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Dear Editors,

We are pleased to submit our manuscript, "Systematic Literature Review of Housing Policies in Carbon Emission Reduction: Reflection for Indonesia." We do hope that publishing this article is of your highest consideration.

This article is a pioneering work on the topic in the Indonesian context as it offers a new perspective for developing policies on low carbon emissions for the construction sector.
The perspective will invite further discussion from researchers, practitioners of architecture, and urban designers, as well as policymakers on sustainability. In this regard, comments and inputs from you and colleague readers are highly expected to extend the research.

Thank you, and with best regards,

Dr. Ilya Fadjar Maharika

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Systematic Literature Review of Housing Policies in Carbon Emission Reduction: Reflection for Indonesia

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Abstract. Housing cannot be separated from the discourse of carbon emissions in all building cycles: planning and design, material preparation, construction, operations, and demolition. Various countries have successfully reduced carbon emissions in the housing sector, one of which is by using policy instruments. However, reviewing the effectiveness of these policies has yet to be thoroughly explored. Using the systematic literature review method, this article aims to identify the policies implemented to reduce carbon emissions in housing and contextualize them for Indonesia. After careful identification of the relevant articles, 16 selected articles were reviewed. The study found that taxation, zero-carbonization, and strategies for retrofitting are adequate policies in many countries. Framework for Indonesia was discussed for recommendations.

Keywords: carbon emission, zero-emission, housing sector,

1. Introduction

Every stage of housing development cannot be separated from the carbon emissions caused to the environment. In the design and planning process, it causes emissions of 370 kgCO2 (Shang & Geng, 2021). Preparing building materials produces carbon by 5% of the world's carbon emissions for cement (Hasanbeigi et al., 2012) and 0.488 tons CO^2/hour – 0.993 tons CO^2/hour for transporting materials by ship (Utami & Puriningsih, 2014). Construction produces 50,553 kg CO^2 or 139.95 kg CO2 /m^2 (Pacheco-Torres et al., 2014). The operational process produces 374.21 kg CO^2/year for electricity and 593.43 kg CO^2/year for fuel oil (Kurdi, 2008).

Reducing carbon emissions in residential homes is proposed with various solutions. In design, carbon emissions in residential homes can be reduced by using plants through the vertical garden method, which can expand the leaf contact area with the air so that it is more effective in reducing carbon emissions (Kusminingrum, 2018). In energy utilization operations, using efficient heating and cooling systems utilizing solar energy combined with heat pumps and steam injection can reduce carbon emissions by 12.1 tons per year and save 5 tons of coal (Fan et al., 2020). On a broader dimension, it can also be done through household activities that are wiser in dealing with cars, air traffic, and meat consumption, and the size of the house will reduce carbon emissions (Dubois et al., 2019). In addition, the zero-carbon homes policy can also reduce carbon emissions, as was done in the United Kingdom in 2016. However, there are still many obstacles in practice, such as economic barriers, skills and knowledge, industry, legislature, and culture (Heffernan et al., 2015). The support of a clear and robust policy framework and solid industrial support is needed to overcome these obstacles (Forde et al., 2021).

doi:

In Indonesia's context, based on World Bank data, carbon emission per capita, as one of the critical environmental indicators, is still increasing. The situation is also challenging as other indicators need to be more supportive of increasing the quality of the environment, such as the loss of forest land and low renewable energy initiatives (The World Bank, 2023). Although some new housing development utilizes low carbon emissions strategies, such as green building certification (Kementerian Pekerjaan Umum dan Perumahan Rakyat, 2023), the impact still needs to be measured. It is still necessary to explore effective policies for Indonesia, where rapid urban development is present. Exploring how other countries' policies respond to the carbon emission reduction program in housing is essential to determine the area of concern for further development of the policies in the future, especially for Indonesia contextualization. We are still dealing with large amounts of carbon emissions that cause the earth's temperature to increase, resulting in changes in rainfall patterns, sea level rise, and desert expansion (Sassi, 2006).

