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Decarbonization of the Building Sector in Morocco – A Systematic Review

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ABSTRACT

This article is a systematic review of the decarbonization of the building sector in Morocco. It explores the different approaches and technologies used to reduce greenhouse gas emissions and achieve decarbonization targets in this sector. The article examines the policies and regulations in place in Morocco to encourage decarbonization of the building sector, as well as the initiatives taken by key actors to reduce carbon emissions in their buildings. It also reviews sustainable building technologies and renewable energy systems currently used in the country. The systematic review concludes that while Morocco has put in place policies and regulations to encourage the decarbonization of the building sector, there is still much to be done to achieve the ambitious decarbonization targets set by the country. The authors of the article recommend greater investment in sustainable building technologies and renewable energies, as well as increased collaboration between public and private sector actors to accelerate the transition to low-carbon buildings.

INTRODUCTION

According to the International Energy Agency (IEA) (Kober et al. 2020), the building sector is responsible for approximately 40% of energy consumption and 33% of global CO2 emissions. The global challenges of decarbonizing buildings are multiple and crucial to combat climate change and achieve the goals of the Paris Agreement. The building sector is indeed one of the largest emitters of greenhouse gases worldwide, responsible for around 40% of energy consumption and 33% of CO_2 emissions (Lowans et al. 2023).

In light of this reality, the need to decarbonize the building sector has become a priority for governments, businesses, and civil society. The challenges are even greater as the global population continues to grow, increasing the demand for housing and infrastructure. The rapid economic growth of emerging and developing countries such as China and India also significantly impacts construction and building demand (Gruenig & O'Donnell 2016).

Decarbonizing buildings also present significant economic opportunities, particularly in job creation in the construction, energy renovation, energy efficiency, and renewable energy sectors. Investments in these sectors can also generate long-term energy savings and reduce costs for households and businesses (Ugwu et al. 2022).

However, there are many challenges to be addressed in decarbonizing the building sector, including the high costs of innovative technologies and materials, the need for training and awareness-raising among construction stakeholders, the complexity of regulations and standards in different countries and regions, as well as the need to involve citizens and local communities in the energy transition (Sadeghian et al. 2021).

At the global level, initiatives have been launched to encourage the decarbonization of buildings, such as the Global Alliance for Buildings and Construction (GABC) and the Net Zero Carbon Buildings Commitment (González-Torres et al. 2022) initiative, which aims to achieve carbon neutrality in the building sector by 2050. However, more ambitious and concerted actions are needed to achieve the goals of the Paris Agreement and limit global warming to 1.5°C.

In Morocco (Ministry of Energy and Mines - Kingdom of Morocco 2020), the building sector accounts for about 25% of the country's final energy consumption. It is responsible for nearly 20% of the country's greenhouse gas emissions. This makes it a key sector for the country's energy transition. Despite Morocco's efforts and initiatives in renewable energy development, few studies have been conducted to evaluate specific efforts in the building sector. That's why this systematic literature review on decarbonizing buildings in Morocco is of great importance. It aims to identify the most effective practices for reducing GHG emissions in the building sector while highlighting the challenges and obstacles to overcome to support the energy transition. This study will thus identify benchmarks and numerical references in the field of decarbonizing buildings in Morocco based on

rigorous analysis of the available scientific literature on the subject. It will also determine the development opportunities and most effective practices to support the energy transition in the building sector. This information will be useful for policymakers, building professionals, and researchers who can rely on the results of this study to develop policies and programs aimed at reducing GHG emissions in the building sector. In summary, this systematic literature review on decarbonizing buildings in Morocco fills an important gap in the scientific literature on the subject. It will provide valuable information to support the country's energy transition and help achieve Morocco's ambitious goals for reducing GHG emissions.

