \leq K < 0.8$, medium expert competence coefficient.

$K < 0.5$, low expert competence coefficient.

2.4. Calculation of the Argumentation Quotient (Ka)

The Argumentation Quotient (Ka) is obtained by adding the scores assigned by the expert to various sources of argumentation within their knowledge. The expert was presented with different sources of argumentation and asked to indicate the level of influence on their knowledge in the area, which could be High, Medium, or Low. It is calculated by averaging two components: the expert's declared knowledge on the subject (self-evaluation) and the scientific basis or experience that supports said knowledge [44,53,55]. A value of $ka \geq 0.8$ suggests high competence.

2.5. Calculation of the Knowledge Quotient (Kc)

The Knowledge Quotient (Kc) is obtained from the expert's self-assessment of their knowledge on topics relevant to the study. The expert rated their knowledge on a scale of 0 to 10, where 0 represents complete ignorance and 10 represents complete knowledge. It measures the homogeneity or agreement between the experts' assessments [44,52,57]. This score is multiplied by 0.1 to obtain the Kc.

In the context of research that requires critical and substantiated evaluations, having qualified experts ensures that decisions are informed and based on in-depth knowledge of the subject. In this study, experts were selected using the competency indicator, a method recognized for its effectiveness in determining the suitability of participants in research processes.

The Competency Indicator (K) is calculated using the following formula [59]:

$$K = \frac{1}{2}(K_c + K_a) \quad (1)$$

where [60]:

Kc is the expert's theoretical knowledge, evaluated on a scale of 1 to 10.

Ka is the expert's practical argumentation capacity, determined through exercises or applied cases relevant to the topic of study.

This index validates that the selected group can provide reliable judgments for the study [37,44], with coefficients interpreted such that values of K close to 1 indicate highly qualified experts, while lower values suggest limited suitability [44,53,55].

Expert opinions, derived from theoretical knowledge and practical experience, constitute qualified judgments that support evaluations with adequate knowledge and relevant arguments [36,38]. For the specific selection criteria, it is recommended to consider: (a) verifiable expertise in the subject area, such as publications, years of professional practice, and positions held [56,58]; (b) academic level and relevant complementary training [57]; (c) recognition by peers or by the academic/professional community [55]; (d) willingness and commitment to participate in the validation process [52]; and (e) heterogeneity of perspectives to ensure methodological balance and minimize bias [53].

Finally, it is essential to establish threshold values for the coefficients to determine the inclusion or exclusion of experts in the final group, thereby guaranteeing quality and robustness in the evaluation and validation of instruments or consensus-building processes [52,61–63]. The average coefficient value determines the expert's suitability to participate in specialized research, with a minimum criterion of $K \geq 0.8$ required for inclusion in this study [44].

Here, K corresponds to the expert's theoretical knowledge, evaluated through a self-assessment using a scale from 1 to 10, while 0 reflects practical argumentation, determined by the expert's ability to solve applied cases related to the ICMM. Only experts with a value equal to or greater than 0.8 were selected, ensuring that participants possess an adequate level of theoretical and practical competence [44] (Table 2).

Table 2. Selection of experts.

Expert	Organization	Kc	Ka	K	Level of Competence
1	UNDP	1.0	0.9	0.95	High
2	MINEM	1.0	0.9	0.95	High
3	UNE	0.9	1.0	0.95	High
4	IHES	0.9	1.0	0.95	High
5	MINCEX	0.9	1.0	0.95	High
6	FFRC	0.9	0.9	0.90	High
7	UNE	0.9	0.9	0.90	High
8	UNIDO	0.9	0.9	0.90	High
9	CEDEL	0.9	0.8	0.85	High
10	UNE	0.8	0.9	0.85	High
11	INRH	0.7	0.9	0.80	High
12	UNISS	0.9	0.9	0.90	High

Source: Authors' elaboration.

All experts presented a high level of competence, which supports the validity of their judgments [44].