2. Methods

This study utilized the Systematic Literature Review method. This method is helpful before empirical research (Xiao & Watson, 2017). As an inclusion criterion, we included studies from disciplines related to architecture, engineering, and construction and excluded disciplines that were considered far from it. We only included studies written in English. As the identification process, the search was carried out utilizing Harzing's Publish or Perish (PoP) application, which was connected to Scopus only. As the search procedure, we used the keywords "carbon emission," "housing," "house," and "policy." Scopus search settings were set as in the title and keywords. In keyword typing, we used the following technique: the carbon emission keyword is enclosed in quotation marks (") to become "carbon emission" so that the keyword search became specific, and then the keywords "housing," "house," and "policy" were added with the conjunction "AND" and "OR." Hence the search string was "carbon emission" AND house OR housing AND policy.

Initial screening on title search using keywords found only one related article. On the keyword search, we found 200 more articles (the Harzing's Publish or Perish search limit was not more than 200 articles at once). As the second screening, we limited only the last five years of articles (2018-2022) and found 68 articles. Then the third screening eliminated the conference articles and found 56 articles. The fourth screening was by looking at the article's relevance to the studied topic through the abstract in the article. In this stage, we found 32 related articles. The last screening was looking at the article's relevance to the investigated topic through the study results and finding 16 articles. Table 1 below shows the technical details of article screening.

Table 1. Data Collection Scheme

Search on Scopus via Harzing's Publish or Perish	Search on title by keyword: “carbon emission” AND house OR housing AND policy	Search on keywords by keyword: “carbon emission” AND house OR housing AND policy
Initial Screening	1 article	200+ articles
Second Screening: Articles of the last five years (2018-2022)	68 articles	
Third Screening: Journal article	56 articles	

Fourth Screening: Relevance of articles through abstracts	32 articles
Fifth Screening: The relevance of the article through the study results	16 articles

The analysis technique is by reviewing the results of the entire article and then collecting the study results on the same topic. This analytical technique is a quantitative descriptive analysis focusing on systematically analyzing data to find percentages and trends (Hardani et al., 2017) in a study discussion. The study results on the same topic are interrelated to form descriptive sentences. Conclusions are drawn from the essence of descriptive sentences.

3. Result and Discussion

Sixteen articles examine policies in various countries. Table 2 below shows the whole article.

Table 2. List of policy studies

Policy Location Context	References	Policy Topics	Issues Outline for policy	Policy	Policy Year
Australia	(Vidyattama et al., 2021)	The impact of the fuel tax policy on rural communities in areas far from public transportation	Inequality	Fuel tax	Planned since 2014, fuel excise cuts in the 2022-2023
Australia	(Li et al., 2022)	policy evaluation issues and incentives regarding zero carbon homes	Policy alternative	Zero carbon home policy	2018-2050
Asia Pacific	(Zhang et al., 2021)	the gap in the zero carbon emission building sector	Policy alternative	Low carbon building policy	2010-2030
Global	(Malafry & Brinca, 2022)	the gap in the carbon tax between rich and poor households encourages preference	inequality	Carbon tax policy	indefinite
Brazil	(Moz-Christofoletti & Pereda, 2021)	distribution effect and effectiveness of energy tax subsidy policy	Policy effectiveness	Tax subsidy policy	still, a dilemma to be revoked
United Kingdom	(Forde et al., 2021)	explore and understand the use of local planning policies to reduce carbon emissions through zero carbon homes	Policy effectiveness	Zero carbon home policy	2006-2030

