



Win-Win Solutions Considering Problems in the Development of Energy Efficient Buildings in Iran Based on Public-Private Partnerships (PPP)

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ABSTRACT

This study evaluates the performance of Public-Private Partnerships (PPPs) in developing energy-efficient (EE) buildings in Iran, addressing stakeholder perspectives on both barriers and win-win solutions. By focusing on architects, constructors, policy makers, and owners across nine case studies, the research provides valuable insights into PPP theory application for overcoming EE challenges based on key elements of PESTEL (political, legal, economic, social, technological, legal and environmental). Data were collected from 36 stakeholder through pre-interviews, checklists, and semi-structured interviews, analyzed using thematic analysis to identify key patterns and themes. Findings reveal significant barriers to implement energy efficiency, including high costs, technical limitations, client preferences, and regulatory issues. Furthermore, the study proposes win-win solutions including robust policy frameworks, financial incentives, capacity building, technological innovation, and effective monitoring mechanisms. These strategies highlight the potential for PPPs to align public and private sector interests, fostering sustainable development. The study underscores the importance of tailored approaches and collaborative efforts to achieve energy efficiency goals, emphasizing PPPs as a strategic tool for infrastructure development. This research contributes to the global pursuit of energy-efficient buildings, promoting sustainable and inclusive growth in Iran's built environment.



Keywords: Barriers, Building industry, Energy efficient building, Public-Private Partnerships (PPPs), Win-win Solutions

1 INTRODUCTION

Environmental and energy concerns have gained significant prominence in recent years, with issues like global warming, ozone layer depletion, and increasing waste accumulation taking center stage internationally (Cabeza et al., 2014). According to Wei et al. (2018), the building industry plays a crucial role in global energy consumption and natural resource depletion. Energy efficiency, improvement, and environmental performance in buildings have emerged as critical priorities for many nations. Regulations addressing energy consumption were initially spurred by the 1970s energy crisis, ozone layer depletion, and concerns over global warming. Since then, sustainable design and development have become focal points in architecture, aiming to integrate energy-saving technologies and enhance energy sustainability, particularly in energy-intensive regions like Iran (Asghari & Ehyaei, 2015). The rapid depletion of energy resources and environmental impacts from fossil fuel consumption have intensified debates in energy and environmental sectors, underscoring the urgent need to preserve and manage natural resources more effectively.

Architectural spaces are pivotal arenas where human activities unfold, offering substantial opportunities for environmental protection, pollution reduction, and energy conservation. Sustainable architecture represents a paradigm shift rooted in climate considerations, local materials, and energy conservation principles (Karteris et al., 2016). Given that the construction industry consumes 40% of global energy, enhancing the energy efficiency of existing structures and promoting energy conservation are critical imperatives (Asghari & Ehyaei, 2015). Public-Private Partnerships (PPPs) seems to offer a promising avenue to tackle these challenges, facilitating collaboration between the public and private sectors to leverage creativity, efficient management, and specialized expertise.

PPPs, as defined by Roehrich et al. (2014), involve collaborations between public and private sectors to achieve various objectives such as creativity, efficient management, and expertise for advancement. The term was coined over two decades ago to describe this alternative financing and management approach, which supplements or complements existing tools to



meet infrastructure and service needs across various sectors, from environmental remediation to education and healthcare (Hodge & Greve, 2005).

The European Commission (EC) has proposed PPP initiatives to stimulate economic recovery and enhance productivity in key sectors affected by the global financial recession. These initiatives, integral to the EU 2020 Strategy, aim to promote sustainable growth and leadership through robust, inclusive development (European Commission, 2008). PPPs enable the transfer of market volatility from government to private sectors, particularly in projects traditionally funded by governments. Today, both developing and developed countries utilize PPPs as a strategy to deliver development solutions.

PPP programs provide essential low-cost financing for early-stage green infrastructure projects, attracting private capital and facilitating investment. As these projects mature and risks decrease, they can be securitized and sold to institutional investors, with financial instruments like green bonds further enhancing investment and contributing to climate change mitigation (Meltzer, 2016). Despite their potential benefits, PPPs face challenges related to risk allocation and management among host governments, private sector partners, bilateral funders, and multilateral organizations. International financial institutions (IFIs) often step in to resolve disputes and ensure equitable sharing of risks and benefits among all stakeholders involved in PPPs. Addressing these challenges requires innovative public procurement approaches that leverage the private sector's expertise in implementing energy efficiency projects. By "win-win," we mean achieving a balance between public and private sectors to develop energy-efficient buildings in Iran (Roshchanka & Evans, 2016).

Despite the extensive research on energy efficiency (EE) in architecture and the development of various tools and strategies worldwide, significant gaps remain, particularly in the context of Iran. While numerous studies have explored barriers and proposed solutions for EE globally (Ascione et al., 2013; Rocha et al., 2015; Shari & Soebarto, 2012; Xu et al., 2021), and specific tools have been tailored for regional contexts, such as Attia's (2012) energy-oriented software for Egypt and Taleb's (2015) study on integrating natural ventilation in Dubai, research specific to Iran's unique climatic and architectural challenges is limited. Although there have been efforts to investigate traditional and modern EE solutions in Iran (Heidari & Barzegar, 2013; Khalil & Amindeldar, 2014), these studies often focus on theoretical or historical approaches



and lack comprehensive, practical frameworks for implementation. Furthermore, the enforcement of energy efficiency standards in Iran faces significant obstacles, including bureaucratic inefficiencies, corruption, and a general lack of awareness among stakeholders (Habib et al., 2016). This creates a critical need for research that not only addresses these enforcement challenges but also integrates practical solutions tailored to Iran's diverse climatic conditions and architectural practices. This study aims to fill this gap by focusing on the development and implementation of Public-Private Partnerships (PPPs) to enhance EE in Iranian buildings. By leveraging the strengths of both public and private sectors, this approach seeks to create sustainable, enforceable, and effective EE strategies that are both contextually relevant and practically applicable.

