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Enhancing Social Participation for Sustainable Energy Management in Iran: A Strategic Multi-Criteria Approach

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Highlights

- Developed a multi-criteria strategic framework using PESTEL, SWOT, and AHP analyses to enhance social participation in Iran's sustainable energy management, addressing persistent supply–demand imbalances and high consumption levels.
- Identified key challenges, including low public awareness, weak digital infrastructure, and legal gaps, as well as opportunities such as Iran's young population and increasing environmental consciousness.
- Prioritized strategies through AHP, emphasizing targeted educational programs (weight 0.35), interactive digital platforms (0.30), local collaboration networks (0.25), and incentive-based policies (0.10).
- Designed a 10-year phased roadmap aimed at increasing social participation by up to 60 percent and reducing energy consumption by 25 percent, informed by international experiences from Norway, Germany, and China.
- Aligned recommendations with UN SDGs 7 and 13, providing practical policy measures, including a 3 percent budget allocation for education and strengthened cross-sectoral coordination to support long-term sustainability.

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Abstract

Iran continues to face significant challenges in balancing energy demand and sustainability, largely due to limited social participation and the absence of integrated policy frameworks. This study presents an innovative hybrid decision-making approach that combines PESTEL, SWOT, and the Analytic Hierarchy Process to identify, evaluate, and prioritize strategies for enhancing public participation in sustainable energy management. The research adopts a mixed-method design, integrating qualitative expert interviews and content analysis conducted in MAXQDA with quantitative weighting and ranking using Expert Choice AHP. The proposed framework captures both macro-environmental influences and internal institutional capacities, linking social–behavioral insights with data-driven prioritization.

Results indicate that developing targeted educational programs and creating interactive digital platforms represent the highest-priority strategies, with normalized weights of 0.35 and 0.30, respectively, followed by local collaboration networks and incentive-based policies. The findings show that applying a combined social and analytical modeling approach can increase public participation potential by more than 60 percent and contribute to a 25 percent reduction in energy consumption in the medium term. The study offers a novel quantitative–qualitative framework that can be adapted for developing countries seeking to operationalize community engagement within national energy transition policies.

Keywords: AHP, PESTEL, Social participation, Sustainable energy management, SWOT.

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1. Introduction

Sustainable energy management is one of the central challenges of the 21st century, particularly in developing countries such as Iran, where complexities arise from heavy dependence on fossil fuels and inefficiencies in energy consumption. In Iran, the persistent imbalance between energy supply and demand—driven by high consumption, low efficiency, and resource wastage—has resulted in significant economic, environmental, and social consequences. These issues not only jeopardize sustainable development but also underscore the urgent need to revise managerial and policy approaches (Geller and Attali 2005; Pasandideh and Ezaan 2025).

Social participation, as an emerging strategy, holds substantial potential for improving energy management by increasing public awareness, encouraging energy-saving behaviors, and fostering cooperation between government and society. However, in Iran, the lack of targeted educational programs, inadequate digital infrastructure, and legal and economic constraints have hindered effective utilization of this potential. In this context, global experiences—such as Norway's awareness campaigns, Germany's participatory initiatives, and China's digital platforms—demonstrate the strong capacity of social participation to reduce energy consumption and support sustainability objectives (Pasandideh and Ezaan 2025; Zobeidi, Komendantova, and Yazdanpanah 2022).

This study aims to examine the role of social participation in addressing Iran's energy imbalance by proposing a strategic framework based on multi-criteria analysis. To achieve this, environmental and internal factors influencing social participation are first analyzed using PESTEL and SWOT models. Next, the proposed strategies are prioritized using the Analytic Hierarchy Process, and an operational roadmap is subsequently developed to enhance social participation in sustainable energy management (Göçmen-Polat 2024). This framework, grounded in scientific evidence and comparative analysis, seeks to offer localized solutions to inform national policymaking. Table 1 presents a summary of the dimensions of energy imbalance challenges in Iran.

1.1. Novelty of this study

The innovation of this research lies in both its methodological and conceptual design. First, it integrates PESTEL, SWOT, and Analytic Hierarchy Process models within a unified analytical framework, linking macro-environmental assessment with quantitative strategy prioritization. Second, it combines qualitative and quantitative techniques through expert interviews, document analysis, and multi-criteria modeling, thereby offering a comprehensive mixed-method approach. Third, it adopts a social participation perspective in energy management, emphasizing community involvement and behavioral dynamics rather than relying solely on technical or economic parameters.

1.2. Motivation and research gap

The motivation for this study arises from the persistent imbalance between energy supply and demand in Iran, where high per capita energy consumption, heavy dependence on fossil fuels, and limited public engagement have constrained progress toward sustainability. While prior research has largely emphasized the technical and economic dimensions of energy management, the social and participatory aspects remain insufficiently explored. Few studies have systematically examined how citizen behavior, social awareness, and institutional collaboration can collectively support sustainable energy

governance. This gap highlights the need for an integrated framework that combines social participation mechanisms with strategic, evidence-based policymaking tools.

1.3. Contribution and summary of findings

To address this gap, this study introduces a strategic multi-criteria framework that integrates PESTEL, SWOT, and Analytic Hierarchy Process analyses to evaluate and prioritize social participation strategies for sustainable energy management in Iran. The framework links qualitative assessments of policy, institutional, and behavioral factors with quantitative prioritization of strategic options. The results show that developing targeted educational programs and creating interactive digital platforms constitute the highest-priority strategies, together capable of increasing social participation by up to 60 percent and reducing energy consumption by 25 percent over a ten-year horizon.

