Environ Res Tec, Vol. 7, Issue. 1, pp. 118–130, March 2024

Environmental Research and Technology
https://ert.yildiz.edu.tr - https://dergipark.org.tr/tr/pub/ert
DOI: https://doi.org/10.35208/ert.1320207

Review Article

Towards net zero energy buildings: A review of barriers and facilitators to the adoption of building energy efficiency practices

Yahaya Hassan LABARAN[1*], Hussaini MATO[2], Gaurav SAINI[3], Auwal Alhassan MUSA[4]

[1]Department of Civil Engineering, Gaziantep University, Gaziantep, Türkiye
[2]Department of Civil Engineering, Sharda University, Greater Noida, India
[3]Department of Civil Engineering, Netaji Subhas University of Technology, Delhi, India
[4]Department of Civil Engineering, Mewar University, Rajasthan, India

ARTICLE INFO

Article history
Received: 27 June 2023
Revised: 16 September 2023
Accepted: 10 October 2023

Key words:
Building; Carbon emission; Energy efficiency; Renewable energy; Sustainable construction

ABSTRACT

With recent and unprecedented attention toward the implementation of Energy efficient building which aids in advocating sustainable construction, numerous attempts have made in establishing flexible approaches to which these practices will assist in savings cost of construction, improve the quality of indoor air as well as lowering the GHG emissions. However, the system is lacking proper and standardized methodology of implementations. Therefore, this, study dwelt in examining several factors capable of influencing the application of energy conservation practices in buildings, along with the advantages and barriers for implementation based on existing literatures, which focuses on raising awareness, providing information, implementing proper policies, and creating incentives to provide alternative solutions for building owners. As presented, study's outcomes offer a blueprint for comprehending the nuanced dynamics of building energy efficiency and lay out a clear course for further investigation. The study also, identifies significant factors which majorly influences building energy efficiency which include government supervision, design standards, construction quality, and energy-efficient materials. The study recommends utilizing cutting-edge innovations, building automation systems, and IoT devices to improve energy monitoring and conservation.

Cite this article as: Labaran YH, Mato H, Saini G, Musa AA. Towards net zero energy buildings: A review of barriers and facilitators to the adoption of building energy efficiency practices. Environ Res Tec 2024;7(1)118–130.

INTRODUCTION

As cities grow and populations rise, the need for energy increases at an alarming rate [1, 2]. According to studies, the construction and building industry alone accounts for over 30 percent of all primary energy consumption and contributes significantly to greenhouse gas emissions [3, 4]. However, by improving energy efficiency in buildings, this amount of energy will be decrease and help in saving resources and lessen the impact to the environmental [5, 6]. Hence, it is crucial for facility managers, building owners, and utility companies to understand energy consumption patterns and make informed judgements on energy-saving measures [7, 8]. Researchers have been fascinated by building energy efficiency for years and have focused mostly on identifying factors that contributes in building energy consumption [9, 10]. In addition to that, numerous experts have related the energy efficiency of

***Corresponding author.**
*E-mail address: yahayakura@gmail.com

various buildings to their age, which is particularly an interesting aspect, as older buildings may require more extensive renovations to improve their efficiency [11, 12]. However, it is pertinent to note that even older buildings and structures can be retrofitted to meet energy-efficient standards [13, 14].

Energy efficiency is a crucial aspect of achieving a sustainable future [15]. It involves reducing energy use to the lowest possible level without compromising on living standards, production quality, or profitability [16]. That is to say, instead of abstaining from using energy altogether, energy efficiency focuses on using it in a manner that reduces the amount necessary to operate equipment and services [5, 17]. As such, improving energy efficiency in domestic and industrial buildings is essential in decreasing demand on the main supply plants while maintaining the quality of energy services [18]. This can be accomplished by implementing a well-planned strategy and involving various stakeholders, such as the government and building owners, in the process [19]. In addition, energy efficiency policies are not only beneficial to the environment but also to the economy [2]. Those policies can help market forces and enhance household efficiency, the transportation system, offices, and factories [20]. Also, by consuming energy more efficiently, more resources can be freed up on economic sector and more energy will be available in other sectors [21]. This can help in reducing the need for energy exchange and changes in the electricity supply [22].

The need for building energy efficiency design standards across different climatic zones is crucial to reducing energy consumption [23, 24]. However, achieving these standards can be challenging, this is because they are influenced by several factors, such as occupants' behavior, government oversight, the usage of energy-saving materials, design quality, etc., [13, 23]. Hence, the adoption of energy efficiency practices by owners/occupants can greatly impact the energy demand of an area [25], leading to several benefits including job creation, cost savings, energy security, diverse business opportunities, improved health conditions etc., [5, 26]. Furthermore, energy-efficient buildings do not only improve the use of energy but, also enhance the overall life cycle phases of the buildings [10]. Hence, it's vital for property owners, building occupants, facility managers, and utility providers to comprehend how energy usage in buildings tends to behave and take proactive measures toward enhancing its efficiency [27]. Therefore, by understanding the barriers and implementing effective energy management strategies at the public, private, and residential levels, a realistic significance can be noticed in reducing energy consumption, while promoting sustainability [13].

The main trends in influencing factors for energy-efficient buildings have drastically improved in recent times. Factors that were previously evaluated among those that impact building energy efficiency and those that affect energy efficiency investment in existing residential houses have now been merged with occupant behaviour in building management [6]. Hence, it is critical to investigate the factors influencing building energy efficiency uptake behaviour in order to identify the energy conservation difficulties in residential dwellings. This justifies the aim of this study at reviewing various contributions by the previous researchers to identify the primary impediments to implementing energy efficiency practices in our buildings.

IMPORTANT PHRASES

Energy Efficiency

As scoped to the buildings, Mitsushima et, al., [28] defined energy efficiency as the capability to generate a substantial output with minimal energy input, usually expressed as a percentage [28]. According to Demirel and Ibrahim [29] efficiency of electric motors can be described as the amount of mechanical energy produced by an electric motor for a given quantity of electrical energy input [29]. The EU Energy Efficiency Directive defines energy efficiency as the ratio of output, such as goods, performance, services, to energy input.

Building Energy Efficiency

This is described as a designing and construction of a buildings in such a manner that the energy required for conditioning, heating and lighting is considerably reduced, independent of the equipment utilised or the energy source used [30, 31].

Household

This refers to one or more people who live together and share meals. This may be a single-family home or any other group of people living together [32]. In many social, microeconomic, and governmental models, the home is regarded as the fundamental unit of study and is crucial to both economics and demography. If living quarters or meals are not shared, a house is thought to contain more than one household.

Net Zero Energy Building (NZEB)

These are structures that yearly produces as much energy as it uses [24]. This is accomplished by employing renewable energy sources, such as wind or solar energy, and by applying energy-efficient design and technologies to decrease energy usage [33]. These buildings are meant to be self-sufficient and eventually consume no energy. Also, the energy consumption of zero energy building should be reduced accordingly to meet the passive house standards.

Renewable Energy

This is often known as clean energy or non-conventional energy, derived from renewable natural resources or production techniques [34]. Although using the power of nature has long been utilised for transportation, lighting, heating, and other purposes, renewable energy is frequently thought of as a relatively recent technology [31]. Wind, sun, biomass, hydropower, and geothermal are all examples of renewable energy sources.

