Power System Technology
ISSN:1000-3673

Received: 16-05-2024 *Revised: 12-06-2024* *Accepted: 07-07-2024*

Overcoming Challenges and Unlocking Potential: Advancing Energy-Efficient Building Solutions in the Warm Climates of Iran

[1]Fereshteh Hajigholami, [2]*Corresponding author: Mohamad Fakri Zaky Jaafar,

[1]PhD Candidate, Department of Architecture, Faculty of Design & Architecture, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia, fereshteh_hajigholami@yahoo.com

[2]PhD, Department of Architecture, Faculty of Design & Architecture, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia, email: zakyjaafar@upm.edu.my

ABSTRACT

This study aimed to investigate the main barriers and potential solutions in developing energy efficient buildings (EEBs) of warm climates of Iran. The sample of this study was architect groups of energy-efficient case studies and the data gathering tool was semi-structured interviews. As a result of a qualitative research design involving eight energy-efficient buildings, this paper presents eight categories of barriers to the development of (EEBs) and four categories of measures to overcome the barriers in order to promote sustainable building practices. Eight energy-efficient case studies' sixteen interviewees pointed out the following obstacles: Iran has low energy prices; 2) lack of interest by clients in using EE solutions; 3) EE solution application is too expensive;4) lack of political will, legislation, and enforcement;5) Participants of the project team lack technical understanding;6) Participants of the project team lack interest;7) Some EEB components are not available in Iran; and8) There is a lack of leadership in EEB projects. However, the following actions are recommended by those surveyed: 1) government action; 2) education sector action; 3) private sector action; and 4) client action. The article states that to promote sustainable development locally, regional factors must be taken into account in any sustainability evaluation techniques.

Keywords: Barriers; Building industry; Energy efficiency; Energy efficient building; Potential Solutions; Sustainable building; Iran.

1 INTRODUCTION

Buildings contribute significantly to global energy use and carbon emissions and they are crucial in developing sustainable development plans (Li et al., 2013). According to Chang et al. (2016), the International Energy Agency (IEA) has brought attention to the fact that residential buildings use more energy globally due to their bigger proportion in terms of both building count and floor area. In light of the significant contribution of buildings to global energy use and carbon emissions, it becomes crucial to address the barriers that have led to the high energy consumption in residential structures. Recognizing and mitigating barriers, while simultaneously offering mutually beneficial solutions, is imperative for the advancement of sustainable development initiatives focused on enhancing energy efficiency and environmental

Power System Technology
ISSN:1000-3673
Received: 16-05-2024 Revised: 12-06-2024 Accepted: 07-07-2024

preservation. In the pursuit of sustainable building practices, the identification and resolution of these obstacles are pivotal for achieving long-term environmental and economic benefits.

Researchers have looked at barriers to the development of energy-efficient (EE) buildings over time. For example, Nduka and Ogunsanmi (2015) found that among the obstacles preventing the use of EEs was a lack of awareness in their survey of 150 Nigerian professionals in charge of building construction. When Saraswat and Shukul (2015) polled 75 builders in Vadodara City, India, they discovered that over half of them had little exposure to different information sources. In addition to ignorance, another barrier is that certain cultures are less likely to value EEs and, as a result, are less likely to try to employ them (Dale et al., 2017). Furthermore, a Chinese study discovered that people's intentions to use renewable energy technology were also influenced by cultural norms (Chen, Xu, & Frey, 2016). More recently, Carlander and Thollander (2023) used stakeholder interviews as part of a municipal district development project to identify obstacles to the adoption of energy-efficient building technology. Two new sorts of barriers—fear and ignorance—were proposed. The adoption of energy-efficient technologies was hampered primarily by inertia, risk, lack of knowledge, and access to capital.

Furthermore, some studies have been done to present solutions (such as technical, theoretical, and critical) in developing EE in buildings throughout the world (Abolhassani et al., 2023; Ascione et al., 2013; Attia et al., 2012; Che & Kaushik, 2018; Jedrzejuk & Marks, 2002; Taleb, 2014; Wong & Fan, 2013). Attia et al., (2012), for instance, provided an energy-oriented software tool as a technical solution that suits the Egyptian environment while also providing useful support for zero-energy building decision-making. Taleb (2014) analyzed the possible energy savings prospects of combining natural ventilation with heating systems in Dubai's residential structures as a technical solution. To summarize, this article has shown that combining active cooling systems with natural passive ventilation solutions has the potential to offer a better outcome in terms of lowering temperature levels and cooling loads, as well as decreasing expenses for inhabitants. Zucker et al. (2014) stated critical solutions that the effective parameters in reducing energy consumption of the building include the number of residents, building area, number of floors, proximity, window-to-wall ratio, length-to-width ratio, and the number of building facades. The results indicate that the most effective parameter was the ratio of window-to-wall.

Furthermore, in the context of Iran, some studies have been conducted in presenting solutions to EE in Iranian buildings. Habibzadeh and Gosili (2019), studied theoretical solutions for designing and constructing buildings with zero-energy consumption in cold and dry mountainous climates. In light of the significant energy consumption, particularly in heating, in cold and dry alpine climates, Habibzadeh and Gosili (2019) researched theoretical solutions. It has been noted that the measures used in the building have decreased the energy consumption below its optimal level, indicating the category A in energy consumption, and leading to the conclusion that the building is under excellent circumstances for energy utilization. Kazemi and Kazemi (2022) identified the main financial barriers to residential buildings' energy efficiency in Iran. The findings show that the main viewpoints on financial barriers to residential buildings' energy efficiency in Iran are misplaced incentives, unpriced costs and benefits, fear of hidden costs, contentious evaluation methods, distortionary fiscal and

Power System Technology
ISSN:1000-3673
Received: 16-05-2024 Revised: 12-06-2024 Accepted: 07-07-2024

regulatory policies, focus on initial costs, and false beliefs in energy efficiency. To get around these obstacles, it is advised to use regulation, loan financing, project finance, grants and subsidies, fiscal incentives, setting real fossil fuel prices, and awareness and training campaigns.