The experts evaluated the relevance of each questionnaire item. Reliability was analyzed using SPSS v.20, with Cronbach's alpha employed as the primary indicator of internal consistency due to its suitability for cross-sectional self-administered surveys. Although alternative approaches such as structural equation modeling and split-half methods exist, Cronbach's alpha was considered the most appropriate for this study. As a central measure of reliability, Cronbach's alpha demonstrates its usefulness in instruments with multiple dimensions and criteria [62] and remains a solid resource for ensuring consistency in extensive surveys [63]. In the initial stage of the research, Exploratory Factor Analysis (EFA) was conducted to validate the construct of the proposed model based on data collected through the administered questionnaire.

3. Results

3.1. Results: Reliability Analysis with Cronbach's Alpha

Several reliability analysis models are available in SPSS V.20 and other similar statistical programs. To measure the internal consistency of the activities that constitute the ICMM components, Cronbach's alpha was selected. This coefficient determines the extent to which the items used in an instrument are correlated. It is particularly useful as it summarizes the average correlations among the items comprising an instrument and indicates the degree to which the construct, concept, or factor being measured is consistently represented across items. For its application, data may be dichotomous, ordinal, or interval, but must be numerically coded [44,60].

The validation of a questionnaire includes evaluating the reliability of its components, with Cronbach's alpha being one of the most widely used indicators for assessing the internal consistency of items that make up a construct or dimension. This coefficient quantifies the relationships among items in the instrument, indicating how homogeneous the set is and, therefore, the reliability of the construct being measured [44,56].

According to Sigüenza et al. [56], Cronbach's alpha values above 0.7 are considered adequate for educational research, with this threshold being the minimum acceptable to ensure internal consistency. Values between 0.8 and 0.9 reflect good to excellent reliability, while values above 0.9 may suggest redundancy among items. Martínez et al. [63] note that for questionnaire validation in health sciences and education, a Cronbach's alpha equal to or greater than 0.7 is sufficient, though interpretation should be contextualized according to the number of items and the nature of the construct. For questionnaires with few items, values close to 0.6 may be temporarily acceptable if complemented with other validity indicators. Silva and Rioseco [53] argue that an alpha coefficient between 0.70 and 0.95 is desirable in the educational field, cautioning that excessively high values (greater than 0.95) may be counterproductive, as they could indicate excessive similarity or redundancy among items, thereby limiting the instrument's ability to capture diverse dimensions of the construct [44,60].

In social and educational research contexts, scholars generally agree that Cronbach's alpha should ideally exceed 0.7, emphasizing that lower values suggest the need to review items to improve instrument homogeneity [40]. Cronbach's alpha requires only a single test administration and is used to determine internal consistency in unidimensional scales. Reliability is defined as the degree to which a multi-item instrument consistently measures a sample of the population. Consistency refers to the extent to which a measure is free from error. The reliability coefficient indicates the strength of the association, ranging from -1 to $+1$: a value of 0 indicates no relationship between scores, while values approaching -1 or $+1$ indicate a strong negative or positive relationship [44,59].

A positive value indicates that individuals with high scores on the first administration of the scale will also score high on the second administration. Negative reliability suggests either a calculation error or significant inconsistency in the scale. Internal consistency is achieved when instruments designed to measure a construct can be indirectly validated through the relationships among the items comprising the scale; that is, when there is strong interrelation among the questions or sections that form the instrument. Cronbach's alpha coefficient is calculated using the following equation [44,59]:

$$\alpha = \frac{k}{k-1} \left(1 - \frac{S_i^2}{S_{\text{sum}}^2} \right) \quad (2)$$

where:

k = Number of test items

S_i^2 = Item variance (from 1. . . i)

S_{sum}^2 = Total test variance

The reliability of the proposed questionnaires, as proposed, was determined by calculating the general Cronbach's Alpha coefficient and the alpha obtained by eliminating each of the items concerning their internal consistency, to estimate the existing correlation between them and identify items that are inconsistent or that are far from the aspects that influence the process of applying statistical techniques in many areas. According to Cornetero and López and Pedroso et al. [64,65], this coefficient takes values between 0 and 1. 0 represents zero reliability, and 1 represents total reliability. The author herself insists that there is no rule indicating from which specific value the instrument loses reliability. Cronbach's alpha coefficient has been used because it works well in extensive questionnaires. It combines all items into a single coefficient, showing how homogeneous they are. It requires only one test administration, not repeated applications. It is also sensitive to the number of items. The more related items included the more stable and reliable the coefficient becomes. [64]. For this research, Castañeda Rodríguez et al. (2024) [60] classifies Cronbach's Alpha coefficient according to the following limits [44]:

Very low reliability: $\alpha \leq 0.30$

Low reliability: $0.30 < \alpha \leq 0.60$

Moderate reliability: $0.60 < \alpha \leq 0.75$

High reliability: $0.75 < \alpha \leq 0.90$

Very high reliability: $\alpha > 0.90$.