Non-Renewable Energy
This is also referred to conventional energy, which usually generated from resources that cannot be replenished in a short period of time [34]. Fossil fuels including coal, oil, natural gas, and nuclear energy are examples of non-renewable forms of energy. The buried remnants of plants and animals that lived hundreds of millions of years ago are thought to have served as the source of fossil fuels [33].

ENERGY EFFICIENCY: DEFINITIONS AND APPLICATIONS IN BUILDING COMPONENTS

Energy efficiency is an important concept that refers to the equivalent work being completed with less energy. It's a way to reduce energy consumption, lower costs, and minimize the environmental impact of energy use [35, 36]. There are several approaches to achieving energy efficiency, from simple changes in behavior to more complex technological solutions [18]. Among the easiest methods to improve energy savings is by using energy-efficient devices and appliances. Utilizing a compact fluorescent light bulb (CFL) instead of an incandescent bulb, for instance, might save energy as CFLs use less power to produce the same amount of light [37, 38]. This is just one example of how using energy-efficient technology can make a big difference in reducing energy consumption. Another important aspect of energy efficiency is the system and building design itself. Insulating a building can lower the amount of energy required to cool and heat it [39]. Additionally, designing buildings with energy efficiency in mind, might result in lower energy use. This includes using natural lighting, proper ventilation, and making sure that the cooling and heating systems are properly sized for the building [17].

Energy management systems are also key component of energy efficiency. These systems allow users to monitor energy usage and identify areas where energy is being wasted [38]. They can also help in implementing energy-saving strategies and make informed decisions about energy use [22]. In addition to that, energy efficiency can also be achieved through energy conservation, which is the practice of reducing or managing the use of energy. This may be accomplished by taking easy actions like switching off equipment and lights when they're not in use, unplugging chargers and electronics when they are fully charged, and using power strips to reduce standby power usage [18]. Furthermore, energy efficiency can also be achieved through more advanced measures such as implementing building automation systems that can manage HVAC, lighting, and other appliances to minimize energy consumption [16].

Another important aspect is the implementation of energy-efficient practices in industries and businesses. This include upgrading equipment and machinery, implementing energy-efficient processes, and incorporating energy management systems [40]. Not only can this decrease energy consumption, but it can also enhance productivity and competitiveness in the industry [37]. Apart from that, government policies and incentive programs such as credits for energy-efficient appliances and equipment, financial incentives for making energy-efficient upgrades to existing buildings, and regulations mandating energy-efficient building codes while aide towards promoting the adoption of energy efficiency practices [8, 41]. Overall, energy efficiency is a comprehensive approach that involves a combination of technology, behavior, policies, and regulations to reduce cost and energy usage, while reducing the environmental impact of energy use [42]. It's a vital strategy for addressing climate change, energy security, and economic growth [39]. The Table 1 illustrate some policies to enhance energy efficiency practices [39].

Table 1. Guidelines and plans for energy efficiency

Sectors	Guidelines and plans
Appliances efficiency	Technology
Architects	Design
Behavioral	Occupants behavior
Public authority	Compile a comprehensive strategy
Public	Conditional behavior
Private developers	Sustainable housing design and development

Objectives of Energy Efficiency
Energy efficient buildings provide households with a comfortable and quality indoor environment with low energy consumption. The key to unlocking this sustainable future lies in implementing policies that not only lower energy consumption but also enhance the overall well-being of its inhabitants. To bring this vision to life, a comprehensive energy efficiency policy must be put in place by taking the following three objectives [43].

i. Provision of livable buildings.
ii. Provision of resilient buildings.
iii. Provision of affordable buildings.

3.2. Bioclimatic Architectural Design

Achieving energy efficiency in buildings begins with implementing bioclimatic architectural design [44]. This approach involves designing a building to work in harmony with the local climate, utilizing natural elements such as sunlight, wind etc., to minimize the requirement for artificial cooling and heating [31]. By utilizing bioclimatic design principles, buildings can achieve a comfortable indoor environment while minimizing resources such as energy and water [45]. Not only does this approach led to cost savings, but it also improves the overall well-being of the building's inhabitants [44]. Figure 1 outlines the procedure for incorporating bioclimatic strategies into building design [43].

3.3. Energy efficient Mechanical Systems

In addition to using bioclimatic techniques, active systems such as air conditioning are necessary to ensure the comfort and well-being of building occupants. To be resource-effi-

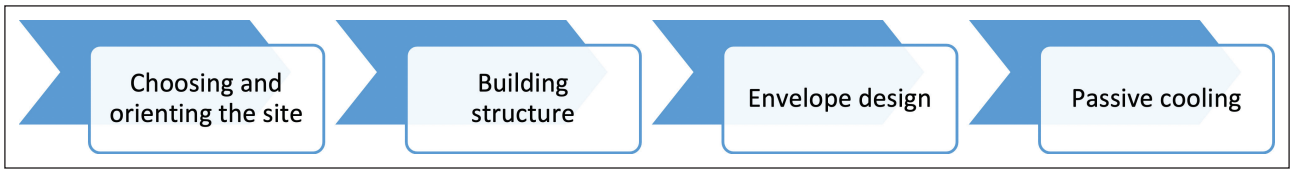

Figure 1. Bioclimatic design sequence [43].

cient, appliances and energy efficiency measures should be used as needed [44]. That is to say, after successfully reducing heat sources from outside, the next step is to decrease the quantity of heat produced within the building through efficient cooling [31].

3.4. Renewable Energy

Passive design and mechanical systems are game-changers when it comes to reducing energy demand. But incorporating renewable energy sources can take the building's performance to the next level [31, 34]. Additionally, incorporating resilient design elements means will result in having less dependency on energy supply, ultimately providing you with peace of mind [46].

Benefits of Implementing Energy-Efficient Building Practices

The energy-efficient building offers numerous advantages to both the environment and the occupants of the building. Some of the key benefits include improved comfort, cost savings, indoor air quality, and a reduction in fossil fuel usage, greenhouse gas emissions, etc., [31, 36]. However, in this study, a concentration will be on three major benefits; environmental, social, and economical benefits as shown in the Figure 2.

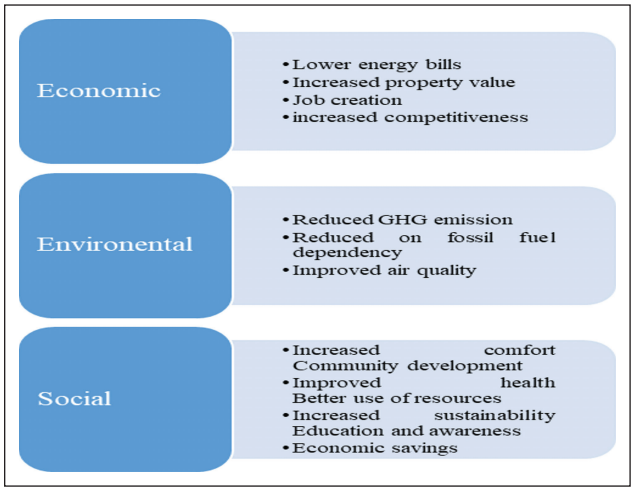

Figure 2. Benefits of building energy efficiency.

