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Presenting a Green Government Model for Renewable Energy Development in Iran's Electricity Industry

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A B S T R A C T

The development of renewable energy in Iran's electricity industry faces numerous structural, institutional, and policy-related barriers, among which the absence of a coherent and domestically adapted governance framework is one of the most significant. The present study aimed to design and validate a green government model for renewable energy development in Iran's electricity industry. The study employed an exploratory sequential mixed-methods approach grounded in the pragmatist paradigm. In the qualitative phase, an interpretive approach and Braun and Clarke's thematic analysis method were applied. Data were collected through semi-structured interviews with 20 experts, and sampling continued until theoretical saturation was achieved. In the quantitative phase, based on statistical power calculations conducted using G*Power, a sample of 188 experts and managers from the electricity industry was selected. The data were analyzed through variance-based structural equation modeling using SPSS version 24 and SmartPLS version 3. The findings of the qualitative phase resulted in the extraction of 102 basic themes, categorized into 33 organizing themes and 11 global constructs: green institutional capacity, green energy policymaking, green financing, green economic support, green diplomacy, green energy infrastructure, green technological innovation, green human capital, green social participation, environmental sustainability, and energy security. In the quantitative validation phase, the measurement and structural model fit indices were found to be satisfactory, and all 26 relationships in the model were confirmed with statistically significant path coefficients ($p < .001$). The strongest causal relationship was observed between green energy policymaking and green financing ($\beta = .836$).

Keywords: *green government, renewable energy, thematic analysis, structural equation modeling*

1. Introduction

The global transition toward renewable energy has become a central component of contemporary sustainable development, climate governance, and energy-security agendas. Electricity systems based predominantly on fossil fuels are increasingly confronted with the interconnected challenges of greenhouse gas emissions, air pollution, resource depletion, price volatility, and vulnerability to geopolitical and supply disruptions. Renewable energy resources—including solar, wind, hydropower, geothermal energy, and biomass—offer opportunities to decarbonize electricity generation while strengthening long-term energy resilience and supporting more sustainable patterns of economic development. However, renewable energy development is not merely a technological substitution process. It requires coordinated institutional reform, appropriate regulatory frameworks, long-term investment, technological learning, infrastructure modernization, public participation, and consistent governmental commitment. Accordingly, the quality of government intervention and governance arrangements has become a decisive factor in determining the pace, direction, and sustainability of national energy transitions (Al-Shetwi, 2022; Olabi & Abdelkareem, 2022; Twidell, 2021).

Renewable energy development has gained additional urgency because of the close relationship between energy production and climate change. Fossil-fuel-based electricity generation remains a major source of carbon emissions, while the expansion of low-carbon electricity is essential for achieving national and international climate targets. Research indicates that increasing renewable energy consumption, improving technological innovation, and developing financial systems capable of directing capital toward low-carbon projects can jointly contribute to reducing emissions and meeting climate commitments (Wang et al., 2020). Evidence from European countries similarly demonstrates that renewable energy deployment is closely associated with sustainable development performance, although the strength and form of this relationship depend on national institutional structures, economic capacities, and policy priorities (Włodarczyk et al., 2021). Declining renewable energy technology costs have further increased the feasibility of large-scale electrification under low-emission scenarios, but cost reductions alone cannot guarantee successful deployment without supportive institutions, investment mechanisms, and grid integration policies (Luderer et al., 2022).

The transition toward renewable electricity is also shaped by the technical characteristics of renewable resources. Solar and wind energy are variable and weather-dependent, and their large-scale integration requires flexible generation, energy-storage capacity, demand-side management, transmission expansion, digital control systems, and more advanced electricity-market arrangements. The complementarity of renewable energy resources can reduce variability and improve system reliability when different resources are geographically and temporally coordinated (Jurasz et al., 2020). Smart energy systems can also facilitate the integration of distributed generation, storage facilities, smart meters, and responsive electricity demand, thereby creating a more adaptable pathway toward renewable energy development (Rezaei et al., 2020). Consequently, renewable energy policy must extend beyond the construction of generating facilities and address the broader transformation of electricity networks, operational practices, technical standards, and energy-management systems.

International experience demonstrates that renewable energy transitions are profoundly influenced by the coherence, stability, and credibility of government policies. Comparative research on China, the United States, and Brazil shows that renewable energy outcomes vary significantly according to policy instruments, institutional arrangements, market structures, national priorities, and the continuity of governmental support (Muhammed & Tekbiyik-Ersoy, 2020). Likewise, the experience of leading Indian states indicates that successful renewable energy development depends on a coordinated combination of regulatory instruments, investment incentives, implementation capacity, infrastructure planning, and context-sensitive policy design (Elavarasan et al., 2020). Renewable energy policy can also affect the long-term sustainability and strategic behavior of energy firms by changing investment expectations, technological choices, and market opportunities (Zhang & Kong, 2022). These findings suggest that governments must move beyond fragmented interventions and establish integrated policy frameworks capable of aligning economic, technological, environmental, and social objectives.

The growing literature on green government provides a useful conceptual foundation for understanding this required institutional transformation. Green government refers to a mode of public governance in which environmental sustainability is embedded in governmental structures, administrative procedures, policy priorities, budgeting systems, regulatory practices, and public-service delivery. It is not limited to environmental protection agencies or isolated ecological programs; rather, it involves integrating environmental principles across the entire machinery of government. Empirical studies of subnational government initiatives indicate that green government can facilitate the localization of sustainable development goals, strengthen ecological responsibility, and improve coordination between public institutions and local development actors (Megawati et al., 2024). Research on the implementation of green government in regions affected by environmentally damaging extractive activities also shows that formal ecological commitments must be supported by effective regulation, institutional accountability, and consistent enforcement if they are to influence actual development outcomes (Dama et al., 2021).

From a theoretical perspective, green government can also be examined through the concept of governmentality, which emphasizes how governmental institutions shape conduct through policy discourse, knowledge production, measurement systems, administrative classifications, incentives, and regulatory mechanisms. Governmentality perspectives highlight that environmental governance does not operate solely through direct commands or legal prohibitions; it also functions by defining problems, constructing policy indicators, establishing standards, and encouraging organizations and citizens to adopt particular forms of environmentally responsible behavior (Rydin, 2021). Studies of climate-risk regulation demonstrate that green governmentality may reorganize institutional responsibilities and risk-management practices by incorporating environmental concerns into accounting, oversight, and administrative reform (Rana et al., 2023). Similarly, analyses of sustainability governance in forestry and food systems show that the effectiveness of environmental governmentality depends on whose knowledge is recognized, how sustainability problems are framed, and whether governance mechanisms permit participation, adaptation, and institutional learning (Smallwood et al., 2023).

A green government approach to renewable energy development therefore requires robust institutional capacity. Government agencies must possess clear mandates, specialized organizational units, qualified personnel, reliable data systems, and effective mechanisms for interagency coordination. In the electricity sector, institutional fragmentation may create overlapping responsibilities, inconsistent licensing procedures, delayed project implementation, and uncertainty for investors. Conversely, administrative coherence can facilitate policy implementation, improve accountability, and align renewable energy programs with national development strategies. Government transparency is equally important because public access to information regarding generation capacity, licensing decisions, tariffs, contracts, and project performance can reduce uncertainty, strengthen public trust, and support evidence-based oversight. Green government publicity may also influence pro-environmental behavior by increasing citizens' awareness and reinforcing perceptions that environmental protection is a legitimate governmental priority (Lin et al., 2022).

