Research Article

Factors Influencing Energy-Efficiency Retrofits in Commercial and Institutional Buildings: A Systematic Literature Review

Amy A. Kim,[1] Lysandra Medal[2]

[1]State of Washington
[2]TRC Companies, Inc

Corresponding Author: Amy A. Kim, State of Washington; email: amyakim12@gmail.com

ABSTRACT

Renovating existing buildings to render them more energy efficient is critical. However, current energy-efficiency efforts in the building sector remain insufficient. Despite the growing literature related to energy efficiency in buildings, context-driven reasons for stakeholders to undertake energy-efficiency retrofits remain less understood. The researchers conducted a systematic literature review to synthesize and consolidate the results of studies worldwide from 2009 to 2020, examining factors and associated contexts that influence building stakeholders' decisions to implement energy-efficiency retrofits. The review involved searching databases and topic-specific journals using multiple keywords and synonyms for energy-efficiency retrofits and decision-making. The initial search yielded 25,093 articles, and 134 were further assessed for inclusion and exclusion. Forty-two of those articles met the criteria for inclusion and were examined to evaluate the factors and context associated with the decisions related to energy-efficiency retrofits. Recent relevant research was analyzed, considering methodologies, regions, economic development, building types, participant characteristics, and study size. Based on the extensive review of the literature, this study identified 30 factors that can be categorized under seven decision criteria involved in determining retrofits: economic feasibility, team process, technical practicality, institutional characteristic, governmental policy, occupant impact, and environmental impact. The main factors that influenced energy retrofit decisions included life cycle cost, coordination and collaboration, system compatibility, internal value, government commitment, satisfaction and well-being, and eco-friendly installation. Variations regarding factors influencing stakeholders' perceptions among different regions and building types were also examined. The study found that risk management, technology readiness, and standards and regulations were more significant in countries with developing economies. Conversely, system compatibility, reputation, and political influence were more important in developed economies. The findings from this study provide insights into future research that may guide the development of more context-appropriate strategies that drive stakeholders to implement energy-efficiency retrofits in their buildings.

Keywords: Decision-making; Building portfolio; Context; Energy-efficiency retrofit; Facilities management

1. INTRODUCTION

Opinions from building stakeholders about energy efficiency are critical in successfully planning and implementing retrofits in existing buildings. The building sector contributed 20% of global-delivered energy consumption in 2018 (EIA, 2019), thereby indicating a need for an international collective effort to reduce energy use in residential and commercial buildings. However, stakeholders' differing perceptions about what is important creates a barrier that highlights the complexity of renovating existing buildings. Building stakeholders can be classified into two groups: those who participate directly in energy-related processes (e.g., energy manager, building owner, tenant), and those who do not participate directly but have a specific interest in or are affected by the energy management outcomes (e.g., local government, energy auditor, community-based organization) (Li et al., 2017). In addition, the researchers found that the stakeholders' impact on energy performance occurs at various stages, most notably at the operation and maintenance stage by energy managers and during planning, design, and construction stages by other stakeholders.

Building owners and managers' perceptions are of particular interest to researchers in understanding the decision processes of retrofitting buildings. This group of stakeholders are the key decision-makers who manage the investment and have a critical role in daily activities. One study suggested that stakeholders who support energy efficiency have attributes associated with a considerable level of knowledge in building energy and sustainability and a solid position of power (Zedan & Miller, 2018). In contrast, organizations that do not have a skilled workforce and support from high management are more likely not to pursue energy improvement projects (Valero et al., 2016; Woodroof, 2011). Government is also a critical stakeholder that sets energy target policies and programs to encourage building owners to participate in the local and national sustainability agenda (Barnes & Parrish, 2016; Liang et al., 2015). Other important stakeholders are the building occupants, who have received much attention from researchers since their characteristics and behavior significantly affect the actual energy performance of the buildings (Zou et al., 2018). Understanding the drivers and barriers regarding energy-efficiency retrofits from these stakeholders' perspectives is crucial.

The literature on this subject has been growing but is scattered across diverse contexts (e.g., geographic location, building type) and disciplines, making the knowledge fragmented. For instance, Less et al. (Less et al., 2012) argued that the carbon content of electricity varies markedly by geographic area, a factor that should be considered for deep energy retrofit planning. Thus, decision-makers may weigh the concerns about reducing a carbon footprint differently depending on the geographic area. Another study suggested that national incentives are warranted to advance feasible energy retrofits in climates typical of southern Italy (Ascione et al., 2015). This strategy indicates that availability of incentives may be perceived as a driver by stakeholders in one climate but a barrier and a strategy that lacks government support in other climate zones.

Explanations for the gap to energy efficiency should also allow for relative contributions that vary between groups of users and building types. Academic institutions that promote low-energy buildings enjoy increased staff satisfaction with their work environment (Meron & Meir, 2017) and improved engagement among the community to foster education and innovation (Ahmed et al., 2017; Sesana et al., 2016). Meanwhile, the American Society for Healthcare Engineering reported that stability and resilience in designs for facilities such as healthcare buildings that respond to disasters, terrorism, and mass casualties constitute critical factors in improving energy efficiency (Carpenter & Hoppszallern, 2011). Buildings housing the high-technology sector can consume up to 100 times more energy than do conventional buildings (Naughton, 2000). However, energy-efficiency improvements are often overlooked because they are weighed against other capital investments with a payback period of less than a year (Mills et al., 2008). On the other hand, mandatory policy and dedicated financing mechanisms are critical to retrofit government buildings for energy efficiency (Alam et al., 2019). These studies highlighted that each business sector adopts a significantly distinct focus when evaluating energy-efficiency retrofits.

Until now, a comprehensive review of accumulated current scientific knowledge to shed light on the similarities and differences of stakeholders' views in multiple contexts regarding retrofits was lacking. To fill the research gap, the researchers have herein compiled and synthesized recent academic journal publications that examined factors influencing stakeholder decisions to implement energy-efficiency retrofits in commercial and institutional buildings. The study will also investigate how stakeholders' perceptions may vary depending on context, including geographical regions, economic development, and building types.

2. THEORETICAL BACKGROUND

2.1. Pertinent Literature

Energy-efficiency retrofits in buildings is a complex topic comprised of various aspects from multiple disciplines. This section discusses pertinent literature related to factors influencing energy-efficiency retrofits and clarifies the contribution of this systematic literature review (SLR) beyond the published review papers on the subject.

Many review studies have been conducted on existing retrofitting approaches to improve energy efficiency in buildings. For example, Pombo et al. (Pombo et al., 2016) reviewed studies on housing retrofits from academic journals, technical journals, books, and reports. They found that passive strategies such as window replacement and envelope insulation are the most common retrofitting approaches, but wide variations of their assessment methodologies limited the analysis when trying to compare the results across studies. Ruparathna et al. (Ruparathna et al., 2016), when reviewing existing approaches used on improving the energy efficiency of commercial and institutional buildings, found that technological advancement has been the focus of peer-reviewed journal articles from 2000 to 2014, while behavioral changes have been understudied. Ma et al. (Ma et al., 2012) reviewed various methodologies and strategies for selecting the best sustainable building retrofits. They found that most of the numerical simulation studies in commercial offices demonstrated improved energy and environmental performance; however, no reported actual energy savings may affect the confidence of building owners to retrofit their buildings. Other literature reviews assessed building energy-efficiency trends in construction material development (Rao et al., 2018), regional policies (Liu et al., 2020), approaches in specific building types (Berg et al., 2017; Lidelöw et al., 2019).

Another group of recent review articles focused on particular aspects of building energy efficiency discussed in this SLR, such as indoor environmental quality and occupant behavior change. For example, a study of peer-reviewed journals from the last 5 years focusing on housing found that retrofitted buildings may pose indoor environmental quality risks, such as a build-up of pollutants, overheating, and noise (Ortiz et al., 2020). The study indicated several risks associated with health and suggested the importance of future research to consider the comfort and health of occupants to establish a better relationship with the retrofitted buildings. Maslesa et al. (Maslesa et al., 2018) identified indicator categories, building types, and assessment methods related to environmental building performance (EBP). Although only five of 69 selected articles examined the nonresidential sector, the study found that environmental impacts in nonresidential buildings were higher. The study called for researchers to pay more attention to EBP studies in nonresidential buildings. Paone and Bacher (Paone & Bacher, 2018) reviewed studies related to the impact of building user behavior on energy efficiency and suggested eco-feedback and gamification as some strategies to influence behavioral change. Hashempour et al. (Hashempour et al., 2020) reviewed studies on energy performance optimization of existing buildings that show a growing interest in the multicriteria approach. Similar to a few of the reviews mentioned earlier, the review found that most studies focused on environmental and economic objectives and used residential buildings as case studies. This study indicated a need to pay more attention to social-related factors (e.g., comfort) in the optimization criteria and to expand the research of energy-efficient measures to varying building types and climate conditions.

Overall, none of the existing reviews have combined all existing empirical studies to present a comprehensive list of factors that influence building stakeholders' decisions regarding energy-efficiency retrofits, nor have those factors been assessed in their various contexts—such as their similarities or differences—to ascertain how retrofit considerations are affected. Doing so will help identify research gaps still needing to be explored in order to aid stakeholders when making retrofit decisions. In other fields of sustainable energy, literature reviews about stakeholders' perceptions have been conducted to provide insight for policy development, such as factors affecting green building (Darko et al., 2017), sustainable process technology adoption (Fu et al., 2018), and public perceptions of hydropower projects (Mayeda & Boyd, 2020). This study will provide a valuable reference for decision-makers when considering energy-efficiency retrofits for nonresidential buildings, particularly commercial and institutional buildings (e.g., hospitals, hotels, offices, schools).

2.2. Context Dimensions in Building Energy-Eciency Retrofits

Contextualizing building energy-efficiency retrofits is essential to understand how and why retrofits happen and whom it involves. For example, understanding context allows researchers to explore whether the results of a study with participants working under a given organizational structure would yield similar findings had the participants worked under another (Rubin et al., 2009). One of the prevalent definitions of context in an organizational behavior study is "situational opportunities and constraints that affect the occurrence and meaning of organizational behavior as well as functional relationships between variables" (Johns, 2006). Research about perceptions of energy efficiency is often attributed to contextual conditions, but few studies have discussed this holistically. The influence that context has on retrofit decisions is often unrecognized or underappreciated. When the context is studied, the "contextual features are often studied in a piecemeal fashion, in isolation from each other" (Johns, 2006). Besides providing worldwide views based on academic journals, this study will identify, analyze, and report the contextual differences when considering energy-efficiency retrofits.

The context classification in energy-efficiency retrofits, which consists of physical, functional, and social contexts, was initially suggested by Medal and Kim (Medal & Kim, 2020) and further explored by Medal et al. (Medal et al., 2021). The physical context refers to how the building's physical condition and the surrounding environment may be associated with evaluating energy-efficiency retrofits, such as building type, portfolio size, geographical region, and climate zone. The functional context refers to how building owners' and tenants' organizational values may affect the evaluation of energy-efficiency retrofits, such as ownership type and tenants' business sector. The social context refers to how the building stakeholders' characteristics and preferences may influence decisions related to energy-efficiency retrofits, such as stakeholders' personalities, job title, and project role. Building upon context theory from Johns (Johns, 2006), Fig. 1 shows the contextual framework of the built environment and its connections with factors influencing energy-efficiency decisions (discussed in detail in the Results and Discussion section). This SLR will explore the contextual factors of retrofit decisions based on geographical regions, economic development, and building types.