3.5.1. Economic Benefits

a) Lower energy bills: Among the most significant economic advantages of an energy-efficient structure is that it can result in decreased cost of energy bills for the building's occupants [20]. This is achieved by using energy-efficient appliances, lighting, and HVAC systems, in addition to implementing energy-efficient building design features like proper insulation and air sealing [30]. These measures can result in significant cost savings for building owners and renters.

b) Increased property value: Another financial advantage of an energy-efficient building is that it can enhance the value of a property [47]. Energy-efficient buildings are more attractive to potential buyers or renters and may be valued higher than similar, less efficient properties. This is because energy-efficient buildings can provide a more comfortable living environment, lower energy bills, and a smaller environmental footprint [47].

c) Job creation: Building energy efficiency can also lead to job creation in related industries such as construction, manufacturing, and engineering. As demand for energy-efficient buildings increases, so too will the need for professionals who can design, build, and maintain these structures [48].

d) Increased competitiveness: Building energy efficiency can also help businesses to reduce operating costs and increase their competitiveness in the marketplace. By using less energy, businesses can decrease their energy expenses and pass on savings to their customers [49].

3.5.2. Environment Benefits

a) Reduced greenhouse gas (GHG) emissions: Among the significant environmental benefits of building energy efficiency is that it can lower the amount of GHG emissions linked to electricity generation [38]. As such, by consuming less energy, buildings lessen their carbon footprint and contribute towards combating global warming [33].

b) Reduced dependence on fossil fuels: Building energy efficiency can also decrease reliance on fossil fuels, which are a limited resource as well as a leading cause of global warming [38]. Hence, by using less energy, buildings can lessen reliance on fossil fuels and their environmental consequences [50].

c) Improved air quality: Building energy efficiency can also enhance indoor air quality by minimizing the number of pollutants and moisture that can enter the building [50]. This can be achieved by using high-efficiency air filters, proper ventilation, and controlling indoor humidity levels [30]. Moreover, the health and well-being of the building's occupants may be positively impacted by better indoor air quality, which may also lessen allergy and asthma symptoms [51].

3.5.3. Social Benefits

a) Increased comfort: Building energy efficiency can lead to increased comfort for the people living or working

inside the building. This is achieved by controlling temperature and humidity, improving indoor air quality, and providing natural daylight. Energy-efficient building design and technology can also help to reduce drafts and eliminate hot and cold spots in a building [30].

b) Improved health: The health and well-being of the building's occupants may be positively impacted by better indoor air quality, which may also lessen allergy and asthma symptoms [51]. This is an important social benefit that can enhance the general quality of life for those residing in or employing the structure [52].

c) Increased sustainability: Building energy efficiency may assist to foster a more stable environment for the community as well as the planet by reducing energy consumption and dependence on fossil fuels. This can lead to even more responsible resource usage and a more sustainable future for all [53].

d) Economic savings: Building energy efficiency can lead to economic savings for building owners, renters, and even the local economy. Lower energy bills and increased property value can contribute to the overall financial well-being of the community [47].

e) Community development: Job creation and increased competitiveness can lead to community development and growth. As energy-efficient building becomes more prevalent, they can create new opportunities for employment and economic growth [48].

f) Better use of resources: Building energy efficiency can make better use of resources and reduce the strain on the environment which will help toward conserving natural resources and reducing waste [53].

g) Education and awareness: Energy efficiency can also help to improve public understanding about the necessity of energy efficiency and environmental responsibility. Hence, by showcasing the advantages of energy conservation, building owners and operators can inspire others to adopt more sustainable practices and promote a culture of conservation [49, 54]. In summary, building energy efficiency offers a wide range of benefits that can positively impact on the society, the economy, and environment as a whole. As such, by investing in energy-efficient building design and technology, building owners, developers, and occupants can reduce their environmental footprint, save money on energy costs, and improve the comfort and health of those who live or work inside the building, as well as contribute to community development and the better use of resources [20].

3.6. Building Energy Efficiency Design Tools

When it pertains to constructing and designing energy-efficient buildings, the right tools and software can make all the difference. With so many options available, it can be overwhelming to know where to start [55]. Luckily, many tools have been created across the world to aid with decision-making and guide the design team and building occupants into the future [38, 56]. One of the most impactful tools in recent years is simulation-based optimization software. This technology has increased flexibility in the design process, reduced the time required to complete the design, and made the software more user-friendly [57]. This means that not only can you achieve energy efficiency more easily, but you can also do it in less time and with less hassle. The future of energy-efficient building control design is also being shaped by new-generation tools [49]. These tools are based on control-focused features that can improve the overall performance of the building. This means that not only can you design an energy-efficient building, but you can also control and monitor its performance in real-time to ensure that it continues to operate at peak efficiency [58].

Currently, the community is already utilizing advanced control and simulation software and devices to construct energy efficiency. Typical software and technologies used for comprehensive design of buildings includes; Athena, Eco-Bat, the IES Virtual Environment, and Green Building Studio [55]. These tools have been widely adopted and tested, and have proven to be effective in designing energy-efficient buildings. For those looking to design energy-efficient buildings, there are a plethora of options available. Passive house planning packages, Energy Plus, eQuest, HOT 2000, DesignBuilder, IDA-ICEA, Revit, Modelica/Dymola, Simulink/Matlab, and ESP-r are just some of the tools and software available [59, 60]. Each of these options has its unique features and capabilities and can be used to design energy-efficient buildings that are sustainable, and comfortable for their occupants [61].

4. BARRIERS TO ENERGY EFFICIENCY PRACTICES

Energy efficiency barriers can include a lack of methods and tools to calculate energy savings, the absence of financial incentives for energy-efficient equipment, high initial costs for such equipment, challenges in obtaining funding, and difficulties in procuring, deploying, running, and maintaining energy efficiency systems and techniques [62]. According to Seddiki et, al., (2009) [63], economic and behavioral barriers are more prevalent in the building sector, while the transportation sector faces more institutional and economic obstacles [64]. However, the expense of executing energy-efficient measures is frequently considered as the most significant obstacle to attaining energy efficiency [65]. The high initial investment required for energy-efficient equipment and retrofits can be a significant obstacle for many building owners and operators; hence, the major barrier across all sectors is the financial barrier [42, 66]. The three main types of barriers to adopting energy efficiency in buildings are depicted in Table 2 [67].

4.1. Behavioral Barriers

Behavioral barriers, including a lack of understanding about the concept of energy conservation and the advantages of non-energy alternatives, a low level of trust, a lack of information, or inconsistent behavior, can all impede

Table 2. Major barriers to energy efficiency practices

Description of barrier types	Description
Behavioral	Cultural saving shortage, savings attentiveness, scarcity of skills, social crowd interface, knowledge scarcity, and information trust.
Institutional	Existence of infrastructural limitation, non-combined goals and confliction strategies, Ineffective legislative initiatives and regulations.
Economical	Insufficient financial resources, indecision of savings, higher risk of investment, and encouragement of monetary shortage.