Government policy must also address the economic structure of the energy system. Renewable energy projects commonly require substantial initial investment, long repayment periods, and predictable revenue streams. In economies where fossil-fuel prices are subsidized or electricity tariffs do not reflect production costs, renewable energy projects may face structural disadvantages despite their environmental and long-term economic benefits. Governments can respond through feed-in tariffs, competitive auctions, renewable portfolio standards, tax exemptions, customs-duty reductions, concessional loans, guarantees, targeted subsidies, and public–private partnerships. Government intervention can alter the competitive relationship between green and non-green supply chains and may improve social welfare when policy instruments are appropriately designed (Monjazeb et al., 2021). Green subsidies can also stimulate corporate green innovation by reducing financial constraints and increasing the expected returns from environmentally oriented investment (An et al., 2025). Furthermore, green government subsidies, cleaner production, and circular-economy entrepreneurship can jointly support sustainability-oriented business performance when public incentives are linked to broader organizational and environmental objectives (Mamash et al., 2025).

Nevertheless, poorly designed subsidies may produce dependency, inefficiency, rent-seeking, or uneven access to public resources. Green industrial policy must therefore combine support measures with performance requirements, technological upgrading, domestic value-chain development, and transparent evaluation mechanisms (Kazempour, 2024). The diffusion of new technologies is rarely automatic; it depends on information flows, organizational capabilities, complementary investments, market formation, and the interaction between early adopters, institutions, and policy incentives (Kalyani et al., 2025). In renewable energy industries, this implies that government support should not be confined to purchasing imported equipment. It should also promote domestic research and development, knowledge-based firms, university–industry collaboration, technical training, patenting, technology transfer, and the development of local manufacturing capacity.

Innovation policy is particularly important because the renewable energy transition is inseparable from technological change. Innovation affects equipment efficiency, storage capacity, grid flexibility, digital monitoring, forecasting, demand management, and the cost competitiveness of renewable technologies. The influence of innovation-policy standards on local renewable energy development indicates that clear and contextually appropriate standards can strengthen local implementation capacity and improve policy effectiveness (Damayra & Khatib, 2022). Green supply-chain practices, digital technologies, and energy prices can also shape renewable energy innovation, especially in emerging economies where firms face financial, technological, and institutional constraints (Huang & Tan, 2025). More broadly, investment in energy research and development can contribute to green growth by expanding technological capabilities and improving the productivity of environmental innovation (Eid et al., 2026). Advanced computational methods are also creating new possibilities for managing complex data, uncertainty, and evaluation processes; developments in deep learning and performance metrics across applied fields illustrate the increasing importance of transparent, reliable, and data-intensive analytical systems for complex decision environments (Chen et al., 2025).

Digital government may further strengthen the institutional foundations of green innovation. Digital public services can reduce administrative delays, improve access to information, standardize licensing processes, and increase the traceability of governmental decisions. Evidence suggests that digital government can stimulate corporate green innovation by improving service efficiency, reducing transaction costs, and creating a more transparent institutional environment (Cao et al., 2025). In the renewable energy sector, digital platforms may support online licensing, project monitoring, resource mapping, electricity-market transactions, public reporting, and coordination among governmental institutions. These capabilities are particularly valuable in sectors characterized by multiple regulatory agencies, geographically dispersed projects, and complex interactions among public organizations, investors, technology providers, and electricity-network operators.

Green finance constitutes another critical pillar of renewable energy development. Conventional financial institutions may perceive renewable energy projects as risky because of policy uncertainty, unfamiliar technologies, currency fluctuations, long investment horizons, and the absence of stable power-purchase arrangements. Green finance seeks to address these constraints by directing capital toward environmentally beneficial projects through green bonds, dedicated credit lines, climate funds, concessional lending, guarantees, and sustainability-linked financial instruments. The evolution of green finance demonstrates that its expansion depends on enabling regulations, credible standards, financial-market development, disclosure systems, and institutional support (Bhatnagar & Sharma, 2022). Green bonds have been used to finance renewable energy and energy-efficiency projects, but their effectiveness requires clear taxonomies, supportive public policies, project pipelines, and investor confidence (Azhgaliyeva et al., 2020). Empirical evidence also suggests that green finance development can increase renewable energy deployment by alleviating financing constraints and improving access to investment resources (Li & Umair, 2023).

The broader level of financial development likewise affects renewable energy consumption. Evidence from Türkiye shows that financial-sector development can support renewable energy expansion by mobilizing investment and facilitating access to capital, although the relationship is conditioned by economic and policy structures (Mukhtarov et al., 2022). Emerging approaches increasingly emphasize the interaction among green finance, artificial intelligence, renewable energy, and sustainable development, suggesting that financial and digital innovation can reinforce one another when embedded within coherent governance frameworks (Omri et al., 2025). For countries facing restrictions on international financial transactions, however, access to global green bonds, climate funds, and foreign investment may be limited. Under such conditions, governments must develop domestic green financing mechanisms, reduce investment risk, create credible contractual arrangements, and use diplomatic channels to expand access to international environmental finance.

Green diplomacy is therefore an essential component of a comprehensive green government model. Renewable energy transitions are increasingly influenced by international climate agreements, sustainable development commitments, regional electricity markets, technology partnerships, and international financial institutions. Green diplomacy can help governments obtain financing, facilitate technology transfer, participate in regional energy projects, harmonize technical standards, and strengthen their position in international climate negotiations. It can also create opportunities for cross-border electricity trade and regional grid integration, particularly where renewable resources differ across neighboring countries. Trends in renewable energy markets show that regions with substantial resource potential still face institutional, financial, infrastructural, and political barriers that require coordinated domestic and international action (Alex-Oke et al., 2025). Forecasts of renewable energy generation similarly indicate continued global expansion, but the distribution of future growth will depend on investment conditions, government policy, technology costs, and the capacity of national electricity systems to absorb new generation (Khaleel et al., 2025).

The social dimension of renewable energy governance is equally important. Energy transitions affect employment, regional development, household costs, land use, local communities, and the distribution of economic benefits. A technically efficient transition may encounter resistance if decision-making is opaque, local concerns are ignored, or benefits are concentrated among a limited group of actors. Public consultation, civil-society access to information, consumer awareness, and community participation can improve policy legitimacy and reduce implementation conflicts. Renewable energy development should also advance energy justice by expanding access to reliable and affordable energy in disadvantaged, remote, and rural areas. Government communication can promote pro-environmental behavior, but communication must be supported by credible policies and meaningful opportunities for participation (Lin et al., 2022). Green government should consequently connect renewable energy development with social inclusion, fair benefit-sharing, employment creation, and the retraining of workers whose livelihoods depend on fossil-fuel industries.

Environmental sustainability also requires attention to the full life cycle of renewable energy technologies. Although renewable electricity generally produces substantially lower operational emissions than fossil-fuel generation, projects may still generate environmental impacts through land occupation, habitat disturbance, mineral extraction, manufacturing, construction, and end-of-life waste. Sustainable renewable energy policy must therefore include environmental impact assessment, biodiversity protection, recycling standards, waste-management systems, and circular-economy principles (Al-Shetwi, 2022). The green economy literature further demonstrates that environmental sustainability is a multidimensional concept encompassing ecological integrity, economic restructuring, social welfare, resource efficiency, and institutional change rather than a single focus on emissions reduction (Merino-Saum et al., 2020). Related sectors such as transportation also show that green transitions require integrated strategies combining technology, infrastructure, regulation, behavioral change, and investment rather than reliance on one isolated intervention (Shah et al., 2021).

These considerations are highly relevant to Iran, which possesses considerable solar, wind, biomass, and geothermal potential but continues to rely heavily on fossil fuels for electricity generation. The country's renewable energy development has been constrained by economic uncertainty, subsidized fossil-fuel energy, investment risks, administrative complexity, limited access to international finance, technological dependence, and weaknesses in implementation continuity. Iranian studies have emphasized the necessity of developing context-specific renewable energy scenarios and aligning urban and regional planning with energy-transition requirements (Ebadi et al., 2023). Research has also highlighted the role of government policy in establishing a sustainable development model centered on renewable energy, confirming that governmental action is not peripheral but foundational to the transition process (Jalili et al., 2025). The Iranian context therefore requires a model that is both theoretically comprehensive and institutionally adapted to the country's electricity-sector conditions.