2 METHODOLOGY

The participants of the current study were 36 individuals (9 architects, 9 constructors, 9 owner/user and 9 policy makers of projects) related to the nine case studies from different cities of Iran such as Tehran, Tabriz, Hamedan, Yazd, and so on. The names of the participants were anonymous in the case of confidentiality. Table 1 list the case studies and their status.

Table 1

Source of EE Case Studies in Iran

Name of Projects (Case Studies)	Condition	Architects
Case study 1: Iran Green Complex	Constructed	Mr Naser Golzari Mr Hasan Moradi
Case study 2: Ayatollahi House	Constructed	Mr Hosein Ayatollahi Mr Hasan Ayatollahi
Case study 3: Iranian Solar House	Constructed	Mr Mehdi Heidari
Case study 4: Solar Building, University of Science and Technology	Constructed	Mr Bijan Rafii
Case study 5: Supreme Audit Court Of Country	Constructed	Mohammad Taghi Rezayi Hariri



Case study 6: Tehran Climate House	Unconstructed	Mr Ahmad Rasekh Mr Reza Hasani
Case study 7: Shahid Hassan Bagheri School	Unconstructed	Mr Iman Shahri
Case study 8: Yadman twin tower	Unconstructed	Ms. Lida Beliallen Mr. Dariush Sattarzadeh
Case study 9: Kosar Green Residential Towers	Unconstructed	Mr Hamed Kamelnia

Source: *The author (2022)*

The required data for this study was gathered during the academic year 2020-2021 from September to June. The main focus of this study was on the perception of architects, constructors, policy makers and owners (users) on the win-to-win solutions in developing energy efficiency of buildings in Iran. At first stage the researcher studied the related dissertation, articles and books and surfed at the net to find energy efficient building in Iran to gather documents about them. After that the researcher distinguished 9 case studies in different areas of Iran. In second stage, a total number of 36 architects, constructors, policy makers and owners (users) related to the nine case studies in different cities of Iran was selected based on convenient sampling to take part in the treatment. Pre-interview with selected 36 involved persons were conducted. This phase took more than four months to be completed. Next, based on the related literature and the objective of the study and based on the key terms such as PPP and PESTLE, a checklist was designed. Besides PPP, the current study used PESTLE (political, legal, economic, social, technological, legal, and environmental) framework, which considers six critical external factors. Politically, strong governmental commitment at international, national, and local levels is crucial for overcoming opposition and ensuring project stability. Financially, PPPs rely on the ability to secure substantial private sector investments, necessitating robust financial frameworks and project-specific funding mechanisms. Socially, public acceptance of private sector involvement and addressing societal needs unmet by traditional funding sources are key factors shaping PPP viability. Technologically, access to advanced energy-efficient technologies and expertise is essential for successful project implementation. Environmentally, adherence to stringent sustainability and impact standards guides project evaluation and execution, particularly in regions with rigorous environmental regulations. Legally, consistent and transparent legal frameworks are fundamental to building investor confidence and facilitating PPP implementation across diverse national legal systems. These components collectively influence the effectiveness and feasibility of PPPs in advancing energy-efficient building initiatives globally (IRJET, 2016).

The designed checklist piloted with 10 of the key stakeholders (2 architects, 2 constructors, 3 policy makers, and 3 users) and during piloting phase, the vague items were discarded and they



were replaced with the comprehensible items, which resulted in high reliability, validity, and practicality. After this stage, the checklist filled out by the 36 main involved persons.

The fifth phase was the semi structured in-depth interview phase (main interview), which some preliminary preparation has been done with the interviewees. The reason for the interview was gathering the point of views of participants on the solutions in developing energy sustainability of Iranian buildings. The participants voluntarily took part in the interview session which lasted for about 20 minutes for each person. The interview's questions revolved around the solutions on energy efficiency and the researcher took notes from the answers of the participants. At this phase, there were both audio-recording of the interviews and the note-taking of the researcher for gathering information to design the scale.

Since the current study also was qualitative in nature, the researcher used a thick description of transcriptions of semi-structured interviews during data analysis phase. The interviews were in Persian but the transcriptions were designed in English. Each participant was interviewed on an individual audiotape to ensure there was no confusion and the participants were identified by the researcher based on the codes. The researcher's desire is to allow the interview to remain fairly conversational and situational to gain a collection of comprehensive study data. After this process, the researcher analyzed the transcripts looking for the brief trends and patterns. In order to analyze the interview results thematic analysis was used. "Thematic analysis is a method for identifying, analyzing, and reporting patterns (themes) within data" (Braun & Clarke, 2006, p. 79). Knowing the data, creating initial codes, looking for themes within the codes, reviewing themes, defining and labeling themes, and producing the final report are all steps in thematic analysis (Braun & Clarke, 2006). To find relevant qualitative units for analysis, the researcher alternated between reading the codes line by line and processing the data. The researcher chose a sample that has some of the prior coding and did blind recoding to ensure that the coding was accurate. Furthermore, for the aim of reliability, about 20% of the data was rechecked by a PhD in architecting, who was familiar with the nature of the study, to report the reliability of the findings. The results of the interviews were extracted thematic analysis as well as manual analysis and they were reported in the form of themes and extracts.