The results of this study reflect experts' perceptions of international cooperation management models for the development of renewable energies. Based on the questionnaire responses, key aspects such as the adequacy of the evaluated activities were analyzed. Figure 2 presents the Cronbach's alpha values obtained for each subprocess [44].

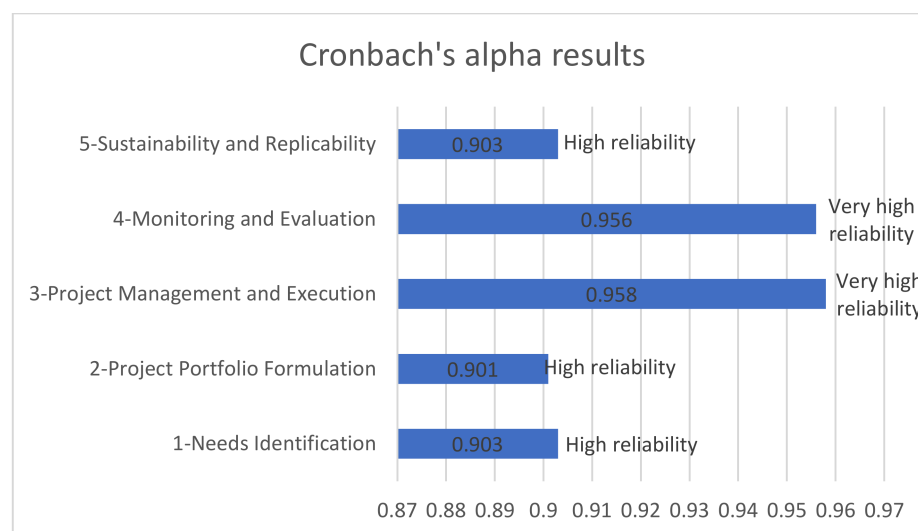


Figure 2. Results of Cronbach's alpha for each subprocess. Source: Authors' elaboration.

These results are comparable with recent studies [44,63,64] on the validation of international management and cooperation instruments, where Cronbach's alpha values greater than 0.90 are considered optimal for complex and multidimensional instruments (Refer to Supplementary Material S3 Cronbach's alpha results for the five subprocesses).

3.2. Results: Construct Validity with Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) refers to a group of multivariate statistical techniques aimed at identifying the smallest number of underlying constructs also known as

dimensions, latent variables, synthetic variables, or internal attributes that can adequately account for the covariation among a set of items, which are also referred to as measured variables, observed variables, manifest variables, effect indicators, reflective indicators, or surface attributes. EFA is suitable for studies with an exploratory nature (i.e., early-stage studies) because it can help in identifying the underlying constructs or reducing the model complexity [66].

EFA can also be defined as a set of multivariate statistical methods based on the interdependence of observable variables (e.g., items), whose objective is to identify the latent variables (e.g., factors) underlying a dataset. EFA constitutes a multivariate interdependence technique because it simultaneously examines the relationships among a large number of observed variables, relying on the correlation matrix that reflects those associations [67].

Exploratory Factor Analysis (EFA) using the principal axis factoring method assumes that all variables within the first group and matrix are computed when the factor is remove. Consequently, factors were sequentially extracted until the correlation matrix accounted for a sufficiently large variance [66].

$$X = LF + \varepsilon \quad (3)$$

$$\begin{bmatrix} X_{i,1} \\ X_{i,2} \\ \vdots \\ X_{i,16} \end{bmatrix} = \begin{bmatrix} L_{1,1} & L_{1,2} & L_{1,3} & L_{1,4} \\ L_{2,1} & L_{2,2} & L_{2,3} & L_{2,4} \\ \vdots & \vdots & \vdots & \vdots \\ L_{16,1} & L_{16,2} & L_{16,3} & L_{16,4} \end{bmatrix} \bullet \begin{bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_{16} \end{bmatrix} \quad (4)$$

where X is the matrix of observed variables, L is the matrix of factor loading, F is the common factor and ε is the matrix of unique factors or error variation. It should be noted that L is the correlation between a variable and a factor. The covariance matrix of X can be decomposed into [50]:

$$\Sigma = L\Phi L' + \Psi \quad (5)$$

where Φ is the covariance matrix of the factors.