As previously mentioned, the residential sector is the most significant globally in terms of overall energy consumption, with the US, China, and EU leading the pack (Berardi, 2015). Moreover, Iranian buildings consume a normal amount of energy. Iran's Ministry of Energy claims that the country's excessive energy usage has an adverse effect on the environment, particularly in the building industry. Due to Iran's vast geography, diverse range of climates, and year-round wide temperature variations, the country uses excessive amounts of electricity for cooling and excessive amounts of heating gas in the winter and other cold months (Ebadati & Ehyaei, 2020). Moreover, 42% of Iran's overall energy consumption is accounted for by residential and commercial buildings. Additionally, this energy consumer group produces the highest levels of CO2 emissions. This issue has taken on a new form in recent times due to the rising standard of living in both urban and rural areas, population growth, and the unsynchronized speed of new power plant building. Additionally, there has been little to no usage of renewable energy sources. The nation's natural resources have suffered irreversible ecological harm as a result of ecological failures and escalating energy-related expenditures for heating and cooling, including a sharp increase in air pollution, a rise in greenhouse gas emissions, and the urban heat island effect. As per Ahmadi et al. (2020). Improving the energy efficiency (EE) of buildings is a viable way to reduce energy use and, in turn, the environmental effects in Iran (Ministry of Energy of Iran, 2013). The development of energy-efficient buildings is critical, especially in Iran's warm climates, to mitigate the environmental impact of excessive energy consumption. However, this endeavor is challenged by several critical barriers that hinder progress. Addressing such barriers is imperative for the sustainable development of energy-efficient buildings in warm climates. Regardless of the existence of a bulk of studies in the area of EE buildings, obstacles, and solutions, there is fewer comprehensive studies, which aimed to discover barriers in the development of energy efficient buildings in Iran and present potential solutions to the obstacles. Thus, this study seeks to identify, analyze, and propose potential solutions to the barriers in order to promote the widespread adoption of energy-efficient building practices, reduce energy consumption with sharing suitable solutions based on the existed barriers, and contribute to a more sustainable built environment in Iran's warm climates. Furthermore, by studying the past architecture of Iran, we found out how the architects of that time without access to technology have faced this challenge well in different climates. However, it must be admitted that the need for extra solutions in buildings to save energy and increase sustainability is a requirement.

The current study adds to the body of knowledge regarding the obstacles to the implementation of sustainability, including studies that examine actual practices (Blair & Evans, 2004; Häkkinen & Belloni, 2011) and those that adopt a theoretical and classificatory approach (Trudgill, 1990). The research methodology is initially described in the paper. Following that, the interviewees' stated obstacles to energy efficiency are explained. The interviewees'

Power System Technology
ISSN:1000-3673
Received: 16-05-2024 Revised: 12-06-2024 Accepted: 07-07-2024

recommendations for removing these obstacles and advancing energy efficiency in the Iranian construction sector are then presented.

2 METHODOLOGY

The goal of this study is to identify the primary obstacles to the development of energy-efficient buildings in Iran's warm environment. The study's other goal was to give the expert-suggested remedies for removing those obstacles and advancing EE in Iranian buildings.**2.1 Participants** The participants of the current study were 16 architects in the big area of sustainability and EE buildings. The participants were the main actors of all 8 energy efficient projects (both constructed and unconstructed) in Iran. Out of the 8 EE projects, 16 Architects (two females and 14 males), with the age range between 38 to 67, had the main roles in projects. From the total of 16 architects, four of them related to 2 constructed projects on energy efficiency in Iran and the rest of 12 experts related to 6 unconstructed projects.

2.2 Data Collection Procedure

The initial phase of data collection was the preliminary observation and photography as well as primary personal communications and interviews into two study phases. In the first stage, the results were used to identify the pertinent energy-efficient case studies for the research after a thorough review of all available information sources, including websites, officials, conference reports, and interconnected reports, among others. Altogether, eight energy efficient projects were identified in Iran and these were selected for the study. At this stage, experts in the building industry as well as experts in building energy efficiency in Iran were contacted. They were informed regarding the research.

Semi-structured interviews were used in the second and final phases to identify the primary obstacles to the development of energy-efficient buildings in Iran as well as possible solutions. Eight carefully chosen energy-efficient projects' sixteen architects participated in semi-structured interviews to determine the obstacles and potential solutions. The interviewee's background on the subject and their part in it were taken into consideration when crafting the questions for the semi-structured interviews. The topics of discussion were on the obstacles and possible fixes for EE buildings in Iran's warm environment.

The researcher conducted one-on-one interviews with each architect while recording their voices for further analysis and presentation. The Farsi version of the questions was used for the current study. The interviewees then provided their responses in Farsi, which were afterwards translated into English and presented as part of the study's qualitative data. For examining the validity of interviewing finding, physical observation finding and Trudgil finding were compared and it was needed to have a minimum of three groups were needed, which this research had 3 group of architects of the selected EE case studies. When each respondent shared the same idea with the others, it can be claimed that the results have validity. Table 2 shows the validity report of the interviews.

Power System Technology
ISSN:1000-3673

Received: 16-05-2024 *Revised: 12-06-2024* *Accepted: 07-07-2024*

Table 2
Validity of Analysis

	Architects (group 1)	Architects (group 3)	Architects (group 3)
Interviewing ’s Finding	Agree with Results of Finding	Agree with Results of Finding	Agree with Results of Finding
Physical Observation ’s Finding	Agree with Results of Finding	Agree with Results of Finding	Agree with Results of Finding
Trudgil ’s Finding	Agree with Results of Finding	Agree with Results of Finding	Agree with Results of Finding

For estimating credibility of the interview questions, the researcher presented the information gathered from the interviewees and asked them to pay attention to each question and the answers were given by themselves to see whether there is any problem with or differences in the answers. The participants approved the accuracy of the data and so the credibility of the interview was approved. For the aim of dependability, 30% of the results of the interview were re-checked by two of the researcher’s colleagues who were familiar with the data analysis section and the results of the inter-rater reliability was reported to be .95.

2.3 Data Analysis Procedure

In semi-structured interview, the criteria for stopping the interview were both saturation and ensuring that the point of view of each and every expert on the barriers and solutions was collected. After the sessions devoted to the interviews, the results of the interviews analyzed qualitatively. The Trudgil framework was used as the analysis approach for the interview part. The framework is made up of six main categories of hurdles, known as the "AKTESP" barriers (acronym for agreement, knowledge, technological, economic, social, and political). These obstacles don't have to be present simultaneously or in the specified order. It's possible for several to overlap. Table 3 displays the six major groups into which the barriers are divided.