Existing studies have made substantial contributions by examining renewable energy technologies, financial development, green innovation, policy instruments, sustainable development, and government intervention. Nevertheless, much of the literature addresses these factors separately. A fragmented approach may fail to explain how institutional capacity, policymaking, financing, economic support, diplomacy, infrastructure, innovation, human capital, social participation, environmental sustainability, and energy security interact as components of a single governance system. The complexity of renewable energy transitions requires a multidimensional model that captures both direct and indirect relationships among governmental capacities, policy instruments, implementation mechanisms, and sustainable outcomes. Moreover, a model developed specifically for Iran's electricity industry must reflect the institutional, economic, technological, environmental, and geopolitical characteristics of the national context rather than simply transferring frameworks designed for other countries.

Accordingly, the aim of the present study was to design and validate a green government model for the development of renewable energy in Iran's electricity industry.

2. Methods and Materials

From a paradigmatic perspective, the present study is situated within the framework of pragmatism, as this paradigm makes it possible to employ practical strategies that are appropriate to the nature of the research problem in order to achieve the study objectives. In terms of methodological approach, the study is classified as mixed-methods research, and in terms of purpose, it is applied research. In the first phase, qualitative data were collected through semi-structured interviews with experts to extract and identify relevant themes. The qualitative analytical strategies consisted of Braun and Clarke's thematic analysis and Attride-Stirling's thematic network approach, as thematic analysis is a systematic method of qualitative data analysis that facilitates the identification of semantic and conceptual patterns and latent structures within experts' perspectives. Sampling in the qualitative phase was purposive and information-oriented, and theoretical saturation was used as the criterion for determining the sample size. To enhance the credibility and dependability of the qualitative findings, control strategies such as continuous data review, constant comparison of codes and themes, and participant feedback for confirming the results were employed (Strauss & Corbin, 1998). In this phase, the expert panel consisted of 20 university faculty members and executive managers associated with the subject of the study. Table 1 presents the distribution of the demographic characteristics of the participating experts.

Table 1

Frequency and Percentage Distribution of Demographic Characteristics (N = 20)

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Male	12	60.0
	Female	8	40.0
Academic degree	Doctorate (Ph.D.)	15	80.0
	Master's degree	5	20.0
Field of study	Public administration	11	40.0
	Electrical engineering and renewable energy	6	25.0
	Other	3	15.0

An examination of the descriptive statistics related to the demographic characteristics indicates that the research sample possessed an acceptable level of scientific expertise and professional experience. In addition, several strategies were used to assess the validity of the qualitative findings. First, content validity was established by asking some participants to review the coding results to ensure that the extracted themes were consistent with their experiences and perspectives. Second, the identified themes were compared with the theoretical foundations of the study to evaluate their consistency with the conceptual framework and with the findings of previous studies. Third, to strengthen the transferability of the findings, a detailed and rich description of the research context, participant characteristics, and data collection process was provided. Moreover, Cohen's kappa coefficient was used to assess the reliability of the interview coding process in the qualitative phase. This method is among the most common techniques for evaluating reliability in qualitative research and determines the degree of consistency and coherence in data interpretation by comparing independent coding performed by two coders. Accordingly, one researcher was selected as the second coder. The principal researcher and the second coder then independently coded four selected interviews. The results of the comparison between the coding performed by the two coders are presented in Table 2.

Table 2

Calculation of Intercoder Reliability Using the Kappa Coefficient

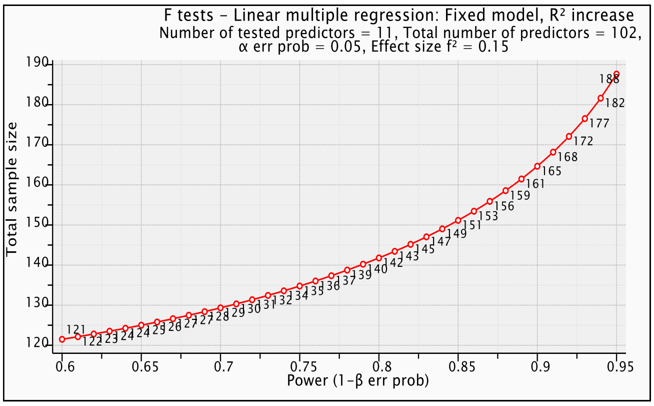
Row	Total Number of Codes	Number of Agreements	Number of Disagreements	Intercoder Reliability (%)
1	70	55	10	85.0
2	32	35	2	88.6
Total	102	90	12	86.7

As shown in Table 2, the total number of recorded codes was 102. Of these, 90 codes were assigned identically by both coders, whereas disagreement was observed in 12 cases. Accordingly, intercoder reliability was calculated as 86.7%. In the second phase of the study, which was quantitative in nature, structural equation modeling was used to evaluate and test the relationships among the constructs identified during the qualitative phase. At this stage, a structured questionnaire was developed based on the indicators extracted from the thematic analysis, and its items were rated on a five-point Likert scale. Following the initial development of the instrument, the face and content validity of the questionnaire were evaluated using expert judgments, and the necessary revisions were made. The required data were then collected by distributing the questionnaire among the target population, and the causal relationships among the study constructs were validated using structural equation modeling techniques. The sample size in the quantitative phase was determined by considering four principal criteria: the acceptable margin of error, the expected effect size, statistical power, and the intended level of generalizability of the findings (Hall, 2019; Neuman, 2014). In the present study, the sample size was determined according to the number of observed and latent variables identified during the qualitative phase using G*Power software. This software makes it possible to calculate an appropriate sample size based on the principal parameters and the relevant formula (Cohen, 1988).

In this formula, α represents the significance level, $1 - \beta$ represents statistical power, and d represents the effect size. In general, the lower the alpha error level and the higher the statistical power, the greater the generalizability of the sample findings to the larger population and the lower the probability of Type I and Type II errors. The G*Power output used to determine the final sample size is presented in Figure 1.

Figure 1

*G*Power Software Output*



Based on the output presented in Figure 1 and the analyses conducted using the specialized G*Power software, considering an error level of .15, statistical power of .95, and the identification of 11 global themes as latent variables and 102 subcodes as observed variables in the conceptual model of the present study, the required statistical sample size for the quantitative phase was estimated to be 188 participants.

3. Findings and Results

To extract and refine the themes, the thematic analysis strategy based on Braun and Clarke's (2006) six-phase model was employed. Subsequently, using the thematic network approach, the coding process was conducted at three levels: subcodes, main codes, and global themes. The results of the theme extraction process are presented in Table 3.

