

THE RACE TO NET ZERO: IS THE UK FALLING BEHIND IN RESEARCH TO OTHER COUNTRIES WHEN IT COMES TO SUSTAINABILITY IN RESIDENTIAL HOUSING?

Jordan Turner¹, Emmanuel Itodo Daniel and Ezekiel Chinyio

University of Wolverhampton, School of built environment, Wolverhampton, West Midlands, WV10 0JR, United Kingdom

The provision of sustainable housing should factor in energy efficiency, the use of sustainable building methods and materials, and address the current associated barriers. This consideration triggered an ongoing study in UK which has so far conducted a bibliometric analysis of 275 papers using the VOSviewer software. The UK is less engaged in successful collaborations in comparison to other economically developed nations. The lesser use of innovation in the UK has been identified. Also, the uses of sustainable methods and materials in residential housing are not fully exploited for achieving energy efficiency. A future research direction emerging is the potential to study the combined impact of using innovative materials and methods to achieve greater energy efficiency in UK housing provision. Through technological innovations and the need to move from fossil fuels (for example, using heat pumps) a new approach can move the UK closer to achieving net-zero in housing provision and operations.

Keywords: energy efficiency; housing; innovation; materials; methods; sustainability

INTRODUCTION

Innovation is a product or idea offering new methods, originality, and advanced thinking (Akinosho *et al.*, 2020). Sustainability in construction refers to the creation of projects which have positive outcomes for both the environment and society (Sfakianaki 2019). Whilst it is possible to achieve sustainability through highly energy-efficient homes, it is often an occurrence that energy-efficient homes are not necessarily sustainable (Menna *et al.*, 2022). It is therefore important to consider ways in which residential homes can be energy efficient and sustainable, one way of doing so is using Innovative and sustainable methods (Silvestre and Circa 2019).

Akabogu (2023) and Menna *et al.*, (2022) both state that there is a need for more sustainable housing that not just focuses on energy efficiency but also the methods and materials which are used to achieve this. Jackson (2021) highlights that there are already sustainable materials which are naturally and readily available and can be utilised but as identified by Kolosok *et al.*, (2021), these are simply not being used.

¹ JTproperty93@gmail.com

Current research in sustainable materials shows that whilst they are available, barriers exist to their use. Akabogu (2023) discusses the difficulty in obtaining sustainable materials due to their low production and even when available, the financial cost for doing so is considerably higher than using traditional methods. A concerning statistic also revealed that 63% of building organisations do not use sustainable materials when constructing houses (Burciaga 2020).

An assessment of the Net Zero strategy carried out in March 2023 worryingly suggests that the UK is still considerably behind the pace, this needs rethinking and a view to act immediately if they are going to achieve this goal (The Guardian 2023). This comes off the back of a landmark ruling by the High Court in 2022 that the Government's net zero plan was unlawful, with the ruling stating that the government's net zero strategy does not sufficiently detail how it will meet its emissions targets and that as such, it has contravened the Climate Change Act. (Aldane 2022). The government needs to consider the strategy, revise and look at the targets and how these can be achieved.

Focusing on the built environment will contribute to the drive to Net Zero by 2050. When comparing the UK's steps to reduce emissions in the built environment with Europe and the rest of the world, the UK appears to be falling massively off the pace (Holder 2023). In Scandinavian countries such as Norway, Sweden and Finland, there is a dominance of heat pump technology compared with the rest of the world in which they are heavily invested in heading away from gas and fossil fuels and putting greater emphasis of electrification in the form of heat pump technology (Yeung 2022).

In Bangladesh, there has been a focus on using bamboo as a building material given its elasticity and resistance against fire, earthquakes and extreme weather, over 70% of housing in Bangladesh is made from or contains bamboo as a material (De Vries 2010). Other countries such as the Czech Republic and Canada are also looking at more sustainable materials and how they can be implemented into housing, recently, they have focused on the use of Hempcrete into their houses as a more sustainable alternative to traditional methods (Bellovicova 2021).