United Kingdom	(Bobrova et al., 2021)	potential policy intervention in residential retrofit	Policy effectiveness	residential retrofit policy	2012-2040
Great Britain	(Lane et al., 2020)	alternative sub-sector of zero carbon homes	Alternative policy	Zero carbon homes policy	2006-2030
United Kingdom	(O'Neill & Gibbs, 2020)	the failure of the zero carbon homes agenda	Policy effectiveness	Zero carbon homes policy	2006-2030
United Kingdom	(Trotta, 2018)	the main determinants of investment in energy-efficient residential retrofit	Policy alternative	residential retrofit policy	2012-2040
United Kingdom	(Edmondson et al., 2020)	Zero carbon home policy	Policy alternative	Zero carbon homes policy	2006-2030
Japan	(Jiang et al., 2020)	efficient decarbonization measures based on urban emission levels	Policy alternative	Urban Decarbonation Policy	not mentioned
Japan	(Shigetomi et al., 2021)	The influence of lifestyle and its effect on reducing carbon emissions	Policy alternative	household carbon mitigation	not mentioned
Switzerland	(Ott & Weber, 2022)	increased carbon tax for heating/air conditioning in housing	Policy effectiveness	Carbon Tax Policy	not mentioned
Turkey	(Keskin et al., 2020)	policy revision and development strategy	Policy effectiveness	Energy efficiency policy	not mentioned
European Union	(Faure et al., 2022)	acceptance of energy efficiency policies among European households	Inequality	Energy efficiency policy	not mentioned

3.1. Descriptive Mapping of Policies

Articles that discuss emissions, housing, and policies simultaneously have different spikes in time. In 2018, two studies discussed this topic, but in 2019 no discussion on this topic. A surge in studies occurred in 2021, with seven studies on this topic. There are differences in the number of studies from different countries. The most prominent is the United Kingdom, where six studies have discussed policies in the last five years (2018-2022). Other countries, such as Australia and Japan, have two studies that discuss residential policies and carbon emissions, and other countries have 1 study only (Table 1).

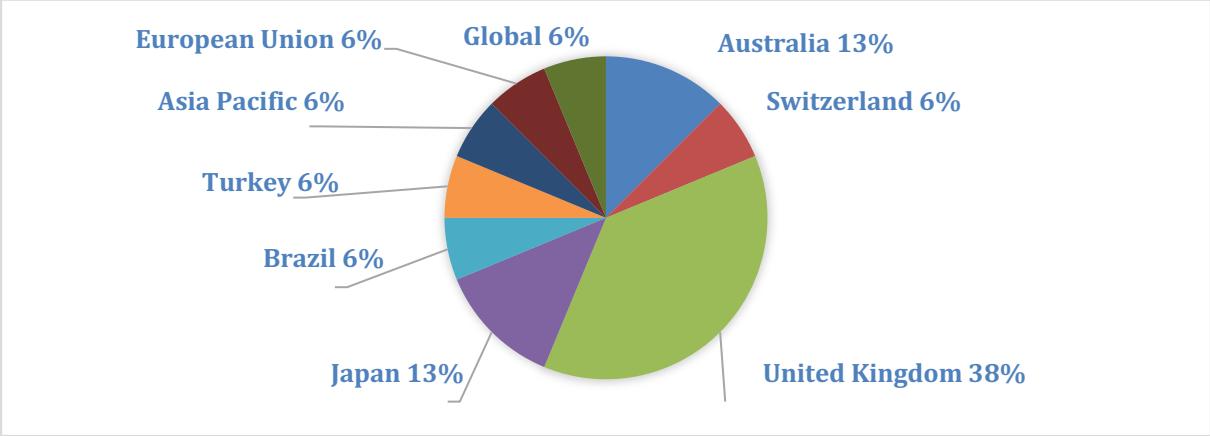

Figure 1. Comparison of the number of studies by countries (source: analysis)

Seen from the building life-cycle European Standard EN 15978:2011 and its implementation for assessment of the Building Life Cycle (BLC) (Giordano et al., 2021), most of the policy addresses design and planning aspects and operational aspects. The highest aspect given by the policy is the operational aspect of the household, including fuel consumption, use of electrical energy, number of vehicles, and use of renewable technology. Meanwhile, the design and planning aspects only cover the design of a zero-carbon home. In addition, aspects that address both include retrofit home technology and designs that adapt to low-carbon lifestyles.