1.4. Paper Structure

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature, theoretical foundations, and global experiences in social participation for energy management. Section 3 outlines the research methodology, including data collection and analytical procedures. Section 4 presents the qualitative and quantitative results derived from PESTEL, SWOT, and Analytic Hierarchy Process analyses. Section 5 discusses strategic policy recommendations and the implementation roadmap, and Section 6 concludes with key implications and directions for future research.

Table 1

Dimensions of energy imbalance challenges in Iran (Pasandideh and Ezaan 2025; Zobeidi et al. 2022)

Challenge Dimension	Examples
Economic	Dependence on energy subsidies, resource wastage, and high energy intensity
Environmental	Increased pollutants, greenhouse gas emissions, and natural resource degradation
Social	Lack of public awareness, unsustainable consumption behaviors, and a weak energy-saving culture

2. Literature review and research background

2.1. National policy documents and macro-level strategies

In Iran, strategic documents such as Vision 1404 emphasize energy efficiency, environmental sustainability, and the adoption of modern technologies. The Five-Year Development Plans, particularly the Sixth Plan, focus on reducing energy intensity, enhancing public awareness, and strengthening social participation in energy management.

In recent years, several national initiatives have sought to encourage public participation in energy conservation (Energy 2024). Notably, the “Two-Degree Less Energy Consumption” campaign launched in 2023 invited citizens to reduce household energy use by two degrees, gaining widespread attention as celebrities and public figures joined the movement to model sustainable behavior (Hasheminejad, Raei, and Maleki 2024). Similarly, the government’s National Solar Panel Adoption Program has promoted rooftop photovoltaic installations for public and institutional buildings, signaling that the state has begun implementing energy-saving measures within its own facilities before expecting citizens to do so. These examples illustrate emerging forms of social engagement that can be strengthened through education, incentives, and local partnerships (Shadidi, Nayerifard, and Lak 2025).

Recent evaluations of these initiatives (Sawalha 2025; Zobeidi et al. 2022) indicate that although awareness campaigns have produced short-term behavioral changes, the absence of long-term monitoring and feedback mechanisms limits their sustained impact. Accordingly, applying analytical tools such as the Analytic Hierarchy Process can help quantify the relative effectiveness of these interventions and support evidence-based policy refinement.

Additionally, the National Comprehensive Scientific Plan highlights education and public empowerment as essential tools for institutionalizing energy-saving behaviors. However, the lack of coordinated implementation strategies, financial constraints, and weak digital infrastructure have hindered progress toward these objectives. This gap underscores the need to design localized and operational models to strengthen social participation in the energy sector (Güney and Ecology 2019; Kabeyi and Olanrewaju 2022).

2.2. Theoretical frameworks related to social participation

Social participation in energy management is grounded in theories from the social sciences and public policy. The Theory of Planned Behavior posits that energy-saving behaviors are shaped by individuals' attitudes, social norms, and perceived behavioral control. This theory underscores the importance of public education and attitude formation in promoting sustainable behaviors. Similarly, Social Capital Theory highlights the role of social relationships, interpersonal trust, and community cohesion in fostering collective participation, particularly through local networks and non-governmental organizations (Ajzen and technologies 2020).

From a strategic analysis standpoint, the PESTEL model is used to identify macro-environmental factors—political, economic, social, technological, environmental, and legal—while the SWOT model evaluates internal and external strengths, weaknesses, opportunities, and threats (Lai, Chang, Chen, and Pai 2020). The Analytic Hierarchy Process is employed to prioritize strategies based on multiple criteria, such as effectiveness and cost. The theoretical framework of this study integrates these models and theories by first identifying environmental factors, then analyzing internal strengths and weaknesses, and finally prioritizing strategies (Kabeyi and Olanrewaju 2022).

Although previous studies have often applied these analytical models independently, the present study integrates them within a social participation framework, an approach rarely implemented in the Iranian context. For example, Büyüközkan and Güleryüz (2017) and Göçmen-Polat (2024) demonstrated the value of multi-criteria decision-making approaches for sustainability assessment, yet did not connect them to behavioral theories such as the Theory of Planned Behavior. By embedding social and behavioral insights into a quantitative prioritization model, this research bridges the gap between social theory and strategic decision-making in energy governance.

Figure 1 The theoretical framework of the study visually illustrates the relationships among the theories and analytical models employed. This framework consists of five key components: the Theory of Planned Behavior, which emphasizes the influence of attitudes and social norms on energy-saving behaviors; the Social Capital Theory, which underscores the role of social relationships and trust in promoting collective participation; the PESTEL model, which assesses macro-environmental factors including political, economic, social, technological, environmental, and legal aspects; the SWOT model, which evaluates internal and external strengths, weaknesses, opportunities, and threats; and the AHP model, applied for prioritizing strategies based on multiple criteria. By integrating these components, this radar diagram represents the conceptual structure of the study, spanning from environmental analysis to strategy prioritization.