Table 3. Key Hurdles in Advancing Energy-Efficient Buildings in the Warm Climates of Iran Using the Trudgil Framework

Main finding barriers through semi-structured interview	Categories of barriers according Trudgil
Lack of leadership in energy efficiency building projects (2.1% of the replies)	Political barrier
Lack of some energy efficient building components on the local markets (5.5% of the replies)	Technical barrier
Lack of interest by project team members (7.8% of the replies)	Agreement barrier
Lack of technical understanding among project team members (8.9% of the replies)	Knowledge barrier

Power System Technology
ISSN:1000-3673

Received: 16-05-2024 *Revised: 12-06-2024* *Accepted: 07-07-2024*

Lack of political will, legislation and enforcement (11.9% of the replies)	Political barrier
Applying energy efficiency solutions in building cost too much (13.8% of the replies)	Economy barrier
Lack of interest by client for applying energy efficiency solutions in their building (18.3% of the replies)	Agreement barrier
Low energy prices in Iran (31.7% of the replies)	Economy barrier

As clarified in Table 3, two of the most cited categories of barrier means “Low energy prices” in Iran and “Applying energy efficiency solutions in building cost too much” fall under economy barriers. The payback period is one of the economic tools used to make financial decisions. The number of years needed to recoup the investment cost is the unit measurement for payback period. When a technology's investment cost is associated with a lengthy payback time, the payback period frequently acts as an economic barrier. Long payback periods are usually associated with greater risk. The results show that most of the investors and users care about the cost of applying energy efficient technologies in their building and payback period for EE technology. Allocating adequate subsidies in the sector of energy efficiency in Iranian building construction sector could encourage willingness to pay for EE technology.

The second most cited category of barrier means “Lack of interest by client for applying energy efficiency solutions in their building” and “Lack of interest by project team members” fall under agreement barriers. They should recognize that by using renewable energy, it able to help reduce environmental problems. Extensive information is needed for public awareness about advantage of energy efficient building practices. The third most cited category of barrier means “Lack of political will, legislation and enforcement” and “Lack of leadership in energy efficiency building projects” fall under political barriers. Government’s incentives like tax exemption, subsidies, and low interest loan for EE purchase are effective on alleviate these barriers. The lowest result was related to social barriers. Totally, real barrier lies in the economic aspect.

To guarantee the quick and effective broad adoption of EE technology in Iran, a series of suggested activities might be put forth based on the Trudgill's framework or the AKTESP obstacles. According to this survey, raising awareness continues to be one of the biggest obstacles that has to be removed, particularly for college and high school students, in order for the knowledge to be taken home and shared with their families. Therefore, the public and the building industry are not well-informed about EE technology. This can be resolved by expanding the scope of EE education programs via more efficient channels of communication, including as the internet and television. The economic barrier is one more significant obstacle. The majority of responders stated that they were being hampered by EE's high investment cost. The issue of EE's high initial cost contributes to the lengthy return period. Consequently, a larger subsidy is required for the acquisition of an EE installation. These altruistic traits and

Power System Technology
ISSN:1000-3673
Received: 16-05-2024 Revised: 12-06-2024 Accepted: 07-07-2024

social attitude are extra benefits for the quick spread of EE technology. In conclusion, EE demands a long-term commitment from the government and has a lengthy gestation time. One of the key strategies for advancing BIPV technology is the ongoing evaluation of government incentives such as tax exemptions or rebates. Iran's government must constantly evaluate its green policies and initiatives to create a stable market climate that would facilitate the quick uptake of EE technology.

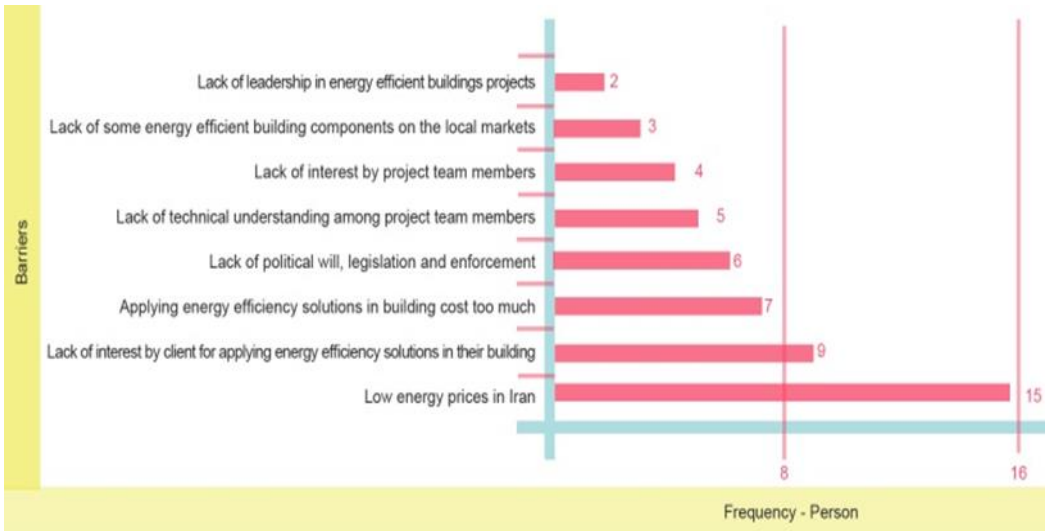
Thematic analysis was employed with the goal of qualitative data analysis, and the results were presented as themes. Following this procedure, the researcher examined the transcripts in an effort to identify any fleeting trends or patterns. According to Braun and Clarke (2006), on page 79, "thematic analysis is a method for identifying, analyzing, and reporting patterns (themes) within data." The process of conducting a thematic analysis involves being acquainted with the data, creating preliminary codes, looking for themes within codes, evaluating themes, identifying and labeling themes, and creating the final report (Braun & Clarke, 2006). Additionally, the researcher alternated between trying to process the data and reviewing the codes line by line in an effort to find relevant qualitative units for analysis. A thorough analysis of the findings is provided below.