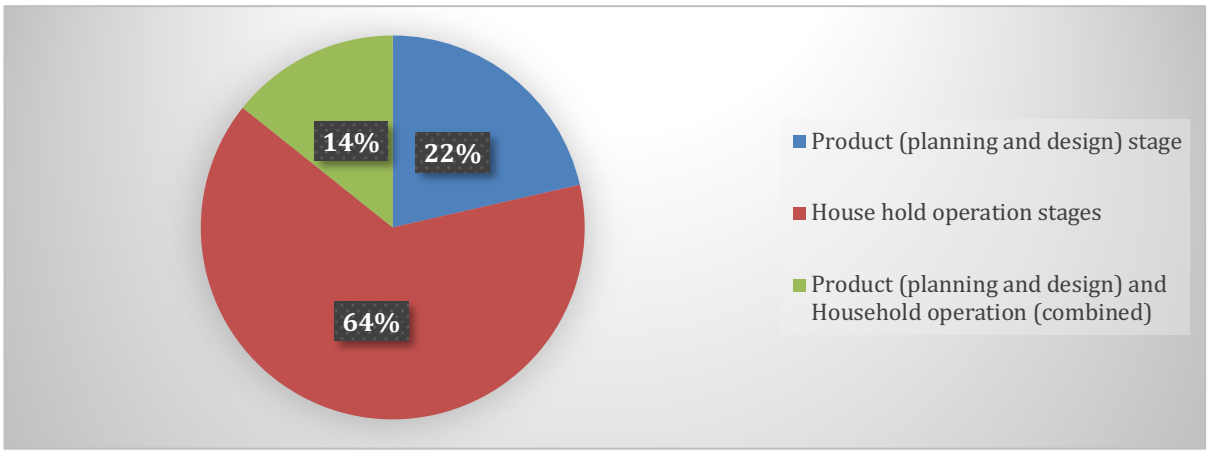

Figure 2. Aspects of the policy (source: analysis)

3.2. Thematic Review of Policies

Several countries implement policies such as paying taxes, low-carbon housing policies, and residential retrofit policies. Australia, Switzerland, Japan, and Brazil use fuel and energy policies on carbon emission tax. Moreover, the United Kingdom and Australia use the zero-carbon home policy, and the United Kingdom uses the residential retrofit policy.

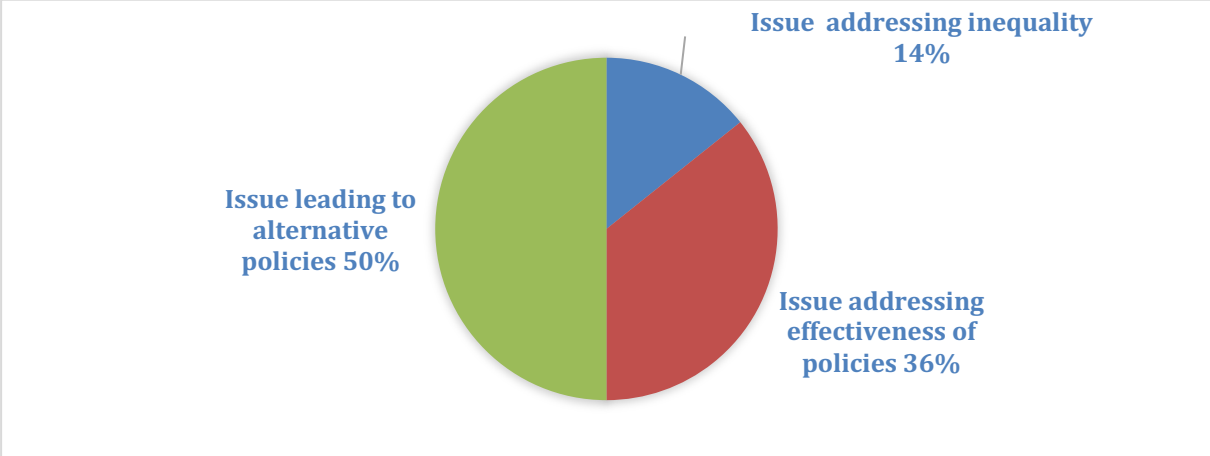

Figure 3. Aspects of the policy (source: analysis)