3 RESULTS

Barriers to EE Buildings

The first research question aimed to explore the barriers existed in the developing EE buildings in Iran in accordance to PPP and PESTEL. The current study focused on the checklists obtained from PPP that were filled by 36 involved persons (9 architect, 9 constructors, 9 policy makers and 9 owners and users) (public and private) of nine case studies based on PESTEL analysis, PPP factors and Sustainable factors. Figure 1 visualizes checklist analysis of all case studies.

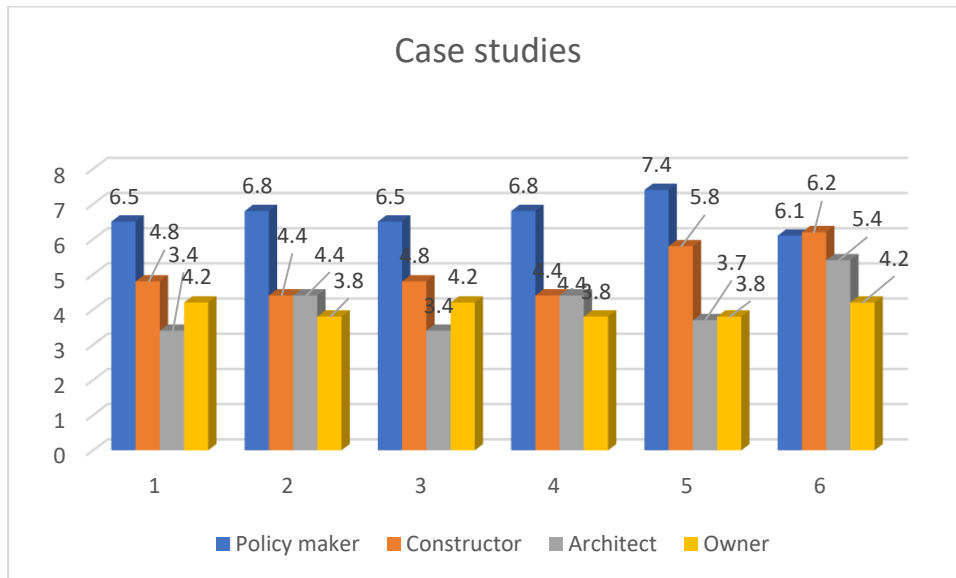


Figure 1: Checklist analysis of all case studies

- 1) political
- 2) economical
- 3) social
- 4) technological
- 5) legal
- 6) environmental

To be concluded, it is worth notifying that, based on the results of observation sheet for 5 constructed and 4 unconstructed case studies, the high scores related to the policy makers. However, the low scores and rates related to the architects and owners of Iranian EE buildings. In my personal point of view, the justification for the high scores of the policy makers can go back to the partisanship of these participants as well as the political reasons since they are directly related to the government, while the low scores of the architects can be devoted to their high level of knowledge in terms of EE buildings and the secrets existed in the high power of the society. In other words, policy makers and constructors were legislators in a society like Iran, hence they could not criticize themselves. Finally, based on the results, in most of the cases, almost all of the participants devoted the high scores to the innovation at the first place, RT at the second and VfM at the third place. The results were circulated in most of the cases with the differences in the scores. It seems that the key stakeholders are eager to disseminate innovation in EE buildings as innovation in technology can result in sustainability in developing EE buildings in Iran. Like the procedure done for the key stakeholders, the general result of PESTLE also has been summarized and reported (Figure 2).