Table 3. Reviewed studies on the barriers to energy efficiency practices

Barriers	Typical barrier	Sources
Behavior (social, culture)	Habits, custom	[38, 67]
	Lack of interest	[67, 74, 82]
	Unawareness of possible savings	[38, 67, 82]
Economic	Insufficient access to financing	[67, 86, 84]
	Inadequate economic institution to funding renewable energy technologies, inadequate instrument	[82, 86]
	Shortage of commercial feasibility	[87]
Environment	Resource competition, pollution and ecological aspects,	[82]
Misconceptions about renewable energy technology	Uncertainty about new technologies and benefits	[82]
Institutional	Complex regulatory procedure	[67]
	inadequate enforcement of pertinent law	[34, 67, 82]
	Insufficient knowledge and information	[34, 82, 85]
	Inadequate infrastructure	[82, 85]
insufficient infrastructure	Issue with infrastructure accessibility	[82]
Technological	Inadequate training facilities	[82, 86]
	Limited ability to implement innovation	[82]
	Operation and management of technological knowledge are insufficient.	[82]
Uncertainty on public authority	Policy uncertainty and under-equipped agencies	[82]

progress in the realm of energy efficiency and building performance [68, 69]. Occupant behavior is critical in influencing energy use and household well-being, but it is frequently not completely understood or incorporated in building energy efficiency due to its interdisciplinary nature, diversity, and complexity [70, 71]. Traditionally, Tenant behavior has been perceived as a passive component, similar to weather, rather than an active participant in building energy consumption [4, 38]. However, recent studies have revealed the significant impact that occupants can have on building energy consumption, leading to a surge of research in this area [72, 73]. Behavioral barriers also impact transportation habits, with individuals often prioritizing convenience over sustainability due to societal attitudes and customs [42, 45].

4.2. Institutional Barriers

Institutional impediments are linked to obstructionist politics, poor strategy management, and opposing perspectives in government decisions [75, 76] The implementation of energy-saving measures necessitates the cooperation and coordination of various actors within the sector [77]. As such, inadequate or non-existent support from both commercial and governmental sectors, often stemming from a lack of clear and straightforward administration and collaboration can impede the energy efficiency guidelines' implementation [21, 38]. Previous research has emphasized the necessity of providing clear, concise, and practical explanations of energy-saving initiatives [70]. Streamlining administrative process can aid reduce confusion and the burden on government systems [67, 78]. Hence, a strong vision for energy efficiency set at the highest administrative level is critical in lowering institutional impediments such as uneven governance configurations and guidelines, redundant strategies, and an absence of policy coherence [67, 79].

4.3. Economic Barriers

Economic barriers, such as difficulties in accessing adequate credit and unbalanced existing finance, high threats to shareholders, and institutional finance, are considered to

Table 4. Reviewed studies on the factors influencing the implementations of building energy-efficiency practice

Sources	Features	Factors	Methodology	Conclusion
Annunziata et al., 2014 [90]	The four factors that have been highlighted include: i. The presence of buildings and capabilities f or energy-efficiency ii. Increasing energy-efficiency capacity iii. Financial and technical assistance iv. Adoption of "low-hanging fruit" energy-saving methods has a knock-on effect.	Capacity building, technical and financial support	Questionnaires were employed for the study.	The findings underline the significance of increasing knowledge efficiency, maintaining and assessing consistency, and establishing a development strategy.
Cui et al. 2014 [91]	Technology and management guidelines	Management effects happened as a result of a clean technical efficiency change guide, whilst technology is influenced as a result of a technological advancement change index.	Panel regression Mode	According to the research, management and technological guidelines are the most important influencers on energy efficiency.
Chen, et al., (2020) [6]	The building's features or attributes	Building type, wall insulation, location, window-to-wall ratio, window glazing, ideal insulation thickness, and insulation materials are some of the factors that can be considered when evaluating a building's energy efficiency.	Article review	To assist occupants in making informed decisions, technological innovations, building services, and tenant behavior management must be prioritized.
	Equipment and technologies	Thermal storage, Variable air volume, heat recovery, improved control, and evaporative cooling.		
	Residents' behavior	Smart grid, access to control, smart meter, and plug load.		
Nair et al, 2010 [66]	Contextual factors	Location, perceived energy cost, thermal comfort, building age, and past investment.	Questionnaires were employed for the study.	In summary, a demanding lifestyle characterized by a high amount of time pressure can lead to a shorter window of opportunity for the utilization of energy conservation measures in the building.
	Personal factors	Income, age, gender, skill, and method used to reduce energy usage, as well as education and		

Table 4 (cont). Reviewed studies on the factors influencing the implementations of building energy-efficiency practice

Sources	Features	Factors	Methodology	Conclusion
		awareness		
Richerzhagen et al., 2008 [93]	The following five issues were identified: i. A cluster of residing individuals ii. Society, life style and attitude. iii. Economic considerations. iv. Awareness, information, and knowledge. v. Legal structure and implementation.	The corporate structure, regulation, and economic variables were recognized as the most powerful and critical aspects influencing building energy efficiency measures.	Questionnaires were employed for the study	The findings suggested that the essential factors for building energy conservation policy development, including the five identified elements, needed to be enhanced.
Yao, 2010 [23]	The study identified seven factors: i. Governmental regulation ii. Design standards iii. Building quality iv. Design quality v. Energy-efficient materials vi. Occupant behavior.	The most important aspects are government oversight, construction quality, and design specifications.	"Decision-Making Trial and Evaluation Laboratory Method"	The findings suggest that the most important criteria to assure the utilization of energy-efficient building techniques are government supervision, design standards, and construction quality.
Fatma, et, al., 2023 [94]	This focused on i. Challenges ii. Motivations iii. Recommendations iv. Futures pathways	These include carbon mitigations, reducing energy use improving building energy performances	Systematic review	Established a rigorous framework for government agencies and other relevant stockholders using the recent literatures as benchmark for implementing for proper energy efficiency in sustainable buildings.
Akram et, al., 2022 [95]	This mainly concerned with i. Fossil energy effects on buildings ii. Exploring other alternative sources of energy	Minimizing the usage of energy in Commercial and residential buildings	Reviewing energy policies and energy best practices	The research will assist relevant stockholders in advocating sustainable and green building through implementation other sources of energy for usage in buildings
Alawneh et, al., 2018 [96]	Achieving UN sustainable goal of i. Energy efficiency in green building ii. And water contribution assessment	Water efficiency, energy standards, and atmosphere standards in green buildings	Quantitative method was employed using structured questionnaire	Comprehensive Contribution to Development Index (CCDI) was proposed as reliable tools of examining the water and energy efficiency in green buildings in Jordan
Shareee\na, 2021 [97]	This attempted to i. Balancing the demand and supply of energy in green buildings ii. Optimize the consumption through the advocate of green building energy	Improving annual cooling and lighting systems in existing buildings	Analytical approach of benefit transfer method	Creating sustainable future roadmap for the optimizing energy usages in Malaysia's housing.
Liu et, al., 2014 [98]	Analyzed the energy efficiency technology application on green building of china	Evaluating and Improving energy efficiency in green buildings	Cost-benefit analysis on green building technology	The research found out that power price is the most sensitive factor, followed by unit increase and lifetime of the building as the most parameters influencing cost of green building technology

be among the major hurdles to the adoption of energy-efficient policies [80, 81]. Quantifying and communicating the economic advantages of these measures can be difficult, and the need to provide evidence of benefits can decrease the return on investment [67, 82]. To overcome these barriers, a public guarantee mechanism may be an effective solution, as it would alleviate monetary risk and make it more attractive for institutional finances to invest in energy-efficient projects for households with low and middling incomes [19, 83]. Moreover, the lack of financing is also a primary contributor to these barriers [45, 84, 85] and manufacturers often face significant major investments and costs related to mass barriers of production caused by limited access to adequate capital [84, 86]. Furthermore, severe controls that limit access to funds, even when money is available on normal models, aggravate the problem [62, 87].