3 RESULTS

3.1 Obstacles Hindering the Advancement of Energy-Efficient Buildings in the Warm Climates of Iran

This study found out 63 barriers in development of energy efficient buildings in warm climates of Iran. They are categorized under 8 categories which are shown in Figure 1 and explained thereafter.

Figure 1. Main barriers in the development of energy efficient buildings in warm climates of Iran



Note: Total barriers cited by 16 interviewees = 63

Power System Technology
ISSN:1000-3673

Received: 16-05-2024 Revised: 12-06-2024 Accepted: 07-07-2024

3..1.1 Low energy prices in Iran

The most cited category of barriers falls under "low energy price in Iran" which represents 31.7% of the replies. Iran is considered as one of the developing countries in the Middle East with high levels of energy consumption. In 2013, Middle East had the third largest primary energy intensity level in the world, stemming from energy intensive industries, low energy efficiency and low energy prices (World Energy Council, 2013).

Targeted subsidy plan of Iran was known as the subsidy reform plan, which was passed by the Parliament of Iran on 5th January 2010. It is unfortunate that we do not have adequate subsidies in the sector of energy efficiency in Iranian building construction sector and as a result, energy efficient component prices are too high. Definitely with consideration of soaring prices of applying energy efficient solutions in the buildings, the investors as well as users prefers the usage of natural energy in their building instead of applying energy efficient solutions in the same.

3.1.2 Client Apathy Towards Implementing Energy Efficiency Solutions in Their Buildings

The second most cited category of barriers (18.3% of the replies) after doing the interview was found out to be the lack of interest in the client. They mentioned that the time and cost factor have to understood and approved by the clients. Clients have to have proper awareness and mentality in terms of constructing, maintaining, or renting such properties. Unfortunately, the number of such clients is really less in Iran at the moment.

The desire by clients is crucial and has a direct impact on the market. If developers want to applying energy efficient features in their buildings, it cannot be possible without market demand by clients. Lack of awareness about the benefits of energy efficient buildings is one of the most cited barriers. Also, perception of high cost of applying energy efficient practices in building and consequently reducing the profit cited as related barriers. It has to be more of a passion as well as understanding the practicality in a longer-term vision, rather than considering as a faster ROI. EEBs are not meant for such faster benefits, rather they are meant for longer sustainable benefits.

The market demand for energy efficient buildings is low in Iran. The benefits of the EEBs and their opportunities are not being exposed to the Iranian public to a major extent. Extensive information is needed for public awareness about advantage of energy efficient building practices like environmental benefits result, reduction in energy usage as well as one of the best strategic solutions for the increased air pollution and global demand for energy etc. They should be aware that, EEB will reduce the energy costs of building by nearly 60 percent and hence the comparatively higher CAPEX (Capital expenditures) involved in EEBs is a onetime cost and will pay back within 5 to 8 years.

Power System Technology
ISSN:1000-3673
Received: 16-05-2024 Revised: 12-06-2024 Accepted: 07-07-2024

3.1.3 Applying energy efficiency solutions in building cost too much

The third category of barriers by 13.8% replies was regarding the high cost of applying energy efficiency solutions in buildings. Majority of the shareholders expect fast returns of their investment. Many of them doesn't know the exact costs associated with energy efficient buildings as well as they consider that the costs is much expensive than conventional building because of lack of awareness. In fact, their presumption of the extra costs for the applying of energy efficient solutions into the buildings might be much above the reality. They should be convinced that the cost of applying energy efficient practices in building is not much higher when compared with the conventional building. Creating wide public awareness of financial profits for applying energy efficient practices in buildings due to saving energy could be adequate solution to encourage public and building stakeholders. Also, they should be convinced that long payback period of return of investment would be compensated by increasing the price for sale as well as rent the buildings. The final price of most energy efficient components in Iran is quite high; especially those components which imported to Iran. This is mainly because of the sanction of Iran which is very high. Some energy efficient construction components are produced in Iran but the price of them is quite high due to allocating low number of subsidies for these kinds of products by government of Iran.

3.1.4 Lack of political will, legislation and enforcement

Around 11.9% of the barriers were related to lack of political will, legislation and enforcement. Development of energy efficiency in building sector of Iran depends on many factors. Proper regulation as well as standards addressing this issue has to be launched as well as come into force in Iran. For attaining such kind of regulations in the building sector in Iran, legislators had to be educated as well as aware about energy efficiency in buildings and their advantages. In this research, most of interviewees stated that the majority of politicians as well as regulatory shareholders had a less understanding of the energy efficient subject as well as associated advantages. This aspect had an adverse effect on legislation of the associated energy efficiency guidelines in Iranian buildings. In fact, politicians as well as regulatory shareholders who do not have adequate awareness in this important, will not be able to develop and implement strategies for raising awareness among public.

3.1.5 Lack of technical understanding among project team members

With 8.9% replies, another main barrier cited by respondents was the lack of technical understanding among project team members. This includes every member who is a part of the team such as the consultants, operations managers, architects, project managers, facility managers, etc. This barrier state that most of the project team member lacked the technical understanding as well as inadequate knows how about energy efficient construction skills. The water leakage from the green roof of the Iran Green Complex is a simple example for the lack in technical understanding of the project members. Majority of the construction workers and even project managers in such projects in Iran lacks adequate technical knowhow, because of the poor-quality training and education system offered by responsible organizations. The lack

Power System Technology
ISSN:1000-3673
Received: 16-05-2024 Revised: 12-06-2024 Accepted: 07-07-2024

of awareness regarding energy efficient issue has led to not consider seriously regarding the need for such training. It is crucial to educate as well as train the project team members regarding the approaches and strategies of applying energy efficient practices in buildings.

It is unfortunate that in Iran there are not many educated individuals who are experts in field of energy efficient building operators and facility managers. One major problem is the non-availability of the expert and operators in Iran for applying energy efficient system in the buildings and to take care of routine and accidental issues/repairs etc. Poor maintenance management is one of the main problems in Iran building sector. This is termed as 'Facility Management' in modern construction industry, where inadequate management and manpower lacking leads to improper management of existing facilities. For instance, in Iran Green Complex, solar collectors are not installed and currently the energy needed for heating is given by the natural gas due to proper repair as well as maintenance services cannot be found. In other word, people avoid applying energy efficient systems in their buildings due to sufficient maintenance and repair are not available in Iran.