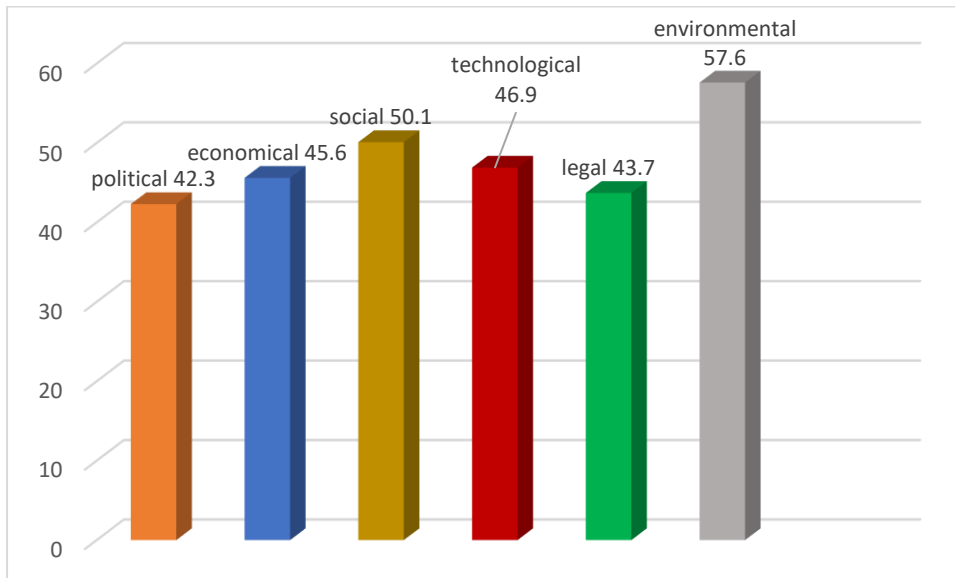


Figure 2: General results of PESTLE

Based on the results presented in Figure 2, participants reacted most strongly to the environmental item, which ranked first among the categories with a score of 57.6%. Social concerns followed, ranking second with a score of 50.1%. Technological factors were next, scoring 46.9%. The economic category was placed between political and legal concerns with a score of 45.6%. Both political (42.3%) and legal (43.7%) categories had similar, lower scores, slightly above 40%. This indicates that participants were most satisfied with environmental aspects and held a positive attitude toward addressing environmental problems to improve energy efficiency (EE) in buildings. Conversely, the political and legal categories received the lowest satisfaction scores, reflecting significant dissatisfaction and indicating that participants viewed issues in these areas as major barriers to developing EE buildings in Iran. Overall, most of the problems were perceived to be rooted in the political and legal sectors, highlighting the critical role of higher authorities in addressing these challenges. The overall results are summarized in Table 2.

Table 2

Main barriers in the development of energy efficient buildings of Iran according to PESTLE and PPP

Main finding barriers through the checklists	categories of barriers according PESTLE	PPP
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Environmental problems in EE buildings (57.6% of the replies)	Environmental	Innovation 26.7% VfM 17.8% RT 13.1%
Public unacceptance of private sector involvement and readiness and unacceptance of EE buildings among building industry players in Iran) (50.1% of the replies)	Social	Innovation 21.3% VfM 15.9% RT 12.9%
Technological barriers on the technicalities of EE buildings in Iran and Lack of access and availability of quality PPP practitioners and experienced project sponsors) (46.9% of the replies)	Technological	Innovation 31.1% VfM 9.3% RT 6.5%
(Lack of access to significant private sector borrowing and the lack of current economical regulations and rules support investments in infrastructure projects by long-term borrowing or debts) (45.6% of the replies)	Economical	Innovation 23.4% VfM 17.4% RT 9.8%
(Lack of simple, transparent and predictable requirements for licenses, permits and planning approvals and the lack of the labor laws that are sufficiently flexible and allow minimum productivity and efficiency) (43.7% of the replies)	Legal	Innovation 21.1% VfM 13.7% RT 8.9%
(Lack of support from the government in enforcing energy efficiency in buildings as regulatory mechanism from international, national and local will or commitment) (42.3% of the replies)	Political	Innovation 20.9% VfM 12.6% RT 8.8%



The study's findings presented in Table 2 highlight the main barriers to developing energy-efficient (EE) buildings in Iran, categorized according to the PESTLE framework and the Public-Private Partnership (PPP) sub-categories. The participants displayed the greatest level of concern for environmental issues, with 57.6% of respondents identifying these as significant barriers. This high level of concern indicates a strong awareness and dissatisfaction with the current environmental challenges related to EE buildings. Environmental issues were predominantly associated with innovation (26.7%), emphasizing the need for innovative solutions to address these problems. Value for Money (VfM) and Risk Transfer (RT) were also notable concerns, but to a lesser extent (17.8% and 13.1%, respectively).

Social issues were the second most significant barrier, with 50.1% of participants highlighting public unacceptance of private sector involvement and the readiness and unacceptance of EE buildings among industry players in Iran. This indicates a substantial social barrier to the adoption and implementation of EE practices. Within the PPP framework, social barriers were primarily linked to innovation (21.3%), followed by VfM (15.9%) and RT (12.9%). This suggests that social acceptance and innovation are crucial for overcoming these barriers.

Technological barriers were identified by 46.9% of participants, focusing on the technical aspects of EE buildings and the lack of access to quality PPP practitioners and experienced project sponsors. Technological concerns were most closely associated with innovation (31.1%), indicating that advancements and improvements in technology are necessary for progress in EE buildings. VfM and RT were less significant in this category, with scores of 9.3% and 6.5%, respectively.

Economic barriers were recognized by 45.6% of participants, emphasizing the lack of access to significant private sector borrowing and inadequate economic regulations supporting long-term investments in infrastructure projects. Economic barriers were linked to innovation (23.4%), VfM (17.4%), and RT (9.8%), indicating that economic innovation and financial incentives are critical for addressing these issues.

Legal barriers, identified by 43.7% of participants, included the lack of simple, transparent, and predictable requirements for licenses, permits, and planning approvals, as well as inflexible labor laws. These legal challenges were associated with innovation (21.1%), VfM (13.7%), and RT (8.9%). The data suggests that legal reforms and innovative approaches to regulatory frameworks are essential for overcoming these barriers.

Political barriers were noted by 42.3% of participants, focusing on the lack of government support in enforcing energy efficiency as a regulatory mechanism. Political barriers were linked



to innovation (20.9%), VfM (12.6%), and RT (8.8%). This indicates that political will and innovation are crucial for creating a supportive environment for EE buildings.

In summary, the data indicates that environmental issues are the most pressing concern, followed by social, technological, economic, legal, and political barriers. Across all categories, innovation emerged as the primary concern within the PPP sub-categories, followed by VfM and RT. This consistent trend highlights the importance of fostering innovation to address the diverse barriers in developing energy-efficient buildings in Iran. The findings underscore the need for comprehensive strategies that integrate innovative solutions, financial incentives, and regulatory reforms to overcome these challenges and promote the development of energy-efficient buildings in the country.