In addition to the barriers discussed earlier, several other impediments to the adoption of energy-efficient building practices have been explored by previous studies, providing valuable insights into the field. Some of these studies are summarized Table 3.

5. FACTORS INFLUENCING THE IMPLEMENTATION OF ENERGY EFFICIENT BUILDING PRACTICES

Three main factors have been identified by previous studies as the main influencers towards incorporating energy-efficient building techniques: occupant behavior, building characteristics, equipment, and technologies [21]. Building features such as orientation, design, window glazing, insulation, and materials all have a part in influencing energy usage [55]. In addition to that, heat recuperation, thermal energy storage, evaporative cooling, and adjustable air system are other major contributors to energy efficiency [18]. Occupant behavior, including the use of smart meters, smart grids, and control access, also plays a crucial role in determining energy consumption [86]. However, it is crucial to highlight that building attributes alone cannot ensure the optimal approach to designing a structure because it may be dependent on other aspects [6]. Additionally, economic and environmental benefits are not always considered in energy-efficient design solutions, also significant difficulties still exist in terms of cost-effectiveness [6]. As such, interventions aimed at changing occupants' behavior offer a relatively low-cost and simple solution to enhance energy efficiency [89]. These interventions may include technological updates, building service systems, and education to change their attitudes toward energy efficiency [6]. Therefore, technological updates, building service systems, and interventions to change occupant behavior should be considered as energy performance benchmarking to help occupants make smart decisions [6]. Table 4 bring together key insights from previous studies and presents a comprehensive outline of the numerous aspects that play important role in the implementation of energy-efficient building techniques and practices.

6. CONCLUSION

This study provides a thorough review of the various factors that influence the use of energy-efficient building practises, and the issues related to these factors, including barriers to implementation. The majority of reviewed studies focused on examining the impacts of energy efficiency using a questioner survey and decision-making trial and assessment laboratory technique. This study also highlighted that, government supervision, awareness, design standards, construction quality, and Energy Star materials are among the most significant factors influencing the building energy savings practice. Hence, both the government and construction stakeholders' roles are vital to promoting energy efficiency programs, standardizing building codes, and providing incentives for energy-efficient buildings. It is pertinent to remember, that cost-effectiveness is often one of the primary considerations in energy efficiency practices, Furthermore, precise numerical analytical findings are not always feasible to validate under realistic conditions [6]. To achieve this and provide alternative solutions for building owners, it is essential to have awareness, information, proper policy implementation, and other incentive programs. Therefore, by enhancing energy-efficient buildings with relatively low costs and simple construction procedures, the implementation of energy-efficient building practices can be made easy and can be useful for both existing and new buildings.

7. RECOMMENDATIONS

Removing barriers, as well as addressing the interplay of obstacles to the operation of energy-efficient building practices, are both essential and necessary. Possible suggestions for addressing these barriers include the following;

- To improve energy efficiency, it is essential to carry out local energy audit programs in buildings. This will make it easier to find areas that need improvements and create energy-saving initiatives. Additionally, regular monitoring and reporting of energy consumption can help to track progress and identify additional opportunities for savings [21].
- To increase energy efficiency awareness among residents, it is vital to involve the media in educating the public about environmental issues and energy conservation [46]. This can include public service announcements, news articles, and educational campaigns to promote energy-saving behaviors and technologies [24].
- It is critical to disseminate innovative technologies that use renewable resources throughout the world in order to increase energy efficiency. This will encourage the use of alternative energy methods and lessen reliance on fossil fuels [38]. Furthermore, in order to maintain the efficacy and cost of green energy sources, it is essential to encourage research and development of new solutions [13].
- To overcome financial hurdles to energy efficiency, it is critical to conduct research and form cooperation with institutions and international organizations [35].

This can include grants, low-interest loans, and tax incentives for energy-efficient upgrades. Additionally, financing options such as energy performance contracting (EPC) can also be considered.

- To reduce transaction costs, it is advisable to use marketplace-based regulations such as energy performance contracting (EPC). EPCs have been shown to have significant financial benefits and can be used to pay for energy efficiency measures. Additionally, implementing policies such as cap-and-trade systems or carbon pricing can also help to reduce transaction costs and incentivize energy efficiency.
- To ensure the effective execution of energy efficiency programs, it is crucial to involve all stakeholders, including individuals and institutions. This will help to build support for energy efficiency measures and to overcome any obstacles that may arise. Additionally, involving community members and local organizations can help to build grassroots support for energy efficiency efforts and increase participation in programs and initiatives. Furthermore, it is essential to consider the cultural and societal implications of energy efficiency, as different communities may have different needs and preferences.

DATA AVAILABILITY STATEMENT

The author confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

REFERENCES

[1] K. Amasyali, and N. M. El-Gohary, "A review of data-driven building energy consumption prediction studies," Renewable and Sustainable Energy Reviews, Vol. 81, pp. 1192–1205, 2018. [CrossRef]

[2] U. Berardi, "A cross-country comparison of the building energy consumptions and their trends," Resources, Conservation and Recycling, Vol. 123, pp. 230–241, 2017. [CrossRef]

[3] T. Hong, C. Koo, J. Kim, M. Lee, and K. Jeong, "A review on sustainable construction management strategies for monitoring, diagnosing, and retrofitting the building's dynamic energy performance: Focused on the operation and maintenance phase," Applied Energy, Vol. 155, 671–707, 2015. [CrossRef]

[4] D. Yan, T. Hong, B. Dong, A. Mahdavi, S. D'Oca, I. Gaetani, and X. Feng, "IEA EBC Annex 66: Definition and simulation of occupant behavior in buildings," Energy and Buildings, Vol. 156, pp. 258–270, 2017. [CrossRef]

[5] M. A. McNeil, N. Karali, and V. Letschesrt, "Forecasting Indonesia's electricity load through 2030 and peak demand reductions from appliance and lighting efficiency," Energy for Sustainable Development, Vol. 49, pp. 65–77, 2019. [CrossRef]

[6] S. Chen, G. Zhang, X. Xia, S. Setunge, and L. Shi, "A review of internal and external influencing factors on the energy efficiency design of buildings," Energy and Buildings, Vol. 216, Article 109944, 2020. [CrossRef]

[7] M. Killian, and M. Kozek, "Ten questions concerning model predictive control for energy-efficient buildings," Building and Environment, Vol. 105, pp. 403–412, 2016. [CrossRef]