3. METHODOLOGY

3.1. Inclusion criteria

An SLR was conducted for all research articles published in the English language relevant to decision-makers' perceptions of energy-efficiency retrofits in buildings during the 12 years from January 1, 2009, to December 31, 2020. In addition, while writing this paper, the researchers used a notification tool available in databases that sent an email on new suggested articles published beyond 2020 based on saved keywords.

Comprehensive criteria for inclusion were developed to identify relevant articles that focus primarily on the perceptions of building stakeholders about energy-efficiency retrofits. They included articles examining assessment criteria to implement various energy-efficiency measures in existing commercial and institutional buildings, such as system upgrades, operations, maintenance optimization, renewable energy installations, and public engagement initiatives. These assessment criteria included the factors affecting the evaluation of energy-efficiency retrofits. Publications on residential buildings were outside the scope of this paper. In addition, this review only includes primary source articles as defined by Colling (Colling, 2003); thus, commentaries and literature review articles are excluded.

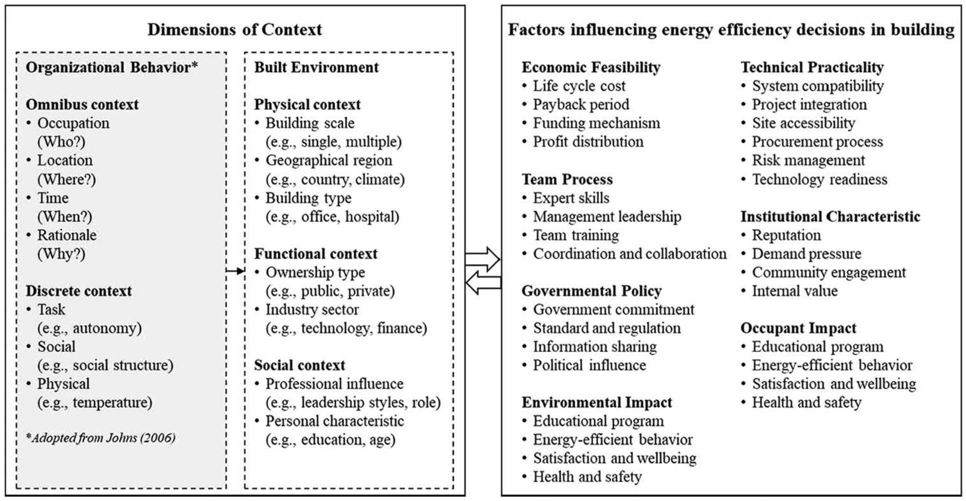

FIGURE 1.—Conceptual framework linking context to building energy efficiency

The keywords were designed to identify research articles that included energy-efficiency aspects and perceptions from the building stakeholders. A library scientist at the University of Washington, Seattle, assisted in determining relevant terms and synonyms to ensure a comprehensive search. Boolean operators were used to search for relevant articles (Page, 2008). The word 'AND' includes all identified keywords, 'OR' consists of any of the specified keywords, and the wildcard asterisks allow for identifying plurals and other word suffixes. The following string of keywords was used as the search term for all searches performed: ((Energy OR electricity OR heating OR cooling OR lighting) AND (Retrofit* OR upgrade* OR refurbish* OR renovat* OR "existing building" OR "existing structure" OR "existing buildings" OR "building improvements" OR "building improvement") AND (Hotels OR hospital OR hospitals OR buildings OR schools OR "non residential" OR "office building" OR "office spaces" OR "office space" OR commercial OR institutional OR campus OR campuses) AND (Conserve* OR conservation OR green OR sustainab* OR efficien* OR "fossil fuels" OR "fossil fuel" OR renewable OR solar OR "energy saving" OR "energy retrofit" OR "energy retrofits" OR "energy use" OR "energy usage" OR "energy utilization" OR "energy consumption" OR "energy upgrade" OR "energy upgrades" OR "energy performance" OR "carbon neutral" OR "low carbon" OR "carbon emissions")).

3.2. Literature search process

This SLR adopted a four-step process developed by Khan et al. (Khan et al., 2003) to ensure that relevant articles were collected. First, comprehensive searches of seven computerized bibliographic databases were conducted to identify relevant articles: *Engineering Village (i.e., Inspec and Compandex databases), ASCE Library, Environment Complete, JSTOR Sustainability, GreenFILE, and Business Source Complete*. Second, key journals that included publications relevant to the topic were identified to determine if any articles were missed when searching the bibliographic databases. These journals include *Journal of Management in Engineering, Renewable and Sustainable Energy Reviews, Energy and Buildings, Energy Policy, Energy Research and Social Science, Energy, Sustainability, Applied Energy, International Journal of Energy Research, Sustainable Cities and Society*. Third, the reference lists of all the articles that met the inclusion criteria were examined for any citations that could lead to research articles for review. Fourth, all articles that met the inclusion criteria were computed into the Google Scholar database to determine if any articles citing these studies could also be relevant research articles. Citations were further examined for possible pertinent additional articles during the review of the final set of research articles collected.

However, the search of the computerized databases might have missed articles if the article authors used none of the keywords. This limitation was addressed through additional searches of reference lists, key journals, and Google Scholar. Nonetheless, there could have still been missed articles, such as articles only available in databases other than the seven databases used in this study, which thus becomes a limitation of this study. Saturation was achieved when no new studies emerged, but the same articles reappeared across the additional searches.

3.3. Analysis and Coding

All articles collected were initially screened by reading the titles for relevance. Next, the abstracts were examined to categorize the articles to be removed from the SLR and the articles likely to meet the inclusion criteria. Then, the full text of articles was reviewed to determine articles. A total of 25,093 research articles from the database and journal searches were imported into Endnote, and duplicates from all databases were removed. After reviewing the titles and then the abstracts, the remaining 134 full-text articles were assessed for eligibility. A total of 42 articles met the inclusion criteria and were ultimately included in this review.

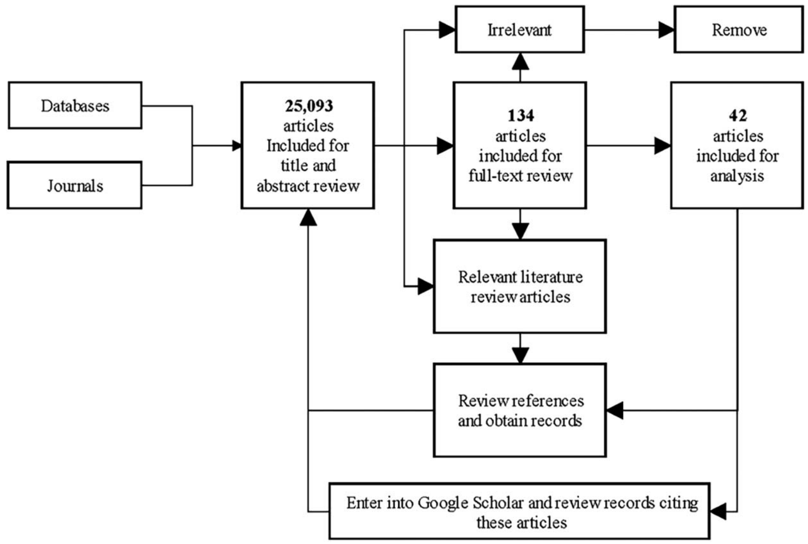

FIGURE 2.—Literature search and selection process

The qualitative data consisting of 42 articles were thoroughly reviewed to examine the following study characteristics and findings: the geographical region, building type, objective, data collection method, case study and sample size, and participant characteristics. In addition, the articles were examined based on the economic classification of the country where the research was conducted. To determine key factors influencing building stakeholders' decisions to implement energy-efficiency retrofits, the data were qualitatively coded using the *ATLAS.ti* software by following an inductive coding process that allowed themes to emerge naturally from the data (Richards, 2020). The initial coding resulted in 658 codes. The next step of the coding process was to adopt preexisting codebooks based on 15 factors grouped under five criteria identified by Medal et al. (Medal et al., 2021). For example, codes such as "Loss of significant original building fabric" and "Building conservation compatibility" were recoded as "System compatibility" under the technical practicality criterion. When new themes emerged, the authors added new criteria and factors to accommodate emerging themes that cannot be considered under any preexisting codes. For example, codes such as "Strong school-community partnerships" and "Difficult to organize and coordinate" were recoded as a new factor—"Coordination and collaboration"—under the team process. Finally, the 658 codes were classified under 30 factors and seven criteria associated with energy-efficiency retrofit decisions. The literature search and selection process are illustrated in Fig. 2.

4. Results and Discussion

4.1. Descriptive Analysis

This section focuses on how 42 analyzed articles are distributed over time and explains how relevant and saturated the topic of decision factors is in building retrofits. This section also reports on the article distribution according to publication outlets to show how diverse the subject is in research communities. Next, the distribution of articles based on geographical regions and building types is discussed to illustrate how similar or different the assessment criteria of energy retrofitting are based on physical and functional contexts, as previously described in Section 2. Last, this section summarizes the objectives of the research articles, data collection approaches, case studies, and participant characteristics.

4.1.1. Distribution across time: The allocation of research articles within one decade is shown in Fig. 3. The oldest relevant articles reviewed were in 2011, while the most recent articles were in 2020. Study topic articles increased from 2009 to 2017 and then began a decreasing trend. Most articles were published between 2016 and 2017 (22 articles—52% of total articles in 12 years). Research on the subject began to decrease in 2018 and may decline or stabilize at a low number of publications in the next decade. The general findings of the factors that influence stakeholders' decisions to retrofit their buildings are similar across diverse regions and building types, as will be discussed in detail in a later section. Moreover, these studies can be used as guidelines in retrofitting decisions in various contexts.

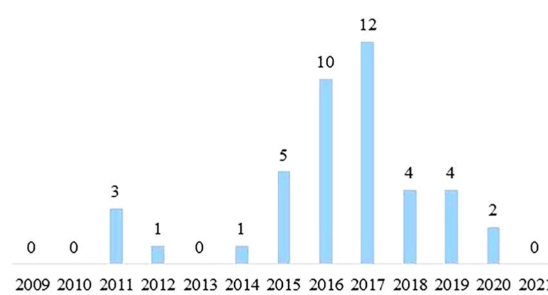

FIGURE 3.—Distribution across time between 2009 and 2020

TABLE 1.—Distribution across journals

Journal	Article	Journal	Article
Applied Energy	1	*Sustainable Cities and Society*	5
Buildings	1	*Renewable and Sustainable Energy Reviews*	2
Energy Policy	5	*Journal of Technology and Design*	1
Facilities	2	*Procedia Engineering*	1
Journal of Architectural Engineering	1	*Structural Survey*	1
Energy and Buildings	5	*Journal of Management in Engineering*	1
Energy Procedia	1	*Renewable Energy*	1
Journal of Cleaner Production	3	*Smart and Sustainable Built Environment*	1
Built Environment Project and Asset Management	1	*Strategic Planning for Energy and the Environment*	1
International Conference on Urban Regeneration and Sustainability	1	*Journal of the American Planning Association*	1
International Journal of Building Pathology and Adaptation	1	*Journal of Construction Engineering and Management*	1
International Journal of Energy Sector Management	1	*Journal of Performance of Constructed Facilities*	1
International Journal of Environmental Research and Public Health	1	*Journal of Green Building*	1

4.1.2. Distribution across main journals: Table 1 presents the distribution of articles among scientific journals. Seventeen out of 42 publications are in the journals classified within the Energy subject area (*Applied Energy, Energy and Buildings, Energy Policy, Energy Procedia, International Journal of Energy Sector Management, Renewable Energy*, and *Strategic Planning for Energy and the Environment*). Sustainability and health-related journals (i.e., *International Conference on Urban Regeneration and Sustainability, International Journal of Environmental Research and Public Health, Journal of Cleaner Production, Journal of Green Building, Smart and Sustainable Built Environment, and Sustainable Cities and Society*) represent the next significant portion, with 12 (29%) articles, followed by journals on building, facilities, and construction (19%), engineering (10%), and survey (2%). The dominant journals of the analyzed articles are *Energy and Buildings*, *Energy Policy*, and *Sustainable Cities and Society*, each containing five research articles that were selected for this study. Importantly, this finding reveals that the topic is being addressed in considerably diverse research communities, although predominantly in journals specializing in the Energy subject area.