The policies resulted in several problems, such as inequality between the community and the policy's effectiveness. Policies related to carbon emission taxes will affect the financial inequality of poor and related wealthy households. Another issue is policy effectiveness and alternatives, which shows that community assessment actions related to the policies are adequate.

The policies resulted in several problems, such as inequality between the community and the policy's effectiveness. Policies related to carbon emission taxes will affect the financial inequality of poor and related wealthy households. Another issue is policy effectiveness and alternatives, which shows that community assessment actions related to the policies are adequate.

Table 3. Problems and policy alternatives

Policy	Problems	Alternative Policies
Carbon Emission Tax	• Reducing the income of rural people • Higher tax value than the initial framework • A low tax is not enough to trigger a change in the short term • The negative impact of public acceptance on enforced	• Promotion of fuel-efficient equipment • Consumption of low-carbon processed foods • Financial subsidies for the poor for energy use and utilizing renewable energy sources • High tax can lead to significant adaptation steps • Counseling through education and information
Zero Carbon House	• Financial adequacy • Human Resources and equipment technical capacity • The initial response from the community was positive, but then it became negative.	• Promotion of fuel-efficient equipment • Consumption of low-carbon processed foods • Financial subsidies for the poor for energy use and utilizing renewable energy sources • High tax can lead to significant adaptation steps • Counseling through education and information
Residential retrofit	• lack of public interest in retrofitting	• retrofit grouping into three in a specific products, design choices, and technology systems

		• homeowner's implementation experience to have a positive attitude towards retrofit innovation • positive information is orally distributed by the owner of the house to the surrounding community • residential retrofits are targeted at buildings built before 1990 and detached or semi-detached houses (old buildings)

Source: analysis

The carbon emission tax policy on fuel oil, although it reduces the use of fuel oil, also reduces the income of the rural area community and the poor due to the lack of public transportation (Vidyattama et al., 2021). Moreover, the tax value must be lowered compared to the initial policy framework (Malafry & Brinca, 2022). Alternative policies are to promote the use of fuel-efficient equipment by the government, encourage people to consume foods with low processed carbon emissions (Jiang et al., 2020), and reduce dependence on private vehicles (Shigetomi et al., 2021). Another policy alternative is that the government can provide financial subsidies to increase the purchasing power of the poor (Zhang et al., 2021) but still focus on using clean energy, reducing energy consumption, and utilizing renewable energy sources (Keskin et al., 2020).

There needs to be more than a slight tax increase to trigger a change in the short term. On the other hand, significant changes may lead to more significant adaptation steps (Ott & Weber, 2022). However, it is necessary to pay attention to the form of policy coercion so that it is not excessive because it harms household acceptance of the policy. It is better if counseling through education and information on energy-saving measures is considered better than carbon taxes and consumption limits (Faure et al., 2022).

There are financial constraints to building a zero-carbon home due to the additional development costs when applying the zero-carbon home standard, which is also recognized by stakeholders (Li et al., 2022) and human resource and technical equipment capacity (Forde et al., 2021). In addition, the response received by a zero-carbon building is initially positive and then becomes negative (Edmondson et al., 2020). The approach is to hand over the construction of zero-carbon homes to the community with the support of financial subsidies and apply a physical framework (local land acquisition), conceptual (relationship between the house and its residents, and affective space (ease of access to administration in different responsible departments) (Lane et al., 2020; Edmondson et al., 2020).