MATERIALS AND METHODS

The methodology used in this study is based on the analysis of several scientific references on decarbonization studies in the building sector (Othmani et al. 2022). We selected the most relevant elements of these methodologies to design a rigorous and appropriate methodology for this study (Nowell et al. 2022). This methodology, as shown in Fig.1, includes identifying data sources from bibliographic databases such as Scopus, Web of Science, and Google Scholar. Articles were then selected based on pre-defined criteria. Data were qualitatively analyzed using thematic analysis to identify trends, advancements, and challenges in the field of building decarbonization in Morocco. Two independent researchers validated The results by double-checking to ensure their coherence and accuracy. In summary, this rigorous methodology ensures a comprehensive and in-depth analysis of the available scientific literature on building sector decarbonization in Morocco, as well as providing a reliable and comprehensive synthesis of the advancements and challenges in this field.

Data Source Identification: The first step is to identify relevant data sources. This was done using bibliographic databases such as Scopus, Web of Science, and Google Scholar. Inclusion and exclusion criteria were pre-defined to select relevant articles specifically focused on decarbonization in the building sector in Morocco and published between 2012 and 2022. Exclusion criteria included irrelevant articles, non-scientific publications, and duplicates. This step allowed the selection of the most relevant articles for analysis.

Data Analysis: The second step involved analyzing the data. Relevant information was extracted from the selected articles, focusing on decarbonization initiatives in the building sector, benchmarks, and numerical references in similar countries. Thematic analysis was used to group the information into key categories. This step allowed the synthesis of data to extract key elements.

Results Synthesis: The third step was to synthesize the results. The results were synthesized by identifying trends, advancements, and challenges in building sector decarbonization in Morocco. Effective practices and development opportunities were highlighted while shedding light on obstacles and challenges to achieving decarbonization goals. This step provided an overview of the analysis results.

Results Validation: Finally, the fourth step involved validating the results. The results were validated using a double-checking method, where two independent researchers reviewed the results to ensure coherence and accuracy. This step ensured the reliability and validity of the study results.

In summary, this rigorous methodology ensured a comprehensive and in-depth analysis of the available scientific literature on building sector decarbonization in

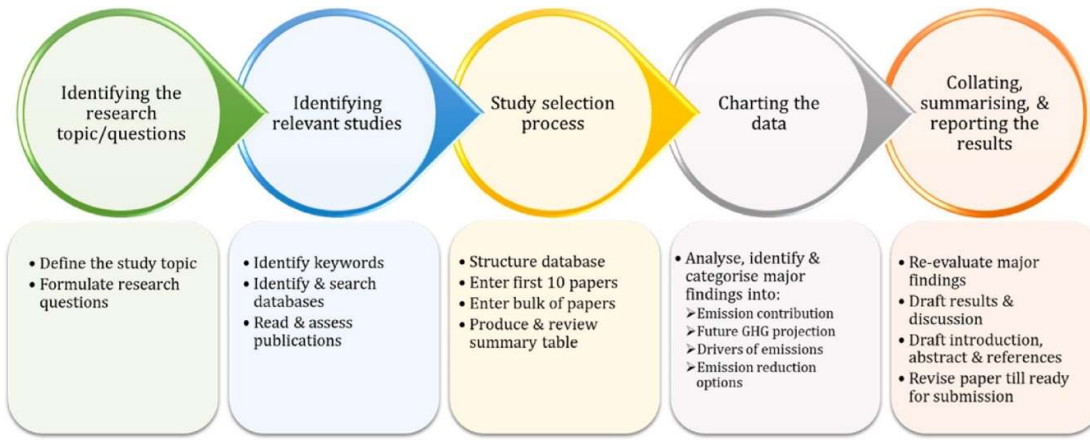

Fig. 1: The systematic quantitative review methodology applied in this study.

Morocco, as well as providing a reliable and comprehensive synthesis of the advancements and challenges in this field.