Win-win Solutions to EE buildings

In-depth face to face interview was done with 36 selected stakeholders of 9 selected case studies to answer the second research questions. Each of the nine case studies involved interviews with key stakeholders: one architect, one constructor, one owner/user, and one policy maker. This approach ensured comprehensive insights from various perspectives within each project, contributing to a thorough understanding of the factors influencing energy-efficient building development. It is worth noting that most of the key terms were repeated and the saturation was happened. The concept of saturation focuses on developing sociological theory from textual data to explain social phenomena. Based on the saturation in the data and the key constructs obtained from the interview sessions of case studies, a set of win-win solutions with the consideration of PESTEL in the form of suggestions was listed (See Table 3).

Table 3

Summary of suggestions to reduce barriers of developing energy efficient buildings in Iran stated by interviewees

<i>Category of proposed suggestions by interviewees</i>	PESTLE	Number of recorded	
		N	%



Actions by Government (public)		80	57.7%
<i>1 Encouraging and Supporting</i>			
-Reduce subsidies to encourage to using energy efficient practices in buildings	Economical+political+legal	29	21.4
-Providing financial incentives for developers and builders	Economical+political+legal	8	6.2
- Construction of energy efficient government buildings as role models to encourage public.	Environmenta+social+political+legal	4	2.8
-Establish Training Programs	Social+political+legal	3	2.1
-Establish Research and Development Programs	Social+political+legal	5	3.5
-Promote Green Certification Programs	Environmenta+political+legal	4	2.8
-Encourage Public-Private Partnerships	Political+legal	2	1.4
<i>2 Awareness</i>			
-Raise awareness about energy efficient construction among policy maker	Social+political+legal	5	3.5
-Raise Public Awareness	Political+legal	3	2.1
Raise awareness to avoid air pollution via EE buildings	Environmenta+political	4	2.8
<i>3 Stringent regulations</i>			
-Implement Stringent Building Codes	Legal	3	2.1



-Review and reforms of current legislation and developing new stringent regulations in energy efficient building practice.	Political+legal	6	4.2
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4 <i>Checking and monitoring</i>	Political+legal		1.4
		2	
<hr/>			
-Checking and monitoring enforcement of regulation	Political+legal	2	1.4
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Actions by the Education Sector (public + private)		31	22%
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5 <i>Awareness</i>	Social+technological		8
-Raise awareness through social media		11	
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-Providing energy efficiency training classes for public	Social	3	2.1
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-Raise awareness through educational institutions, schools, universities, etc.	Social+political+legal	2	1.4
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6 <i>Cooperation</i>	Social+political+legal		
Integrate Energy Efficiency in Curriculum		2	1.4
<hr/>			
Facilitate Research Initiatives	Political+legal	4	2.8
<hr/>			
Promote Student Competitions	Social+political+legal	2	1.4
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Collaborate with Industry Partners:	Social+political+legal	3	2.1



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Demonstration Projects on Campuses	Social+legal	2	1.4
	Social+political+legal	2	1.4
Cooperation between education sector and government			
Actions by the Private Sector (private)		16	11.2
<i>7 Encouraging and Supporting</i>			
Incorporate Sustainable Design Consultants	Social+environmental	4	2.8
Implement Green Building Certification Standards	Social+environmental	2	1.4
Provide Incentives for Employees	Social+economical	2	1.4
Collaborate on Industry Initiatives	Social+political	1	0.7
-Create demand	Social	1	0.7
-Use energy efficient technologies in their projects	Social+technological	2	1.4
<i>8 Awareness</i>			
Invest in Research and Development:	Social+economical+environmental	2	1.4
	<i>Social</i>	2	1.4
-Update and raise their knowledge about subject matter			
Actions by the Clients (public + private)		13	9.1
<i>9 Awareness</i>			
	Environmental+technological		



Promote Sustainable Material and Equipment Selection		2	1.4
Demand Life-Cycle Cost Analysis	Economical	2	1.4
Prioritize Renewable Energy Integration:	Social+political+technological+environmental	1	0.7
Encourage Smart Building Technologies	Social+political+technological+environmental	3	2.1
Explore Sustainable Financing Options	Social+political+economical	1	0.7
-Develop own understanding of advantages and impacts of living in energy efficient buildings	<i>Social +environmental</i>	2	1.4
-Supporting energy efficient construction industry by renting and buying energy efficient buildings	<i>Social+economical +environmental</i>	2	1.4
Total number of suggestions recorded		140	100

The research identified 140 actions suggested by 36 interviewees (architects of energy-efficient case studies) to reduce barriers to energy-efficient building development in Iran. These actions are categorized into four groups: Government, Education Sector, Private Sector, and Clients, each with specific recommendations reflecting the multifaceted approach required to overcome these barriers.

Government Actions (57.7% of suggestions)

The majority of suggestions (57.7%) pertain to actions by the government, indicating a strong emphasis on the role of public policy in promoting energy efficiency in building construction. Interviewees perceive government intervention as crucial in overcoming barriers to energy-efficient building development. Key recommendations in this category include several measures aimed at encouraging and supporting the adoption of energy-efficient practices.