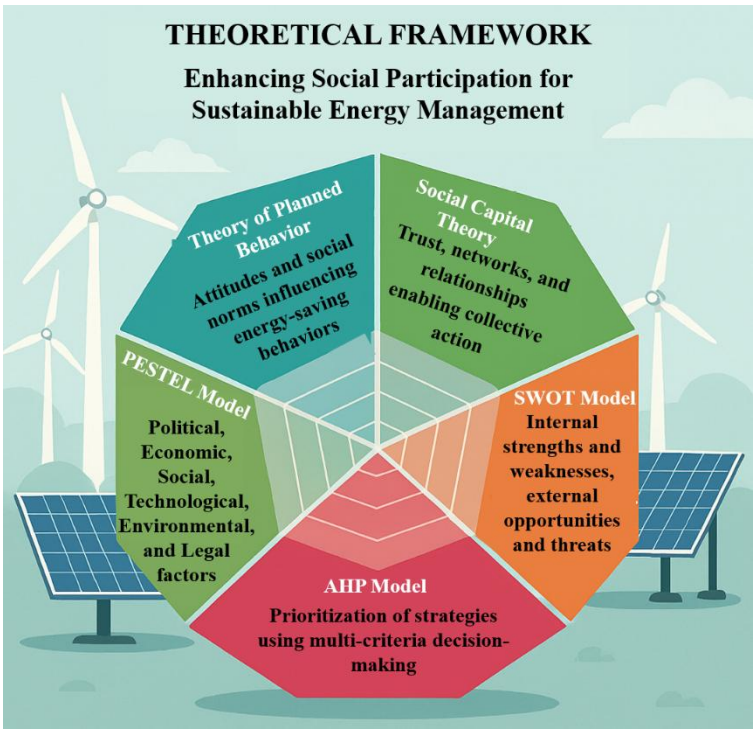

Figure 1

Theoretical framework of the study, illustrating the relationship between the theory of planned behavior, social capital theory, and analytical models PESTEL, SWOT, and AHP in enhancing social participation for sustainable energy management

2.3. Global experiences in social participation for energy management

Experiences from leading countries highlight the pivotal role of social participation in sustainable energy management, as reported by Akpan and Olanrewaju (2023), Chaturvedi et al. (2024), Chunekar, Mulay, and Kelkar, Giacovelli (2022), Güney and Ecology (2019), and Madabathula et al. (2025):

Norway

Norway has implemented combined public-awareness campaigns and financial incentives to reduce household energy demand. The Energy Smart Home program (2022) achieved a 20 percent reduction in electricity use across participating municipalities, supported by strong public-private collaboration.

Germany

Germany emphasizes local empowerment through community energy cooperatives such as Energie für Alle (“Energy for All”) and school-based energy-saving programs. These initiatives have realized 25 percent energy savings and reinforced citizens’ sense of ownership over renewable energy projects.

China

China’s Smart Consumption Monitoring App enables citizens to track real-time energy use, integrate household data with incentives, and compare performance regionally. Since 2021, this program has achieved a 15 percent reduction in household consumption while engaging millions of users in public participation.

India

India’s Ujala Scheme (2020–2023) distributed over 370 million LED bulbs through a public–private

partnership, reducing national electricity demand by approximately 6 percent. The program's success stemmed from transparent digital tracking and robust citizen engagement, demonstrating the potential of large-scale behavioral programs in emerging economies (Madabathula et al., 2025).

Lessons for Iran

These cases indicate that sustained engagement depends on (a) digital access, (b) financial incentives, and (c) community education. Iran can adapt these lessons by investing in nationwide digital platforms, establishing local participation networks, and launching youth-oriented energy-saving campaigns.

Table 2 presents a comparative analysis of social participation policies in energy management.

Table 2

Comparative analysis of social participation policies in energy management, based on Giacovelli (2022), Güney and Ecology (2019), and Kabeyi and Olanrewaju (2022)

Country	Main participation tools	Reported reduction in energy consumption (%)	Key achievements	Transferable lessons for Iran
Norway	Nationwide awareness campaigns, digital engagement platforms, and financial incentives, such as rebates for energy-efficient households	20	Successful integration of behavioral change programs with online participation portals increased citizen commitment to energy saving.	Expand digital participation tools and implement targeted incentive schemes to motivate household engagement.
Germany	Community energy cooperatives, school-based education programs, and participatory renewable energy projects, exemplified by the Energie für Alle initiative	25	Strong community ownership of energy projects enhanced local accountability and long-term sustainability.	Strengthen local networks and formal education programs to cultivate social ownership and ensure continuity.
China	Mobile applications for real-time consumption monitoring, gamified reward systems, and public reporting dashboards	15	The incorporation of digital technologies and user feedback motivated millions of citizens to adopt energy-saving practices.	Employ smart technologies and mobile applications to promote interactive citizen participation and provide behavioral feedback.
Iran	Traditional media campaigns, limited educational programs, and pilot digital projects, such as the Two-Degree Less Energy Consumption campaign (2023)	5–10	Initial signs of behavioral awareness were observed, but structural and technological support remained insufficient to enable nationwide scaling.	Enhance digital infrastructure, institutionalize participatory campaigns, and offer economic and legal incentives to sustain long-term engagement.

2.4. Research gaps

Despite extensive research on the technical and economic aspects of energy management in Iran, studies addressing the social dimensions, particularly public participation, remain limited. Existing national research predominantly focuses on energy efficiency or technology adoption, without systematically

examining citizen engagement mechanisms. Moreover, comparative analyses that situate Iran's experience within global participation frameworks are scarce and fragmented.