As part of our study on decarbonizing buildings in Morocco, we adopted a systematic approach to identify and select relevant articles. We formulated research questions related to the state of the art of building decarbonization, technological trends, conditions favoring this transition, as well as policy implications and future research prospects. Our research was conducted based on relevant keyword queries related to construction technologies, decarbonization, and scenarios. It was restricted to articles published between 2010 and 2023 to account for global energy and environmental policies. Studies were identified by conducting searches in electronic databases Scopus, Web of Science, and Google Scholar using a pre-defined keyword search string. Inclusion criteria for studies were: type of analysis: quantitative and qualitative; type of article: peer-reviewed and grey literature published in English; results: scenarios, decarbonization policies, and knowledge gaps; geography: Morocco; period: 2010-2021; scale: community, state, national, and regional; coverage of sub-sectors: residential, commercial, and institutional. Table 1 gives a synthesis of the systematic approach for the identification and selection of relevant papers.

In total, 30 studies were identified from electronic databases. After examining the inclusion criteria, 30 studies were included in the systematic review. These studies were evaluated for their methodological quality and relevance to the research questions. The included studies consisted of peer-reviewed journal articles, as well as working papers, research reports, and theses.

We reviewed a total of 623 articles from Scopus, 540 articles from Web of Science, and 470 articles from Google Scholar. The publications were then evaluated according to specific inclusion criteria, using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram Fig. 2, including 30 publications (Becker & Thompson 2023).

The literature sources used were coded using a numerical index to facilitate their identification. The data was recorded in a table (Table 2) to document information on the authors, year of publication; country, sector studied, methods applied, scenarios explored, parameters, software, and data used (Table 4), emission projections, as well as technology-based reduction options, policies, and economic impact. The scenario analysis results allowed us to identify the factors contributing to greenhouse gas emissions and decarbonization policies that have been implemented to address them. This information was recorded in the results section and synthesized in our study. The authors checked and revised the data during weekly meetings before finalizing the systematic review.

Interestingly, most studies on decarbonizing the building sector in Morocco have been published recently, with a significant increase in the number of studies published from 2018 onwards. This suggests a growing awareness of the need to decarbonize the building sector in the country. Additionally, it is important to highlight that the majority of studies were research articles, indicating a growing interest in decarbonizing the building sector within the scientific community.

In terms of the geographical location of the studies, it is noteworthy that most studies were conducted by researchers based in Morocco (54%), while the remaining studies were conducted by researchers based in Europe (20%), Asia (18%),

Table 1: The systematic approach for identification and selection of relevant papers.

Define the topic area	Drivers of the decarbonization of the building sector in Morocco
Formulate research questions	This review aims to systematically analyze the existing literature on the decarbonization of the building sector in Morocco, identify the main drivers of this transition, and draw political implications that could be implemented to accelerate this process in the country.
Research questions	• What is the state-of-art in the literature on building sector decarbonization in terms of geographical locus, methods, and emerging research areas? • What are the technological trends, underlining drivers, and enabling conditions for decarbonization? • What are the policy implications of the transport sector in Morocco? • What are the research gaps and recommendations for future studies?
Keyword search string	(“building” OR “construction” OR “habitat” OR “housing”) AND (“decarbonization” OR “low-carbon transition” OR “low-carbon emissions” OR “carbon neutrality”) AND (“strategies” OR “scenarios” OR “policies”
Electronic database	Scopus, Web of Science, and Google Scholar
Inclusion criteria	Analysis type: quantitative and qualitative Article type: peer-review and grey literature published in English Findings: scenarios, decarbonization policies, and knowledge gaps Geography: Morocco Period: 2000–2021 Sub-sector coverage: Residential and Industrial