4.1.3. Distribution across geographical regions: The articles were coded to denote whether the study area was located within a developed or developing economy, as classified by the United Nations (Nations, 2019). Countries with developed economy identified in the study included Australia, Denmark, Germany, Greece, Ireland, Italy, Spain, United Kingdom (UK), United States, and other European counties that were not named. Countries with developing economy included China, Egypt, Malaysia, Nigeria, Sri Lanka, Taiwan, and Vietnam. One study combined developed and developing countries in the study (Jin & Marjanovic-Halburd, 2018); thus, this article was counted in both categories. Thirty of the studies, (71%), focused on countries with developed economies. The remaining 12 studies (29%) were conducted in developing countries. Distribution of case study locations of the research articles by regions is shown in Fig. 4. The studies were located in various regions around the world, including the following: Australia, China, Denmark, Egypt, Germany, Greece, Ireland, Italy, Malaysia, Nigeria, Spain, Sri Lanka, Taiwan, UK, United States, Vietnam, and a mix of several European countries that were not named. The country hosting the majority of studies was the United States, which appeared in 14 out of 42 articles. China was next, with six articles, then Australia and the UK, each with four articles. Although most articles covered a single region, two articles conducted a multi-country case study to compare the findings among diverse regions, both based on the significant differences and similarities.

Si and Marjanovic-Halburd (Jin & Marjanovic-Halburd, 2018) found differences in expert opinions about retrofit projects between the UK and China, given their distinctive national contexts. Their case study showed that UK experts emphasize the economic performance of green technology, while Chinese experts place significant importance on technical performance. Tozer (Tozer, 2020) conducted interviews with experts from Stockholm, London, and San Francisco based on their similarities, including their international leadership in carbon governance, leadership heterogeneity, and evidence of leadership in building decarbonization. That study investigated the political effectiveness of implementing decarbonization initiatives. Case studies conducted in multiple countries in Europe were

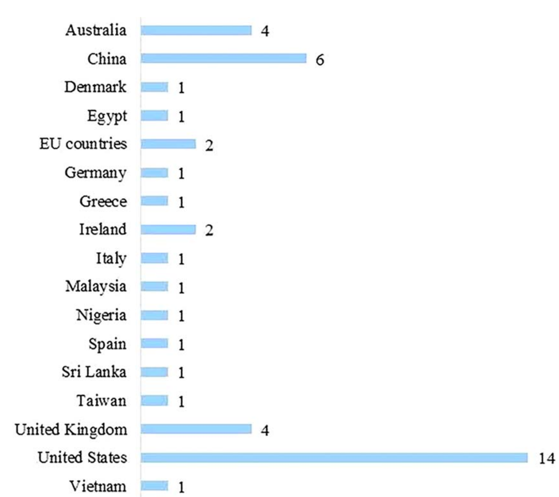

FIGURE 4.—Distribution across geographical regions

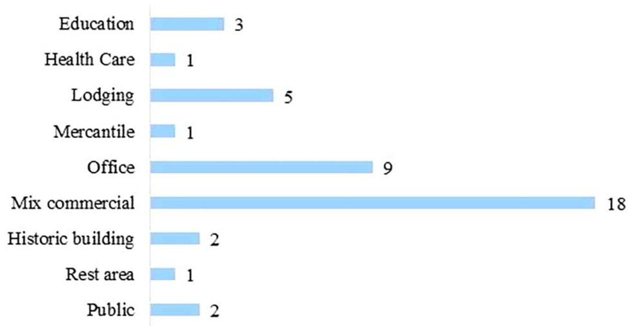

FIGURE 5.—Distribution across building types

similarly aimed at examining the effect of the identical policies implemented in the countries. Valero et al. (Valero et al., 2016) investigated common pan-European challenges in making refurbishment decisions and presented insights regarding a proposed decision-support tool for local administrations. Haase et al. (Haase et al., 2015) found similar features amid the practices of rehabilitation of European shopping centers. Thus, the study used three shopping centers in different European countries to define the common drivers of retrofitting European shopping centers.

4.1.4. Distribution across building types: The distribution of articles across building types is shown in Fig. 5. The buildings used in these case studies can be categorized into eight types: education, health care, lodging, mercantile, office, mixed commercial, historic building, and public facilities. This study partly follows the definitions of building types determined by the Energy Information Administration (EIA) (EIA) to simplify the classification where possible but keeps some definitions of types of buildings found in the original articles to maintain the particular characteristics of the buildings when being evaluated for energy retrofits. Studies of mixed commercial buildings are identified in 18 articles. These studies either did not specify in detail about the use of facilities or used multiple building types in their research to obtain a consensus about factors affecting retrofit in commercial buildings. For example, Clancy et al. (Clancy et al., 2017) identified drivers and barriers of energy efficiency by conducting 750 interviews across a statistically representative sample of commercial businesses in Ireland, including retail, hotel, public houses and restaurants, offices, and warehouses and storage. The second most studied building types are offices (9 articles), followed by lodging (5 articles). The articles focusing on hotels focused on the significant energy consumption of this building type. Luxury hotels may spend up to 50% of their expenses on energy (SLEMA, 2009) and represent a savings potential of 20% (Karawita & Withanage, 2013). Buildings categorized as for education were discussed in three articles, including for public and private schools and higher education institutions. The collected data covered use of the buildings for academic or technical classroom instruction, administration buildings, dormitories, libraries, and teaching hospitals. Public facilities were identified in three articles: one argued that limited studies analyze the implementation of sustainable measures in public buildings (Abdallah et al., 2016), and two explored how fundamental differences in the public sector compared to the non-government sector can present unique challenges to energy-efficiency projects (Alam et al., 2019; Bertone et al., 2018). The historic building was discussed in two articles that represented growing interest in focusing energy-efficiency efforts on historic buildings and emphasizing the value of preserving the structural qualities and aesthetics while still seeking energy efficiency (Lidelöw et al., 2019). Last, a health care building type and mercantile building type were each only used in one article for a case study, indicating the lack of examination about perceptions of energy-efficiency retrofits in these building types. Mohammadpour et al. (Mohammadpour et al., 2017) focused on examining patient safety during energy-efficiency retrofits of healthcare facilities. Haase et al. [8] filled the gap of studies in the mercantile sector by understanding the energy efficiency and sustainability issues in shopping centers.

4.1.5. Overview of research objectives, data collection approaches, and participant characteristics: Table 2 summarizes reviewed articles, including the region, building type, objective, data collection, case study and sample size, and participant characteristics. Most of the selected papers had straightforward goals to identify drivers, barriers, and information requirements to implement energy-efficiency retrofits. Some articles used specific building types for a case study, such as shopping centers (Haase et al., 2015), hotels (Xu et al., 2012), and schools (Castleberry et al., 2016). In contrast, other studies focused on the decision factors at different retrofitting phases, such as during the initial intention phase (Liang et al., 2016) and actual project level executions (Fasna & Gunatilake, 2019). Factors influencing energy retrofit were also identified in articles that defined the retrofit challenges by focusing on the stakeholders' characteristics. For example, retrofit decisions were examined based on the impact of ownership type, tenant demand, and market competitiveness (Kontokosta, 2016) and the interactive effect of participants' experience, knowledge, and roles on sustainable building practices (Nguyen et al., 2017; Zuhaib et al., 2017). Another theme of the selected articles included studies that aimed to comprehensively assess the state-of-the-art methods, processes, and technologies of retrofitting. For example, Mohammadpour et al. (Mohammadpour et al., 2017) examined current retrofit practices in healthcare facilities focusing on patient safety. Other studies assessed the preferences on various energy reporting, data tracking, and labeling mechanisms available in the market (Christensen et al., 2018) and examined the retrofit decision process by investigating relationships among decision factors (Kim et al., 2019). The remaining articles aimed at evaluating existing buildings with green standards (e.g., (Komolafe

TABLE 2.—Summary of articles examining factors influencing energy-efficiency retrofits in buildings

No.	Research article	Region	Building type	Objective	Data collection	Case study and sample size	Participant characteristic
1	Woodroof (2011) [5]	United States	Education	Identify the key success factors for selecting the best energy consultant to identify conservation opportunities that do not require equipment upgrades.	Interview	16 school districts that had implemented energy savings programs for over 2 years.	School district representatives.
2	Xu et al. (2011) [66]	China	Lodging	Develop the critical success factors of EPC for sustainable energy-efficiency retrofits of hotel buildings.	Interview; survey	Representatives from 9 hotels, with 17 professionals for the interview and 91 professionals for the survey.	Engineering managers from hotels, project managers from contractors, academic researchers, energy service companies (ESCOs), governments, and consultants.
3	Zografakis et al. (2011) [67]	Greece	Lodging	Assess the state of the art of practices and technologies of energy-saving and renewable energy sources in hotels.	Survey; information sessions	32 hotels.	Hotel managers.
4	Xu et al. (2012) [51]	China	Lodging	Formulate key performance indicators for the sustainability assessment of energy-efficiency retrofits in hotel buildings.	Interview; survey	Representatives from 9 hotels, with 17 professionals for the interview and 91 professionals for the survey.	Engineering managers from hotels, project managers from contractors, academic researchers, ESCOs, governments, and consultants.
5	Gultekin et al. (2014) [64]	United States	Office	Develop an understanding of the process and energy-efficiency design strategies used to deliver an energy-efficient deep retrofit project.	Interview; collaboration meetings; document review	An energy innovation center.	Architect, owner's representative, construction manager, and mechanical, electrical, and plumbing designer.
6	Bruce et al. (2015) [68]	Australia	Office	Explore the barriers preventing investment in the reuse of low-grade multistory building stock.	Interview	Multiple organizations associated with commissioning retrofitting projects and an architectural firm.	Real estate manager, construction manager, developer, architect, asset manager, energy-efficiency retrofit advisor.
7	Gliedt and Hoicka (2015) [69]	United States	Mix commercial	Examine the decision-making process that leads to energy performance improvements.	Survey	178 professionals representing multiple commercial properties.	Property owners/ managers who have participated in the Energy Star program.
8	Haase et al. (2015) [43]	European countries	Mercantile	Define the drivers of retrofitting shopping centers.	Interview; survey	3 shopping centers.	Customers, tenants, owners, and managers.
9	Liang et al. (2015) [69]	China	Office	Integrate critical success factor analysis with stakeholders in energy-efficiency retrofit projects.	Interview; survey	16 experts involved in multiple retrofit projects.	Project director, technical specialist, purchasing specialist, designer, researcher, contract manager, contractor, auditor.
10	Yang et al. (2015) [70]	United States	Office	Identify the information requirements needed by integrated design teams during advanced energy retrofit design review meetings held in immersive settings.	Survey; discussion; document review	16 professionals for an old building being renovated with meeting spaces, offices, research, and monitoring labs.	Architect, energy modeling expert, integrated design group members.
11	Abdallah et al. (2016) [48]	United States	Public	Present an economic and greenhouse gas emission analysis of implementing various sustainable measures in rest area buildings.	Site visit; document review	6 rest area buildings.	Facility managers for collecting documents.