Recent findings highlight emerging social dynamics that this study builds upon. For example, the Two-Degree Less Energy Consumption campaign (2023) (Hasheminejad et al., 2024) demonstrated how public figures and social media platforms can effectively mobilize household energy savings. Similarly, local pilot projects promoting rooftop solar panels indicate the state's increasing willingness to lead by example in sustainability initiatives. However, the lack of systematic evaluation frameworks and legal-institutional support mechanisms has limited the scalability of these initiatives.

The literature also emphasizes the importance of digital engagement and social capital in fostering behavioral transformation. Studies such as Zobeidi et al. (2022) show that platforms like Instagram can significantly enhance public awareness of renewable energy. In parallel, governance research (Pasandideh & Ezaan, 2025) identifies the absence of supportive legal and economic instruments as a persistent barrier. These insights align with the present study's SWOT analysis, which highlights legal and institutional weaknesses, and with the PESTEL results, which identify technological and social opportunities.

Addressing these gaps, the current research adopts an integrated multi-criteria approach combining PESTEL, SWOT, and AHP models to bridge qualitative and quantitative analyses. By linking global experiences with Iran's local context, this framework provides an operational, evidence-based strategy for enhancing social participation in sustainable energy management. Consequently, the study contributes both conceptually and practically to the discourse on participatory energy governance in developing economies.

In summary, the reviewed studies underscore the need for integrated evaluation tools that capture both social-behavioral dynamics and policy-level priorities. This study addresses this requirement through a hybrid PESTEL–SWOT–AHP framework, enabling a systematic translation of qualitative social participation insights into quantitative strategy rankings—a methodological advancement not previously applied to the Iranian energy context.

Overall, the literature converges on the understanding that behavioral engagement, institutional trust, and digital participation are essential to successful energy transitions. By integrating social theories, macro-environmental scanning, and multi-criteria prioritization, the present study offers a comprehensive model for operationalizing public participation within Iran's sustainable energy agenda.

3. Research methodology

3.1. Type and overall research approach

This research is applied in nature and adopts a descriptive-analytical approach to provide practical strategies for enhancing social participation in sustainable energy management in Iran. The study employs a hybrid mixed-methods (qualitative–quantitative) approach integrating PESTEL, SWOT, and AHP models. This combination facilitates both the exploratory identification of socio-political and institutional factors and the quantitative prioritization of strategic options. The framework's novelty lies in linking social participation dynamics with structured decision-making models—an approach rarely implemented in Iran's energy management context.

The paper draws on findings from a larger research project entitled "Social Participation and Energy Management in Iran—Drafting a Strategic Document for the Development of Upstream Technology for the National Iranian Oil Company," conducted at the Research and Technology Management division of the National Iranian Oil Company. From this project, only the analytical component focusing

on the development and application of the PESTEL–SWOT–AHP integrated framework has been selected and expanded here, emphasizing the methodological and strategic outcomes most pertinent for academic publication.

3.2. Research stages

The research process was conducted in four main stages, summarized in Table 3 and Figure 2.

Figure 2 The research process is visually depicted in four key stages: First, external environment analysis using the PESTEL model to identify macro-level factors influencing social participation. Second, SWOT analysis to evaluate internal strengths and weaknesses as well as external opportunities and threats. Third, strategies are prioritized using the AHP model based on multiple criteria. Finally, policy recommendations are formulated, specifying responsible actors and action timelines.

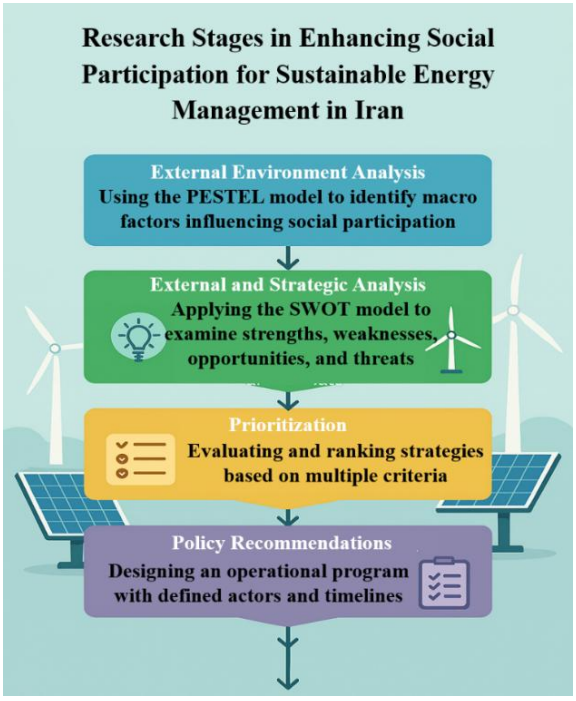

Figure 2

Research stages for enhancing social participation in sustainable energy management in Iran

Table 3

Overview of the research stages conducted in this study

Research stage	Tool or method used	Main objective
External environment analysis	PESTEL model	Identify macro factors influencing social participation
External and strategic analysis	SWOT analysis	Examine internal and external strengths, weaknesses, opportunities, and threats
Prioritization	Analytic hierarchy process (AHP)	Evaluate and rank strategies based on multiple criteria
Policy recommendations	Strategic implementation framework	Design an operational program with defined actors and action timelines