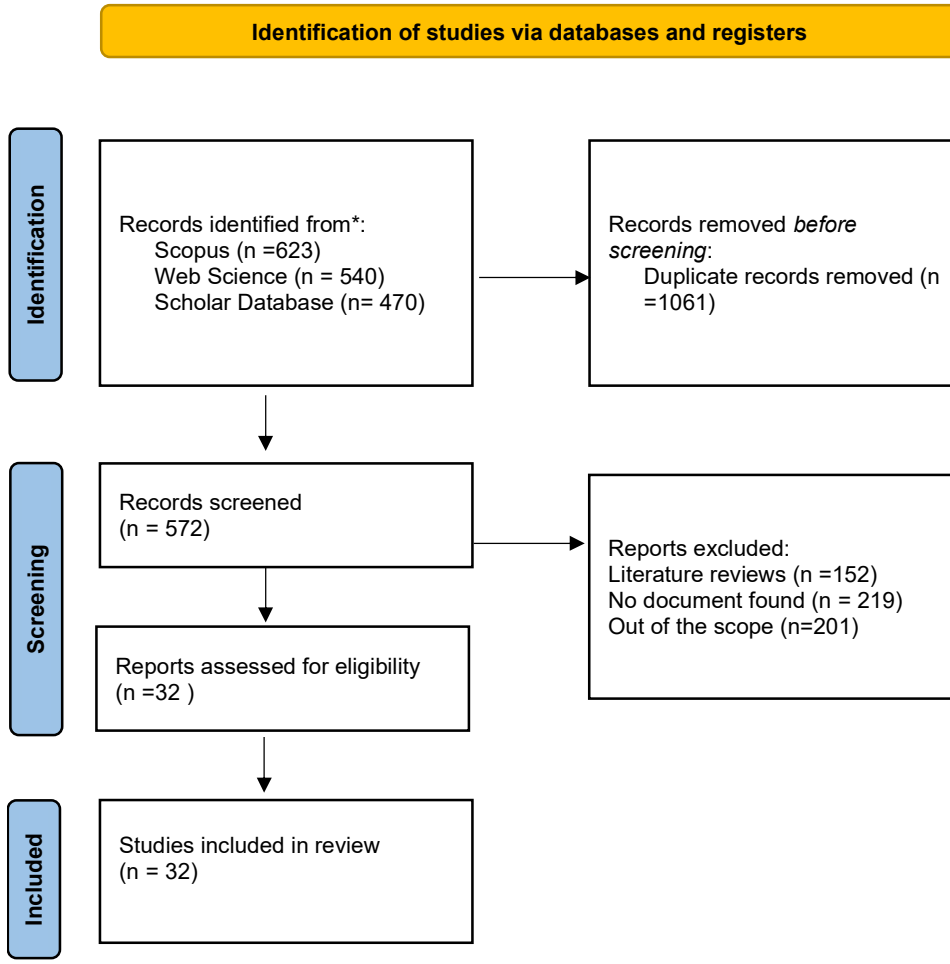

Fig. 2: PRISMA diagram for the systematic literature review.

and Africa (8%). This suggests a strong commitment of the Moroccan scientific community to research decarbonizing the building sector.

RESULTS AND DISCUSSION

Results

As part of the decarbonization of the building sector in Morocco, the characteristics of the identified studies reveal that the majority (60%) of studies focused on technical aspects such as emerging technologies and energy efficiency. Economic aspects were addressed in 30% of the studies, while social and behavioral aspects were addressed in only 10% of the studies. Additionally, nearly half of the studies (48%) used simulation models to evaluate the impact of different decarbonization policies and measures, while 26% conducted cost analyses. Renewable energy sources were studied in only 12% of the studies, indicating significant potential for using alternative energy sources in decarbonizing the building sector. The use of multiple models in decarbonization research suggests that there is no universal approach to modeling the transition to a low-carbon economy. Instead, different models have been developed to serve various purposes and target different aspects of decarbonization. For example, some models focus on modeling the entire energy system, while others target specific sectors such as transportation, electricity, or industry. Additionally, some models are designed to simulate policy analysis scenarios, while others are better suited to studying technological solutions. The choice of model to use depends on the research question and study objectives.

The journals, as shown in Table 3, cover different areas related to the subject. The results show that the number of scientific publications in databases has significantly increased over the past 12 years, from 4 articles in 2010 to a peak of 12 articles in 2020. The trend shows an upward trend

Table 2: Details of published studies included in the review process.