3.1.6 Lack of interest by project team members

Around 7.8% of the barriers were about the "lack of interest by project team members". Lack of interest by the team members can also be due to the lack of technical know-how regarding the subject matter. That is, in most cases, the building professionals have limited knowledge regarding the EEBs. They should encourage that only those who are passion to learn and passed related training classes, will aid good results in implementing successful EEBs. By rising awareness and knowledge among building professionals about energy efficiency and related techniques, we will witness of rising interest among them.

3.1.7 Lack of some energy efficient building components on the local markets

Around 5.5% of barriers were about lack of some energy efficient building components on the local markets of Iran. Lack of energy efficient components and materials on the regional market was found to be an obstacle to apply energy efficient technical solution in buildings in Iran.

Some energy efficient construction components are produced in Iran but the price of them is quite high due to allocating low amount of subsidies for these kinds of products by government of Iran. Also, due to the lack of availability in terms of raw materials, technology and manpower some energy efficient components cannot be produced in Iran.

There are some imported energy efficient components and materials in Iran market as well but the price of this kind of imported components is even higher than those produced in Iran. In terms of sanctions of Iran with other nations, Iran imposes heavy levy on imported goods and this is visible in the energy efficient components as well. Also, the energy performance of the products and their quality should to be evaluated.

Power System Technology
ISSN:1000-3673

Received: 16-05-2024 *Revised: 12-06-2024* *Accepted: 07-07-2024*

Also there are some non-standard energy efficient components available in the Iran market and they have used in the region due to their low prices. The cheaper prices of these non-standard components make the standard ones' use lesser comparatively and adding on to the reduced energy efficiency of the buildings.

3.1.8 Lack of leadership in energy efficiency building projects

Nearly 2.1% of the barriers were found to be in terms of leadership. Lack of leadership is the specific obstacle as there is no appropriate management of the entire process of energy efficient building projects. The energy efficient building projects are the ones which require a lot of planning, co-ordination as well as overall leadership skills to follow up the projects.

Lack of an appropriate leadership has been fundamental reason for hindering some energy efficient building projects in Iran. Energy efficient buildings definitely consume a lot of time and money when designed, implemented and maintained. Appropriate leadership makes a link of adequate and transparent communication between the designers and developers even from the very early stages of designing and feasibility study. This will prove the project to be a great success in terms of long term.

3.2 Unlocking Potential Solutions for Energy-Efficient Building Development in the Warm Climates of Iran

In addition to identifying the primary obstacles to the construction of energy-efficient buildings in Iran, the respondents in this study offered some recommendations for reducing these obstacles and advancing energy efficiency in the country's construction sector. In all, 16 architects who were interviewed for 8 carefully chosen energy-efficient case studies in this study proposed 94 different interventions. According to Table 3, the research has identified four kinds of recommendations made by interviewees to lower barriers: actions taken by the government, the private sector, the education sector, and ultimately, the clients themselves.

Table 3: Recommendations for Mitigating Barriers to Energy-Efficient Building Development in the Warm Climate of Iran

Category of proposed suggestions by interviewees	**Number of recorded**	
	N	**%**
Actions by Government	47	50
1 *Encouraging and Supporting*		
-Reduce subsidies to encourage to using energy efficient practices in buildings	17	
-Providing financial incentives for developers and builders	10	35
	6	

Power System Technology
ISSN:1000-3673

Received: 16-05-2024 *Revised: 12-06-2024* *Accepted: 07-07-2024*

	- Construction of energy efficient government buildings as role models to encourage public.		
2	*Awareness*		
	-Raise awareness about energy efficient construction among policy maker	7	7.5
3	*Stringent regulations*		
	-Review and reforms of current legislation and developing new stringent regulations in energy efficient building practice.	5	5.5
4	*Checking and monitoring*		
	-Checking and monitoring enforcement of regulation	2	2
Actions by the Education Sector		25	26.6
5	*Awareness*		
	-Raise awareness through social media -Providing energy efficiency training classes for public -Raise awareness through educational institutions, schools, universities, etc.	10 8 5	24.5
6	*Cooperation*		
	Cooperation between education sector and government	2	2.1
Actions by the Private Sector		14	14.9
7	*Encouraging and Supporting*		
	-Create demand -Use energy efficient technologies in their projects	8 4	12.8
8	*Awareness*		
	-Update and raise their knowledge about subject matter	2	2.1
Actions by the Clients		8	8.5
9	*Awareness*		
	-Develop own understanding of advantages and impacts of living in energy efficient buildings -Supporting energy efficient construction industry by renting and buying energy efficient buildings	6 2	8.5
Total number of suggestions recorded			100

Note: Totally 94 suggestions proposed by 16 interviewees.

Power System Technology
ISSN:1000-3673
Received: 16-05-2024 Revised: 12-06-2024 Accepted: 07-07-2024

3.2.1 Action by government

With 47% replies, action by government was the most cited actions. The respondents stated that government and related organizations that are responsible for regulation and standardization have great deal of role to play in developing energy efficient building in Iran. Of the respondents, 35% proposed the encouragement as well as support from government via: 1) reduce subsidies to encourage energy efficient practices in buildings; 2) providing financial incentives for developers and builders to support the cost of energy efficient measures in their projects; 3) construction of energy efficient government buildings as a role models to encourage public. 7.5% of respondents pointed out the significance of raising awareness among government officials and politicians on the need of developing energy efficient building in Iran. 5.5% indicated the review and reforms of current legislation and developing new stringent regulations in energy efficient building practices in Iran. Finally, 2% stressed on the need for checking and monitoring enforcement of regulation.

3.2.2 Actions by the education sector

With 25% of replies, action by education sector is second most cited actions. 24.5% of suggestions concerned the raising the awareness through: 1) raise awareness through social media; 2) providing energy efficiency training courses for public; 3) raise awareness through educational institutions, schools, universities, etc. Education and government sector partnership and cooperation was also proposed by 2.1% of replies.