TABLE 2. Continued

No.	Research article	Region	Building type	Objective	Data collection	Case study and sample size	Participant characteristic
12	Andrews et al. (2016) [71]	United States	Mix commercial	Examine an implementation problem in regulating the pursuit of energy-efficient reuse of existing buildings.	Interview; focus groups; survey; document review	49 communities for the first survey from Pennsylvania, California, Colorado, Maryland, and Washington. 43 code officials in Pennsylvania for the second survey.	Municipal officials, regional building officials, building professionals.
13	Barnes and Parrish (2016) [7]	United States	Mix commercial	Describe the efforts of a multi-organization collaboration and their demonstration partners in developing a library of case studies that promote and facilitate energy efficiency in the small commercial buildings market and a case study template that standardized the library.	Document review	Multi-organization project team participating in the U.S. Department of Energy's "Better Buildings: Commercial Energy Efficiency Solutions" program.	Lawrence Berkeley National Laboratory; Architecture 2030; City of San Jose, Seattle 2030; District, Pittsburgh 2030; District, Cleveland 2030; District, Arizona State University.
14	Castleberry et al. (2016) [52]	United States	Education	Examine factors that may encourage or inhibit a public school district from adopting energy-saving technologies and practices.	Survey	97 survey responses representing 76 school districts in Oklahoma.	Representatives from the school districts.
15	Hou et al. (2016) [72]	China	Mix commercial	Comprehensively probe essential aspects associated with existing commercial building retrofit industry.	Interview; site visit; document review	Surveys in 4 pilot cities: Tianjin, Chongqing, Shenzhen, and Shanghai.	Local construction government, commercial building owners, energy management companies, and financial institutions (e.g., banks).
16	Komolafe et al. (2016) [61]	Nigeria	Office	Investigate the extent to which green building features are evident in office properties and determine compliance with green standards.	Interview; site visit	133 office properties, primarily multi-tenants for financial, recruitment, and manufacturing services.	Two users who were dealing with property operations and maintenance in the organization.
17	Kontokosta (2016) [55]	United States	Office	Examine the effects of ownership type, tenant demand, and market competitiveness on building energy retrofit decisions in the commercial office sector.	Survey	393 commercial properties managed by CB Richard Ellis, focusing on 19 cities.	Asset managers.
18	Liang et al. (2016) [53]	China	Mix commercial	Reveal the underlying logic of the industry's reluctance to conduct green retrofit by analyzing the behaviors of the building owners and occupiers, who are the direct decision-makers for initiating green retrofit at the initial intention phase.	Interview	19 experts from Hong Kong and Mainland China who have participated in green retrofit projects.	Project manager, designer, facility manager, contract manager, contractor, and third-party consultant authorized by the government to audit projects.
19	Mosgaard et al. (2016) [53]	Denmark	Lodging	Define the constellations of stakeholders that make energy renovations happen.	Interview; site visit	11 stakeholders involved in energy renovation of a small hotel.	Hotel manager, electricians, plumber, local bank managers, energy engineer, board members.

TABLE 2. Continued

No.	Research article	Region	Building type	Objective	Data collection	Case study and sample size	Participant characteristic
20	Valero et al. (2016) [4]	European countries	Mix commercial	Present the central insights of a new decision-support tool for local administrations developed under a pan-European project sponsored by the Climate Knowledge and Innovation Community.	Workshop; interview; meeting	103 interviews with potential tool users across the 9 countries.	Local authorities, service providers (e. g., network operators, ESCOs, construction and refurbishment companies, renewable energy developers, utilities, energy consultancy companies, urban planners or building construction materials' suppliers), citizen representatives.
21	AbdelAzim et al. (2017) [65]	Egypt	Mix commercial	Present the outcomes of a recent study among engineering professionals and academics to propose a criteria-based energy-efficiency rating system for existing buildings.	Survey	61 responses from Egyptian engineering professionals.	Engineering professionals with a background in green building concepts and rating systems or working in a field related to design and construction buildings.
22	Clancy et al. (2017) [45]	Ireland	Mix commercial	Identify the characteristics of commercial companies likely and unlikely to engage in energy-efficiency actions and identify the barriers to and drivers of energy efficiency.	Interview; survey	750 phone interviews across a statistically representative sample of commercial businesses in Ireland, including retail, hotels, public houses, restaurants, offices, warehouses, and storage.	Company representatives.
23	Curtis et al. (2017) [73]	Australia	Mix commercial	Report on a state government program in which the uptake of retrofit support program was lower than expected, prompting the program team to consider whether targeting facilities managers rather than building owners might be a better way of delivering the program.	Interview	10 interviews with facilities managers, with the draft of the findings reviewed by the CEO of the Facility Management Association of Australia (FMA).	Facilities managers that are members of the FMA.
24	Ginks and Painter (2017) [74]	UK	Historic building	Investigate how conservation professionals in the UK approach and sanction energy retrofit measures in historic buildings.	Survey; interview; document review	52 survey responses, 7 interviews (4 from England, 2 from Scotland, and 1 from Wales), and 7 local authority databases.	UK conservation professionals.
25	Kim et al. (2017) [75]	United States	Office	Identify key adaptive-management strategies during the lighting retrofit process on one floor of an existing office building.	Survey; focus group interview	40 occupant survey responses and 6 interview participants.	Real estate managers, occupant representatives, facility services managers who served communication liaisons during the planning, implementation, and calibration of the new system.
26	Masrom et al. (2017) [76]	Malaysia	Mix commercial	Identify the potential barriers and drivers that influence commercial building owners' decisions to implement sustainable refurbishment.	Interview	4 managers from 4 commercial office buildings.	Building manager, building executive, facility manager, assistant building manager.

TABLE 2. Continued

No.	Research article	Region	Building type	Objective	Data collection	Case study and sample size	Participant characteristic
27	Mohammad-pour et al. (2017) [50]	United States	Health Care	Investigate current practices of retrofitting healthcare facilities, particularly focusing on patient safety and energy efficiency.	Meetings; phone calls; emails; interviews	33 interview participants from 3 healthcare facilities.	Head of the facilities departments, project managers, project engineers, safety experts, energy experts, and the contractor's project managers or engineers.
28	Nguyen et al. (2017) [56]	Vietnam	Mix commercial	Examine the interactive effect of participants' characteristics (experience, knowledge, and roles) on sustainable building practices in conventional buildings.	Interview; survey	7 interview participants and 169 surveys.	Owner representatives (senior executive, division head), constructor (executive, construction manager), designer (architect, division head), construction professionals.
29	Roberti et al. (2017) [62]	Italy	Historic building	Present a methodology that identified a variety of optimal retrofits for historical buildings, taking into account energy savings, thermal comfort, and the whole range of conservation compatibility.	Survey	10 Italian experts (2 heritage authorities, 3 conservators, 5 university professors of restoration).	All experts were architects who specialized in the refurbishment of historic buildings, with many years of experience in cultural heritage.
30	Strachan and Banfill (2017) [77]	UK	Mix commercial	Identify the attributes that professionals consider important in selecting energy performance improvement measures and establishing their relative importance.	Survey	13 experts among the membership of a private sector industry-led environmental forum and from public-sector agencies.	Architecture, engineering, and facilities management qualifications with experience within at least one of these sectors: client, guidance, heritage, industry, non-heritage.
31	Tsai et al. (2017) [78]	Taiwan	Mix commercial	Clarify the decision-making considerations of planners for improving the openings of existing buildings.	Survey; interview	A representative for each of the 7 townhouses and 1 condominium.	Government-assigned counselors, designers, and owners proposing retrofitting strategies.
32	Zuhaib et al. (2017) [57]	Ireland	Mix commercial	Assess the attitudes, approaches, and experiences of construction professionals regarding energy-efficient buildings, particularly net-zero energy buildings.	Survey; workshop; interview	90 surveys, 85 workshop participants, and 11 interviews.	Net-zero energy building experts, policy stakeholders, market players for envelopes.
33	Bertone et al. (2018) [49]	Australia	Public	Identify the main challenges and coping strategies for accelerating the retrofitting rate of public buildings.	Workshop; interview; scenario modeling	Interview with experts in the country, including 2 in Brisbane, 1 in Melbourne, and 2 in Perth. Workshops with 15 participants in Queensland and 29 participants in Western Australia.	Champions from the industry sectors, Australian state governments.
34	Christensen et al. (2018) [58]	United States	Office	Assess energy reporting, data tracking, and labeling preferences, and upgrade decision-making.	Interview	33 interviews representing institutional owners managing large portfolios.	Large scale property owners, investors, and managers. Typical respondents controlled a portfolio of 20–60 office buildings, and all made decisions related to energy performance and reporting.

TABLE 2. Continued

No.	Research article	Region	Building type	Objective	Data collection	Case study and sample size	Participant characteristic
35	Si and Marjanovic-Halburd (2018) [41]	UK, China	Mix commercial	Propose default criteria weights based on previously developed criteria tree organized around green technologies' environmental, economic, social, and technical performance.	Survey	25 survey responses from the UK and 29 from China.	Professionals working in the built environment and experienced in building retrofit, mainly with backgrounds from architecture, engineering, planning, and design.
36	Yang et al. (2018) [60]	United States	Office	Examine buildings that both had and had not adopted Leadership in Energy and Environmental Design or Energy Star in the New York metropolitan area.	Document review	205 building projects for 273 organizations (102 new construction and 103 renovated buildings) in New York City and the surrounding metro area.	Directories of office buildings in New York City from a private database, non-profit organization, and a federal agency.
37	Alam et al. (2019) [17]	Australia	Public	Understand how the public building retrofitting barriers differ from existing retrofitting barriers reported in the literature and identify the top barriers and associated coping strategies from the personnel employed within government departments or agencies.	Focus group discussion	2 focus groups in 2 states of Australia where public building retrofitting programs failed. 10 and 28 participants for the first and second focus groups.	Senior personnel in a government organization (i.e., director, manager, policy, and program officer) who have at least 10 years of experience in retrofit projects.
38	Fasna and Gunatilake (2019) [54]	Sri Lanka	Lodging	Explore the barriers and strategies that affect the successful implementation of building energy-efficiency retrofits in actual project-level executions.	Interview	11 respondents actively involved in the selected 2 cases from completed building energy efficiency retrofit projects in Sri Lankan hotel buildings.	Owner representatives (director-general manager, engineering manager, engineers, senior foreman, foreman, cost controller), contractor (assistant manager), consultant (chief technical advisor).
39	Kim et al. (2019) [59]	United States	Education	Understand the decision-making processes in energy-efficiency projects at a higher education institution, particularly the factors that facilities managers consider and their interrelationships.	Interview; document review	6 expert interviews who manage facilities services, housing and food services, campus engineering and operations, an office tower. Secondary data from occupant survey, university policy and practice, and city policy.	Resource conservation manager, capital planning and sustainability manager, assistant director, manager, supervisor.
40	Zheng et al. (2019) [63]	China	Mix commercial	Propose an investment prediction model for large-scale building energy-saving retrofit by considering owners' willingness factors that possess fuzzy attributes and random characteristics.	Survey	100 public buildings in Shanghai, including public institutions, hotels, shopping malls, and commercial offices.	Building owners.
41	Jimenez-Pulido et al. (2020) [79]	Spain	Mix commercial	Identify both the demands of the Spanish industry to improve the management of buildings and the contextual challenges of inspections.	Survey; panel discussion	52 experts who completed both rounds of the Delphi consultation.	Senior architects, engineers.