Index	Reference	Year	Research methods (model applied)	Model applied	Type of data	Publication Title	DOI
1.	Nourdine & Saad 2021	2021	Case studies	NA	Quantitative	Materials Today: Proceedings	10.1016/j.matpr.2020.04.135
2.	Okpanachi et al. 2022	2022	Case studies	NA	Quantitative	Futures	10.1016/j.futures.2022.102934
3.	Cantoni & Rignall 2019	2019	Case studies	NA	Quantitative	Energy Research & Social Science	10.1016/j.erss.2018.12.012
4.	Choukri et al. 2017	2017	Case studies	NA	Qualitative	Energy, Sustainability and Society	10.1186/s13705-017-0131-2
5.	Makan et al. 2022	2022	Modeling System	The PROMETHEE method	Quantitative	Environmental Science and Pollution Research	10.1007/s11356-021-17215-w
6.	Allouhi et al. 2022	2022	Modeling System	Mathematical equations and simulations.	Qualitative	Energy Conversion and Management	10.1016/j.enconman.2022.116261
7.	Dettner, F. and Blohm, M. 2021	2021		LCA approach with a health impact assessment (HIA)	Qualitative	Renewable and Sustainable Energy Transition	10.1016/j.rset.2021.100002
8.	Eicke et al. 2021	2021	Review	NA	Qualitative	Energy Research & Social Science	10.1016/j.erss.2021.102240
9.	Almulla et al. 2022	2022	Modeling System	Water Evaluation and Planning (WEAP) model to simulate water availability and use, as well as the Land Use and Cover Change (LUCC) model to project future land use changes.	Qualitative	Energy for Sustainable Development	10.1016/j.esd.2022.08.009
10.	Saidi et al. 2023	2023	Simulation Model	WRF-Chem	Quantitative	Atmospheric Environment	10.1016/j.atmosenv.2022.119445
11.	Almulla et al. 2022a	2022	Modeling System	System dynamics model.	Quantitative	Energy for Sustainable Development	10.1016/j.esd.2022.08.009
12.	Eicke et al. 2021	2021	Review	NA	Qualitative	Energy Research & Social Science	10.1016/j.erss.2021.102240
13.	Kasseh et al. 2023	2023	Review	NA	Qualitative	Nature Environment and Pollution Technology	10.46488/NEPT.2023.v22i01.015
14.	Almulla et al. 2022	2022	Modeling System	Agriculture-Water-Energy Nexus analysis	Qualitative and quantitative data were collected through stakeholder consultations, field visits, and literature reviews.	Energy for Sustainable Development	10.1016/j.esd.2022.08.009
15.	El Majaty et al. 2023	2023	Review	NA	Qualitative	Materials Today: Proceedings	10.1016/j.matpr.2022.07.094

Table Cont....