In this study, when EFA correctly classified items under their respective constructs (i.e., following the predetermined model), it confirms that those dimensions are meaningful and distinct. This alignment between theoretical grouping and empirical factor structure is a strong sign that the identified factors represent real conceptual constructs [50].

The suitability of the data for factor analysis was determined using the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy. The KMO measure represents the proportion of variance in the constructs that may be attributed to the underlying items. A high KMO value, approaching 1.0, suggests that factor analysis is suitable for the data. Conversely, if the value is less than 0.5, the results of the factor analysis may not be very useful. The KMO can be calculated as follows:

$$KMO = \frac{\sum r_{ij}^2}{\sum r_{ij}^2 + \sum p_{ij}^2} \quad (6)$$

where r_{ij} represents the correlation between variables i and j and $\hat{r}_{ij}$ represents the partial correlation between variables i and j .

The Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity must be performed prior to the factor extraction exercise. IBM SPSS Statistics version 20.0 was used for the analysis. Table 3 presents the results of the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity, both preliminary tests used to assess the suitability of the dataset for factor analysis. Bartlett's test of sphericity is significant ($p = 0.001 < 0.05$).

These findings confirm that the sample data are adequate and appropriate for factor extraction through Principal Component Analysis. These two tests, KMO and Bartlett's test of sphericity, validate the relevance of proceeding with the Exploratory Factor Analysis (EFA) [68].

Table 3. KMO and Bartlett's Test.

Subprocess	KMO Measure of Sampling Adequacy	Approximation Chi-Square *	Degree of Freedom (Df)
1	0.74	≈510.2	231
2	0.77	≈528.6	231
3	0.71	≈495.4	231
4	0.69	≈482.7	231
5	0.73	≈505.9	231

* Significance (p value < 0.05), highly significant at p < 0.001; Source: Authors' elaboration.

The results show that all subprocesses have $KMO \geq 0.69$, indicating that factor analysis is viable. Bartlett's Test is significant in all cases ($p < 0.001$), confirming that the correlation matrices are not identical. Subprocess 4 is the weakest ($KMO = 0.69$, barely acceptable), while Subprocess 2 is the strongest ($KMO = 0.77$).

Within the factor analysis function, the Varimax rotation method was selected. Varimax rotation is used in this study because the measured constructs are independent and do not influence each other [66].

The following section presents the results of communalities and total variance explained, from which the factors corresponding to the five subprocesses of the model are derived in Tables 4–6. (Refer to Supplementary Material S4 Results of the Exploratory Factor Analysis for the five subprocesses).

Table 4. Communalities.

Items	Subprocess 1	Subprocess 2	Subprocess 3	Subprocess 4	Subprocess 5
ACT_1.1	0.923	0.673	0.929	0.890	0.850
ACT_1.2	0.891	0.573	0.887	0.863	0.985
ACT_1.3	0.799	0.874	0.934	0.932	0.956
ACT_1.4	0.888	0.981	0.845	0.909	0.912
ACT_2.1	0.854	0.928	0.972	0.737	0.893
ACT_2.2	0.890	0.926	0.941	0.846	0.958
ACT_2.3	0.965	0.911	0.635	0.946	0.938
ACT_3.1	0.891	0.936	0.941	0.635	0.981
ACT_3.2	0.820	0.856	0.925	0.844	0.987
ACT_3.3	0.926	0.885	0.943	0.901	0.936
ACT_4.1	0.907	0.944	0.972	0.853	0.836
ACT_4.2	0.893	0.959	0.950	0.889	0.947
ACT_4.3	0.932	0.839	0.941	0.894	0.988
ACT_5.1	0.959	0.822	0.701	0.913	0.937
ACT_5.2	0.945	0.963	0.956	0.921	0.995
ACT_5.3	0.948	0.932	0.966	0.926	0.994
ACT_5.4	0.983	0.916	0.918	0.921	0.969
ACT_6.1	0.951	0.971	0.956	0.940	0.965
ACT_6.2	0.982	0.929	0.957	0.819	0.839
ACT_7.1	0.965	0.924	0.923	0.894	0.856
ACT_7.2	0.926	0.945	0.909	0.894	0.964
ACT_7.3	0.619	0.976	0.952	0.813	0.822

Source: SPSS V.20.