TABLE 2. Continued

No.	Research article	Region	Building type	Objective	Data collection	Case study and sample size	Participant characteristic
42	Tozer (2020) [42]	UK, Germany, United States	Mix commercial	Examine political effectiveness in implementing urban decarbonization initiatives.	Interview	40 interviews from case studies of urban building, low carbon governance in Stockholm, London, and San Francisco.	Representatives from the urban development industry, government, utilities, building owners, and nongovernmental organizations involved in building and energy decarbonization.

et al., 2016; Yang et al., 2018)), proposed a new methodology for optimal retrofit (e.g., (Komolafe et al., 2016; Roberti et al., 2017)), and evaluated new energy-efficiency programs or decision-support tools (e.g., (Zheng et al., 2019)).

Nineteen out of the 42 studies used qualitative methods for data collection, such as interviews, meetings, document review, panel discussions, site visits, focus group discussion, and workshops to assess participants' perceptions. Fifteen articles used a mix of quantitative and qualitative methods. The rarest method used was the quantitative method via survey, which was identified in eight papers. The case study sizes ranged from focusing on a single building case study (Gultekin et al., 2014) to covering the extensive building portfolio of a real estate firm located in multiple cities (Kontokosta, 2016). The study with the most participants was Clancy et al.'s (Clancy et al., 2017), which was comprised of 750 phone interviews that statistically represented diverse commercial businesses in Ireland. Experts and practitioners who participated in the studies through interviews, focus groups, and surveys worked in the built environment and held extensive experience in building retrofit projects. Professions that were represented included owner representatives (e.g., executives, facility managers, project managers, engineers), contractor representatives (e.g., managers, energy specialists), and consultants (e.g., technical advisors, architects). In addition, some studies required participants to have a particular experience depending on its study objectives. For example, a retrofit investment study of a historic building required perceptions from experts with many years of experience in cultural heritage (Roberti et al., 2017). Another study desired engineering professional participants with knowledge about green building concepts and rating systems when proposing a new energy-efficiency rating system for existing buildings (AbdelAzim et al., 2017). A few studies also included academic researchers for a specific building type (e.g., (Xu et al., 2011)), government officials for public buildings and a regional case study (e.g., (Alam et al., 2019)), and occupants for a customer-centric type of building (e.g., (Haase et al., 2015)).

4.2. Content Analysis

This section discusses themes that emerged for criteria and factors influencing decisions to implement energy-efficiency retrofits.

4.2.1. Key factors based on assessment criteria: Based on the SLR of 42 selected articles, this study identified 30 key factors that influence the implementation of energy-efficiency retrofits. These factors can be grouped into seven decision criteria, each of which emerged in multiple articles: *economic feasibility* (EF; 32 articles), *team process* (TPro; 29 articles), *technical practicality* (TPra; 28 articles), *institutional characteristic* (IC; 27 articles), *governmental policy* (GP; 24 articles), *occupant impact* (OI; 24 articles), and *environmental impact* (EI; 17 articles). EF is considered

TABLE 3.—Summary of articles and codes on assessment criteria of building retrofit

No.	Research article	EF	TPro	TPra	IC	GP	EI	OI
1	Woodroof (2011) [5]		7			1		
2	Xu et al. (2011) [66]	7	8	2	3	1		
3	Zografakis et al. (2011) [67]	2	1	2	2		4	
4	Xu et al. (2012) [67]	2	2		2		1	1
5	Gultekin et al. (2014) [64]	1	2	2	1			2
6	Bruce et al. (2015) [68]	1	1	3	4	2		2
7	Gliedt and Hoicka (2015) [69]	2	1			1	1	
8	Haase et al. (2015) [43]	2	3		1			2
9	Liang et al. (2015) [69]	7	5	11	2	2		1
10	Yang et al. (2015) [70]	2		2				
11	Abdallah et al. (2016) [48]	4					1	
12	Andrews et al. (2016) [71]					4		
13	Barnes and Parrish (2016) [7]	1				4		
14	Castleberry et al. (2016) [52]	4	3		1		1	
15	Hou et al. (2016) [72]		2	1		3		
16	Komolafe et al. (2016) [61]	1		1			10	
17	Kontokosta (2016) [55]	9	1	3	5		1	1
18	Liang et al. (2016) [53]	13	4	1	1	4		2
19	Mosgaard et al. (2016) [53]	2	2	1			1	
20	Valero et al. (2016) [4]	1	5			4		
21	AbdelAzim et al. (2017) [65]			3	1		4	
22	Clancy et al. (2017) [45]		4		2			3
23	Curtis et al. (2017) [73]	3	2	1	1	1		1
24	Ginks and Painter (2017) [74]	1	2	10	5	3		1
25	Kim et al. (2017) [75]		2	1				
26	Masrom et al. (2017) [76]	5	2		2	2	1	2
27	Mohammadpour et al. (2017) [50]							5
28	Nguyen et al. (2017) [56]		4	2	3	1	21	9
29	Roberti et al. (2017) [62]	1		4				1
30	Strachan and Banfill (2017) [77]	5	1	6	2		3	5
31	Tsai et al. (2017) [78]	1		3	1	1		1
32	Zuhaib et al. (2017) [57]	6	10	8	4	7	3	3
33	Bertone et al. (2018) [49]	4	7	1	1	4		1
34	Christensen et al. (2018) [58]	12	2	6	7	1	2	3
35	Si and Marjanovic-Halburd (2018) [41]	5		6	3		4	3
36	Yang et al. (2018) [60]		2					
37	Alam et al. (2019) [17]	14	21	12	11	16		1
38	Fasna and Gunatilake (2019) [17]	3	18	9	3	3		2
39	Kim et al. (2019) [59]	9	3	8	4	4	4	3
40	Zheng et al. (2019) [63]	5		5	2	1		
41	Jimenez-Pulido et al. (2020) [79]	1		10	4	1	1	1
42	Tozer (2020) [42]					3		
	Number of codes	136	127	124	78	74	63	56

most important and has a strong interrelationship with other criteria, meaning that a change in financial performance can affect the performance of other criteria. EI criterion is mentioned least as an influencer of retrofit decisions. Table 3 summarizes the total number of articles and the frequency of the assessment criteria being coded. The following sections discuss the primary factors under each assessment criteria that influence retrofit decisions.

EF—life cycle cost. Factors related to EF were observed in 32 of 42 articles reviewed (76%) and included life cycle cost, funding mechanism, payback period, and profit distribution. The participants across the literature consistently indicated that energy-efficiency improvements were ultimately made based on financial decisions. The primary factor under this criterion is life cycle cost, covering 74 of 136 codes (54%). The coded statements from the reviewed articles indicated that life cycle cost was seen as a critical measure of success. The high upfront cost of technology installation (Castleberry et al., 2016; Haase et al., 2015; Zuhaib et al., 2017), uncertainty in improving building value and rent (Fasna & Gunatilake, 2019; Liang et al., 2016), and financial risks of savings overestimation (Bertone et al., 2018; Bruce et al., 2015) are some barriers related to life cycle cost that hinder retrofit implementation. Participants across the reviewed literature often noted that a retrofit project can be implemented if it can generate an economic return. A retrofit realization can be driven by pursuing affordable retrofitting cost (Tsai et al., 2017) by starting with more minor, simple, low to no-cost improvements (Christensen et al., 2018). Other retrofits requiring significant capital investment can then be considered when financial incentives become available and the affordable retrofit projects prove to be a cost benefit within a short payback period (Christensen et al., 2018). While financial incentives help encourage retrofits, barriers associated with split incentives among stakeholders are highlighted in the reviewed literature. For example, when the government department tenant does not receive enough incentive to retrofit when public buildings are leased, ad-hoc financing mechanisms such as environmental upgrade finance could help address the split-incentives issue [49]. Energy-efficiency investment that can provide attractive economic returns through reduced building energy bills for tenants and higher rents for building owners will drive more implementation of energy-efficiency retrofits (Kontokosta, 2016).

TPro—coordination and collaboration. Factors categorized under TPro were mentioned in 29 of 42 articles reviewed (69%) and included coordination and collaboration, expert skills, management leadership, and team training. The primary factor is coordination and collaboration, covering 54 of 127 codes (43%). Some barriers to retrofits discussed regarding coordination and collaboration include lack of quality management system (Hou et al., 2016); weak negotiation power (Liang et al., 2016); the reluctance of energy companies to share data (Valero et al., 2016); lack of trust and good relationships (Woodroof, 2011; Xu et al., 2011); potential high coordination cost (Liang et al., 2016); lack of involvement of experts, owners, and occupiers, which leads to conflicting opinions (Bertone et al., 2018; Zuhaib et al., 2017); an unsystematic way of making decisions [54]; and difficulties in establishing communication between parties (Fasna & Gunatilake, 2019). Improving the project organization process is a key success factor to effective coordination. Senior leadership should involve multidisciplinary stakeholders, including facility managers and engineers, throughout the process as the key decision-makers who directly interact with the day-to-day building operations and the occupants [35]. Recommendations from the reviewed articles suggest the need to perform project management under internationally recognized systems, communicate the program's goals and progress across stakeholders through eco-charrette to formulate a shared vision and produce a preventive maintenance plan (Alam et al., 2019; Kim et al., 2017; Xu et al., 2011).

TPra—system compatibility. TPra factors were identified in 28 of 42 articles reviewed (67%) and included system compatibility, risk management, project integration, technology readiness, site accessibility, and procurement process. Under this criterion, the most cited factor was system compatibility, covering 43 of 124 codes (35%). The physical limits on the types of energy-efficiency technologies that can be installed (Ginks & Painter, 2017; Jimenez-Pulido et al., 2020; Kontokosta, 2016), lack of spare parts for older equipment that requires major disruptions (Curtis et al., 2017), and lack of availability of one-stop solutions (Zuhaib et al., 2017) were some of the main concerns discussed by participants across the studies. Constructability, ease of installation, and functionality of the retrofit technology are critical in fueling stakeholders' confidence to invest in energy-efficiency improvement (Mosgaard et al., 2016; Strachan & Banfill, 2017; Tsai et al., 2017). Evaluating the existing building condition and its environment and improving the inspection processes (Jimenez-Pulido et al., 2020; Liang et al., 2015) should be an essential step to minimize system compatibility issues during retrofitting.

IC—internal value. Factors related to IC—including internal value, demand pressure, community engagement, and reputation—were observed in 27 of 42 articles reviewed (64%). Internal value is mentioned the most, covering 30 of 78 codes under IC (38%). It is well known that companies may not see reducing energy use as a top priority when investing capital. In fact, participants in some studies even perceived energy-efficiency retrofits as work that could harm the value of their organization or building. For example, historic building experts are concerned that retrofits are insensitive toward architectural and cultural aspects (Zuhaib et al., 2017). They could lead to a loss of historical material and might not maintain the building's heritage value (Ginks & Painter, 2017; Jimenez-Pulido et al., 2020; Zuhaib et al., 2017). A case study in Australia showed that building code development such as fire safety and disability access prevented heritage-listed buildings from being renovated for reuse because they became significantly more expensive to retrofit (Bruce et al., 2015). In another study, Ginks and Painter found a regional variation: conservation professionals in Scotland had different perceptions about energy retrofits in historic buildings than conservation professionals throughout the rest of the UK (Ginks & Painter, 2017). Consequently, overcoming this gap in knowledge and beliefs should be a priority when considering potential added value for all stakeholders. For example, most companies in a U.S.-based study believed eco-labels and energy ratings add value to their real estate assets by attracting the market and identifying improved energy performance (Christensen et al., 2018). When retrofitting historic buildings, conservation professionals and heritage agencies are encouraged not to view energy-efficiency renovations as modernizing the facilities but rather as ensuring the buildings' long-term survival (Ginks & Painter, 2017).