3.2.3 Action by the private sector

Role of private sector actions to reduce the energy efficiency barriers was shown to be 14%. Developers, contractors, manufacturers of raw material for energy efficient components, manufacturers of energy efficient tools and components are responsible to help and encouraging energy efficient building practices. In this segment 12.8% targeted on the responsibilities of the private sector for encouragement and support of energy efficient practices in building construction via: 1) create of demand for energy efficient buildings; and 2) use of energy efficient technologies and components in their projects. 2.1% was the replies that stressed on the significance of raising awareness among private sector on the subject matter.

3.2.4 Action by the clients

8% of respondents pointed out the significance of the responsibility of clients. The actions by clients, as per the proposal by respondents include: 1) development of own understanding of advantages and impacts of living in energy efficient buildings; and 2) supporting of energy efficient construction industry by renting and buying energy efficient buildings.

Power System Technology
ISSN:1000-3673

Received: 16-05-2024 *Revised: 12-06-2024* *Accepted: 07-07-2024*

4 DISCUSSIONS

This study focuses on finding main barriers and potential solutions of developing energy efficient buildings in warm climates of Iran. This study indicates that energy efficiency in construction sector of Iran has not been developing during last decades. As clarified in Figure 1 two of the most cited category of barrier means "Low energy prices" in Iran and "Applying energy efficiency solutions in building cost too much" fall under economy barriers. Iran has nearly 11 percent of oil reserves of the worlds and nearly 15.3 percent of gas reserves of the world. Energy consumption domestically also is growing on a faster rate. The price of energy in Iran has been highly subsidized with nearly 12 percent of the GDP which is one of the main problems of high energy consumption in Iran. Iran has one the world's highest energy intensity index (double the global average) as well as has been increasing by around 3.4 percentage average per year over the past forty years in the nation (Central Bank of Iran Economic Indicators, 2013; Moshiri, 2013).

The substantial subsidization of energy prices in last years has resulted to the increased use of gas, water as well as electricity because of low cost of energy in Iran. For example, Iran owns one of the cheapest prices for gas in the world- 40 cents for a gallon or 10 cents per liter. Apart from this, water as well as electricity price is also inexpensive in Iran. Most Iranian experts agree that such unsustainable subsidies motivate energy wastage.

The payback period is one of the economic tools used to make financial decisions. The number of years needed to recoup the investment cost serves as the unit of measurement for payback period. When a technology's investment cost is associated with a lengthy payback time, the payback period frequently acts as an economic barrier. Long payback periods are usually associated with greater risk. The results show that most of the investors and users care about the cost of applying energy efficient technologies in their building and payback period for EE technology. Allocating adequate subsidies in the sector of energy efficiency in Iranian building construction sector could encourage willingness to pay for EE technology. The economic barriers mentioned in the current study were also were the most important barriers in Ugulu's study (2019) that investigated the barriers to and motivations for PV adoption in urban Nigeria. Data regarding the main obstacles to and drivers of PV adoption were acquired through interviews, and the findings were examined. The results show that a lack of funding and high capital costs are the main obstacles. Power outages, energy cost savings, especially fuel theft involving generator use, awareness, and financing accessibility were the main drivers behind the introduction of PV. The findings indicate that political and regulatory action is required. Effective PV awareness-raising initiatives and promotional techniques would also be required given Nigeria's evolving electricity supply landscape.

According to the results, the second most cited category of barrier means were "Lack of interest by client for applying energy efficiency solutions in their building" and "Lack of interest by project team members", which fall under agreement barriers. It is worth noting that end users should understand that by using renewable energy, they would help to reduce environmental problems. Extensive information is needed for public awareness about advantage of energy efficient building practices.

The results are in harmony with Yeatts et al., (2017) study that concluded lack of knowledge was the most important barrier in the use of energy-efficient technologies (EETs), such as low-

Power System Technology
ISSN:1000-3673
Received: 16-05-2024 Revised: 12-06-2024 Accepted: 07-07-2024

energy windows and programmable thermostats. The results are also in congruent with Cristino's study (2021) that similar to the current research focused on barriers and solutions towards building energy-saving technologies and reported that lack of knowledge in terms of technologies was the most important barrier from among 27 identified barriers to the adoption technologies.

The third most cited category of barrier means "Lack of political will, legislation and enforcement" and "Lack of leadership in energy efficiency building projects" fall under political barriers. Government's incentives like tax exemption, subsidies, and low interest loan for EE purchase are effective on alleviate these barriers. According to Bon and Hutchinson (2000), economic indicators like taxes and incentives that are geared toward the market work considerably better to promote sustainable construction than laws and regulations. The results are in line with research by Langlois-Bertrand et al. (2015) that discussed the institutional and political impediments. The authors categorize these barriers and divide them into three main groups: lack of policy coordination, competing rules in the governance system, and political obstruction.

Furthermore, "Lack of technical understanding among project team members", which fall under knowledge barriers was the other high-cited barrier by the participants. Reducing these obstacles can be achieved by raising public awareness of EE through media and technology. Education level has a big impact on people's knowledge and comprehension of using EE to lessen environmental issues. Thus, additional educational initiatives aimed at raising public awareness of renewable energy sources are required in order to get beyond this obstacle. Additionally, the most efficient way to promote EE technology is through media attention. In the context of Malaysia, a similar study to the current study was conducted that the authors mentioned to the lack of technical understanding among project team to promote sustainable building practices (Shari & Soebarto, 2012). The last barrier, "Lack of some energy efficient building components on the local markets", fall under technology barriers. Availability of EE technology and appropriateness of EE technology is a proper way to reduce these barriers. The lowest result was related to social barriers. Totally, real barrier lies in the economic aspect.

Additionally, this study offered some possible remedies for the obstacles listed. Based on the data analysis findings, 16 architects from the eight chosen energy-efficient case studies in this research were interviewed, and their suggestions totaled 94 actions. According to the studies, there are four types of ideas made by interviewees to lower barriers: actions taken by the government, the private sector, the education sector, and clients themselves. Regarding the government's actions, Qian (2010), who emphasized the active role of government interventions—such as making BEE legal requirements—can be used to support the findings. She felt that these actions are required to establish an economically feasible and effective environment for BEE promotion in China. It is possible to suggest a series of steps that should be taken to guarantee that EE technology is successfully and quickly adopted throughout Iran.