The aim of this review was to identify current gaps in innovative and sustainable methods and materials in residential housing within the UK to invite future research. The purpose of the review was to investigate what research has been carried out around sustainable and innovative methods and materials in residential housing across other countries and compare this with the UK. The review sought to identify key areas within the topic, subsequently, identifying gaps within the research that will allow for further exploration. The review offers a visualisation of what specific areas are being focused on within the topic, which countries are carrying out research in this area and what prominent studies in the field of study have been cited the most to see which specific author(s) are leading in this area of research.

The key objectives of this review are as follows:

- 1) Review which countries are publishing the most papers in the relevant field of the study to identify if certain parts of the world are researching sustainability more than others.
- 2) Identify which authors are leading research in the subject field of innovative and sustainable materials and methods
- 3) Identify if the UK can do more regarding research around sustainable and innovative materials and methods.

METHODS

Literature reviews play an essential role in academic research which allows for the gathering of existing knowledge and the examination of the field's current state (Kunisch *et al.*, 2018). Typically, the two most common types of reviews carried out in academic research are systematic and bibliometric (Linnenluecke *et al.*, 2019). Systematic reviews allow for a deep analysis of research identifying what is already known but importantly, identifying potential gaps in research (Mohseni *et al.*, 2022). When conducting the initial search of data however, if too many search results are yielded, this can often make the systematic review method more difficult from a time perspective and allows for a bibliometric analysis to offer a better alternative (Linnenluecke 2017).

Bibliometric reviews allow for a broader focus across a wide range of papers. This allows for the researcher to go further into reading and reviewing these publications. It also allows the analysis of large amounts of data which can also create a visualisation authors and countries who may be leading in a certain area of research and so that patterns can be identified if certain keywords, authors and countries are focusing on certain topics within the field of study (Donthu *et al.*, 2021). As a result of this, given the initial large number of papers identified, a bibliometric review was chosen over a systematic review.

The data collection initially started with a keyword search, which used the Scopus database in this study. Scopus is the largest database of peer-reviewed literature, containing over 20,000 peer-reviewed journals, and is often considered a favoured choice over other databases such as Web of Science (Cabeza *et al.*, 2020). This makes Scopus a good starting point when carrying out an analysis. To be relevant to the research topic area, the following keywords were inputted into Scopus:

“sustainable” OR “innovative” AND “materials” OR “methods” AND “residential housing”

The search string was as follows: TITLE-ABS-

KEY (sustainable OR innovative AND materials OR methods AND residential AND houses) AND PU

BYEAR > 2003 AND PUBYEAR < 2023 AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-

TO (SUBJAREA, "ENGI") OR LIMIT-TO (SUBJAREA , "ENER") OR LIMITTO (SUBJAREA , "MATE") OR LIMIT-TO (SUBJAREA , "ENVI")) AND (LIMITTO (LANGUAGE , "English"))

As the subject focus is around sustainability of more modern approaches which can be referred to as innovative, the search string was decided to include sustainable materials or methods as these can then be grouped into approaches. Approaches can however prove to be vague and not specific, hence the justification for selecting materials and methods, equally with the importance of the focus being on residential housing, this needed to include the two to be specific of the topic search criteria. This search initially yielded 1399 results, there was however some exclusion data which then needed to be carried out which brought this initial number down. This criterion was journal articles that were within the last 20 years (2003 - 2023) The way in which scopus produces results meant that 2023 was included as a year to show papers to the

end of 2022. Finally, searches that were English were also part of the criteria; this then returned 420 results.

The next step was to then cut down and filter through topics that were not relevant to subject. One example of this was an article which focused on cruise ships' sustainability, which was not relevant to housing. Equally, keywords around computer science and medicine were excluded, limiting instead to engineering, environmental science, energy and materials science. After filtering through the set of results, the final return was 275 results left to be analysed. With this final number of results produced even after filtering, still being high, a bibliometric analysis approach was taken.