Table 3

Thematic Network

Global Theme	Organizing Theme	Basic Theme	No.
Green institutional capacity	Green administrative structure	Presence of specialized renewable energy units within the organizational structure of the Ministry of Energy	1
		Formal assignment of responsibilities for renewable energy development to government agencies	2
		Number of renewable energy specialists employed within government institutions	3
	Green interagency coordination	Level of policy integration among the Ministry of Energy, the Renewable Energy and Energy Efficiency Organization, and the Department of Environment in renewable energy development	4
		Presence of an active coordinating institution among executive agencies involved in renewable energy	5
		Alignment of renewable energy development programs with upstream policy documents	6
	Green government transparency and accountability	Presence of a government performance reporting system for renewable energy development	7
		Public disclosure of data on renewable energy capacity and generation	8
		Stakeholder access to information concerning licensing procedures and renewable electricity purchase agreements	9
	Green government implementation capacity	Capacity of government agencies to issue permits for renewable energy projects	10
		Quality of administrative procedures related to the implementation of renewable energy projects	11
		Degree of bureaucratic reduction in the licensing of renewable energy projects	12
Green energy policymaking	National renewable energy targets	Presence of a specific quantitative target for the share of renewable energy in Iran’s electricity mix	13
		Formal governmental commitment to reducing carbon dioxide emissions through renewable energy development	14
		Presence of a time-bound national program for transitioning to renewable energy	15
	Policy instruments supporting renewable energy	Implementation of a feed-in tariff system for renewable electricity	16
		Presence of mandatory renewable energy quotas for electricity suppliers	17
		Implementation of competitive bidding mechanisms for renewable energy projects	18
	Renewable energy policy monitoring	Presence of a continuous monitoring system for renewable energy policy performance	19
		Number of periodic independent evaluations of renewable energy development policies	20
		Extent to which policies are revised based on renewable energy performance-monitoring results	21
Green financing and green economic support	Renewable energy budgeting	Volume of budgetary appropriations allocated to renewable energy projects	22
		Presence of a national renewable energy development fund with sustainable financial resources	23
		Extent to which renewable energy projects benefit from preferential bank financing	24
	Renewable energy investment attraction	Volume of domestic and foreign investment attracted to renewable energy projects	25
		Presence of a legal framework supporting investment in renewable energy	26
		Volume of financing obtained from international climate funds for renewable energy	27
	Market instruments for renewable energy	Presence of a carbon-pricing mechanism linked to renewable energy development	28
		Number of green certificates issued to renewable energy producers	29
		Extent of access of Iranian renewable energy projects to international green financial markets	30
	Tax incentives for renewable energy	Presence of tax exemptions for renewable energy investors	31

		Level of customs-duty reductions for the importation of renewable energy equipment	32
		Presence of tax incentives for companies manufacturing renewable energy equipment	33
	Renewable energy subsidies and tariffs	Level of the renewable electricity feed-in tariff relative to the price of fossil-fuel-based electricity	34
		Volume of targeted government subsidies for renewable energy development	35
		Presence of a mechanism for adjusting renewable electricity purchase tariffs in accordance with declining technology costs	36
	Public–private partnerships in renewable energy	Number of public–private partnership contracts for renewable energy projects	37
		Extent of private-sector participation in government-supported renewable energy projects	38
		Quality of the risk-sharing framework in public–private partnership contracts for renewable energy	39
Green energy infrastructure	Development of renewable generation capacity	Installed capacity of solar, wind, and biomass power plants in Iran, measured in megawatts	40
		Annual growth rate of renewable energy capacity in Iran’s electricity grid	41
		Share of renewable energy in total national electricity generation	42
	Smart grid for renewable energy integration	Extent of smart-meter implementation for managing renewable electricity within the grid	43
		Installed energy-storage capacity supporting intermittent renewable energy resources	44
		Level of integration of distributed renewable power plants into the national electricity grid	45
	Technical standardization of renewable energy	Presence of national grid-connection standards for renewable power plants	46
		Updating technical standards in accordance with emerging renewable energy technologies	47
		Level of conformity of Iranian technical standards with international standards	48
Green technological innovation	Renewable energy research and development	Amount of government research and development funding allocated to renewable energy technologies	49
		Number of active national research projects in renewable energy technology	50
		Number of Iranian scientific articles on renewable energy published in reputable journals	51
	Localization of renewable energy technology	Percentage of renewable energy equipment supplied through domestic production	52
		Number of knowledge-based companies active in the renewable energy value chain	53
		Number of domestically registered patents in renewable energy technologies	54
	Renewable energy technology transfer	Number of technology-transfer memoranda of understanding concluded with foreign companies in the renewable energy field	55
		Level of university–industry cooperation in renewable energy technology development	56
		Number of joint government–university renewable energy research centers	57
Green human capital	Specialized renewable energy education	Number of specialized university programs in renewable energy-related disciplines	58
		Number of professionals holding specialized renewable energy certifications	59
		Extent of training provided to government managers in renewable energy policymaking	60
	Employment in the renewable energy sector	Number of direct and indirect jobs created in the renewable energy sector	61
		Ratio of renewable energy employment to total employment in the national electricity industry	62
		Number of retraining programs for fossil-fuel industry employees transitioning to the renewable energy sector	63
	Green organizational culture in government	Extent to which renewable energy criteria are integrated into the performance evaluation of energy organizations	64
		Number of government incentive programs promoting renewable energy use in public buildings	65
		Level of commitment of senior Ministry of Energy managers to renewable energy development objectives	66
Green social participation	Public participation in renewable energy development	Presence of a public participation mechanism in the renewable energy project licensing process	67

		Number of public consultation meetings held before the implementation of major renewable energy projects	68
		Civil society access to renewable energy planning information	69
	Renewable energy awareness raising	Level of public awareness regarding the environmental and economic benefits of renewable energy	70
		Number of government campaigns promoting renewable energy consumption through national media	71
		Consumers' willingness to pay a higher price for renewable electricity	72
	Equity in access to renewable energy	Extent of access to renewable energy in deprived and rural areas	73
		Presence of government programs for renewable energy development in disadvantaged regions	74
		Equitable distribution of the economic benefits of renewable energy projects among local communities	75
Environmental sustainability	Carbon emission reduction through renewable energy	Reduction in carbon dioxide emissions resulting from the replacement of fossil fuels with renewable energy, measured in tons per year	76
		Carbon intensity of electricity generation in Iran and its declining trend	77
		Degree of progress toward achieving Iran's nationally determined contribution targets through renewable energy development	78
	Environmental management of renewable energy projects	Percentage of renewable energy projects with approved environmental impact assessment reports	79
		Quality of the environmental impact assessment process for renewable energy projects	80
		Extent of compliance with environmental recommendations during the implementation of renewable energy projects	81
	Circular economy in renewable energy	Presence of a waste-management program for renewable energy equipment, including solar panels and wind turbines	82
		Extent of material recycling at the end of the useful life of renewable energy equipment	83
		Presence of circular-economy regulations specifically applicable to the renewable energy industry	84
Green diplomacy	International commitments to renewable energy development	Level of Iran's participation and membership activity in the International Renewable Energy Agency	85
		Alignment of Iran's renewable energy policies with the Sustainable Development Goals	86
		Degree of progress in implementing international renewable energy development commitments	87
	Regional cooperation in renewable energy	Number of renewable electricity export agreements with neighboring countries	88
		Iran's participation in joint regional renewable energy projects	89
		Presence of a regional cooperation framework for developing a renewable electricity grid	90
	International climate finance for renewable energy	Volume of financing obtained from international climate funds for Iranian renewable energy projects	91
		Access of Iranian renewable energy projects to green bonds and international green financial instruments	92
		Presence of active mechanisms for financing renewable energy projects under sanctions	93
Energy security	Diversification through renewable energy	Ratio of renewable energy to Iran's total installed electricity generation capacity	94
		Reduction in dependence on fossil fuels through renewable energy development	95
		Rate of achievement of the national renewable energy vision document targets	96
	Grid resilience through renewable energy	Reduction in the vulnerability of the electricity grid to fossil-fuel price fluctuations through increased renewable energy deployment	97
		Level of electricity-grid resilience to energy crises with the support of renewable resources	98
		Degree of reduction in dependence on energy imports through domestic renewable energy development	99
	Economic value creation through renewable energy	Economic value of the domestic renewable energy industry value chain	100
		Foreign-exchange savings resulting from replacing fossil-fuel imports with domestic renewable energy	101
		Growth in the renewable energy industry's share of Iran's gross domestic product	102

The results presented in Table 3 led to the extraction of a three-level coding structure for the research model. Accordingly, 102 subthemes were identified and organized into 33 main, or organizing, themes. These themes were ultimately integrated into 11 global themes: green institutional capacity, green energy policymaking, green financing, green economic support, green energy infrastructure, green technological innovation, green human capital, green social participation, environmental sustainability, green diplomacy, and energy security. Before designing the model, a sensitivity analysis was conducted. The results are presented in Table 4.

