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Will Cities Survive?

Design research role in supporting net-zero buildings

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ABSTRACT: The way we build is evolving to deliver net-zero (energy and carbon) and healthy buildings. While this has been steadily adopted in developed countries, the housing demand is expected to be greater in countries under development, where people face wide barriers and challenges to embracing the net-zero future. The Passivhaus standard has played a critical role in the net-zero building process in North America and Europe. This paper explores how design research can be used to support the net-zero evolution using the Passivhaus standard as a building design model in Latin America while supporting the Sustainable Development Goals.
Design research provides a comprehensive approach for research on net-zero and healthy buildings, construction, capacity building, and engagement activities involving academics, professionals, and policymakers. This work presents the lessons learned through different initiatives delivered in Latin America between 2020 and 2022. These initiatives developed using the Passivhaus standard are the LatamHaus Network, the Ice Box Challenge delivery in Santiago de Chile, and a workshop with academics to shape a collaboration agenda for future projects. This paper aims to present a model that can be replicated to support the decarbonisation challenges for developing countries, particularly those in the Global South.
KEYWORDS: Passivhaus, net-zero buildings, Design research, Latin America

1. INTRODUCTION

In recent years, there has been much talk about levelling up our building stock to provide a zero-carbon future, particularly with regard to the building industry. While this is plausible in the developed world, the reality is very different in developing countries. Here, the opportunities and benefits of net-zero buildings could be more meaningful as net-zero buildings approaches have been recently introduced [1] and the building stock is expected to grow above record levels [2], but they face key challenges and barriers to their uptake.

The zero-carbon building concept is based on the energy balance calculation, where the energy consumption of a building is balanced with on-site and/or off-site energy generation systems — interacting with the utility grid. The goal is to reduce the energy consumption in buildings enough so that little energy produced on-site is needed for their upkeep. The Passivhaus Standard has been demonstrated as a method to achieve this goal around the globe [3], and even to be a positive energy building.

A Passivhaus is "*a building for which thermal comfort (ISO 7730) can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to achieve sufficient indoor air quality conditions – without the need for additional recirculation of air* [4]." The Passivhaus centres its design around five key principles: 1) adequate insulation, 2) thermal bridge-free construction, 3) airtight building envelope, 4) use of high-performance doors and windows, and 5) adequate ventilation, usually provided through Mechanical Ventilation with Heat Recovery (MVHR) systems (Figure 1). In the case of warmer climates, where solar radiation is considerable, such as those in Latin America, it is also suggested to take into consideration solar shading as a 6th principle to avoid overheating [5].

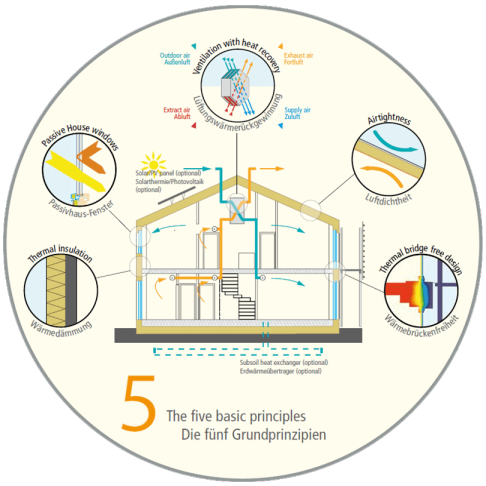

Figure 1: Passivhaus principles. Source: Passive House Institute (https://passivehouse.com/).

In recent years, the Passivhaus has started to expand outside of Central European climates where it was first born. Nowadays, there are Passivhaus examples in China, New Zealand and Latin America. The Passivhaus uptake in Latin America started in 2013 with an office building in Chile, followed in 2014 with the first home in Mexico City [1]. Since then, other buildings have followed, which have been extensively studied. These studies show evidence of thermal comfort [6], [7], energy [8], [9], economic [10], [11] or environmental [12] performance, as well as the feasibility [13], [14] of Passivhaus buildings in Latin America.

Nonetheless, the uptake of the Passivhaus in Latin America faces several barriers and challenges. The most important are economic, social acceptance, local building regulations and the lack of energy-efficient targets in these countries [[1]. Latin American stakeholders had also identified these barriers in the work presented here. Between May 2020 December 2020, the authors of this present paper have been working on developing an approach using design research methods to identify barriers and solutions and agents of change through a series of a series of initiatives planned for delivery between January 2021 and December 2022: 1) developing a network to support the Passivhaus in Latin America called LatamHaus (already in place), 2) the Ice Box Challenge in Santiago de Chile during the COP 26, and 3) an international workshop that brings academics to develop research projects that support the net-zero future.

This paper does not intend to provide detailed insights on the planning, delivery and findings of these activities. Instead, it seeks to provide a framework for approaching challenges for net-zero buildings in developing countries throughout these three main steps. It also provides an overview of the insights and the lessons learned from activities 1 and 2. Therefore, this paper presents the framework so that it could be used and applied as a reference to support the decarbonisation challenges for developing countries, particularly those in the Global South.

2. LATAMHAUS NETWORK

The LatamHaus Network (www.latamhaus.net) is an initiative joining international efforts to bring academics, industry and policymakers together to discuss issues related to the uptake of the Passivhaus standard in Latin America. This Network was born through several talks between the Latin American Passivhaus Institute (ILAPH) with the Authors. The planned objectives were set up as three milestones for the Network: 1) serve as a key player in developing capacity-building activities in Latin America, 2) bring together people that are interested in the Passivhaus to shape the agenda for its development in their countries and the rest of Latin America, and 3) produce evidence-based on the views of different stakeholders on different initiatives to support the Passivhaus development.