Reducing subsidies to promote energy-efficient practices in buildings was the most prominent suggestion, with 29 recorded instances (21.4%). Additionally, providing financial incentives for developers and builders was suggested by 8 interviewees (6.2%), highlighting the importance of economic incentives in driving the adoption of energy-efficient technologies. Constructing energy-efficient government buildings as role models was suggested by 4 interviewees (2.8%), emphasizing the importance of demonstrating the feasibility and benefits of energy-efficient practices through practical examples. Establishing training programs (2.1%) and research and development initiatives (3.5%) reflect the perceived need for capacity-building and knowledge dissemination within the construction industry. Promoting green certification programs (2.8%) and encouraging public-private partnerships (1.4%) were also noted as significant actions. Raising awareness about energy-efficient construction among policymakers (3.5%) and the general public (2.1%) was seen as critical. Additionally, raising awareness to avoid air pollution via energy-efficient buildings was suggested by 4 interviewees (2.8%). Implementing stringent building codes (2.1%) and reviewing/reforming current legislation (4.2%) were suggested to ensure compliance and enhance the regulatory framework for energy efficiency. Effective monitoring and enforcement of regulations (1.4%) were emphasized to ensure compliance with energy efficiency standards.

Education Sector Actions (22% of suggestions)

The significance of the education sector's involvement is highlighted by approximately 22% of the total suggestions, both public and private. This underscores the recognition of the pivotal role that educational institutions can play in promoting energy efficiency awareness and practices. Within this category, the majority of suggestions emphasized raising awareness through social media (8%). Additionally, providing energy efficiency training classes for the public (2.1%) and raising awareness through educational institutions such as schools and universities (1.4%) were noted. Integrating energy efficiency into the curriculum (1.4%) and facilitating research initiatives (2.8%) were suggested to foster a culture of energy consciousness and drive innovation. Promoting student competitions (1.4%), collaborating with industry partners (2.1%), and demonstrating energy-efficient technologies on campuses (1.4%) were also emphasized.

Private Sector Actions (11.2% of suggestions)

The suggestions attributed to the private sector represent 11.2% of the total recorded suggestions. While not as predominant as government or education sector actions, the private



sector still plays a significant role in advancing energy efficiency in building development. Key recommendations include incorporating sustainable design consultants (2.8%), implementing green building certification standards (1.4%), and providing incentives for employees (1.4%). Other suggestions included collaborating on industry initiatives (0.7%), creating demand (0.7%), and using energy-efficient technologies in projects (1.4%). Additionally, investing in research and development (1.4%) and updating knowledge about energy-efficient building practices (1.4%) were noted as crucial actions for the private sector.

Client Actions (9.1% of suggestions)

The suggestions attributed to clients represent 9.1% of the total recorded suggestions. While clients may not directly engage in construction activities, their choices and preferences significantly influence the demand for energy-efficient buildings. Key recommendations in this category include promoting sustainable material and equipment selection (1.4%), demanding life-cycle cost analysis (1.4%), and prioritizing renewable energy integration (0.7%). Encouraging smart building technologies (2.1%), exploring sustainable financing options (0.7%), and supporting energy-efficient construction by renting and buying energy-efficient buildings (1.4%) were also noted.

Summary

The analysis underscores the need for a comprehensive approach involving government actions, educational initiatives, private sector engagement, and client awareness to overcome barriers to energy-efficient building development in Iran. Government interventions, particularly in economic policies, training, and stringent regulations, are deemed critical. The education sector's role in raising awareness and fostering cooperation is also significant. The private sector's contribution through sustainable practices and innovation is essential, while client awareness and demand for energy-efficient buildings play a pivotal role in driving market adoption. Integrating these multifaceted efforts can significantly advance energy efficiency in Iran's building sector.

These actions demonstrate a recognition of the role that individual choices and preferences play in driving demand for energy-efficient buildings and supporting the growth of the energy-efficient construction market. Following three extracts from the interviewees clarify the themes.



Extract 1 (Architect of the second case study): *Surely, the government can invest in research and development programs focused on advancing energy-efficient building technologies. Collaborate with universities, research institutions, and private companies to develop innovative solutions that can be implemented in construction projects. By fostering a culture of innovation, the government can support the growth of a sustainable and energy-efficient construction industry.*

Extract 2 (Owner of the third case study): *The government can foster collaborations between the government and private sector to promote energy-efficient building initiatives. This can involve partnering with private developers to create pilot projects showcasing innovative and sustainable construction practices. By combining public resources with private sector expertise, the government can accelerate the adoption of energy-efficient building methods on a larger scale.*

Extract 3 from one of the interviewees is about the students' competition and a win-win solution in the education sector.

Extract 3: (constructor of the fifth case study): *The education center can organize competitions and challenges among students to design energy-efficient buildings. This can stimulate creativity and drive students to explore innovative solutions for sustainable construction. Recognizing and rewarding outstanding designs can further motivate students to prioritize energy efficiency in their future projects.*

The analysis of suggestions provided by interviewees underscores the multi-dimensional nature of addressing barriers to energy-efficient building development in Iran, with an emphasis on government intervention, economic incentives, capacity-building, awareness-raising, regulatory frameworks, and enforcement mechanisms. Effective strategies should integrate these various elements to create an enabling environment for the widespread adoption of energy-efficient practices in the construction industry. The study suggests a comprehensive Public-Private Partnership (PPP) approach to effectively promote energy efficiency in buildings, integrating policy support, financial incentives, capacity building, technology innovation, collaboration, and monitoring to achieve sustainability goals. This collaborative approach harnesses the strengths and resources of both the public and private sectors to address the complex challenges associated with energy-efficient building development and create a more sustainable built environment for the future.