Table 4

Sensitivity Analysis of the Model Relationships

Independent Variable (Predictor)	Dependent Variable (Target)	VIF	Conclusion
Green institutional capacity	Green financing	4.41	No high multicollinearity
	Green economic support	2.69	No high multicollinearity
	Green diplomacy	4.45	No high multicollinearity
Green energy policymaking	Green financing	3.18	No high multicollinearity
	Green economic support	5.14	No high multicollinearity
	Green diplomacy	3.12	No high multicollinearity
Green financing	Green energy infrastructure	4.36	No high multicollinearity
	Green technological innovation	3.19	No high multicollinearity
	Green human capital	3.96	No high multicollinearity
	Green social participation	3.22	No high multicollinearity
Green economic support	Green energy infrastructure	4.30	No high multicollinearity
	Green technological innovation	4.20	No high multicollinearity
	Green human capital	3.27	No high multicollinearity
	Green social participation	2.10	No high multicollinearity
Green diplomacy	Green energy infrastructure	2.76	No high multicollinearity
	Green technological innovation	5.78	No high multicollinearity
	Green human capital	2.61	No high multicollinearity
	Green social participation	3.86	No high multicollinearity
Green energy infrastructure	Environmental sustainability	5.01	No high multicollinearity
	Energy security	3.77	No high multicollinearity
Green technological innovation	Environmental sustainability	2.69	No high multicollinearity
	Energy security	3.15	No high multicollinearity
Green human capital	Environmental sustainability	2.88	No high multicollinearity
	Energy security	3.42	No high multicollinearity
Green social participation	Environmental sustainability	4.05	No high multicollinearity
	Energy security	3.56	No high multicollinearity

Based on the results presented in Table 4, the variance inflation factor values for all relationships between the independent and dependent variables were reported to be outside the range of −1.96 to +1.96. This finding was interpreted as indicating that no high linear correlation existed among the independent variables included in the model. Accordingly, the development of the exploratory model was considered feasible.

Following the development of the conceptual model, variance-based structural equation modeling based on Hair's (2009) approach was used to test and analyze the relationships among the model paths. Within the PLS algorithm, the measurement model was first implemented and evaluated. Under the PLS approach, reflective measurement models were estimated based on the degree of correlation and the validity of the observed indicators and measures. Figure 2 illustrates the implementation of the research model in standardized form. At this stage, the factor loadings of the variable indicators could be evaluated, and the construct validity indices, including convergent and discriminant validity, and the reliability of the model could be assessed. Reliability was examined through composite reliability, shared reliability, and Cronbach's alpha coefficient (Ringle et al., 2008). The results of this phase are presented in Table 5.

Figure 2

Standardized Research Model

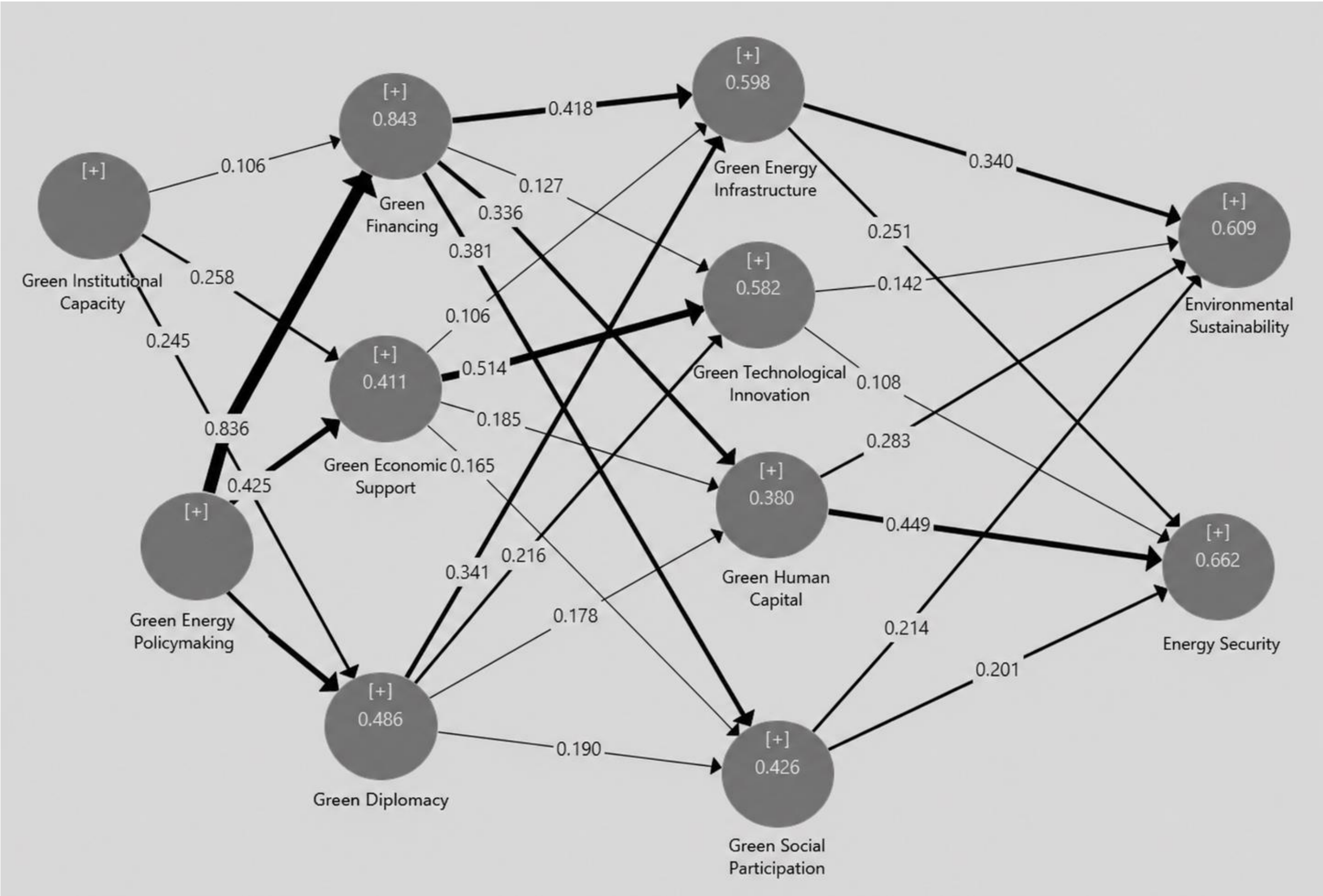


Table 5

Standardized Model and Reliability Indices

No.	Latent Variable	Cronbach's Alpha	Spearman's Reliability	Composite Reliability	Shared Reliability
1	Green institutional capacity	.86	.88	.91	.64
2	Green energy policymaking	.84	.86	.89	.62
3	Green financing	.87	.89	.92	.66
4	Green economic support	.83	.85	.88	.61
5	Green diplomacy	.81	.83	.87	.58
6	Green energy infrastructure	.85	.87	.90	.63
7	Green technological innovation	.88	.90	.93	.67
8	Green human capital	.82	.84	.88	.60
9	Green social participation	.80	.82	.86	.57
10	Environmental sustainability	.89	.91	.94	.68
11	Energy security	.86	.88	.91	.65

As shown in Table 5, Cronbach's alpha coefficients for all study variables exceeded .70; therefore, the reliability of the variables was confirmed. The composite reliability results also indicate that the values for all variables were greater than .70; accordingly, the composite reliability of the model was confirmed. In addition, the reported shared reliability values, or the corresponding shared indices, exceeded .50 for all constructs, thereby confirming the shared reliability of the model. According to the convergent validity criteria proposed by Hair et al. (2014), AVE should be equal to or greater than .50, and CR should be equal to or greater than .70. In the present study, CR was also greater than AVE; therefore, the convergent validity of the model was confirmed (Ringle, 2015).