According to this survey, raising awareness persists as one of the biggest obstacles that has to be removed, particularly for college and high school students, in order for the knowledge to be

Power System Technology
ISSN:1000-3673
Received: 16-05-2024 Revised: 12-06-2024 Accepted: 07-07-2024

taken home and shared with their families. Therefore, the public and the building industry are not well-informed about EE technology. This can be resolved by expanding the scope of EE education programs via more efficient channels of communication, including as the internet and television. The economic barrier is one more significant obstacle. The majority of responders stated that they were being hampered by EE's high investment cost. The issue of EE's high initial cost contributes to the lengthy return period. Consequently, a larger subsidy is required for the acquisition of an EE installation. This altruistic trait and social mindset are a bonus for the EE technology's quick spread. In conclusion, EE demands a long-term commitment from the government and has a lengthy gestation time. One of the key strategies for advancing BIPV technology is the ongoing evaluation of government incentives such as tax exemptions or rebates. Iran's government must constantly evaluate its green policies and initiatives to create a stable market climate that would facilitate the quick uptake of EE technology.

CONCLUSIONS

The main objective of the current research was studying both barriers and potential solutions in developing of energy efficient buildings of warm climates in Iran. As a result of data gathering procedures from 16 architects in the big area of sustainability and EE buildings, some barriers and solutions were obtained. The most important reason base of this research finding is low energy prices in Iran. This study lists the following additional obstacles to Iran's energy efficiency development: clients' disinterest in implementing energy-saving measures in their buildings; excessive costs associated with doing so; Lack of interest from the project team; lack of technical knowledge among team members; lack of political will, regulation, and enforcement; lack of certain energy-efficient building components on the local commerce; and, lastly, lack of leadership in energy-efficient construction projects.

The study also recognized category of interviewee’s suggestions to reduce barriers of developing energy efficiency in Iran including: Actions by government, Actions by the academic sector, Actions by the private sector and Actions by clients. The most replies were under action by government including: Reduce subsidies; Providing financial incentives for developers and builders; and Construction of energy efficient government buildings as a role model to encourage public. Also raising awareness among government officials and politicians on the need of developing energy efficient building is necessary. Based on the results, a set of pedagogical implications can be pointed out. One of the implications of this study highlights the role of awareness raising in terms of EE buildings. Training is essential in EE adoption. Providing some training courses regarding raising public awareness about energy efficiency in building is recommended. Also, it is recommended that remote areas can be accessed to energy chapter of the Iranian building code via web and have online training courses. Besides, a baseline guide for energy efficient building standards in Iran can be established to assist comparing buildings in level of energy efficiency.

Like all of the studies, this research pertains to some limitations. One main limitation was low sample size of the participants. The sample size was relatively small due to the qualitative nature of the research design. Therefore, caution should be exercised when generalizing the

Power System Technology
ISSN:1000-3673

Received: 16-05-2024 *Revised: 12-06-2024* *Accepted: 07-07-2024*

findings to a larger population. Secondly, relying solely on interviews may have introduced biases or limitations in capturing the full range of experiences related to the barriers and potential solutions reported by the architects. Moreover, since interviews were used to collect data, participants' responses might be influenced by social desirability bias or their own perceptions of what is expected from them. This could affect the accuracy and reliability of the data collected. For further studies, some recommendations can be stated. In order to enhance the knowledge and improvement on EE in Iran's building construction sector, there is a need to conduct a study on appropriate strategies for reviving the energy efficient elements in traditional architecture of Iran and using them for developing energy efficiency in Iranian buildings. Further research also needed on the EE components and materials which is producing in regional market of Iran as well as level of quality and performance of them. Furthermore, advantages and opportunities of energy efficient buildings in Iran can be exposed to developers and users in future studies. Finally, it is recommended to study the analysis of integration of EE in educational curriculum in schools, universities and related institutions and its future impact on the construction industry of Iran.

ACKNOWLEDGEMENTS

The author expresses gratitude to her supervisor, Dr. Zaki, and co-supervisor, Dr. Zalina, for their invaluable guidance and encouragement. Additionally, heartfelt thanks are extended to her family for their unwavering support and assistance throughout the course of this study.

REFERENCES

1. Abolhassani, S. S., Joybari, M. M., Hosseini, M., Parsaee, M., & Eicker, U. (2023). A systematic methodological framework to study climate change impacts on heating and cooling demands of buildings. *Journal of Building Engineering*, *63*, 105428.
2. Aboulnaga, M. (2013). Sustainable Building for a Green and an Efficient Built Environment *Sustainability, Energy and Architecture* (pp. 131-170): Academic Press.
3. Ahmadi, A., Ehyaei, M. A., Jamali, D. H., Despotovic, M., Esmaeilion, A. F., & Hani, E. B. (2020). Energy, exergy, and economic analyses of integration of heliostat solar receiver to gas and air bottom cycles. *Journal of Cleaner Production*, *12*, 43-62.
4. Ascione, F., Bianoo, N., Rossi, F., Turni, G., & Vanoli, G. P. (2013). Green roofs in European climates. Are effective solutions for the energy savings in air-conditioning? *Applied Energy, 104*, 845–859.
5. Attia, S., Gratia, E., De Herde, A., & Hensen, J. L. (2012). Simulation-based decision support tool for early stages of zero-energy building design. *Energy and buildings*, *49*, 2-15.
6. Berardi, U. (2015). Building energy consumption in US, EU, and BRIC countries. *Procedia engineering*, *118*, 128-136.
7. Blair, F., & Evans, S. (2004). Seeing the Bigger Picture: Delivering Local Sustainable Development. York: Rowntree Foundation.
8. Bon, R., & Hutchinson, K. (2000). Sustainable construction: Some economic challenges. *Building Research & Information*, *28*(5/6), 310-314.
9. Chang, R. D., Soebarto, V., Zhao, Z. Y., & Zillante, G. (2016). Facilitating the transition

Power System Technology
ISSN:1000-3673

Received: 16-05-2024 *Revised: 12-06-2024* *Accepted: 07-07-2024*

to sustainable construction: China's policies. *Journal of Cleaner Production*, *131*, 534-544.