4 DISCUSSIONS

The purpose of the current study was to improve and develop energy-efficient buildings in Iran by identifying main win-win solutions considering existing barriers in the building sector, based on the Public-Private Partnership (PPP) approach.. The first research question investigated the problems faced in promoting energy efficiency in Iran. The results showed that architects and owners of energy-efficient buildings consistently scored low, possibly due to their high expectations and involvement leading to dissatisfaction. Constructors were less satisfied than policymakers with government policies. Significant barriers identified included political and legal issues, lack of government support, and technological challenges. Participants highlighted the importance of innovation, return on investment, and value for money. Economic barriers were prominent, with low energy prices and high costs of implementing energy-efficient solutions being major concerns. The payback period for investments in energy-efficient technology was often seen as too long, discouraging investment. Agreement barriers included a lack of interest from clients and project team members, while political barriers involved insufficient political will, legislation, and leadership. Knowledge barriers related to a lack of technical understanding among project teams, and technology barriers were due to the unavailability of some energy-efficient building components in local markets. Social barriers were less significant.

The participants recommended increasing awareness, particularly among students, to promote energy-efficient building practices. Education programs and effective communication channels such as TV and the internet were suggested to address the knowledge gap. Economic barriers could be mitigated by providing higher subsidies for energy-efficient installations to address high investment costs and long payback periods. In sum, a comprehensive approach involving government regulation, education, private sector leadership, and informed client choices is essential to drive the development of energy-efficient buildings in Iran. This approach should include policy support, financial incentives, capacity building, technology innovation, collaboration, and robust monitoring to create a sustainable built environment.

Similar to this study, Alam et al. (2019) studied the barriers and coping strategies for retrofitting government buildings for energy efficiency, focusing on insights from government workers in two Australian states. Their research identified key obstacles, including lack of political will, finance protocols, department/agency competency, industry capability, quality assurance, and misaligned incentives. They recommended a top-down government-supported strategy to



overcome these barriers, including allowing government departments to incur debt for financing retrofit projects, developing a required energy efficiency retrofitting strategy, securing specific financing sources, adopting a flexible procurement approach, establishing a facilitation team, and creating a list of pre-qualified professionals. These findings are congruent with the current study, which also highlighted political and legal issues as significant barriers to energy efficiency in Iran. Also Kazemi and Udall (2023) identified similar barriers in Iranian buildings, including legal, social, technological, economic, and environmental obstacles, with behavioral constraints being the most significant. The lack of awareness among building inhabitants, traditional teaching methods, inadequate internet feedback, and lax enforcement of legislation were highlighted as major issues. They also pointed out that the lack of practical solutions, aesthetic and symbolic benefits, and inadequate government policies make energy-efficient technology unappealing to consumers. These findings are in harmony with the current study's results, which emphasize the importance of addressing behavioral and educational barriers to promote energy efficiency.

Furthermore, Zhang and Wang (2013) found that financial and economic incentives, along with government involvement, are crucial for promoting building energy efficiency in China. Their findings align with the current study, which identified economic barriers and the need for government intervention as critical factors in developing energy-efficient buildings in Iran. Similarly, Cristino et al. (2021) indicated that financial/economic and governmental/political/regulatory barriers are significant impediments to energy-efficient buildings in Brazil, mirroring the barriers identified in the current study.

Political barriers were reported as severe obstacles in the current study, consistent with findings from Langlois-Bertrand et al. (2015), that categorized political and institutional barriers into lack of policy coordination, competing rules in the governance system, and political obstruction. These studies collectively emphasize the need for comprehensive strategies, including government intervention, financial incentives, education, and behavioral change, to overcome the multifaceted barriers to energy-efficient building development.

The next research question was an attempt to explore the way forward to promote adoption of energy efficiency in buildings in Iran base on PPP. To answer the research question, semi-structured interviews were conducted with 36 key stakeholders involved in energy efficiency (EE) projects in Iran, including architects, constructors, policymakers, owners, and users from both public and private sectors. The interviews focused on their experiences and roles, and the



data were analyzed using thematic analysis. Thematic analysis is a method for identifying, analyzing, and reporting patterns within data (Braun & Clarke, 2006). The study revealed that Iran faces significant challenges and barriers in adopting energy-efficient building principles. These barriers include high costs, land ownership complications, unavailability of necessary building components, lack of technical expertise among project team members, and inadequate repair and maintenance services. Political and legal issues, such as lack of government support and transparent requirements, also impede progress. Economic considerations, technological barriers, and stakeholder involvement further contribute to the suboptimal adoption of energy-efficient practices. To overcome these barriers, a holistic approach leveraging Public-Private Partnerships (PPPs) is recommended. This approach includes establishing a robust policy framework with clear guidelines, regulations, and incentives to encourage private sector participation, and providing financial incentives and support mechanisms such as grants, subsidies, and low-interest loans to mitigate upfront costs and incentivize investment in energy-efficient building projects.

Similar to this study, Kazemi and Kazemi (2022) identified financial barriers as the primary obstacles to energy efficiency in Iran's residential structures. Their study, which also used surveys and semi-structured interviews with energy efficiency experts, highlighted misplaced incentives, unpriced costs and benefits, fear of hidden costs, contentious evaluation methods, distortionary fiscal and regulatory policies, focus on initial costs, and false beliefs in energy efficiency as major financial barriers. They recommended government intervention through regulation, loan financing, project finance, grants and subsidies, fiscal incentives, setting real fossil fuel prices, and awareness and training campaigns to overcome these obstacles.