[8] A. Foucquier, S. Robert, F. Suard, L. Stéphan, A. Jay, "State of the art in building modeling and energy performance prediction: A review," Renewable and Sustainable Energy Reviews, Vol. 23, pp. 272–288, 2013. [CrossRef]

[9] Y. Guo, J. Wang, H. Chen, G. Li, J. Liu, C. Xu, R. Huang, and Y. Huang, "Machine learning-based thermal response time ahead energy demand prediction for building heating systems," Applied Energy, Vol. 221, pp. 16–27, 2018. [CrossRef]

[10] P. Hernandez, X. Oregi, S. Longo, and M. Cellura, "Life-cycle assessment of buildings," in Handbook of Energy Efficiency in Buildings, 2019, pp. 207–261. [CrossRef]

[11] M. G. Patterson, "What is energy efficiency?," Energy Policy, Vol. 24(5), pp. 377–390, 1996. [CrossRef]

[12] J. Sousa, "Energy simulation software for buildings: review and comparison," Information Technology for Energy Applications, pp. 6–7, 2012. [CrossRef]

[13] Z. N. Zhao, H. M. Zhang, Y. F. Ding, and L. Y. Shen, "Analysis on the Influencing Factors of Building Energy Consumption—A Southwest China Case Study," in Proceedings of the 21st International Symposium on Advancement of Construction Management and Real Estate, K. Chau, I. Chan, W. Lu, and C. Webster, Eds. Springer, Singapore, 2018. [CrossRef]

[14] L. Gustavsson, and A. Joelsson, "Energy conservation and conversion of electrical heating systems in detached houses," Energy and Buildings, Vol. 39(6), pp. 717–726, 2007. [CrossRef]

[15] A. Trianni, and E. Cagno, "Dealing with barriers to energy efficiency and SMEs: Some empirical evidence," Energy, Vol. 37(1), pp. 494–504, 2012. [CrossRef]

[16] Y. A. Çengel, "Energy efficiency is an inexhaustible energy resource with perspectives from the U.S. and Turkey," International Journal of Energy Research, Vol. 35(2), pp. 153–161, 2011. [CrossRef]

[17] E. Agharese, U. Etiosa, A. Matthew, O. G. Ogbemudia, P. U. Osazee, and G. O. Ose, "Community Research and Development Centre," Article 6, 2009.

[18] I. U. Hussaini, and N. H. Abdul Majid, "Energy development in Nigeria and the need for strategic energy efficiency practice scheme for the residential building sector," Management of Environmental Quality: An International Journal, Vol. 26(1), pp. 21–36, 2015. [CrossRef]

[19] M. Economidou, V. Todeschi, and P. Bertoldi, "Accelerating energy renovation investments in buildings," 2019.

[20] S. O. Oyedepo, "Efficient energy utilization as a tool for sustainable development in Nigeria," Int J Energy Environ Engineering, Vol. 3(11), 2012. [CrossRef]

[21] A. Allouhi, Y. El Fouih, T. Kousksou, A. Jamil, Y. Zeraouli, and Y. Mourad, "Energy consumption and efficiency in buildings: current status and future trends," Journal of Cleaner Production, Vol. 109, pp. 118–130, 2015. [CrossRef]

[22] O. C. Chibuisi, "Energy efficiency," Global Scientific Journals, Vol. 7(4), pp. 2320-9188, 2019.

[23] J. Yao, "Analysis of influencing factors of building energy efficiency based on the DEMATEL method," in 2010 International Conference on Optics, Photonics, and Energy Engineering (OPEE), 2010. [CrossRef]

[24] I. C. Ezema, and S. A. Maha, "Energy efficiency in high-rise office buildings: An appraisal of its adoption in Lagos, Nigeria. IOP Conference Series: Earth and Environmental Science,, Vol. 1054, Article 012037, 2022. [CrossRef]

[25] S. Nandi, and R. K. Bose, "The Imperative of Efficient Energy Use in Cities: Analytical Approaches and Good Practices," in R. K. Bose, Ed., Energy Efficient Cities: Assessment Tools and Benchmarking Practices, The World Bank, Washington D.C, 2010, pp. 1–19.

[26] Global Energy Assessment, "Global Energy Assessment - Toward a Sustainable Future,"Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria, 2012.

[27] B. Kiss, "Building Energy Efficiency - Policy, learning, and technology change," International Institute for Industrial Environmental Economics, Lund University, 2013.

[28] S. Mitsushima, B. Gollas, and V. Hacker, "Introduction," in Fuel Cells and Hydrogen, V. Hacker and S. Mitsushima, Eds. Elsevier, 2018, pp. 1–13. [CrossRef]

[29] Y. Demirel, "Energy Conservation," in Comprehensive Energy Systems, I. Dincer, Ed. Elsevier, 2018, pp. 45–90. [CrossRef]

[30] E. Spentzou, "Refurbishment of apartment buildings in the Mediterranean Region for natural ventilation: implications for building design," [Doctorial dissertation], Loughborough University, 2015.

[31] W. Nijs, D. Tarvydas, and A. Toleikyte, "EU challenges of reducing fossil fuel use in buildings – The role of building insulation and low-carbon heating systems in 2030 and 2050," EUR 30922 EN, Publications Office of the European Union, Luxembourg, 2021.

[32] Wikipedia, "Household," Available at: https://en.wikipedia.org/wiki?cv=1&curid=725893 Accessed on Jan 21, 2023.

[33] M. Lackner, "Energy Efficiency: Comparison of Different Systems and Technologies," in Handbook of Climate Change Mitigation and Adaptation, W. Y. Chen, T. Suzuki, and M. Lackner, Eds. Springer, 2017, pp. 1–15. [CrossRef]

[34] P. A. Østergaard, N. Duic, Y. Noorollahi, H. Mikulcic, and S. Kalogirou, "Sustainable development using renewable energy technology," Renewable Energy, vol. 146, pp. 2856-2864, 2020.

[35] Y. M. Wei and H. Liao, "Residential Energy Consumption," in Energy Economics: Energy Efficiency in China. Springer, 2016, pp. 41–60. [CrossRef]

[36] [F. Kern, P. Kivimaa, and M. Martiskainen, "Policy packaging or policy patching? The development of complex energy efficiency policy mixes," Energy Research & Social Science, Vol. 23, pp. 11–25, 2017. [CrossRef]

[37] G. O. Unachukwu, "Energy efficiency measures investigation in cement company: BCC Case study," Nigerian Journal of Renewable Energy, Vol. 10(1&2), pp. 85–92, 2003. [CrossRef]

[38] A. Santangelo, and S. Tondelli, "Consumer Behavior in Building Energy Use," in Affordable and Clean Energy. Encyclopedia of the UN Sustainable Development Goals, W. Leal Filho, A. Marisa Azul, L. Brandli, A. Lange Salvia, and T. Wall, Eds. Springer, 2021, pp. 1–20. [CrossRef]

[39] I. U. Hussaini, "Household energy efficiency practice in Bauchi," [Doctorial dissertation], Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, Kuala Lumpur, 2012.

[40] J. Kellett, "Community-based energy policy: A practical approach to carbon reduction," Journal of Environmental Planning and Management, Vol. 50(3), pp. 381–396, 2007.