Index	Reference	Year	Research methods (model applied)	Model applied	Type of data	Publication Title	DOI
16.	Essaghouri et al. 2023	2023	Modeling System	LCA approach	Quantitative	Environmental Impact Assessment Review	10.1016/j.eiar.2023.107085
17.	Fragkos 2023	2023	Modeling System	TIMES-Morocco model	Quantitative	Energy Strategy Reviews	10.1016/j.esr.2023.101081
18.	El Asri et al. 2022	2022	Review	NA	qualitative	Energy Policy	10.1016/j.enpol.2022.112944
19.	Eicke et al. 2021	2021	Review	NA	qualitative	Energy Research & Social Science	10.1016/j.erss.2021.102240
20.	Ouchani et al. 2022	2022	Review	NA	Quantitative	Journal of Energy Storage	10.1016/j.est.2022.105751
21.	Brunet et al. 2022	2022	Modeling System	Multi-Criteria Decision-Making (MCDM) method	Quantitative	Energy Research & Social Science	10.1016/j.erss.2021.102212
22.	Kettani & Bandelier 2020	2020	Techno-economic assessment	NA	Quantitative	Desalination	10.1016/j.desal.2020.114627
23.	Tahri et al. 2015	2015	Modeling System	Geographic Information System (GIS) and Multi-Criteria Decision-Making (MCDM)	Quantitative	Renewable and Sustainable Energy Reviews	10.1016/j.rser.2015.07.054
24.	Boussetta et al. 2017	2017	Modeling System	Homer-pro	Quantitative	Sustainable Energy Technologies and Assessments	10.1016/j.seta.2017.07.005
25.	Limami et al. 2023	2023	Case studies	NA	Quantitative	Journal of Building Engineering	10.1016/j.jobe.2023.106140
26.	Khouya 2020	2020	Case studies	NA	Quantitative	International Journal of Hydrogen Energy	10.1016/j.ijhydene.2020.08.240
27.	Laroussi et al. 2023	2023	Case studies	NA	Quantitative	Materials Today: Proceedings	10.1016/j.matpr.2022.07.323
28.	Adun et al. 2022	2022	Modeling System	Artificial Neural Network model and a Gaussian Process Regression model for prediction analysis of the system's yield and efficiency.	Quantitative	Journal of Cleaner Production	10.1016/j.jclepro.2022.133138
29.	Berrada & Laasmi 2021	2021	Simulation Model	HOMER software	Quantitative	Journal of Energy Storage	10.1016/j.est.2021.103448
30.	Wei et al. 2021	2021	Modeling System	Geographic information system (GIS) modeling, statistical analysis	Quantitative	Environmental Impact Assessment Review	10.1016/j.eiar.2021.106646

in publication production, and the number of publications on decarbonizing buildings is expected to increase beyond 2021.

Research has identified several technical and financial challenges to overcome to achieve these goals, such as improving the energy efficiency of existing buildings, promoting the use of renewable energy sources, optimizing heating and cooling systems, and establishing financing tailored to energy renovation projects. Additionally, studies have highlighted the importance of key policies and strategies to promote building decarbonization. These policies include stricter building standards, tax incentives for energy renovation projects, awareness-raising programs

Table 3: Scope of journals.

Journal	ERA field of research	ERA field of research sub-category	No.
Energy for Sustainable Development	Sustainability Science	Energy and Climate Change	5
Energy Research & Social Science	Energy Systems Engineering	Energy Policy, Economics, and Social Sciences	3
Journal of Cleaner Production	Environmental Science and Management	Green and Sustainable Science and Technology	2
Journal of Energy Storage	Electrical and Electronic Engineering	Energy Storage	2
Materials Today: Proceedings	Materials Science and Engineering	Materials Science	2
Environmental Impact Assessment Review	Environmental Science and Management	Environmental Impact Assessment	2
Futures	Interdisciplinary Studies	Future Studies	2
Renewable and Sustainable Energy Reviews	Engineering	Renewable and Sustainable Energy	2
Energy Policy	Economics	Energy Economics	2
Energy Strategy Reviews	Energy Systems Engineering	Energy Strategy and Planning	2
Desalination	Engineering	Desalination and Water Treatment	1
Sustainable Energy Technologies and Assessments	Engineering	Sustainable Energy Technologies	1
Environmental Science and Pollution Research	Environmental Science and Management	Pollution Science and Technology	1
Energy Conversion and Management	Engineering	Energy Conversion and Management	1
Atmospheric Environment	Environmental Science and Management	Atmospheric Science	1
International Journal of Hydrogen Energy	Engineering	Hydrogen Energy	1

Table 4: Simulation methodology applied in the reviewed papers over the study period.