In the next stage of the structural equation modeling algorithm, construct validity was examined. Construct validity was assessed from the perspectives of convergent validity and discriminant validity. Convergent validity was evaluated using the AVE criterion and the corresponding shared reliability results. Discriminant validity was assessed using the Fornell–Larcker criterion and supplementary approaches, including multitrait–multimethod evaluations. Table 6 presents the results of the Fornell–Larcker test for assessing the degree of correspondence between the model structure and the observed data. In addition, based on the recommendations of Henseler et al. (2015), the heterotrait–monotrait ratio was used in addition to the Fornell–Larcker criterion to ensure discriminant validity, because this criterion is considered more comprehensive and reliable. Accordingly, the HTMT results were also reported to verify the absence of critical correlations among the model constructs. Table 7 presents the results of this discriminant validity test.

Table 6

Fornell–Larcker Criterion

Research Construct	1	2	3	4	5	6	7	8	9	10	11
Energy security	.828										
Green financing	.719	.857									
Green economic support	.615	.635	.745								
Green diplomacy	.596	.685	.603	.864							
Green energy infrastructure	.601	.720	.578	.692	.807						
Green human capital	.718	.576	.506	.520	.399	.836					
Green energy policymaking	.665	.916	.619	.678	.725	.541	.844				
Green institutional capacity	.596	.734	.577	.616	.701	.474	.751	.821			
Green social participation	.650	.617	.521	.551	.478	.629	.565	.481	.865		
Green technological innovation	.543	.602	.729	.614	.684	.394	.595	.549	.430	.765	
Environmental sustainability	.733	.741	.599	.625	.635	.586	.723	.673	.587	.544	.803

Table 7

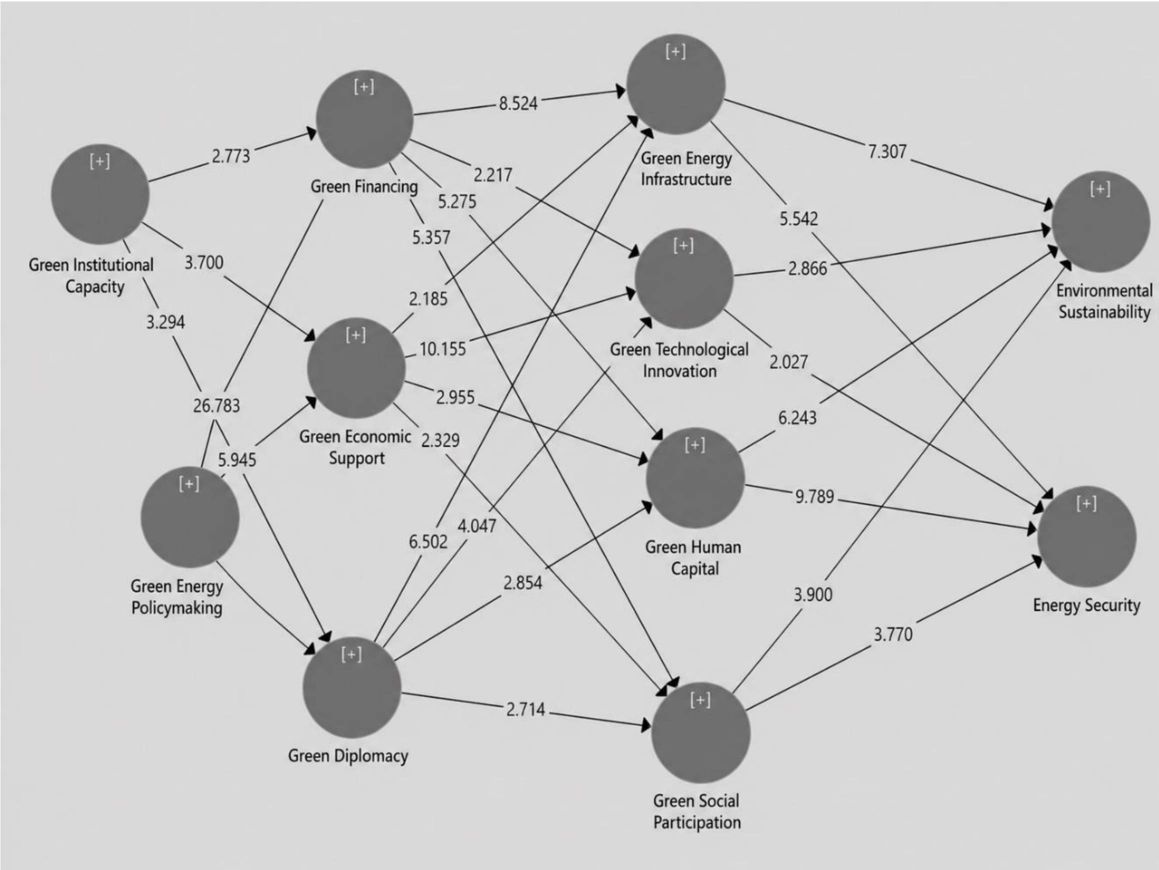
Heterotrait–Monotrait Ratio of Correlations

Research Construct	1	2	3	4	5	6	7	8	9	10	11
Energy security											
Green financing	.623										
Green economic support	.617	.726									
Green diplomacy	.847	.862	.840								
Green energy infrastructure	.871	.632	.831	.876							
Green human capital	.698	.867	.841	.741	.568						
Green energy policymaking	.563	.356	.880	.826	.715	.778					
Green institutional capacity	.883	.361	.823	.765	.893	.706	.857				
Green social participation	.548	.855	.821	.732	.651	.716	.761	.670			
Green technological innovation	.854	.836	.679	.828	.823	.582	.805	.756	.630		
Environmental sustainability	.485	.698	.872	.793	.837	.875	.639	.880	.812	.758	

According to Henseler et al. (2009), discriminant validity is established when the AVE of each construct is greater than the squared correlation between that construct and the other constructs. The software output presented in Table 6 indicates that discriminant validity was confirmed based on the Fornell–Larcker criterion. Moreover, the results presented in Table 7 indicate that all coefficients in the pairwise comparisons between the variables were less than 1. Therefore, no critical convergence was observed among the constructs, and discriminant validity was consequently confirmed. Within the structural equation modeling algorithm and after completing the measurement model stage, path analysis was conducted at the significance level to test the research hypotheses (Ringle, 2015). Figure 3 presents the research model with the significance coefficients and serves as the basis for analyzing the hypotheses and evaluating the implications derived from the theory and explanations developed in the study.

Figure 3

Research Model With Significance Coefficients



In the subsequent stage of the structural equation modeling algorithm, the quality of the model measurement was tested to determine the fit of the measurement model in accordance with Hair’s (2012) approach. This test serves as an alternative to the goodness-of-fit indices used in covariance-based structural equation modeling software. The results are presented in Table 8.