GP—government commitment. Factors related to the GP were identified in 24 of 42 articles reviewed (57%); they included government commitment, standards and regulations, information sharing, and political influence. Government commitment is the most crucial factor, with 31 of 74 codes identified from the article (42%). Barriers to retrofits cited in the literature included lack of energy code enforcement and efficiency (Andrews et al., 2016), lack of citizen education (Valero et al., 2016), delays in getting approval from the local authority (Fasna & Gunatilake, 2019), and lack of knowledge and support of high-level government officials responsible for introducing retrofit programs (Alam et al., 2019). That study [17] further expressed concerns that energy-efficiency retrofits are not a priority unless the state government mandates them. Ensuring that the mandated target is realistic and is followed by clear guidelines is necessary for a successful mandate. Further, the commitment to the energy-saving program should also start at the implementation phases (Woodroof, 2011).

OI—satisfaction and wellbeing. Factors related to OI—including satisfaction and wellbeing, health and safety, educational program, and energy-efficient behavior—were mentioned in 24 of 42 articles reviewed (57%). Satisfaction and wellbeing were discussed the most, with 21 of 56 codes identified (38%). Key barriers to retrofits that were cited include interrupting productivity and complaints from tenants (Curtis et al., 2017; Strachan & Banfill, 2017). One study in a hospital setting focused on understanding the impact on patients during the construction phase of retrofitting (Mohammadpour et al., 2017). Three case studies of healthcare facilities indicated various patient safety and wellbeing issues included noise, vibration, coordination, dust, and asbestos. The study suggested that considering input from the occupants as end-users during the design phase will improve current practices.

EI—eco-friendly installation. Factors included in EI, such as eco-friendly installation, carbon dioxide emissions, sustainable resources, and waste management, were observed in 17 of 42 articles reviewed (40%). The primary factor under this criterion, covering 28 of 63 codes identified (44%), is eco-friendly installation, which explores the feasibility of implementing various energy-efficiency improvement strategies with an environmental emphasis. Examples include eco-friendly refrigerants and fire suppression systems (AbdelAzim et al., 2017), use of reused building materials in the project (Nguyen et al., 2017), and use of materials with recycled content (Jin & Marjanovic-Halburd, 2018; Nguyen et al., 2017). An empirical study about sustainable building practices in Vietnam suggested the need to provide green building-related training to experienced practitioners to successfully implement various sustainable building applications in conventional buildings (Nguyen et al., 2017).

4.2.2. Key factors based on diverse regions and building types: This section discusses the 30 factors mentioned in the selected articles that apply across different regions and building types.

Factors by regions. Table 4 shows factors influencing retrofit decisions that emerged in different regions. Seventeen regions around the world were used as case study locations within the selected literature. Three factors discussed in most regions included life cycle cost (14 regions), system compatibility (11 regions), and coordination and collaboration (10 regions). China, the United States, Australia, and the UK cover most of the 30 identified factors; 27 factors emerged in China and the United States, while 23 factors emerged in studies in Australia and the UK. Denmark and Egypt explored the least number of factors—only four factors each. This observation is in line with the number of articles that explored these regions. The studies are more concentrated in the United States and China, with 14 articles undertaken in the United States and six articles in China, resulting in 90% of the factors identified for each country. In contrast, Denmark and Egypt were only represented by one article each, limiting the representation of more diverse factors for these countries (13%).

Although research articles are primarily from developed countries with higher per capita income than developing countries, both types of countries see EF criteria that focuses on life cycle cost and funding mechanisms as the most dominant considerations. However, some differences in concern exist between developed and developing economies. Studies featuring developing economies raised more concerns about TPra, IC, and GP (85%, 85%, and 69% of the articles) when considering retrofit projects than did developed economies (60%, 57%, and 50% of the articles). Fig. 6 summarizes the percentage of articles that mentioned each decision factor. In studies conducted in developing economies, TPra issues were emphasized for risk management, technology readiness, and system compatibility (54%, 38%, and 38%). In studies conducted in developed economies, the most discussed factor was system compatibility (43%), while risk management and technology readiness were only mentioned in 20% of the articles. Issues related to standards and regulation were more emphasized when considering retrofit projects in developing economies than in developed economies. This finding is consistent with Liang et al. (Liang et al., 2015), who found that government and policy factors are significantly important in energy-efficiency retrofits in China, unlike another study in Australia that indicated the limited role of the government in green building development (Yang & Zou, 2014). However, the impact of political influence in retrofit implementation was discussed in 3 of the 30 studies conducted in developed countries, yet it was not mentioned in any of the 13 studies conducted in developing countries.

Factors by building types. Table 5 demonstrates how the factors influencing retrofit decisions are represented in eight building types identified in the reviewed articles. Like the representation by region, life cycle cost is the factor most discussed across diverse building types; it is mentioned for seven out of eight building types used in the literature. It is followed closely by expert skills, risk management, demand pressure, internal value, and satisfaction and wellbeing, which are equally identified in six building types. Research articles using mix commercial buildings represented the most identified factors (28 of 30 factors), followed by offices (25 factors) and education and lodging (23 factors each). Healthcare facilities covered only

TABLE 4.—Factors influencing retrofit by region

Factor	Australia	China	Denmark	Egypt	EU countries	Germany	Greece	Ireland	Italy	Malaysia	Nigeria	Spain	Sri Lanka	Taiwan	United Kingdom	United States	Vietnam
EF																	
Life cycle cost	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Payback period	✓	✓													✓	✓	
Funding mechanism	✓	✓			✓		✓	✓		✓					✓	✓	
Profit distribution	✓	✓						✓								✓	
TPro																	
Expert skills	✓	✓			✓			✓		✓			✓		✓	✓	✓
Management leadership	✓	✓						✓					✓			✓	
Team training	✓	✓			✓								✓			✓	
Coordination and collaboration	✓	✓	✓		✓		✓	✓					✓		✓	✓	✓
TPra																	
System compatibility	✓	✓					✓	✓	✓			✓	✓	✓	✓	✓	✓
Project integration		✓		✓								✓		✓	✓	✓	
Site accessibility	✓	✓											✓		✓	✓	
Procurement process	✓												✓				
Risk management	✓	✓						✓			✓		✓		✓	✓	
Technology readiness		✓	✓					✓				✓	✓		✓	✓	
IC																	
Reputation	✓	✓					✓			✓					✓	✓	
Demand pressure	✓	✓			✓					✓					✓	✓	
Community engagement	✓	✓		✓			✓	✓				✓	✓		✓		✓
Internal value	✓	✓						✓				✓		✓	✓	✓	
GP																	
Government commitment	✓	✓			✓			✓					✓		✓	✓	
Standard and regulation	✓	✓						✓		✓		✓		✓	✓	✓	✓
Information sharing	✓	✓			✓			✓					✓			✓	
Political influence	✓				✓	✓									✓	✓	
OI																	
Educational program	✓	✓			✓			✓		✓					✓	✓	✓
Energy-efficient behavior		✓						✓					✓			✓	
Satisfaction and wellbeing	✓	✓						✓	✓				✓	✓	✓	✓	✓
Health and safety	✓	✓						✓				✓			✓	✓	✓
EI																	
Sustainable resources			✓	✓			✓	✓			✓					✓	✓
Eco-friendly installation		✓		✓			✓				✓				✓		✓
Waste management		✓									✓				✓	✓	✓
CO_2 emissions		✓						✓		✓		✓			✓	✓	

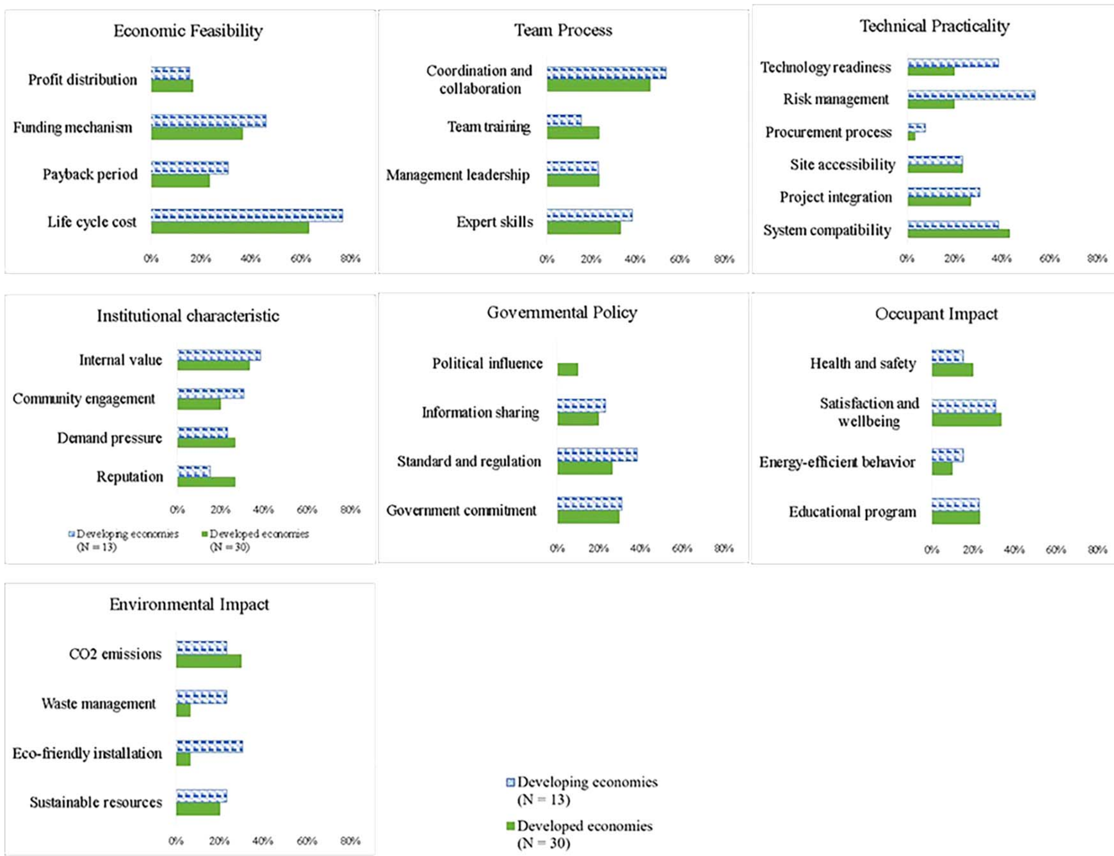

FIGURE 6.—Percentage of articles with criteria influencing retrofit decisions

two of 30 factors, including satisfaction and wellbeing and health and safety. Only one article used a healthcare facility as the case study; thus, this finding does not imply that other factors were not considered by the owners and managers of healthcare buildings. Instead, additional studies that focus on this building may reveal a more comprehensive list of factors considered.