Over the past few decades, the building sector has significantly contributed to energy consumption, necessitating measures to reduce it. Utilizing building energy-efficient (BEE) technologies is one way to achieve this goal without impacting inhabitants' well-being. Numerous BEE technologies are accessible and offer various advantages, but there are obstacles to their implementation. Understanding these obstacles is crucial before attempting to overcome them. Cristino et al. (2021), similar to the current research, identified 105 obstacles to BEE technology adoption and categorized them into six groups: financial, market, technological, professional, political, and behavioral. These categories were then grouped with corresponding timelines, building types, and geographic locations, providing a clear structure



of each barrier type and methods for overcoming them. The general conclusion of this study emphasized the government's role in promoting EE buildings in Iran.

Moreover, Kostka et al. (2013) highlighted the need for proactive government action to encourage energy efficiency in Chinese buildings, identifying organizational, financial, and informational hurdles, along with family ownership structures, lax enforcement, and lack of government support as major barriers. More than 40% of the surveyed businesses were unaware of energy-saving tools or procedures. Babatunde et al. (2014) also identified obstacles to PPP implementation in developing nations through the SLEEPT approach, focusing on social, legal, economic, environmental, political, and technical factors. The study concluded that social, economic, and technological barriers are the most significant. Batra (2021) echoed these findings, identifying structural, contextual, environmental, financial, and execution issues as critical problems for PPP adoption in the housing industry.

The main research question in this study aimed to explore win-win solutions for overcoming barriers to energy-efficient buildings in Iran based on PPP. Solutions included facilitating capacity building, fostering public-private sector collaboration, promoting joint research and pilot programs, and establishing robust monitoring and evaluation mechanisms. Kazemi and Kazemi (2022) also identified financial barriers as primary obstacles to energy efficiency in Iran's residential structures. They recommended government interventions such as regulation, loan financing, grants and subsidies, fiscal incentives, setting real fossil fuel prices, and awareness and training campaigns. Similarly, Othman and Khallaf (2022) examined renewable energy projects worldwide, identifying regulatory and political constraints as primary barriers and emphasizing competent parties and well-prepared contracts as key success factors. Xue et al. (2021) studied obstacles to photovoltaic adoption in Norway, finding high upfront costs and lack of awareness as major issues for individuals, while private sector concerns included risk uncertainty and limited financing. Overall, PPPs hold great promise in overcoming barriers to developing EE buildings by breaking down initial expenses, facilitating information flow, and fostering collaboration. Iran's commitment to sustainable development makes it well-suited for PPP initiatives. By implementing robust policy frameworks, financial incentives, capacity-building initiatives, technology innovation programs, and fostering collaboration through PPPs, Iran can effectively promote energy efficiency in buildings and achieve sustainable development goals.



CONCLUSIONS

The present study on energy-efficient buildings in Iran offers several theoretical implications for the broader field of sustainable construction. By emphasizing Public-Private Partnerships (PPPs) as a catalyst for transformative change, the study underscores the importance of collaborative efforts between government entities and private sector stakeholders. This collaborative approach not only addresses immediate barriers such as high costs and regulatory complexities but also promotes long-term sustainability through shared resources and expertise. Moreover, the study highlights the significance of aligning economic incentives with environmental goals. By recommending the phasing out or reduction of energy subsidies, it advocates for policies that reflect the true costs of energy consumption and encourage adoption of energy-efficient practices. This aligns with theoretical frameworks emphasizing the role of economic signals in shaping sustainable behaviors and investments.

Furthermore, the study's focus on capacity building and technology innovation underscores the theoretical premise that enhancing knowledge and technological capabilities within the construction sector can drive systemic change towards sustainability. By promoting training programs and fostering a culture of energy conservation, the study suggests that educational initiatives are crucial for shaping future practices and attitudes towards sustainable building design.

For policymakers worldwide, the study offers practical insights and strategic recommendations derived from Iran's experiences. Firstly, it underscores the importance of robust policy frameworks that support energy efficiency initiatives. Policymakers are encouraged to establish clear regulatory standards, provide financial incentives for sustainable building practices, and facilitate public-private collaborations to overcome barriers and promote widespread adoption of energy-efficient technologies. Secondly, the study advocates for international cooperation and knowledge sharing among policymakers to learn from successful strategies and adapt them to local contexts. By promoting collaboration through PPPs and sharing best practices in technology innovation and capacity building, policymakers can accelerate progress towards global energy efficiency goals. Thirdly, the emphasis on monitoring and evaluation mechanisms highlights the importance of accountability and transparency in policy implementation. Policymakers are encouraged to implement effective monitoring systems to track the impact of energy efficiency measures, adjust policies as needed, and ensure continuous improvement in building performance. In sum, the study offers valuable theoretical insights and practical recommendations for policymakers worldwide to enhance energy



efficiency in the building sector. By embracing collaborative approaches, aligning economic incentives, and investing in education and innovation, policymakers can foster a sustainable and resilient built environment that supports economic growth, environmental sustainability, and social development globally. For future research, it suggested investigating effective strategies for incorporating energy-efficient elements from traditional Iranian architecture, assessing the impact of energy-efficient training courses on the construction industry, and analyzing the integration of energy efficiency into the educational curriculum of schools and universities. In summary, the study highlighted the potential of PPPs to drive energy efficiency in Iran's building sector, offering strategic recommendations to foster a sustainable and resilient built environment.

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