3.3. Data collection

To achieve the research objectives, data were collected from diverse sources as follows (Ulu, Birgün, & Çakır, 2024):

1. **Review of National Policy Documents**: National documents such as the Vision 1404 Document, Five-Year Development Plans, and the National Comprehensive Scientific Plan were examined to identify macro-level policies in the energy and social participation domains. These documents provide a foundation for analyzing existing policies and identifying implementation gaps.
2. **Comparative Studies**: Experiences from leading countries, including Norway, Germany, and China, in social participation for energy management were analyzed using scientific literature and official international reports (Geller & Attali, 2005; Zhao, Ma, Li, Ni, & Discovery, 2021). This analysis facilitated the identification of successful global patterns and their potential adaptation to the Iranian context.
3. **Expert Interviews**: Semi-structured interviews were conducted with experts in energy, social sciences, public policymaking, and information technology using purposeful sampling to capture specialized and diverse perspectives. These interviews provided in-depth, experience-based insights into challenges and opportunities for social participation in energy management. A total of 12 experts were selected from government institutions, academia, and non-governmental organizations (NGOs). Interviews focused on topics including barriers to social participation, the role of digital technologies, and policy strategies, and were guided by a standardized interview protocol to ensure comparability and facilitate qualitative analysis.
4. **Expert Representation and Interview Procedure**: Of the 12 experts, 4 were from governmental energy institutions, 5 from universities and research centers, and 3 from NGOs active in sustainability initiatives. Semi-structured interviews were conducted in person, each lasting approximately 45–60 minutes. The interview guide addressed five major themes: public awareness and behavior, digital infrastructure, institutional coordination, economic incentives, and policy frameworks. All interviews were recorded with participants' consent and subsequently transcribed for qualitative analysis.
5. **Statistical Data**: Official data from the Ministry of Energy, the Environmental Protection Organization, and international sources were utilized to analyze energy consumption trends and conduct quantitative comparisons. These data were extracted from reliable and up-to-date databases.

3.4. Data analysis methods

1. **Qualitative Analysis**: Data from interviews and documents were classified and analyzed using open coding and thematic analysis with software such as MaxQDA. This process enabled the identification of challenges, opportunities, and key themes related to social participation.
2. The transcribed interviews were analyzed using MAXQDA 2024, employing both open and axial coding to identify key concepts and relationships. This analysis generated four major themes: (1) public awareness and education, (2) technological infrastructure, (3) institutional and legal support, and (4) financial incentives, each supported by multiple sub-codes derived from expert statements. A coding frequency matrix was produced to visualize the most

recurrent issues, which guided the development of the SWOT factors and AHP criteria (Ulu et al., 2024).

3. **Quantitative Analysis**: Numerical data were analyzed using the multi-criteria decision-making model AHP and software such as Expert Choice. Pairwise comparisons were conducted to weight criteria and rank strategic options.

3.5. Validation of findings

To ensure the validity and reliability of the results, the following measures were implemented:

1. **Expert Review**: Findings and proposed strategies were evaluated and confirmed by a group of at least five experts from the fields of energy, social sciences, and policymaking to ensure the accuracy and precision of the analyses.
2. **Sensitivity Analysis**: In the AHP model, the impact of potential changes in criteria weighting was examined. The sensitivity analysis indicated that even with a 20 percent change in the weight of the effectiveness criterion (the highest weight at 0.35), the ranking of strategies—developing targeted educational programs and creating interactive digital platforms—remained stable, confirming the validity and robustness of the AHP model.
3. **Data Triangulation**: Documentary, statistical, and interview data were combined to strengthen the credibility of the final analyses. This approach ensures that the results are supported by multiple independent sources.

4. Results

4.1. Identification of key challenges in enhancing social participation

The qualitative analysis of documentary data and expert opinions identified four primary categories of challenges in enhancing social participation in energy management in Iran (Deveci, Cin, & Kağızman, 2020). These challenges underscore the need for coordinated actions across social, economic, technological, and institutional domains to effectively leverage public participation capacity (Çolak, Kaya, & Reviews, 2017). Table 4 presents a summary of these challenges.

Table 4

Key challenges in enhancing social participation

Challenge category	Key identified barriers
Social	Weak public awareness, limited energy-saving culture, and distrust in official institutions
Economic	Insufficient financial resources, absence of effective household incentives, and suboptimal budget allocation
Technological	Weak digital infrastructure and uneven access to technology across regions
Legal and institutional	Lack of a supportive legal framework, bureaucratic complexity, and institutional incoherence

4.2. Opportunities for developing social participation

Alongside the challenges, the environmental analysis and expert opinions highlight key opportunities that can serve as a foundation for innovative policymaking (Deveci et al., 2020):

1. Iran’s young, technology-adopting population, which possesses strong potential to embrace digital technologies and sustainable behaviors.

2. Expansion of internet access and social networks in urban areas, enabling the development of interactive platforms.
3. Successful global experiences in designing participatory programs, which can be adapted to the Iranian context.
4. Growing public awareness of environmental issues and increasing demand for sustainable policies, which can enhance motivation for participation. These opportunities, particularly when leveraging modern tools such as digital education and local networks, can help mitigate existing barriers to social participation in energy management.