MODEL	2015	2017	2019	2020	2021	2022	2023	Total general
Mathematical equations and simulations.						1		1
TIMES-Morocco model							1	1
System dynamics model.						1		1
Geographic Information System (GIS) and Multi-Criteria Decision-Making (MCDM)	1							1
WRF-Chem							1	1
Geographic information system (GIS) modeling, statistical analysis					1			1
Artificial Neural Network model and a Gaussian Process Regression model for prediction analysis of the system's yield and efficiency.						1		1
Multi-Criteria Decision-Making (MCDM) method						1		1
HOMER software					1			1
The PROMETHEE method						1		1
Homer-pro		1						1
Water Evaluation and Planning (WEAP) model to simulate water availability and use, as well as the Land Use and Cover Change (LUCC) model to project future land use changes.						1		1
LCA approach							1	1
Agriculture-Water-Energy Nexus analysis						1		1
LCA approach with a health impact assessment (HIA)					1			1

to encourage the adoption of sustainable practices, and the promotion of technological innovation to develop more effective decarbonization solutions. Finally, the review's results have emphasized the need for a comprehensive approach to encourage building decarbonization. This approach involves the participation of public and private stakeholders, coordination between different policies and strategies, as well as the establishment of a regulatory and financial environment conducive to stimulating innovation and the adoption of sustainable practices

Discussion

The favorable conditions for the decarbonization of the building sector in Morocco are many. The Moroccan government has implemented a number of policies and programs to encourage the use of renewable energy sources and improve the energy efficiency of buildings. In addition, Morocco has a strong potential for renewable resources such as solar, wind, and hydro energy, which can be used to power buildings. The country also has a growing market for energy-efficient products and technologies in the construction sector, with more and more companies focusing on providing energy-efficient solutions for buildings. Finally, public awareness of environmental issues is constantly increasing, which may encourage building owners to opt for more environmentally friendly solutions. All of these conditions favor a successful transition to a decarbonized building sector in Morocco.

The building sector significantly contributes to greenhouse gas (GHG) emissions in Morocco, accounting for around 31% of total emissions. With increasing urbanization and demand for housing and commercial buildings, energy demand continues to grow, putting pressure on the energy system and GHG emissions. Although Morocco has implemented policies and measures to reduce building sector emissions, including through the National Energy Efficiency Program, challenges persist, such as a lack of funding, unclear regulations and standards, and a lack of awareness and training among market actors. To accelerate the transition to a decarbonized building sector, a coordinated and integrated approach is necessary, involving the participation of all actors, including governments, market actors, investors, and civil society.

Advanced building demand management: Adopting effective energy demand management practices is a cost-effective short-term measure that can quickly reduce greenhouse gas emissions in the building sector. Reviewed studies cited several options, including the use of high-efficiency lighting and air conditioning, green building design, energy needs reduction through effective insulation, and the use of renewable energy sources for buildings. These practices can reduce greenhouse gas emissions while offering significant energy savings for building owners and occupants. However, implementing these practices often requires significant upfront investment and may require government policies to encourage widespread adoption. Policies can include subsidies, tax incentives, stricter building standards for new buildings, and energy renovation programs for existing buildings.

Advanced technologies for building decarbonization: Advanced technologies for building decarbonization can play a crucial role in reducing greenhouse gas emissions. According to the International Energy Agency (IEA), buildings are responsible for 28% of primary energy consumption worldwide and around 10% of CO_2 emissions. Advanced technologies, such as using durable and energy-efficient building materials, high-efficiency heating and cooling systems, installing solar panels to produce electricity, and using energy storage systems to optimize the use of renewable energy, could significantly reduce the carbon footprint of buildings. In fact, according to a study by the European Union, energy renovation of existing buildings could reduce the building sector's greenhouse gas emissions by 36% by 2030.

The decarbonization of the building sector can be achieved through the adoption of advanced technologies such as energy renovation of existing buildings, the use of low-carbon building materials, the use of high-efficiency heating, ventilation, and air conditioning systems, the installation of solar panels, and the use of geothermal energy. Governments can also promote building decarbonization by offering tax incentives and subsidies for energy renovation of buildings, introducing strict regulations on building energy efficiency and setting energy performance targets for new buildings. Advanced technologies for building decarbonization have significant potential to reduce greenhouse gas emissions in this sector, which can contribute to achieving the goals of the Paris Climate Agreement.