[41] T. Fleiter, J. Schleich, and P. Ravivanpong, "Adoption of energy-efficiency measures in SMEs-An empirical analysis based on energy audit data from Germany," Energy Policy, Vol. 51, pp. 863–875, 2012. [CrossRef]

[42] J. Zheng, "Urban Residential Energy Efficiency - Technology Optimization and Behaviour Change: Case study on social housing in Darmstadt, Germany," Darmstadt, Technische Universität, 2019. Available at: https://tuprints.ulb.tu-darmstadt.de/id/eprint/9455. Accessed on Feb 21, 2023.

[43] FMPWH-NESP, "Building Energy Efficiency Guideline for Nigeria (BEEG)," released by the Federal Ministry of Power, Works and Housing, Abuja, 2016. Available at: https://energypedia.info/images/c/c7/Building_Energy_Efficiency_Guideline_for_Nigeria_2016.pdf. Accessed on Jan 08, 2023.

[44] L. A. Bugenings, and A. Kamari, "Bioclimatic Architecture Strategies in Denmark: A Review of Current and Future Directions," Buildings, Vol. 12(2), Article 224, 2022. [CrossRef]

[45] SDG, "Accelerating SDG7 Achievement Policy Briefs In Support Of The First SDG7 Review At The UN High-Level Political Forum 2018," 2018. Available at: https://sustainabledevelopment.un.org/content/documents/18041SDG7_Policy_Brief.pdf?cv=1. Accessed on Mar 06, 2023.

[46] G. Nair, K. Mahapatra, and L. Gustavsson, "Implementation of energy-efficient windows in Swedish single-family houses," Applied Energy, Vol. 89(1), pp. 329–338, 2012. [CrossRef]

[47] M. Hyland, R. Lyons, and S. Lyons, "The value of domestic building energy efficiency - evidence from Ireland," Energy Economics, 2012. University of Oxford Department of Economics Working Paper No. 614. [CrossRef]

[48] American Council for an Energy Efficiency Economy (ACEEE), "Energy efficiency job creation: Real world experience," 2012. Available at: https://www.aceee.org/files/pdf/white-paper/energy-efficiency-job-creation.pdf Accessed on Oct 31, 2023.

[49] IEA, "Accelerating energy efficiency: What governments can do now to deliver energy savings," IEA, Paris, 2022. Available at: https://www.iea.org/commentaries/accelerating-energy-efficiency-what-governments-can-do-now-to-deliver-energy-savings. Accessed on Feb 03, 2023.

[50] B. Lee, "Building Energy Simulation and the Design of Sustainable and Resilient Buildings," in Sustainable Real Estate, T. Walker, C. Krosinsky, L. N. Hasan, and S. D. Kibsey, Eds. Palgrave Macmillan, pp. 177–193, 2019.

[51] D. A. Collins, "A Study of the Barriers and Drivers for Green Leased Offices in Norway," Norwegian University of Science and Technology, 2019.

[52] F. Squinazi, "Managing indoor air quality to protect occupant health," Field Actions Science Reports, Special Issue 21, pp. 8–13, 2020.

[53] K. M. J. Barasa, and O. O. Akanni, "Sustainable Energy Transition for Renewable and Low Carbon Grid Electricity Generation and Supply," Frontiers in Energy Research, Vol. 9, Article 743114, 2022. [CrossRef]

[54] B. Mills, and J. Schleich, "Residential energy-efficient technology adoption, energy conservation, knowledge, and attitudes: An analysis of European countries," Energy Policy, Vol. 49, pp. 616–628, 2012. [CrossRef]

[55] D. E. Marasco, and C. E. Kontokosta, "Applications of machine learning methods to identifying and predicting building retrofit opportunities," Energy and Buildings, Vol. 128, pp. 431–441, 2016. [CrossRef]

[56] V. Eswarlal, "A sustainable supply chain study of the Indian bioenergy sector," Aston University, 2014. Available at: https://publications.aston.ac.uk/id/eprint/22337/1/Studentthesis-2014.pdf?cv=1 Accessed on April 08 2023.

[57] S. Yigit, and B. Ozorhon, "A Simulation-Based Optimization Method for Designing Energy Efficient Buildings," Energy and Buildings, Vol. 178, pp. 216–227, 2018. [CrossRef]

[58] E. Atam, "Current software barriers to advanced model-based control design for energy-efficient buildings," Renewable and Sustainable Energy Reviews, Vol. 73, pp. 1031–1040, 2017. [CrossRef]

[59] J. L. Sousa, A. G. Martins, and H. Jorge, "Dealing with the paradox of energy efficiency promotion by electric utilities," Energy, Vol. 57, pp. 251–258, 2013. [CrossRef]

[60] S. Attia, L. Beltrán, A. Herde, and J. Hensen, "Architect friendly": a comparison of ten different building performance simulation tools," Eleventh International IBPSA Conference Glasgow, Scotland, 27-30, 2009. Available at: https://orbi.uliege.be/bitstream/2268/167578/1/BS09_0204_211.pdf Accessed on Jan 01 2023.

[61] V. S. K. V. Harish, and A. Kumar, "A review of modeling and simulation of building energy systems," Renewable and Sustainable Energy Reviews, Vol. 56, pp. 1272–1292, 2016. [CrossRef]

[62] M. Suzuki, "Identifying roles of international institutions in clean energy technology innovation and diffusion in the developing countries: matching barriers with roles of the institutions," Journal of Cleaner Production, Vol. 98, pp. 229–240, 2015. [CrossRef]

[63] M. Seddiki, A. Bennadji, and M. Tehami, "Barriers to the adoption of energy efficiency measures in Mostaganem, Algeria," Journal of Construction in Developing Countries, Vol. 25(2), pp. 39–61, 2020. [CrossRef]

[64] A. I. Mu'azu, "Scenario of Energy Consumption of Office Buildings in Abuja, Nigeria," International Journal of Science and Advanced Technology, Vol. 2, Article 1546658, 2012.

[65] K.-H. Chain and C. Yeo, "Overcoming energy efficiency barriers through systems approach—A conceptual framework," Energy Policy, Vol. 46, pp. 460–472, 2012. [CrossRef]

[66] G. Nair, L. Gustavsson, and K. Mahapatra, "Factors influencing energy efficiency investments in existing Swedish residential buildings," Energy Policy, Vol. 38(6), pp. 2956–2963, 2010. [CrossRef]

[67] A. Bagaini, F. Colelli, E. Croci, and T. Molteni, "Assessing the relevance of barriers to energy efficiency implementation in the building and transport sectors in eight European countries," The Electricity Journal, Vol. 33(8), Article 106820, 2020. [CrossRef]

[68] E. Igharehbaghi, Q. K. Qian, F. M. Meijer, and H. J. Visscher, "Unravelling Dutch homeowners' behaviour towards energy efficiency renovations: What drives and hinders their decision-making?" Energy Policy, Vol. 129, pp. 546–561, 2019. [CrossRef]

[69] N. Labanca, and P. Bertoldi, "Beyond energy efficiency and individual behaviours: policy insights from social practice theories," Energy Policy, Vol. 115, pp. 494–502, 2018. [CrossRef]