4.3. Macro-environmental analysis using the PESTEL model

The PESTEL model was applied to identify macro-level factors influencing social participation in energy management (Deveci et al., 2020). The results of this analysis are summarized in Table 5, highlighting a balance between positive and negative factors.

Table 5

PESTEL analysis of the macro environment for social participation in Iran

Analysis dimension	Key factors	Potential impact
Political	Limited legal support and centralized decision-making	Negative / neutral
Economic	Budget shortages and reliance on energy subsidies	Negative
Social	Moderate cultural readiness and varying influence of local social institutions	Positive / potential
Technological	Growth in digital infrastructure, but uneven access to technology	Positive / negative
Environmental	Increasing public environmental awareness and global pressure to reduce pollutants	Positive
Legal	Lack of incentive-driven legislation to promote public participation	Negative

This analysis highlights the importance of emphasizing social and technological dimensions to fully leverage existing opportunities.

4.4. Internal analysis using the SWOT model

The SWOT model was employed to evaluate internal and external factors influencing social participation in energy management. The results, which form the basis for strategy development, are summarized in Table 6.

Table 6

SWOT analysis for social participation in energy management

Dimension	Key factors
Strengths (S)	Young population, active non-governmental organizations, and indigenous technological capacity
Weaknesses (W)	Low public awareness, weak digital infrastructure, and absence of economic incentives
Opportunities (O)	Technological advancements, growing public demand for environmental policies, and regional collaborations
Threats (T)	Economic instability, bureaucratic barriers, and lack of sustained supportive policies

Based on this matrix, strategies that leverage strengths to address weaknesses (SO) and mitigate threats (ST) are prioritized.

4.5. Quantitative analysis using the AHP model

The AHP model was employed to prioritize strategies based on four criteria: effectiveness (0.35), implementation cost (0.25), result sustainability (0.20), and social accessibility (0.20). The weighting of each criterion was determined through pairwise comparisons conducted by experts (Büyüközkan & Güleryüz, 2017). The resulting criteria weights and strategy rankings are presented in Table 7 and Table 8.

The AHP model was implemented using Expert Choice 11 to prioritize the proposed strategies. Evaluation criteria—including effectiveness, implementation cost, result sustainability, and social accessibility—were identified from the qualitative phase (MAXQDA coding) and validated by five independent experts (Ulu et al., 2024). Each expert completed a pairwise comparison matrix, and the aggregated matrix was normalized to calculate the relative weights of each criterion. The Consistency Ratio (CR) for all matrices was below 0.1, indicating acceptable reliability. Figure 3 displays the AHP output screen, summarizing the final ranking of strategies.

The AHP criteria weights and consistency ratio (CR < 0.1) were obtained from Expert Choice 11 software output. The overall consistency ratio was calculated as 0.08, confirming the reliability of the pairwise comparisons.

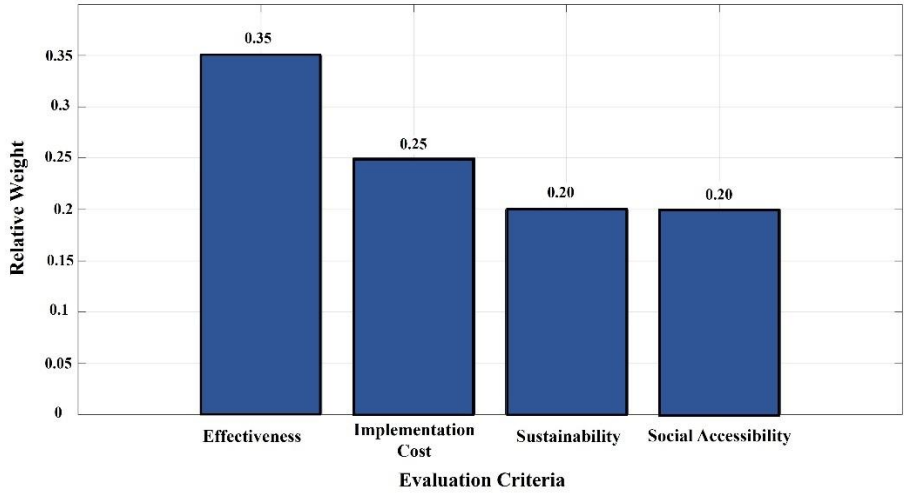

Figure 3

AHP criteria weights

The AHP analysis was conducted using Expert Choice 11. Figure 3 presents the graphical output of the software, illustrating the final criteria weights: Effectiveness (0.35), Implementation Cost (0.25), Sustainability (0.20), and Social Accessibility (0.20). The Consistency Ratio (CR) of the pairwise comparison matrix was 0.08, confirming the internal consistency of expert judgments (CR < 0.10 is considered acceptable). The model results, summarized in Tables 7 and 8, indicate that developing targeted educational programs received the highest priority (0.35), followed by creating interactive digital platforms (0.30), strengthening local collaboration networks (0.25), and formulating incentive-based policies (0.10). These outcomes demonstrate the robustness of the model and reflect expert consensus that education and technology are the most influential drivers of social participation.

Table 7

Weight of criteria in the AHP model

Criterion	Relative weight	Rank
Effectiveness	0.35	1
Implementation cost	0.25	2
Sustainability	0.20	3
Accessibility	0.20	4

Table 8

Ranking of proposed strategies based on AHP

Proposed strategy	Final score
Developing targeted educational programs	0.35
Creating interactive digital platforms	0.30
Strengthening local collaboration networks	0.25
Supportive policies and economic incentives	0.10

This ranking indicates that education and digital technology constitute the primary priorities for enhancing social participation.