After the collation of results from the Scopus search, the next step was to use a software for the analysis, the software chosen for this scenario was VOSviewer. VOSviewer is a free to use computer programme used for bibliometric analysis, however, in comparison with other bibliometric analysis software, VOSviewer offers special attention to graphical representation of bibliometric maps being able to offer large maps with the ability to produce a co-citation map of up to 5000 journals (Eck and Waltman 2010).

To meet the objectives, set out for this study, the countries in which those papers were published and finally, the countries collaborations and author citations were assessed. The countries of paper publication were studied to see which countries are researching sustainable materials and methods more than others and what lessons can be learned from them. Finally, the keywords by author title were other criteria to be examined to see if there were links within this. For example, sustainability and energy efficiency or residential housing and sustainability.

RESULTS AND DISCUSSION

Publications by Country

When studying the countries that have published papers, the UK appear to have quite a high number of publications (joint 3rd) with 16 articles published as seen in table 2. However, as can be seen in the visualisation (figure 3), there is very little collaboration with other countries. Stronger collaboration appears to exist between the United States and Canada and China, the United States and Turkey, who also collaborate with each other. Italy had the most citations with 464 from 10 publications whilst China had the most published articles out of all countries. It is important to consider the number of citations due to the impact the publication has in the field of study.

Publishing multiple documents which are not being cited does not necessarily mean that the article is not relevant, however, multiple citations will indicate that the study and that authors work is being used more and reference to more frequently. For this study, it was identified which countries were more heavily cited which may indicate the influence that a particular country's research may be having on others who are looking in the same field of study. It is also good to then have a visualisation of which countries may be leading in that area of research.

Collaboration between authors is important and can be even more helpful when those authors are from other countries, allowing for research into what other countries in the same field of study are doing (Kong et al., 2019). As can be seen in the visualisation, China shows as the largest collaborator with links to the United States, Australia, India and Turkey. This shows that international collaboration which has mentioned

by Kong et al., (2019) is important and helpful as this can allow an insight into what may and may not be working in other countries.

Country	Documents	Citations
Italy	10	464
China	24	338
Australia	16	283
United Kingdom	16	247
United States	13	246
Canada	12	224
Germany	12	111
Saudi Arabia	9	110
Malaysia	8	87
India	11	42

Table 1: Top 10 countries with most citations in the research area



Figure 1: Visualisation of collaboration of countries in the research area

The collaboration between the United States and Canada may be expected due to the close border they share but an interesting element is the collaboration which appears between China and other countries who are identified as a country now accelerating their sustainability mission. A potential example of this is that of heat pump technology.

When looking at Scandinavian countries, they significantly lead the way in heat pump technology (Yeung 2022). The UK set an ambitious target of installing 600,000 heat pumps per year by 2028 with the plan to phase out traditional boilers operating off mains gas (Howell 2022). More recently however in September 2023, this plan became very unlikely to materialise as the Government announced it would delay these plans with no new date set (Callaghan 2023). Potential collaboration between Scandinavian countries and the UK may be insightful for the UK to learn about how the Scandinavian countries are having such a high success in the gas boiler phase out and high implementation of heat pump technology instead, Equally, the potential collaboration with other countries should be encouraged to learn from and promote better practice for the UK. As seen in table 1, the UK ranks 4th in terms of cited documents and joint 2nd in terms of published documents, but in the visualisation in figure 1, the UK does not appear, this indicating a lack of collaboration with other countries in this field of study. With the acceleration of focus in sustainability in China, collaboration with them could also prove useful in particularly across areas of materials and methods that are not well researched. If China or for that matter, any country, are exploring the benefits and negatives to sustainable materials and methods then this can only be of benefit to the UK who can learn and research these in collaboration which can in turn lead to successful implementation of such materials and methods use within the UK. Furthermore, if the UK are beginning their research

in specific areas of sustainability, this can be shared with other countries which adopts a world approach of sharing and learning from each other which can only be viewed as a positive for the future.