5. CONCLUSIONS AND FUTURE RESEARCH

This SLR aimed to investigate what peer-reviewed articles worldwide have published on stakeholders' perceptions of energy-efficiency retrofits in buildings. This paper identified seven assessment criteria commonly used when considering a retrofit investment: economic feasibility (e.g., life cycle cost), team process (e.g., coordination and collaboration), technical practicality (e.g., system compatibility), institutional characteristic (e.g., internal value), governmental policy (e.g., government commitment), occupant impact (e.g., satisfaction and wellbeing), and environmental impact (e.g., eco-friendly installation). Though much overlap in factors influencing decisions to retrofit exists, the focus of considerations may not be uniform across different contexts, such as across regions, between developing and developed economies, and across building types. Nevertheless, substantial discussions and strong internal dependencies among many of these factors (Kim et al., 2019) suggest that comprehensive retrofitting strategies considering the seven criteria might accelerate the energy-efficiency improvements of the commercial and institutional building stock. The novelty of this research lies in it having explored comprehensive factors in commercial and institutional buildings from multi-context perspectives, unlike previous SLRs on energy-efficiency retrofit decisions.

The findings of the reviewed articles highlight common challenges and recommendations that can be summarized according to three key stakeholder groups. First, industry practitioners (e.g., facility managers, consultants, contractors) play a critical role in successful retrofit projects. Organizations should support improving the knowledge of their personnel at all levels about the evolving field of energy-efficiency improvements by exposing them to training that supplies them with credentials and know-how skills. In this way, stakeholders can address many challenges in retrofitting, such as concerns about the technical capabilities, lack of management leadership, and ineffective communication. Decision-makers should encourage collaboration with multiple disciplines. For example, inviting heritage experts when retrofitting historic buildings or healthcare specialists when retrofitting hospital buildings throughout various project phases

TABLE 5.—Factors influencing retrofit by building type

Factor	Education	Health Care	Lodging	Mercantile	Office	Mix commercial	Historic building	Public
EF								
Life cycle cost	✓		✓	✓	✓	✓	✓	✓
Payback period	✓				✓	✓		✓
Funding mechanism	✓		✓		✓	✓		✓
Profit distribution			✓		✓	✓		✓
TPro								
Expert skills	✓		✓		✓	✓	✓	✓
Management leadership	✓		✓		✓	✓		✓
Team training	✓		✓	✓	✓			✓
Coordination and collaboration	✓		✓		✓	✓		✓
TPra								
System compatibility	✓		✓		✓	✓	✓	
Project integration	✓				✓	✓	✓	
Site accessibility	✓		✓		✓	✓		✓
Procurement process			✓					✓
Risk management	✓		✓		✓	✓	✓	✓
Technology readiness	✓		✓		✓	✓		
IC								
Reputation	✓		✓		✓	✓		
Demand pressure	✓			✓	✓	✓	✓	✓
Community engagement			✓			✓		✓
Internal value	✓		✓		✓	✓	✓	✓
GP								
Government commitment	✓		✓			✓	✓	✓
Standard and regulation	✓				✓	✓	✓	✓
Information sharing			✓			✓		✓
Political influence						✓		✓
OI								
Educational program	✓			✓	✓	✓		✓
Energy-efficient behavior	✓		✓		✓	✓		
Satisfaction and wellbeing	✓	✓	✓		✓	✓	✓	
Health and safety		✓	✓		✓	✓		
EI								
Sustainable resources	✓		✓		✓	✓		
Eco-friendly installation			✓		✓	✓		
Waste management	✓				✓	✓		
CO_2 emissions	✓		✓		✓	✓		✓

EF: Economic Feasibility; TPro: Team Process; TPra: Technical Practicality; IC: Institutional Characteristic; GP: Governmental Policy; OI: Occupant Impact; EI: Environmental Impact

allows the team to consider the varying priorities and added values in retrofitting.

Second, building occupants have not been very included as study participants in most reviewed articles, although they may have important insights about energy retrofitting. This finding is consistent with another literature review study that found that occupant behaviors and preferences are still not well incorporated into the research and development of retrofitting measures in housing (Ortiz et al., 2020). Building owners and managers should be inclusive and involve the occupants and the community directly affected by the projects, especially during the planning phase rather than after completing the project. Early identification of the impacts of retrofit on the occupants and their expectations may address concerns such as energy consumptive behavior due to lack of knowledge among tenants, disruption to occupants' productivity during retrofit activities, tenant retention, and health and safety impact. Building owners should provide access to energy-efficiency education by supplying a building user manual and occupant training for the new system. Moreover, the project team should continuously communicate the progress to the occupants to increase acceptance of the project and help ensure the retrofitted building achieves the intended energy-efficiency improvement.

Third, government agencies are critical players in facilitating energy-efficiency projects that provide clear regulations and set an example by retrofitting public facilities. Concerns mentioned included lack of energy code enforcement, lack of access to comprehensive and consistent information about achieving energy targets, a mismatch between retrofitting projects and the timeframe of political decisions, and a complex procurement process. Key strategies suggested throughout the reviewed articles include having a mandatory energy-efficiency retrofitting policy, flexible incentive programs, a dedicated financing mechanism, and dedicated teams to provide transparent information and facilitate organizations in preparing the business case.

The authors identified at least three needs for future studies based on this SLR's findings. First, building energy efficiency is a field of research that needs an interdisciplinary approach since it overlaps with the indoor environment and public health studies, as also suggested by Kim and Reed (Kim & Reed, 2020). Motivations for sustainable upgrades have been heavily advocated based on how buildings impact the environment. Although the environmental impact is an element to consider, this review indicates that it was not the most influential criteria driving the ultimate decisions of stakeholders. It is crucial to maintain the momentum of energy efficiency by addressing the message that it is a part of more extensive efforts that require an integrated framework to protect both the environment and the health of the humans who spend most of their time in the buildings. This recommendation is consistent with a recent study on the use of public health research to regulate new facilities to improve the pressing topics of public health and climate resilience (Carmichael et al., 2020). Holistically reviewing the building regulations would realize the importance of improving energy efficiency in buildings for climate resilience and public health.

Second, this paper highlights the need for further work to better contextualize the energy-efficiency improvements through research among more diverse regions, building types, and stakeholders. This literature review is based on 42 recent articles, most of which concern the United States and China and which use mixed commercial buildings as the majority of case studies. Opportunities exist for more quantitative and qualitative studies concerning other geographical locations (e.g., developing countries), building types (e.g., hospitals), and multidisciplinary stakeholders (e.g., physicians in health care projects) that have not been well represented in this review. Additional research in other less explored contexts can help clarify the findings in this literature study or supply new elements to the current extensive list of factors. In addition, this SLR was limited in scope to peer-reviewed research articles in academic journals. Future research can expand the knowledge in understanding factors associated with implementing energy-efficiency retrofits by assessing reports, books, and gray literature.

This review calls attention to explore and document the planning, implementation, and evaluation of energy efficiency programs that continue to evolve with technological advancement and sophisticated contracting methods. Institutions worldwide have demonstrated more commitment to supporting clean energy transition through increased grant opportunities. Grant funding improves economic feasibility and encourages further capital investment to reduce carbon emissions, including through the implementation of energy efficiency programs. Finally, as found through this study and discussed in the paper, meeting the cost-effectiveness criteria is the key driver and deterrent to investing in energy efficiency. Future research should identify best practices for building energy domain experts to work in partnership with financing institutions and project developers to create innovative financing solutions.

ACKNOWLEDGMENTS

The graduate student researcher (Lysandra A. Medal) received support from the Indonesia Endowment Fund for Education. The authors thank Diana Louden for assistance in determining relevant search terms and strategies for the SLR.

REFERENCES

Abdallah, M., El-Rayes, K., & Liu, L. (2016). Economic and GHG Emission Analysis of Implementing Sustainable Measures in Existing Public Buildings. *Journal of Performance of Constructed Facilities*, 30(6), 04016055.

AbdelAzim, A. I., Ibrahim, A. M., & Aboul-Zahab, E. M. (2017). Development of an energy efficiency rating system for existing buildings using Analytic Hierarchy Process–The case of Egypt. *Renewable and Sustainable Energy Reviews*, 71, 414–425.

Ahmed, A., McGough, D., & Mateo-Garcia, M. (2017). Testing Innovative Technologies for Energy-Efficiency: Coventry University as a Living Lab. *The International Journal entrepreneurship and sustainability issues*, 4(3).

Alam, M., Zou, P. X. W., Stewart, R. A., Bertone, E., Sahin, O., Buntine, C., & Marshall, C. (2019). Government championed strategies to overcome the barriers to public building energy efficiency retrofit projects. *Sustainable Cities and Society*, 44, 56–69.

Andrews, C. J., Hattis, D., Listokin, D., Senick, J. A., Sherman, G. B., & Souder, J. (2016). Energy-efficient reuse of existing commercial buildings. *Journal of the American Planning Association*, 82(2), 113–133.

Ascione, F., Bianco, N., De Masi, R. F., de'Rossi, F., & Vanoli, G. P. (2015). Energy retrofit of an educational building in the ancient center of Benevento. Feasibility study of energy savings and respect of the historical value. *Energy and Buildings*, 95, 172–183.

Barnes, E., & Parrish, K. (2016). Small buildings, big impacts: The role of small commercial building energy efficiency case studies in 2030 Districts. *Sustainable Cities and Society*, 27, 210–221.

Berg, F., Flyen, A.-C., Godbolt, Å. L., & Broström, T. (2017). User-driven energy efficiency in historic buildings: A review. *Journal of Cultural Heritage*, 28, 188–195.

Bertone, E., Stewart, R. A., Sahin, O., Alam, M., Zou, P. X. W., Buntine, C., & Marshall, C. (2018). Guidelines, barriers and strategies for energy and water retrofits of public buildings. *Journal of Cleaner Production*, 174, 1064–1078.

Bruce, T., Zuo, J., Rameezdeen, R., & Pullen, S. (2015). Factors influencing the retrofitting of existing office buildings using Adelaide, South Australia as a case study. *Structural Survey*, 33(2), 150–166.

Carmichael, L., Prestwood, E., Marsh, R., Ige, J., Williams, B., Pilkington, P., Eaton, E., & Michalec, A. (2020). Healthy buildings for a healthy city: Is the public health evidence base informing current building policies? *Science of the Total Environment*, 719, 137146.

Carpenter, D., & Hoppszallern, S. (2011). *Advancing Efficiency: 2011 hospital energy management survey*.

Castleberry, B., Gliedt, T., & Greene, J. S. (2016). Assessing drivers and barriers of energy-saving measures in Oklahoma's public schools. *Energy Policy*, 88, 216–228.

Christensen, P. H., Robinson, S. J., & Simons, R. A. (2018). The influence of energy considerations on decision making by institutional real estate owners in the U.S. *Renewable and Sustainable Energy Reviews*, 94, 275–284.

Clancy, J., Curtis, J., & O'Gallachóir, B. P. (2017). What are the factors that discourage companies in the Irish commercial sector from investigating energy saving options? *Energy and Buildings*, 146, 243–256.

Colling, J. (2003). Demystifying the clinical nursing research process: the literature review. *Urologic Nursing*, 23(4), 297–299.

Curtis, J., Walton, A., & Dodd, M. (2017). Understanding the potential of facilities managers to be advocates for energy efficiency retrofits in mid-tier commercial office buildings. *Energy Policy*, 103, 98–104.

Darko, A., Zhang, C., & Chan, A. P. (2017). Drivers for green building: A review of empirical studies. *Habitat international*, 60, 34–49.

EIA. *Building Type Definitions*. Energy Information Administration Retrieved from https://www.eia.gov/consumption/commercial/building-type-definitions.php

EIA. (2019). *Global energy consumption driven by more electricity in residential, commercial buildings*.