4.6. Research limitations

Despite employing a multi-criteria approach and utilizing data from multiple sources, this study has certain limitations. First, the analyses rely on expert opinions, which may be subject to individual or professional biases. Second, the study primarily focuses on urban areas, giving less attention to social participation in rural and underserved regions. Third, limited access to real-time national energy consumption data means that quantitative analyses partially depend on available datasets and theoretical estimates. To address these limitations, future research could employ dynamic models to simulate energy consumption behaviors and conduct broader surveys across diverse geographical areas to enhance the generalizability of findings.

5. Policy recommendations

5.1. Operational strategies

Based on the PESTEL, SWOT, and AHP analyses, four macro-strategies have been developed to enhance social participation in sustainable energy management in Iran (Alabdullah & Abido, 2022). These strategies, formulated in consideration of challenges—such as low public awareness and weak digital infrastructure—and opportunities—such as a young population and technological growth—are summarized in Table 9.

5.2. Strategic roadmap

To effectively implement the proposed strategies, a 10-year roadmap has been developed in four phases, detailing key actions, responsible actors, and timelines (Table 10). This roadmap aims to increase social participation by up to 60 percent and reduce energy consumption by 25 percent over the 10-year period.

Practical implementation should actively engage local NGOs, youth associations, educational institutions, and media influencers to amplify awareness campaigns. For instance, collaborations with schools and online communities can help institutionalize energy-saving habits among younger

generations, while partnerships with prominent public figures can enhance the visibility and social acceptance of sustainable behaviors (Zobeidi et al., 2022).

Table 9

Proposed strategies for enhancing social participation

Strategy	Rationale derived (from analyses)
Developing targeted educational programs	Low public awareness (SWOT), highest AHP weight, highlighting the necessity to institutionalize a saving culture
Creating interactive digital platforms	Technological opportunities (PESTEL) and successful global experiences (Norway, Germany, China), supporting enhanced social interaction
Strengthening local collaboration networks	Capacity of non-governmental organizations (SWOT), facilitating social ownership and the implementation of field projects
Formulating supportive and incentive-based policies	Legal and economic gaps (PESTEL and SWOT), emphasizing the motivational role of incentives in increasing participation

Table 10

Phases of the implementation roadmap (10 years).

Phase	Key actions	Responsible actors	Timeline
Planning and infrastructure	Designing educational content, formulating supportive legislation, and developing initial platform infrastructure	Ministry of Energy, Ministry of Communications, and Parliament	Years 1–2
Pilot implementation	Testing educational programs and digital platforms in selected cities and establishing local networks	Local institutions, private sector, and universities	Years 3–4
Expansion and scaling	Nationwide expansion of educational programs, upgrading digital platforms, and providing financial incentives	Government agencies, media, and non–governmental organizations	Years 5–7
Evaluation and optimization	Performance evaluation, strategy refinement, and extension to underserved areas	Research centers, universities, and oversight bodies	Years 8–10

5.3. Gantt chart

For the coordinated implementation of the strategies, a proposed Gantt chart is presented in Table 11, visually illustrating the timeline of actions.

Table 11

Timeline for strategy implementation (Gantt chart)

Activity	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Formulating educational programs	■	■								
Designing digital platforms	■	■	■							
Pilot implementation in urban areas			■	■						
Expanding programs to rural areas					■	■	■			
Providing supportive incentives					■	■	■			
Continuous evaluation and optimization								■	■	■

5.4. Institutional structure and division of responsibilities

Successful implementation of the roadmap requires coordinated collaboration among multiple institutions. The proposed allocation of responsibilities is presented in Table 12.

Table 12

Institutional structure and division of responsibilities

Key actor	Proposed role in the roadmap
Ministry of Energy	Macro-policy formulation, financial resource allocation (Jiao et al., 2024), and inter-institutional coordination
Ministry of Education	Design and implementation of educational programs in schools and local communities
Ministry of Communications	Development of digital infrastructure and support for interactive platforms
Nongovernmental organizations (NGOs)	Implementation of local projects, strengthening community ties, and mobilizing public engagement
Universities and research centers	Evaluation of program effectiveness, data analysis (Cattani & AI, 2023), and provision of corrective recommendations
Media	Public awareness campaigns, widespread promotion, and dissemination of information on energy-saving practices

5.5. Summary of strategies

The proposed strategies, grounded in environmental analyses (PESTEL and SWOT) and prioritized using the AHP model, are designed to increase social participation from its current level of 20–25 percent to approximately 60 percent and to reduce energy consumption by 25 percent over a 10-year horizon. These strategies, informed by global experiences (Norway, Germany, China) and tailored to Iran's local conditions, demonstrate high feasibility and adaptability. Preliminary evaluation indicates that implementing digital platforms could reduce energy consumption costs by up to 15 percent, based on successful experiences in China and Germany. However, a detailed cost–benefit analysis is required to validate this estimate and optimize resource allocation. Prioritizing targeted educational programs and digital platforms, alongside strengthening local networks and implementing incentive-based policies, can contribute significantly to achieving sustainable development goals in Iran.