Table 8

Measurement Model Quality

Variable	Model Quality Coefficient	Evaluation
Energy security	.438	Strong
Green financing	.305	Strong
Green economic support	.370	Strong
Green diplomacy	.454	Strong
Green energy infrastructure	.303	Strong
Green human capital	.458	Strong
Green energy policymaking	.399	Strong
Green institutional capacity	.342	Strong
Green social participation	.350	Strong
Green technological innovation	.400	Strong
Environmental sustainability	.382	Strong

The results presented in Table 8 indicate that the measurement model quality coefficients for all 11 study constructs were evaluated as strong. These coefficients ranged from .303 for green energy infrastructure to .458 for green human capital. According to this criterion, values greater than .360 are considered strong, values greater than .250 are considered moderate, and values greater than .100 are considered weak. Among the constructs, green human capital (.458), green diplomacy (.454), and energy security (.438) had the highest quality coefficients, indicating a highly satisfactory fit for these constructs within the measurement model. In contrast, green energy infrastructure (.303) and green financing (.305) had the lowest values. Nevertheless, both constructs were reported to remain within the strong range and to be substantially above the threshold for moderate quality.

4. Discussion and Conclusion

The present study was conducted to design and validate a green government model for renewable energy development in Iran's electricity industry. The qualitative findings produced a multidimensional framework comprising 102 basic themes, 33 organizing themes, and 11 global constructs: green institutional capacity, green energy policymaking, green financing, green economic support, green diplomacy, green energy infrastructure, green technological innovation, green human capital, green social participation, environmental sustainability, and energy security. The quantitative findings subsequently confirmed all 26 hypothesized relationships among these constructs at the $p < .001$ level. The results therefore indicate that renewable energy development in Iran's electricity industry cannot be explained through a single technological, financial, or regulatory factor. Rather, it emerges from an interconnected governance system in which institutional capacity and public policy shape financial, economic, diplomatic, technological, infrastructural, human, social, environmental, and security outcomes. This interpretation is consistent with the broader literature showing that successful renewable energy transitions require coordinated policy instruments, capable institutions, technological adaptation, financial mobilization, and electricity-system transformation (Al-Shetwi, 2022; Elavarasan et al., 2020; Twidell, 2021).

The first important finding was that green institutional capacity exerted positive effects on green financing, green economic support, and green diplomacy. This result suggests that organizational structures, administrative coordination, governmental transparency, accountability mechanisms, and implementation capacity constitute the institutional foundation upon which other dimensions of renewable energy governance depend. Government agencies cannot effectively mobilize financial resources, provide coherent economic incentives, or pursue international energy cooperation when responsibilities are fragmented, administrative processes are unclear, and implementation authority is weak. The finding accords with green government research emphasizing that ecological principles must be incorporated into public administration, institutional procedures, and regulatory practices rather than being treated as isolated environmental commitments (Dama et al., 2021; Megawati et al., 2024). It is also consistent with the governmentality perspective, according to which governments influence sustainability transitions through administrative knowledge, standards, monitoring systems, classifications, and institutionalized forms of accountability (Rana et al., 2023; Rydin, 2021). Accordingly, strengthening institutional capacity appears to be a prerequisite for converting formal renewable energy goals into implementable programs.

The positive relationship between green institutional capacity and green financing further indicates that the availability of capital is partly an institutional outcome. Financial institutions and investors require clear licensing processes, reliable contractual arrangements, transparent tariff systems, credible public data, and predictable regulation. When these conditions are absent, policy risk increases and renewable energy projects become less attractive, even where technical potential is substantial. This result is compatible with studies showing that green finance depends on enabling regulations, standardized frameworks, project credibility, disclosure systems, and supportive government institutions (Azhgaliyeva et al., 2020; Bhatnagar & Sharma, 2022). It also supports evidence that financial development can increase renewable energy consumption when financial systems are capable of directing resources toward low-carbon investment (Li & Umair, 2023; Mukhtarov et al., 2022). In the Iranian electricity industry, institutional reform may therefore be as important as the nominal availability of funds because the effectiveness of financing depends on the administrative and regulatory environment through which investment is allocated.

The strongest causal relationship in the model was observed between green energy policymaking and green financing, with a path coefficient of $\beta = .836$. This finding demonstrates that policy design is the most powerful direct determinant of financial mobilization in the proposed model. Clear national targets, stable support mechanisms, feed-in tariffs, competitive auctions, renewable energy obligations, and continuous policy monitoring can reduce uncertainty and improve the bankability of renewable energy projects. The result aligns with comparative evidence showing that renewable energy development differs considerably across countries according to policy continuity, regulatory credibility, market design, and government commitment (Elavarasan et al., 2020; Muhammed & Tekbiyik-Ersoy, 2020). It is also supported by findings that renewable energy policies influence the strategic behavior and sustainable development of energy firms by changing investment incentives and expected returns (Zhang & Kong, 2022). In Iran, where electricity pricing, fossil-fuel subsidies, exchange-rate uncertainty, and investment restrictions may weaken market signals, stable green energy policymaking appears particularly important for attracting long-term capital.

Green energy policymaking also had positive effects on green economic support and green diplomacy. The relationship with green economic support indicates that government policies determine the design and allocation of subsidies, tax incentives, tariff mechanisms, customs exemptions, and public–private partnership arrangements. This result is consistent with research showing that government interventions can alter competition between green and conventional supply chains and contribute to social welfare when incentive structures are properly designed (Monjazeb et al., 2021). It also agrees with evidence that green subsidies can promote corporate green innovation by reducing financial constraints and increasing the expected benefits of environmental investment (An et al., 2025). However, the finding also implies that economic support should be embedded in a coherent policy framework rather than implemented as a set of temporary or uncoordinated incentives. Green industrial policy is most effective when financial support is linked to technological upgrading, domestic production, performance assessment, and long-term structural transformation (Kazempour, 2024).

The positive effect of green energy policymaking on green diplomacy suggests that national policy coherence strengthens the country's capacity to participate in regional and international renewable energy cooperation. Governments with transparent targets and credible implementation plans are better positioned to negotiate technology-transfer agreements, attract international climate finance, participate in cross-border electricity trade, and align domestic energy strategies with global sustainable development commitments. This interpretation is compatible with evidence that renewable energy market development is influenced not only by domestic resource availability but also by international cooperation, investment conditions, technology access, and political coordination (Alex-Oke et al., 2025; Khaleel et al., 2025). For Iran, green diplomacy may be especially significant because external financial and technological constraints increase the importance of regional cooperation, bilateral arrangements, and alternative mechanisms for accessing green finance and renewable energy technologies.

The findings further showed that green financing, green economic support, and green diplomacy positively affected green energy infrastructure, green technological innovation, green human capital, and green social participation. These relationships confirm that intermediate governance mechanisms translate institutional and policy capacities into operational capabilities. Green financing provides the capital required for generation facilities, smart grids, storage systems, research projects, training programs, and participatory initiatives. This result corresponds with evidence that green finance supports renewable energy expansion by alleviating capital constraints and enabling investment in clean technologies (Li & Umair, 2023; Omri et al., 2025). The role of green bonds and dedicated financial instruments in supporting renewable energy and energy-efficiency projects also reinforces the importance of specialized financing arrangements (Azhgaliyeva et al., 2020). Thus, financing should not be understood solely as funding power plants; it also supports the wider institutional and technological ecosystem required for renewable energy transition.

Green economic support had its strongest effect on green technological innovation, with a path coefficient of $\beta = .514$. This suggests that tax incentives, subsidies, tariffs, customs support, and public–private partnerships can substantially encourage research, localization, knowledge-based enterprise development, and technology transfer. This finding aligns with research indicating that government green subsidies stimulate green innovation and sustainability-oriented business performance (An et al., 2025; Mamash et al., 2025). It also supports the argument that the diffusion of new technologies depends on complementary investments, incentives, organizational capabilities, and institutional support rather than on technical superiority alone (Kalyani et al., 2025). The result is particularly relevant to Iran because reliance on imported technologies may expose renewable energy development to currency fluctuations and external restrictions. Economic support directed toward domestic research, equipment manufacturing, patenting, and university–industry collaboration may therefore strengthen technological independence and long-term sectoral resilience.