Table 5. Total variance explained: % of rotation variance.

Component (Factor)	Subprocess 1	Subprocess 2	Subprocess 3	Subprocess 4	Subprocess 5
Factor 1	29.095	28.481	35.304	36.030	23.646
Factor 2	20.939	21.968	15.241	19.618	22.639
Factor 3	19.508	19.817	14.437	14.708	15.913
Factor 4	10.784	9.613	13.107	8.797	12.131
Factor 5	9.931	9.501	13.061	8.029	10.842
Factor 6					8.049

Source: SPSS V.20.

Table 6. Total Variance Explained: Cumulative Variance (%).

	Subprocess 1	Subprocess 2	Subprocess 3	Subprocess 4	Subprocess 5
Cumulative Variance (%)	90.258	89.380	91.150	87.182	93.220

Source: SPSS V.20.

4. Discussion

The review of the references shows that Cuba faces major limitations in access to financing sources, technology transfer, governance, and international cooperation mechanisms. These gaps restrict the development of renewable energies. Organizations such as UNIDO, UNDP, and IRENA emphasize the need for global alliances to mobilize resources and technology. European and other regional experiences in the literature demonstrate that international cooperation is decisive in overcoming barriers and accelerating the energy transition. In Cuba, the absence of a solid cooperation model adapted to its political and economic context underscores the urgency of designing a framework that integrates climate financing, technology transfer, and institutional coordination to ensure a sustainable and resilient energy transition.

Applying management concepts to the design of such a model provides an integrated and strategic approach. Strategic management control ensures alignment between national goals and external alliances. Contemporary management theories facilitate coordination between international and local actors. Process management adds clarity to project planning and execution, while strategic innovation management ensures that cooperation goes beyond technology transfer and fosters endogenous capacity building. Together, these approaches create a solid framework for international cooperation to effectively support Cuba's sustainable energy transition.

In the model questionnaire, the coefficient values obtained for all items, if removed, remained above 0.8. The values resulting from their elimination showed no significant difference from the previously obtained results, which led to the decision to retain all items. The experts' assessment reflects high internal consistency, translating into strong reliability [43,44].

Subprocess 1 demonstrates high internal reliability, confirming the consistency of the scale in measuring the construct related to international cooperation management. The item with a low correlation (e.g., ACT_3.3) suggests that this activity is less relevant in the first subprocess but becomes essential in subprocesses 3 and 4 [44].

In Subprocess 2, activities contribute little to internal consistency, although they play a more significant role in other subprocesses. Most items present item-total correlations above 0.4, indicating a good contribution to the scale, particularly items ACT_3.3 and ACT_7.1 [44].

Subprocess 3 shows excellent internal reliability, with a Cronbach's alpha of 0.958, confirming that the items form a consistent and homogeneous scale. Items with low

corrected correlations (e.g., ACT_2.3) should be analyzed for possible reformulation or exclusion [44].

Subprocess 4 also demonstrates excellent reliability, with a Cronbach's alpha of 0.956, indicating that the items consistently measure the construct. As in the previous subprocess, item ACT_2.3 shows a low item-total correlation (0.215) [44].

Subprocess 5 exhibits high internal reliability, confirming the scale's consistency in measuring the construct related to international cooperation management. However, items such as ACT_1.2 and ACT_3.3 show negative or very low correlations with specific items, suggesting the need for further review [44].

The results confirm the feasibility of factor analysis, as all subprocesses present adequate KMO values and Bartlett's Test is significant. While Subprocess 4 shows the lowest adequacy, Subprocess 2 emerges as the most robust within the set. The EFA reveals a solid factorial structure with well-differentiated factors. The explained variance is very high, with values exceeding 0.80, indicating that the model effectively captures the information contained in the data, thereby supporting construct validation in its exploratory phase. Communalities are consistently strong, confirming that the items are well represented. The Varimax rotation facilitated the identification of clear and distinct groupings, enhancing the conceptual interpretation of the model.