Retrofit development can use three new approaches: (1) retrofit technology disaggregation into three levels in a specific product, design choices, and technology systems; (2) the implementation experience of the homeowner to have a positive attitude towards retrofit innovation; (3) positive information that is orally distributed by the owner of the house to the surrounding community (Bobrova et al., 2021). Retrofit development targets people who owned buildings before 1990 and owners of detached or semi-detached houses (Trotta, 2018).

3.3. Discussion Policy Recommendations in Indonesia

Policies related to carbon emissions in Indonesia have problems related to carbon taxes and communication of carbon emission risks to society. The implementation of a carbon tax in Indonesia has been carried out since April 1, 2022, which has only touched electric steam power plants with a carbon trading scheme and carbon tax (Sutartib & Purwana, 2021). However, a carbon tax scheme that is still confidential makes it easier to legally reduce tax (tax avoidance) by taxpayer entities that produce carbon emissions (Lolo et al., 2022). In addition,

implementing emission programs and policies in Indonesia is still a one-way risk communication. This risk communication only touches on the technical-administrative part and has not touched on two-way strategic concepts such as community involvement or emission reduction targets. As a result, messages about potential future environmental hazards due to carbon emissions have not touched the understanding, changes in attitudes, and people's behavior to reduce carbon emissions (Patrianti & Shabana, 2020).

Table 3. Problems and policy alternatives for Indonesia

Policy	Problems	Alternative Policies
Carbon tax and policy delivery	• limited implementation of the carbon tax in the electric steam power plant sector only • facility to do tax avoidance because of the confidentiality principle • one-way policy delivery	• taxes on energy and transportation sectors with a fuel approach • using the principle of carbon tax transparency • emission tax policies are focused on urban areas, especially high-income communities • policy delivery can involve stakeholders and education counseling in urban areas • residential retrofit policy in urban areas focuses on wealthy households

Source: analysis

The applied solution consists of several strategies. The energy and transportation sectors can be managed with a carbon tax mechanism with a fuel approach if, in the future, there is an expansion of the sector subject to a carbon tax (Sutartib & Purwana, 2021). For the principle used in the carbon tax, it should be tax transparency, as used by several other countries, so that the public can monitor the taxpayer entities that produce carbon emissions and reduce the number of fees paid by the community (Lolo et al., 2022). The carbon tax policy can be applied flexibly to archipelagic areas in Indonesia by focusing on areas with high population density (urban areas) with a focus on wealthy households. The carbon tax policy is more efficient because urban areas have better public transportation infrastructure. For carbon risk communication, it is possible to apply the involvement of private stakeholders who can synergize to provide mitigation messages to the community through various communication channels at this time. In addition, messaging development and fear factors are also needed in delivering the risk message (Patrianti & Shabana, 2020). This risk communication can also be in the form of policy counseling by utilizing the education system in urban areas, which will be more effective so as not to trigger a coercive policy reaction against the community.

Another alternative can be done by implementing a residential retrofit policy. Residential retrofit policies in the community will be easy to implement in urban areas with a focus on wealthy households due to technology and adequate financial capital.

4. Conclusion

Several countries, in general, have used carbon emission tax policies, zero carbon homes policies, and community residential retrofit policies. The problems in implementing the policy include inequality between the poor and the rich, the financial community, and human resources capacity, which requires alternative policies that focus more on the rich in urban areas. Policy implementation in Indonesia can use a carbon tax policy and a residential retrofit policy focusing on densely populated islands in urban areas and prosperous communities with a tax transparency system. Policy counseling can take advantage of relevant stakeholders and the education system. Policies can also be implemented by building ownership groups both for tax and zero carbon policies. From Indonesia's context, it predicted easy-to-control

governmental buildings to simulate the effectiveness of the zero-emission strategy at the early phase of regulation implementation.

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