Fasna, M. F. F., & Gunatilake, S. (2019). Overcoming barriers for building energy efficiency retrofits: insights from hotel retrofits in Sri Lanka. *Built Environment Project and Asset Management*, 9(2), 277–295.

Fu, Y., Kok, R. A., Dankbaar, B., Ligthart, P. E., & van Riel, A. C. (2018). Factors affecting sustainable process technology adoption: A systematic literature review. *Journal of Cleaner Production*, 205, 226–251.

Ginks, N., & Painter, B. (2017). Energy retrofit interventions in historic buildings: Exploring guidance and attitudes of conservation professionals to slim double glazing in the UK. *Energy and Buildings*, 149, 391–399.

Gultekin, P., Anumba, C. J., & Leicht, R. M. (2014). Case study of integrated decision-making for deep energy-efficient retrofits. *International Journal of Energy Sector Management*, 8(4), 434–455.

Haase, M., Skeie, K. S., & Woods, R. (2015). The Key Drivers for Energy Retrofitting of European Shopping Centres. *Energy Procedia*, 78, 2298–2303.

Hashempour, N., Taherkhani, R., & Mahdikhani, M. (2020). Energy performance optimization of existing buildings: A literature review. *Sustainable Cities and Society*, 54, 101967.

Hou, J., Liu, Y., Wu, Y., Zhou, N., & Feng, W. (2016). Comparative study of commercial building energy-efficiency retrofit policies in four pilot cities in China. *Energy Policy*, 88, 204–215.

Jimenez-Pulido, C., Jimenez-Rivero, A., & Garcia-Navarro, J. (2020). Sustainable management of the building stock: A Delphi study as a decision-support tool for improved inspections. *Sustainable Cities and Society*, 61.

Jin, S., & Marjanovic-Halburd, L. (2018). Criteria weighting for green technology selection as part of retrofit decision making process for existing non-domestic buildings. *Sustainable Cities and Society*, 41, 625–638.

Johns, G. (2006). The essential impact of context on organizational behavior. *Academy of management review*, 31(2), 386–408.

Karawita, S., & Withanage, K. (2013). *Greening Sri Lanka hotels*. http://greeningsrilankahotels.org/userfiles/Research_Report_Final_2_.pdf

Khan, K. S., Kunz, R., Kleijnen, J., & Antes, G. (2003). Five steps to conducting a systematic review. *Journal of the royal society of medicine*, 96(3), 118–121.

Kim, A. A., McCunn, L. J., & Lew, J. (2017). Successful facility change-management practices for retrofit projects: case study in lighting. *Journal of Management in Engineering*, 33(4), 05017001.

Kim, A. A., & Reed, D. A. (2020). Interdisciplinary Approach to Building Functionality for Weather Hazards. *Risk Analysis*.

Kim, A. A., Sunitiyoso, Y., & Medal, L. A. (2019). Understanding facility management decision making for energy efficiency efforts for buildings at a higher education institution. *Energy and Buildings*, 199, 197–215.

Komolafe, M. O., Oyewole, M. O., & Kolawole, J. T. (2016). Extent of incorporation of green features in office properties in Lagos, Nigeria. *Smart and Sustainable Built Environment*.

Kontokosta, C. E. (2016). Modeling the energy retrofit decision in commercial office buildings. *Energy and Buildings*, 131, 1–20.

Less, B., Fisher, J., & Walker, I. (2012). *Deep Energy Retrofits-Eleven California Case Studies*.

Li, Y., O'Donnell, J., García-Castro, R., & Vega-Sánchez, S. (2017). Identifying stakeholders and key performance indicators for district and building energy performance analysis. *Energy and Buildings*, 155, 1–15.

Liang, X., Peng, Y., & Shen, G. Q. (2016). A game theory based analysis of decision making for green retrofit under different occupancy types. *Journal of Cleaner Production*, 137, 1300–1312.

Liang, X., Shen, G. Q., & Guo, L. (2015). Improving Management of Green Retrofits from a Stakeholder Perspective: A Case Study in China. *International Journal of Environmental Research and Public Health*, 12(11), 13823.

Lidelöw, S., Örn, T., Luciani, A., & Rizzo, A. (2019). Energy-efficiency measures for heritage buildings: A literature review. *Sustainable Cities and Society*, 45, 231–242.

Liu, G., Tan, Y., & Li, X. (2020). China's policies of building green retrofit: a state-of-the-art overview. *Building and Environment*, 169, 106554.

Ma, Z., Cooper, P., Daly, D., & Ledo, L. (2012). Existing building retrofits: Methodology and state-of-the-art. *Energy and Buildings*, 55, 889–902.

Maslesa, E., Jensen, P. A., & Birkved, M. (2018). Indicators for quantifying environmental building performance: A systematic literature review. *Journal of Building Engineering*, 19, 552–560.

Mayeda, A., & Boyd, A. (2020). Factors influencing public perceptions of hydropower projects: A systematic literature review. *Renewable and Sustainable Energy Reviews*, 121, 109713.

Medal, L., & Kim, A. (2020). Context-Driven Factors for Implementing Energy Efficiency Retrofit in a Portfolio of Buildings. ASCE Construction Research Congress, Tempe, Arizona.

Medal, L. A., Sunitiyoso, Y., & Kim, A. A. (2021). Prioritizing Decision Factors of Energy Efficiency Retrofit for Facilities Portfolio Management. *Journal of Management in Engineering*, 37(2), 04020109.

Meron, N., & Meir, I. A. (2017). Building green schools in Israel. Costs, economic benefits and teacher satisfaction. *Energy and Buildings* 154 (2017) 12–18, 154, 12–18.

Mills, E., Shamshoian, G., Blazek, M., Naughton, P., Seese, R. S., Tschudi, W., & Sartor, D. (2008). The business case for energy management in high-tech industries. *Energy Efficiency*, 1(1), 5–20.

Mohammadpour, A., Anumba, C. J., & Messner, J. I. (2017). Retrofitting of healthcare facilities: case study approach. *Journal of Architectural Engineering*, 23(3), 05017003.

Mosgaard, M. A., Kerndrup, S., & Riisgaard, H. (2016). Stakeholder constellations in energy renovation of a Danish Hotel. *Journal of Cleaner Production*, 135, 836–846.

Nations, U. (2019). *World Economic Situation and Prospects (WESP) 2019*. United Nations.

Naughton, P. (2000). Energy savings turn into cash flow savings. *Semiconductor Fabtech*, 15(3), 69–74.

Nguyen, H. D., Nguyen, L. D., Chih, Y.-Y., & Le-Hoai, L. (2017). Influence of Participants' Characteristics on Sustainable Building Practices in Emerging Economies: Empirical Case Study. *Journal of Construction Engineering and Management*, 143(8), 05017014.

Ortiz, M., Itard, L., & Bluyssen, P. M. (2020). Indoor environmental quality related risk factors with energy-efficient retrofitting of housing: A literature review. *Energy and Buildings*, 221, 110102.

Page, D. (2008). Systematic literature searching and the bibliographic database haystack. *Electronic Journal of Business Research Methods*, 6(2).

Paone, A., & Bacher, J.-P. (2018). The impact of building occupant behavior on energy efficiency and methods to influence it: A review of the state of the art. *Energies*, 11(4), 953.

Pombo, O., Rivela, B., & Neila, J. (2016). The challenge of sustainable building renovation: assessment of current criteria and future outlook. *Journal of Cleaner Production*, 123, 88–100.

Rao, V. V., Parameshwaran, R., & Ram, V. V. (2018). PCM-mortar based construction materials for energy efficient buildings: A review on research trends. *Energy and Buildings*, 158, 95–122.

Richards, L. (2020). *Handling qualitative data: A practical guide*. Sage Publications Limited.

Roberti, F., Oberegger, U. F., Lucchi, E., & Troi, A. (2017). Energy retrofit and conservation of a historic building using multi-objective optimization and an analytic hierarchy process. *Energy and Buildings*, 138, 1–10.

Rubin, R. S., Dierdorff, E. C., Bommer, W. H., & Baldwin, T. T. (2009). Do leaders reap what they sow? Leader and employee outcomes of leader organizational cynicism about change. *The Leadership Quarterly*, 20(5), 680–688.

Ruparathna, R., Hewage, K., & Sadiq, R. (2016). Improving the energy efficiency of the existing building stock: A critical review of commercial and institutional buildings. *Renewable and Sustainable Energy Reviews*, 53, 1032–1045.

Sesana, M. M., Grecchi, M., Salvalai, G., & Rasica, C. (2016). Methodology of energy efficient building refurbishment: application on two university campus-building case studies in Italy with engineering students. *Journal of Building Engineering*, 6, 54–64.

SLEMA. (2009). *Energy Management Guide*. Colombo: Sri Lanka Energy Managers Association

Strachan, M. E., & Banfill, P. F. (2017). Energy-led refurbishment of non-domestic buildings: ranking measures by attributes. *Facilities*, 35(5–6), 286–302.

Tozer, L. (2020). Catalyzing political momentum for the effective implementation of decarbonization for urban buildings. *Energy Policy*, 136, 1.

Tsai, I. C., Kim, Y., & Seike, T. (2017). Decision-making consideration in energy-conservation retrofitting strategy for the opening of existing building in Taiwan. *AIJ Journal of Technology and Design*, 23(55), 963–968.

Valero, V., Navarro, M., Mateo, C., & Tesseron-Stevelinck, S. (2016). ACCENT: a pan-European co-created tool to take refurbishment decisions at a city scale based on buildings' energy performance. WIT Transactions on Ecology and the Environment, 204, 65–76.

Woodroof, E. A. (2011). Selecting an Energy Consultant For Your "Energy Diet" Small and Large Facilities Have Different Priorities! *Strategic Planning for Energy and the Environment*, 30(3), 67–75.

Xu, P., Edwin Hon-Wan, C., & Qian, Q. K. (2011). Success factors of energy performance contracting (EPC) for sustainable building energy efficiency retrofit (BEER) of hotel buildings in China. *Energy Policy*, 39(11), 7389–7398.

Xu, P. P., Chan, E. H. W., & Qian, Q. K. (2012). Key performance indicators (KPI) for the sustainability of building energy efficiency retrofit (BEER) in hotel buildings in China. *Facilities*, 30(9-10), 432–448.

Yang, E., Hua, Y., & Diciccio, T. (2018). Diffusion of innovation in sustainable building practices and the role of stakeholders. *Journal of Green Building*, 13(4), 91–102.

Yang, R. J., & Zou, P. X. (2014). Stakeholder-associated risks and their interactions in complex green building projects: A social network model. *Building and Environment*, 73, 208–222.

Zedan, S., & Miller, W. (2018). Quantifying stakeholders' influence on energy efficiency of housing: development and application of a four-step methodology. *Construction Management and Economics*, 36(7), 375–393.

Zheng, D., Yu, L., Wang, L., & Tao, J. (2019). Integrating willingness analysis into investment prediction model for large scale building energy saving retrofit: Using fuzzy multiple attribute decision making method with Monte Carlo simulation. *Sustainable Cities and Society*, 44, 291–309.

Zou, P. X., Xu, X., Sanjayan, J., & Wang, J. (2018). Review of 10 years research on building energy performance gap: Life-cycle and stakeholder perspectives. *Energy and Buildings*, 178, 165–181.

Zuhaib, S., Manton, R., Hajdukiewicz, M., Keane, M. M., & Goggins, J. (2017). Attitudes and approaches of Irish retrofit industry professionals towards achieving nearly zero-energy buildings. *International Journal of Building Pathology and Adaptation*, 35(1), 16–40.