Although most items display high communalities and adequate representation within the extracted factors, certain items—such as ACT_7.3 in Subprocess 1, ACT_1.2 in Subprocess 2, ACT_2.3 and ACT_5.1 in Subprocess 3, ACT_3.1 in Subprocess 4, and ACT_22 in Subprocess 5—show lower shared variance, making them relatively weaker indicators within their constructs. Nevertheless, their values remain acceptable (>0.5), meaning they do not compromise the overall validity of the model, though they suggest the need for closer review to strengthen both its theoretical and practical consistency.

The authors' criterion is to retain all activities, since the questionnaire validation encompasses five subprocesses and some items do not have the same impact across all of them. The design of the questionnaire, validated by experts, has resulted in the development of a research instrument on the management of international cooperation for the development of renewable energies.

The study acknowledges its reliance on expert validation, which, although valuable, may introduce a certain degree of subjectivity and limit the generalizability of the results. It is clearly stated that the findings are confined to the Cuban context, thereby restricting their applicability to other settings. The model has not yet been empirically applied, and therefore its practical effectiveness remains to be verified. Future validations using alternative methods, including empirical applications and quantitative approaches, will be necessary to strengthen the robustness of the results. In a subsequent stage, the model will be empirically validated through the international cooperation project of the Electric Union, as a case study, entitled: "Energy Transition Program in the Special Municipality of Isla de la Juventud through Renewable Energies and Energy Efficiency" [44].

5. Conclusions

This study highlights the need to design an International Cooperation Management Model (ICMM) for the development of renewable energies in Cuba. The implementation of this model is expected to strengthen the sector's international competitiveness by facilitating access to financing and new technologies, thereby supporting the country's Green Energy Transition.

The experts demonstrated a high level of competence, reinforcing the validity of their judgments. Statistical validation confirms that the model's components in the questionnaire meet rigorous standards: they exhibit very high internal consistency (subscales ≥ 0.90)

and strong content reliability, endorsed by expert evaluation. This indicates that the items comprehensively capture the theoretical constructs of interest [44].

The results confirm the feasibility of the model's design phase, as all subprocesses present acceptable KMO values and Bartlett's Test is significant ($p < 0.001$). The cumulative variance explained in each subprocess exceeds 87%, evidencing a solid and consistent factorial structure. Although Subprocess 4 shows the lowest adequacy, overall, the extracted factors robustly represent the items and ensure the validity of the applied model.

Future challenges for Cuba in developing renewable energies through international cooperation focus on overcoming limitations in financing, technology transfer, and governance, as well as strengthening institutional coordination and integrating concepts of strategic management and innovation. The validation of the proposed model's content in this study confirms the need for a framework that is both solid and adapted to the Cuban political and economic context. The main challenge lies in implementing a cooperation scheme that not only mobilizes resources and technology but also fosters endogenous capacities, thereby ensuring a resilient and sustainable energy transition. Model validation studies will depend largely on expert evaluation and statistical tools to assess content and construct validity. Furthermore, the proposed model will require construct validation in a more advanced stage of the research and its application to the case study.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su18126256/s1>, Supplementary Materials S1 Informed Consent to Participate in Survey, Supplementary Materials S2 Anonymous survey for the evaluation of the Management Model of international cooperation and the procedure for its implementation, Supplementary Materials S3 Cronbach's alpha results for the five subprocesses and Supplementary Materials S4 Results of the Exploratory Factor Analysis for the five subprocesses.

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Abbreviations

The following abbreviations are used in this manuscript:

UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Program
BRICS	Brazil, Russia, India, China, and South Africa
OECD	Organization for Economic Co-operation and Development
ICMM	International Cooperation Management Model
MINEM	Ministry of Energy and Mines
UNE	Electric Union
IHES	Indio Hatuey Experimental Station (University of Matanzas)
FFRC	Finland Futures Research Centre. University of Turku
CEDEL	Centre for Local and Community Development
MINCEX	Ministry of Foreign Trade
INRH	National Institute of Hydraulic Resources
ACT	Activity
NGOs	Non-Governmental Organizations

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