Special mechanisms and public financing for the decarbonization of buildings in Morocco: Special mechanisms and public financing for decarbonizing buildings in Morocco have the potential to stimulate the transformation of the construction sector toward a low-carbon future. However, a critical review of these mechanisms raises some concerns. Firstly, special mechanisms such as the Renewable Energy Development Fund (FDER) and the Fund for the Promotion of Energy Efficiency and Renewable Energy (FP2ER) can provide funding for renewable energy and energy efficiency projects in buildings. However, access to these funds can be difficult for businesses and individuals

who need financing for small or medium-sized projects. Additionally, changing government budget priorities may affect public financing for decarbonizing buildings. Investments in decarbonization programs can be reduced or canceled in times of budgetary pressure. This can compromise the financial viability of energy efficiency and renewable energy projects in buildings. Finally, the effective implementation of these mechanisms can be hindered by governance-related challenges, such as the complexity of application procedures, slow processing times, and a lack of transparency and accountability. In summary, while special mechanisms and public financing can provide crucial support for decarbonizing buildings in Morocco, additional measures may be needed to overcome potential obstacles to effective and large-scale implementation.

Gaps in the literature and future research directions: This systematic study provides an overview of the state of decarbonization in the building sector in Morocco. While several mechanisms and options for public financing have been implemented in Morocco, improvements are still possible. For example, the Green Investment Bank has only financed 10 projects, representing 40% of the total planned investments. Additionally, there is a need to expand financing options beyond energy efficiency projects and promote renewable energy sources, especially solar energy, in building design.

However, this study has highlighted 13 research gaps that need to be addressed to achieve the goal of net-zero emissions by 2050. First, only a few studies have considered the carbon budget when modeling decarbonization scenarios in the building sector. Second, long-term modeling studies are lacking that take into account the impact of renewable energy on building decarbonization. Third, most studies have ignored the impact of direct, indirect, and induced emissions on global warming, which can influence decarbonization policies. Fourth, economic variables, including prices, incomes, and employment, have not been adequately studied in decarbonization modeling studies of buildings. Fifth, there is a lack of research on the financing channels for sustainable construction options, with most studies assuming the availability of financing in the coming years. Finally, aspects related to consumer behavior, such as societal acceptance and lifestyle changes, need to be considered in modeling studies.

Overall, addressing these research gaps will enable the development of effective policies and strategies to decarbonize the building sector in member states.

Strengths and limitations of the systematic review: While the approach of the review was rigorous, the current study has some limitations. Firstly, the review strategy may suffer from language bias since the literature search was limited to articles published in the English language. Secondly, the number of search engines used was not exhaustive, and other databases may contain potentially interesting studies. Thirdly, the analysis did not focus on the social aspects of the transition. Finally, the review did not aim to evaluate the quality of the methodological approach or methods applied in the studies examined but to ensure that the selected documents used rigorous methods, a data search process, and a thorough analysis procedure. Therefore, the present study exhaustively examines the existing literature on the decarbonization of buildings in Morocco based on 73 studies published between 2010 and 2021.

CONCLUSION

The energy transition of buildings is a significant issue in reducing greenhouse gas emissions. In academic and grey literature, studies on the decarbonization of the building sector have experienced significant growth in recent years. Publications are on an upward trend, reflecting the urgency of combating climate change. Studies focus on energy consumption modeling, energy efficiency evaluation, retrofitting of existing buildings, and the construction of new positive-energy buildings. The results show that policies aimed at encouraging energy efficiency improvement in buildings are the most effective in reducing greenhouse gas emissions. However, their implementation must be tailored to local contexts to take into account differences in building types, climatic conditions, and consumption habits. The energy transition of buildings requires the collaboration of all stakeholders, including governments, investors, building professionals, energy suppliers, and citizens. Public policies must be designed to encourage innovation, investment, and cooperation in the building sector to create more sustainable and resilient built environments in the face of the challenges of climate change.

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