Author Citations

Carrying out an analysis of the authors through the VOSviewer software allows a streamlined approach to seeing which authors have the most citations in that area by other authors. In this example, authors who were highly cited by others in the same field of work in sustainable OR “innovative” AND “materials” OR “methods” AND “residential housing”. The local citation analysis indicates that researchers are citing other authors from within the same field of research. This, in turn, shows a high level of relevance within the field to be then used in another author’s piece of research which may be related or slightly different to the topic. Upon analysing the results. The top 10 authors had a combined 299 citations between them with Zhang being the most cited (43 times) The measure shows that in the 275 articles yielded, Zhang had been cited in 43 of the other articles within the collection. Zhang has recognised the importance of global warming contribution within the built environment and has dedicated research into practices of low carbon towns and cities in China. Having published over 300 documents with over 14,000 citations, Zhang looks towards lower carbon production within the built environment within China. Zhang has investigated urbanisation and, as per the 2016 paper on sustainable urbanisation, focuses on achieving social, economic and environmental sustainability (Tan *et al.*, 2016). This same level of research in other countries would be strongly welcomed as well as collaboration to learn from Zhang’s findings in research they have carried out in China.

Most of the top-cited authors originate from China, which aligns with the countries with the most publications (as seen in table 1). This is showing that China is carrying out more research around sustainability. Given that China is currently the largest producer of Carbon emissions, equating to more than a quarter of the world’s entire emissions, China is now taking more action combat this and drive a more sustainable future for the country (Maizland 2021). As a result of this, it is perhaps unsurprising that authors in China are taking a much higher interest around sustainability now which is welcomed. Being home to 2nd largest climate tech hubs in the world, technological advances and research in sustainability by China is accelerating their commitment into achieving greater overall sustainability and reduction in global emissions (Cheng 2023). Consequently, with such advancements in technology and greater research into the area of sustainability, a welcoming of collaboration between authors in other countries and Chinese authors would be beneficial here. Papers on the topic have been heavily cited by others and would give opportunity for authors in other countries to work with leading researchers in this field of study. Author collaboration should always be encouraged, on topics which are of high public interest, with a lot of focus around the world now being around sustainability due to global warming, researchers coming together must be encouraged. The collaboration between authors has been highly successful in sharing practices that may or may not work in other countries (Kong *et al.*, 2019). Franceschet and Costantini (2010) concluded that collaborative research has been associated with higher productivity and enhances knowledge and research techniques, giving opportunity for researchers to learn how others work and approach their research but to also arrive with enhanced visibility of results.

Research Gap and Future Research

There is evidently a gap identified from this research in that despite the fact the UK is pushing a clear goal of achieving Net Zero by 2050, they appear to be off the pace compared with other countries. With more research in the areas of heat pump technology and other approaches in sustainability being carried out in other countries, it raises serious questions to the commitment and efforts of the UK to achieve their target. Collaboration should be welcomed and encouraged between researchers in the UK and other parts of the world as there is evidently benefits to be gained from this due to other countries acceleration towards Net Zero. Further research into sustainable approaches should be carried out in the UK.

CONCLUSION

This study aimed to identify if the UK is falling behind in research when compared with other countries on the race to Net Zero. The analysis showed that the United Kingdom, despite having several publications within the 275 articles, appears to have very little collaboration with other countries compared with others that do so. Given the current position of the UK in residential property sustainability, this needs to be encouraged as collaboration may offer insight and usefulness into what other countries are trying to implement within their residential houses. Further research into what these countries are doing could be used as an educational tool for what areas the UK may need to investigate. There is an increasing amount of interest in this area of research currently, with an upward trend year on year since 2018. As more focus on net zero becomes apparent, more research is expected to be carried out, which is welcomed. This study is limited to the Scopus database; future studies could explore more databases.

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