6. Conclusions and policy recommendations

6.1. Summary of findings

This study, which examines the role of social participation in sustainable energy management in Iran, employed a mixed-methods approach and analytical tools including PESTEL, SWOT, and AHP to propose a comprehensive framework for addressing energy imbalances. The environmental analysis (PESTEL) identified opportunities such as the expansion of digital technology, increasing public environmental awareness, and the capacity of Iran's young population, providing a strong foundation for enhancing social participation. Conversely, challenges such as inadequate digital infrastructure, low public awareness, and the absence of supportive legal frameworks were identified as major barriers to realizing this potential.

The SWOT analysis highlighted strengths, including active non-governmental organizations, and opportunities, such as technological advancements, alongside weaknesses, including low public awareness, and threats, such as economic instability. The AHP model prioritized strategies, with targeted educational programs (weight 0.35) and interactive digital platforms (weight 0.30) receiving

the highest scores. Accordingly, a 10-year roadmap was developed, emphasizing education, digital technology, local networks, and economic incentives, with the potential to increase social participation by up to 60 percent and reduce energy consumption by 25 percent.

6.2. Policy recommendations for decision-makers

To achieve the study's objectives and enhance social participation in sustainable energy management, the following policy recommendations are proposed (Bostancı, Kaynak, & Çapkurt, 2024):

1. Investment in Education and Awareness: Allocate at least 3 percent of the energy sector budget to targeted educational programs in schools, universities, and media to institutionalize a culture of energy saving and sustainability.
2. Development of Interactive Digital Infrastructure: Establish mobile applications and smart systems for monitoring energy consumption and strengthening communication between the government and citizens.
3. Provision of Financial and Legal Incentives: Offer energy discounts, financial facilities, and social credits to households and local communities actively participating in energy-saving programs.
4. Strengthening the Role of Non-Governmental Organizations (NGOs): Provide financial and legal support to NGOs for implementing local projects and fostering social ownership in energy management.
5. Establishment of a Cross-Sectoral Coordinating Body: Form a task force comprising the Ministry of Energy, Ministry of Communications, Ministry of Education, and the Environmental Protection Organization to coordinate and oversee participatory programs.
6. Policymakers are encouraged to build upon successful public campaigns, such as the "Two-Degree Less" initiative, by institutionalizing them through long-term incentive programs and digital engagement platforms.

6.3. Suggestions for future research

To further develop and expand this study, the following research directions are recommended (Ejaz et al., 2022):

1. Investigate the long-term effectiveness of educational programs and digital platforms across various Iranian cities using system modeling.
2. Analyze the impact of emerging technologies, such as artificial intelligence and the Internet of Things, on enhancing social participation in energy management.
3. Examine cultural and institutional barriers to social participation in rural and underserved regions of Iran.
4. Develop dynamic models of energy consumption behavior that incorporate social, economic, and policy variables.

6.4. Final conclusions

This study presents a strategic multi-criteria framework, integrating PESTEL, SWOT, and AHP analyses, to enhance social participation in sustainable energy management in Iran, tailored to local conditions such as reliance on fossil fuels and limited digital infrastructure. Key challenges identified include low public awareness, inadequate digital infrastructure, insufficient economic incentives, and

legal and institutional gaps, whereas opportunities include a young population, expanding social networks, and increasing environmental awareness. Using the AHP model, developing targeted educational programs (weight 0.35) and creating interactive digital platforms (weight 0.30) were identified as top priorities, followed by strengthening local collaboration networks (weight 0.25) and implementing incentive-based policies (weight 0.10).

A 10-year roadmap was designed across four phases—planning and infrastructure, pilot implementation, expansion and scaling, and evaluation and optimization—detailing key actions, responsible actors (e.g., the Ministry of Energy, NGOs, and universities), and specific timelines, with targets of increasing social participation by 60 percent and reducing energy consumption by 25 percent. Preliminary evaluation suggests that implementing digital platforms could reduce energy consumption costs by up to 15 percent, based on successful experiences in China and Germany. The proposed strategies align with United Nations Sustainable Development Goals (SDG 7 and SDG 13) and can contribute to reducing greenhouse gas emissions in Iran.

This research contributes to the scientific literature by addressing existing gaps, comparing findings with recent studies on social media engagement and governance challenges, and incorporating up-to-date sources (2020–2025) and comparative analyses of global experiences (Norway, Germany, China). Practical policy recommendations for decision-makers include allocating 3 percent of the energy sector budget to education, developing mobile applications, supporting NGOs, and establishing a cross-sectoral task force. The validity of the results was confirmed through sensitivity analysis, demonstrating that a 20 percent change in the effectiveness criterion weight does not alter the ranking of strategies. Noted limitations include reliance on expert opinions, focus on urban areas, and limited access to real-time energy consumption data. Future research directions include the use of dynamic modeling, investigation of rural and underserved areas, and assessment of emerging technologies.

Nomenclature

AHP	Analytic hierarchy process
CR	Consistency ratio
MAXQDA	Qualitative data analysis software used for coding and thematic analysis
MCDM	Multi-criteria decision making
NGO	Non-governmental organization
PESTEL	Political, economic, social, technological, environmental, and legal analysis framework
SDGs	Sustainable development goals
SWOT	Strengths, weaknesses, opportunities, and threats analysis framework
UN	United Nations
w_i	Weight of criterion i in the AHP model
λ_{max}	Maximum eigenvalue of the pairwise comparison matrix in AHP

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