[70] T. Hong, D. Yan, S. D'Oca, and C. Chen, "Ten questions concerning occupant behavior in buildings: The big picture," Building and Environment, Vol. 114, pp. 518–530, 2017. [CrossRef]

[71] R. R. Kumar, and A. Kumar, "Adoption of electric vehicle: A literature review and prospects for sustainability," Journal of Cleaner Production, Vol. 253, Article 119911, 2020. [CrossRef]
[72] B. F. Balvedi, E. Ghisi, and R. Lamberts, "A review of occupant behaviour in residential buildings," Energy and Buildings, Vol. 174, pp. 495–505, 2018. [CrossRef]
[73] S. Hu, D. Yan, E. Azar, and F. Guo, "A systematic review of occupant behavior in building energy policy," Building and Environment, Article 106807, 2020. [CrossRef]
[74] O. Lah, "The barriers to low-carbon land-transport and policies to overcome them," European Transport Research Review, Vol. 7(1), Article 5, 2015. [CrossRef]
[75] C. Cattaneo, "Internal and external barriers to energy efficiency: which role for policy interventions?" Energy Efficiency. Vol. 12, pp. 1293–1311, 2019. [CrossRef]
[76] S. D'Oca, A. Ferrante, C. Ferrer, R. Pernetti, A. Gralka, R. Sebastian, and P. Op 't Veld 1 "Technical, Financial, and Social Barriers and Challenges in Deep Building Renovation: Integration of Lessons Learned from the H2020 Cluster Projects," Buildings, Vol. 8(12), p. 174, 2018. [CrossRef]
[77] I. L. Wong, and E. Krüger, "Comparing energy efficiency labelling systems in the EU and Brazil: Implications, challenges, barriers and opportunities," Energy Policy, Vol. 109, pp. 310–323, 2017. [CrossRef]
[78] S. Langlois-Bertrand, M. Benhaddadi, M. Jegen, and P.-O. Pineau, "Political-institutional barriers to energy efficiency," Energy Strategy Reviews, Vol. 8, pp. 30–38, 2015. [CrossRef]
[79] L. Castellazzi, P. Bertoldi, and M. Economidou, "Overcoming the split incentive barrier in the building sector," Available at: https://ec.europa.eu/jrc/en Accessed on Jan 5, 2023.
[80] P. Thollander, J. Palm, and P. Rohdin, "Categorizing barriers to energy efficiency: an interdisciplinary perspective," Energy Efficiency, pp. 49–63, 2010. [CrossRef]
[81] M. E. Biresselioglu, M. Demirbag Kaplan, and B. K. Yilmaz, "Electric mobility in Europe: A comprehensive review of motivators and barriers in decision making processes," Transportation Research Part A: Policy and Practice, Vol. 109, pp. 1–13, 2018. [CrossRef]
[82] J. Painuly, "Barriers to renewable energy penetration; a framework for analysis," Renewable Energy, Vol. 24(1), pp. 73–89, 2001. [CrossRef]
[83] S. Sorrell, E. O'Malley, J. Schleich, and S. Scott "Standing on a burning platform: barriers to energy efficiency in the U.K. brewing industry," The Economics of Energy Efficiency: Barriers to Cost-Effective Investment, Cheltenham: Edward Elgar, 2004. Available at: https://ideas.repec.org/b/elg/eebook/2607.html Accessed on Apr 12, 2023.
[84] N. H. Ravindranath, and P. Balachandra, "Sustainable bioenergy for India: Technical, economic and policy analysis," Energy, Vol. 34(8), pp. 1003–1013, 2009. [CrossRef]
[85] S. Thorne, "Towards a framework of clean energy technology receptivity," Energy Policy, Vol. 36(8), pp. 2831–2838, 2008. [CrossRef]
[86] A. Jagadeesh, "Wind energy development in Tamil Nadu and Andhra Pradesh, India Institutional dynamics and barriers—A case study," Energy Policy, Vol. 28(3), pp. 157–168, 2000. [CrossRef]
[87] C. Karakosta, H. Doukas, and J. Psarras, "Technology transfer through climate change: Setting a sustainable energy pattern," Renewable and Sustainable Energy Reviews, Vol. 14(6), pp. 1546–1557, 2010. [CrossRef]
[88] E. M. Rogers, "Diffusion of Innovations," New York: The Free Press; 2003.
[89] D. Espejel-Blanco, J. A. Hoyo-Montaño, J. Arau, G. Valencia-Palomo, A. García-Barrientos, H. Ricardo Hernández-De-León, L. Camas-Anzueto, "HVAC Control System Using Predicted Mean Vote Index for Energy Savings in Buildings," Buildings, Vol. 12, Article 38, 2022. [CrossRef]
[90] E. Annunziata, F. Rizzi, and M. Frey, "Enhancing energy efficiency in public buildings: The role of local energy audit programs," Energy Policy, Vol. 69, pp. 364–373, 2014. [CrossRef]
[91] Q. Cui, H. Kuang, C. Wu, and Y. Li, "The changing trend and influencing factors of energy efficiency: The case of nine countries," Energy, Vol. 64, pp. 1026–1034, 2014. [CrossRef]
[92] C. Richerzhagen, T. von Frieling, N. Hansen, A. Minnaert, N. Netzer, and J. Rußbild, "Energy efficiency in buildings in China: Policies, barriers and opportunities," (DIE Studies, 41), 2008.
[93] J. Chillayil, M. Suresh, V. PK, S. K. Kottayil, "Is imperfect evaluation a deterrent to adoption of energy audit recommendations?," International Journal of Productivity and Performance Management, Vol. 71(4), pp. 1385–1406, 2022. [CrossRef]
[94] F. S. Hafez, B. Sa'di, M. Safa-Gamal, Y. H. Taufiq-Yap, M. Alrifaey, M. Seyedmahmoudian, A. Stojcevski, B. Horan, and S. Mekhilef, "Energy Efficiency in Sustainable Buildings: A Systematic Review with Taxonomy, Challenges, Motivations, Methodological Aspects, Recommendations, and Pathways for Future Research," Energy Strategy Reviews, vol. 45, Article 101013, 2023. [CrossRef]
[95] M. W. Akram, M. F. Mohd Zublie, M. Hasanuzzaman, and N. Abd Rahim, "Global prospects, advance technologies and policies of energy-saving and sustainable building systems: A review," Sustainability, Vol. 14, Article 1316, 2022. [CrossRef]
[96] R. Alawneh, F. E. Mohamed Ghazali, H. Ali, and M. Asif, "Assessing the contribution of water and energy efficiency in green buildings to achieve United Nations Sustainable Development Goals in Jordan," Building and Environment, Vol. 146, pp. 119–132, 2018. [CrossRef]
[97] S. S. A. Azis, "Improving present-day energy savings among green building sector in Malaysia using benefit transfer approach: Cooling and lighting loads," Renewable and Sustainable Energy Reviews, Vol. 137, Article 110570, 2021. [CrossRef]
[98] Y. Liu, X. Guo, and F. Hu, "Cost-benefit analysis on green building energy efficiency technology application: A case in China," Energy and Buildings, Vol. 82, pp. 37–46, 2014. [CrossRef]