10. Chel, A., & Kaushik, G. (2018). Renewable energy technologies for sustainable development of energy efficient building. *Alexandria Engineering Journal*, *57*(2), 655-669.
11. Cristino, T. M., Lotufo, F. A., Delinchant, B., Wurtz, F., & Neto, A. F. (2021). A comprehensive review of obstacles and drivers to building energy-saving technologies and their association with research themes, types of buildings, and geographic regions. *Renewable and Sustainable Energy Reviews*, *135*, 110191.
12. Ebadati, M., & Ehyaei, M. A. (2020). Reduction of energy consumption in residential buildings with green roofs in three different climates of Iran. *Advances in Building Energy Research*, *14*(1), 66-93.
13. Energy balance sheet of Iran 2013 (2013). Ministry of Energy of Iran.
14. Gillham, B. (2000). The Research Interview, (London and New York: Continuum, 2000). Joseph Addison, Tbe Spectolor, no. 9 (Saturday, 10 March 1711).
15. Habib Zadeh, Z. (2019). *Designing solutions for Zero-energy residential units with an approach to cold anddry mountainous climatic conditions* (Doctoral dissertation, University of Mohaghegh Ardabili).
16. Häkkinen, T., & Belloni, K. (2011). Barriers and drivers for sustainable building. *Building Research & Information*, *39*(3), 239-255.
17. Jedrzejuk, H., & Marks, W. (2002). Optimization of shape and functional structure of buildings as well as heat source utilization. Partial problems solution. *Building and Environment*, *37*(11), 1037-1043.
18. Kazemi, M., & Kazemi, A. (2022). Financial barriers to residential buildings' energy efficiency in Iran. *Energy Efficiency*, *15*(5), 30.
19. Laustsen, J. (2008). Energy efficiency requirements in building codes, energy efficiency policies for new buildings. IEA Information Paper.
20. Li, D. H., Yang, L., & Lam, J. C. (2013). Zero energy buildings and sustainable development implications–A review. *Energy*, *54*, 1-10.
21. Liu, H., Zhou, G., Wennersten, R., Frostell, B., 2014. Analysis of sustainable urban development approaches in China. Habitat Int. 41, 24e32.
22. Langlois-Bertrand, S., Benhaddadi, M., Jegen, M., & Pineau, P. O. (2015). Political-institutional barriers to energy efficiency. *Energy Strategy Reviews*, *8*, 30-38.
23. Ministry of Energy of Iran. (2013). *Namagarhaye bakhshe energy*[Energy sector Indicators].

a. http://www.moe.gov.ir/Inner-Pages/MainNav/RulesRegulations/-دسته-بندی-موضوعی/انرژی.aspx (accessed 9 July. 2013).

24. Moshiri, S. (2013). *Energy Price Reform and Energy Efficiency in Iran*. Paper presented at the International Association for Energy Economics.
25. Onwuegbuzie, A. J., & Leech, N. L. (2005). The role of sampling in qualitative research. *Academic Exchange Quarterly*, *9*(3), 45-56.
26. Pongiglione M. & Calderini, C. (2016). Sustainable structural design: Comprehensive literature review. *J. Struct. Eng*, *142*(12), 401-424.
27. Prada, M., Prada, I. F., Cristea, M., Popescu, D. E., Bungău, C., Aleya, L., & Bungău, C.

Power System Technology
ISSN:1000-3673

Received: 16-05-2024 *Revised: 12-06-2024* *Accepted: 07-07-2024*

C. (2020). New solutions to reduce greenhouse gas emissions through energy efficiency of buildings of special importance–Hospitals. *Science of the Total Environment*, *718*, 137446.

28. Qian, Q. K. (2010). Government's roles and measures needed in China for promoting building energy efficiency (BEE). *International Journal of Construction Management*, *10*(4), 119-138.
29. Rezaie, B., Esmailzadeh, E., & Dincer, I. (2008). Renewable energy options for buildings: Case studies. *Energy and Buildings*, *43*(1), 56-65.
30. Rocchi, L., Kadziński, M., Menconi, M. E., Grohmann, D., Miebs, G., Paolotti, L., & Boggia, A. (2018). Sustainability evaluation of retrofitting solutions for rural buildings through life cycle approach and multi-criteria analysis. *Energy and Buildings*, *173*, 281-290.
31. Saxena, R., Rakshit, D., & Kaushik, S. C. (2019). Phase change material (PCM) incorporated bricks for energy conservation in composite climate: A sustainable building solution. *Solar Energy*, *183*, 276-284.
32. Shari, Z., & Soebarto, V. (2012). Developing sustainable building strategies in Malaysia: stakeholders' barriers and aspirations. *ALAM CIPTA, International Journal of Sustainable Tropical Design Research and Practice*, *5*(2), 3-12.
33. Taleb, H. (2014). Monitoring energy reduction through applying green roofs to residential buildings in Dubai. *International Journal of Sustainable Design*, *2*(3), 229-243.
34. Trudgill, S. (1990). *Barriers to a Better Environment: What stops us solving environmental problems?* London, Belhaven Press.
35. Ugulu, A. I. (2019). Barriers and motivations for solar photovoltaic (PV) adoption in urban Nigeria. *International Journal of Sustainable Energy Planning and Management*, *21*, 32-47.
36. Wilberforce, T., Olabi, A. G., Sayed, E. T., Elsaid, K., Maghrabie, H. M., & Abdelkareem, M. A. (2023). A review on zero energy buildings–Pros and cons. *Energy and Built Environment*, *4*(1), 25-38.
37. Wong, K. D., & Fan, Q. (2013). Building information modelling (BIM) for sustainable building design. *Facilities*, *31*(3/4), 138-157.
38. World Energy Perspective. (2013) *Energy efficiency policies: what works and what does not*. World Energy Council.
39. Xu, Z., Liu, S., Hu, G., & Spanos, C. J. (2017). Optimal coordination of air conditioning system and personal fans for building energy efficiency improvement. *Energy and Buildings*, *141*, 308-320.
40. Yeatts, D. E., Auden, D., Cooksey, C., & Chen, C. F. (2017). A systematic review of strategies for overcoming the barriers to energy-efficient technologies in buildings. *Energy research & social science*, *32*, 76-85.
41. Zucker, G., Malinao, J., Habib, U., Leber, T., Preisler, A., & Judex, F. (2014). Improving energy efficiency of buildings using data mining technologies. In *2014 IEEE 23rd international symposium on industrial electronics (ISIE)* (pp. 2664-2669). IEEE.