The positive relationships between green diplomacy and infrastructure, innovation, human capital, and social participation indicate that international and regional engagement can generate benefits beyond foreign financing. Diplomatic cooperation can facilitate technical standard harmonization, joint research, knowledge exchange, specialist training, access to international organizations, and participation in cross-border projects. Such cooperation may accelerate local technological learning and support the diffusion of renewable energy innovations. The finding is consistent with studies emphasizing the role of innovation policy standards and institutional coordination in strengthening local renewable energy development (Damayra & Khatib, 2022). It also accords with evidence that digital technologies, green supply chains, and energy-market conditions can stimulate renewable energy innovation in emerging economies (Huang & Tan, 2025). Furthermore, investment in energy research and development contributes to green growth by expanding technological capability and improving the productivity of low-carbon innovation (Eid et al., 2026).

The model also confirmed that green energy infrastructure, green technological innovation, green human capital, and green social participation positively influenced environmental sustainability and energy security. These results demonstrate that environmental and security outcomes arise from the combined effect of physical, technological, human, and social capacities. Green energy infrastructure directly supports the expansion and integration of renewable generation, whereas smart grids, storage systems, and technical standards improve the reliability of variable energy resources. This finding is consistent with studies showing that renewable energy complementarity and smart energy systems can reduce intermittency, improve flexibility, and facilitate the integration of distributed resources (Jurasz et al., 2020; Rezaei et al., 2020). Declining renewable energy costs further increase the feasibility of low-emission electrification, although infrastructure adaptation remains necessary to realize these benefits (Luderer et al., 2022).

Green technological innovation also contributed positively to environmental sustainability and energy security. Innovation can increase equipment efficiency, reduce generation costs, improve forecasting, support storage deployment, and enable more effective electricity-system management. The relationship is consistent with evidence that technological innovation, renewable energy consumption, financial development, and carbon reduction are interconnected (Wang et al., 2020). It also supports research indicating that renewable energy innovation is influenced by digital technologies, energy prices, and green supply-chain practices (Huang & Tan, 2025). Digital government may reinforce this process by reducing administrative costs, improving information access, and creating more transparent conditions for corporate green innovation (Cao et al., 2025). Although research on advanced analytical technologies has emerged in different applied domains, it similarly highlights the growing importance of data quality, uncertainty assessment, transparent evaluation metrics, and computational capability in complex decision systems (Chen et al., 2025).

Among the final-stage predictors, green human capital had the strongest effect on energy security, with a path coefficient of $\beta = .449$. This finding indicates that renewable energy security depends not only on installed capacity but also on the expertise required to plan, operate, regulate, maintain, and innovate within a transforming electricity system. Specialized university programs, professional certification, managerial training, retraining of fossil-fuel-sector workers, and a green organizational culture can improve adaptive capacity and reduce dependence on external expertise. This result is consistent with the broader understanding that technological transitions require organizational learning and skilled human resources to diffuse and sustain new technologies (Kalyani et al., 2025). It also reinforces the importance of research and development for green growth, because technological investment produces durable outcomes only when accompanied by sufficient scientific and professional capabilities (Eid et al., 2026).

Green social participation positively affected both environmental sustainability and energy security, although its path coefficients were smaller than those of some technical and human factors. This result nevertheless confirms that public awareness, consultation, civil-society access to information, equitable energy access, and community benefit-sharing contribute to the legitimacy and durability of renewable energy policies. Public participation can reduce resistance to projects, improve local responsiveness, and encourage pro-environmental behavior.

This finding is supported by research demonstrating that green government communication can influence citizens' environmental attitudes and behavior (Lin et al., 2022). It also aligns with sustainability-governance studies emphasizing that environmental policies are more effective when diverse forms of knowledge are recognized and affected communities are included in decision-making (Smallwood et al., 2023). The transition should therefore be viewed not only as a technical restructuring of electricity generation but also as a social process requiring trust, fairness, and public legitimacy.

The environmental sustainability construct achieved an explained variance of R^2 = .609, while energy security achieved R^2 = .662. These values indicate that the model explains a substantial proportion of variation in both outcomes. The stronger explanatory power for energy security suggests that renewable energy governance may be especially important for diversifying electricity generation, reducing dependence on fossil fuels, strengthening grid resilience, and limiting exposure to energy-price and supply disruptions. The findings correspond with studies linking renewable energy expansion to sustainable development, lower emissions, and improved energy-system performance (Olabi & Abdelkareem, 2022; Włodarczyk et al., 2021). They also support the view that renewable energy development must be environmentally managed across the technology life cycle, including land use, equipment waste, recycling, and circular-economy requirements (Al-Shetwi, 2022; Merino-Saum et al., 2020). Similar evidence from green transportation research confirms that sustainability transitions require integrated combinations of infrastructure, technology, policy, investment, and behavioral change (Shah et al., 2021).

Overall, the validated model extends previous Iranian studies by integrating previously fragmented determinants into a unified governance framework. Earlier research has emphasized the need for localized renewable energy scenarios and government-centered sustainable development policies (Ebadi et al., 2023; Jalili et al., 2025). The present findings advance this literature by demonstrating how institutional capacity and policymaking influence financing, economic support, and diplomacy, which subsequently shape infrastructure, innovation, human capital, and participation, ultimately producing environmental sustainability and energy security. The satisfactory reliability, convergent validity, discriminant validity, and measurement quality indices further indicate that the identified constructs provide an empirically credible representation of green government in Iran's electricity industry.

The study has several limitations. First, the qualitative findings were derived from interviews with 20 academic and executive experts, and although theoretical saturation was achieved, the perspectives of private investors, local communities, equipment manufacturers, environmental organizations, and electricity consumers may not have been fully represented. Second, the quantitative data were collected through self-report questionnaires, which may be affected by social desirability, common-method variance, or respondents' subjective assessments. Third, the cross-sectional design limits causal interpretation because the relationships were examined at one point in time. Fourth, the model was developed specifically for Iran's electricity industry, and its direct generalization to other industries or national contexts should be approached cautiously. Finally, rapid changes in energy technologies, economic conditions, sanctions, electricity pricing, and regulatory arrangements may affect the stability of some relationships over time.

Future studies should test the proposed model using longitudinal designs to determine how the relationships among institutional, financial, technological, and sustainability constructs evolve over time. Researchers should also examine the model across different provinces, electricity-market segments, and renewable energy technologies, including solar, wind, biomass, geothermal energy, and storage systems. Comparative studies involving countries with similar economic or institutional conditions could clarify which dimensions of the model are context-specific and which are broadly transferable. Future research may incorporate objective indicators such as installed renewable capacity, investment volume, patent registrations, emissions reductions, employment creation, and grid-reliability measures. Multigroup analyses could also compare the perspectives of government officials, private investors, technology firms, researchers, civil-society organizations, and local communities.

Policymakers should establish an integrated green government framework with clearly defined institutional responsibilities, stable renewable energy targets, transparent licensing procedures, and continuous performance monitoring. Dedicated green financing mechanisms, predictable electricity-purchase arrangements, targeted tax incentives, and risk-sharing instruments should be developed to attract domestic and foreign investment. Economic support should prioritize technological localization, knowledge-based firms, university–industry collaboration, energy storage, and smart-grid development. Government agencies should invest in specialized education, managerial training, and workforce-transition programs to strengthen green human capital. Public participation should be institutionalized through consultation, open-data systems, and equitable benefit-sharing arrangements. Finally, green diplomacy should be used to facilitate regional electricity cooperation, technology transfer, access to climate finance, and alignment with international sustainability standards.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were considered.

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