The Network, therefore, engaged with capacity building activities by offering scholarships to take the Passivhaus Designer Course for Latin America to academics, professionals and policy makers. Through this initiative, the Network seeks to plan several seeds of change in key stakeholders so that the Passivhaus principles can start to be embedded in the industry, academia and gradually into national policies. While it is difficult to appreciate the change in the short-term, some of the academics that received the training had already started to implement the Passivhaus design method into their teaching curricula, opening a broader view for net-zero building in their context.

The Network also engaged with local academics to develop research collaboration that looks at the Passivhaus's feasibility in specific climate regions in different countries. These research collaborations are ongoing, but, when finished, will add peer-reviewed cost-benefit analyses for the Passivhaus, not only in terms of energy but also CO_2 emissions and health. These collaborations had also highlighted the potential to include natural and bio-fibre construction materials in Passivhaus making use of the resources readily available in their doorstep.

Although impacted by the COVID-19 restrictions at the time of the delivery, the second milestone was shaped into three online workshops supported by a digital whiteboard for interactive activities between the participants (Figure 2). These workshops supported the discussion about 1) barriers and challenges that the Passivhaus has in Latin America, 2) Passivhaus and the Sustainable Development Goals (SDGs) in Latin America, and 3) how to develop resilient neighbourhoods. With these workshops, we sought insights on how we can support the development of the Passivhaus but also give some background. Therefore, the formats of the workshops were in three sections: lighting talks delivered by key actors for each of the themes and one academic, interactive activity in groups, and finally, a summary of the group discussions to collate and bring all together.

The critical lessons learned through these workshops are to develop initiatives that support the following:

- Developing public engagement activities.
- Cost-benefit analysis for the Passivhaus in all Latino America. Particularly environmental benefits (SDG 9), embodied energy (SDG 7), and health (SDG 3).
- Technical studies and engagement with local manufacturers.

Figure 2 Example of activities in the SDGs and Passivhaus workshop. Participants were asked to weigh the importance and effort needed to support the SDGs through the application of the Passivhaus. Source: Authors.

- Support national and local policymaking.

Finally, these lessons were used to inform the subsequent plans and modify the activities we had planned. Hence, the evidence from the different stakeholders and these lessons supported the delivery of the following two initiatives. These lessons were unavailable to support the action plan for the other activities.

3. ICE BOX CHALLENGE

The Ice Box Challenge is a citizen science engagement activity that involves building two boxes: one to local standard building practices and a second one to the Passivhaus Standard. The boxes are left outdoors with one ton of ice inside. After two weeks, the boxes are opened. The remaining ice is measured, demonstrating its effectiveness in keeping the heat out. By minimising the cooling/heating demand, on-site renewable energy production could suffice to run a building.

The Ice Box Challenge occurred between November 2nd and 11th, 2021, in the Plaza de Armas in Santiago de Chile (Figure 3 and 4). This event was also organised with the momentum of the Ice Box Challenge in Glasgow and the COP26 highlighting the Santiago-Glasgow COP26 route. The Ice Box Challenge had three key objectives: 1) to run an interactive 'living lab' experiment where Santiago's citizens could get involved; 2) to provide scientific evidence of the performance of two 'buildings' with the same use, density, shape and climatic conditions but with a different building envelop; and 3) serve as a lab for undergraduate students across the country so they can explore and understand better the standard in a tangible way.

The Ice Box Challenge has been a great tool not only to engage with the general public. It has proven invaluable to engage with local building materials producers and distributors, contractors and students to provide insights into the Passivhaus principles and construction methods explained through real-life experiences. An Ice Box Challenge was also delivered in Glasgow (July 23rd – August 6th, 2021). Glasgow's Ice Box Challenge provided the opportunity to engage internationally with students, professionals and academics in the UK to share their experiences delivering the Ice Box Challenge with their contra parts in Chile and start an international community to discuss shared interests.

Figure 3: Ice Box Challenge in Santiago de Chile. Source: Authors.

Figure 4: Passivhaus box with the ice inside at the beginning og the 10 days (before closing the box - 1000 kg of ice). Source: Authors.

Both buildings' indoor and outdoor temperatures and relative humidity were monitored and compared to provide rigorous evidence of the differences between both building standards. The Passivhaus remained close to 3.9°C - 5°C, remaining stable throughout the day throughout all the 10 days. The Chilean standard box ranged between 10°C – 19.2°C. After 10 days, both boxes were open and the remaining ice in them was measured. The Passivhaus box contained more than half of the ice with a total of 645 kg (Figure 5) and the box built to the local regulations (Figure 6) had 415 kg less than the Passivhaus box (230 kg). The opening of the box was timed with the Buildings day at COP 26 in Glasgow, where we presented live the results with the Latin American Passivhaus institute (ILAPH) in Chile.

Figure 5: Passivhaus box with the ice inside after 10 days (645 kg of ice). Source: Authors.

Figure 6: Local regulations box with the ice inside after 10 days (230 kg of ice). Source: Authors.

The key lessons learned from the Ice Box Challenge are the following:

- The Living Lab demonstrated how the general public could understand the Passivhaus concepts and apply them to day-to-day scenarios.
- It is essential that contractors and other people involved in the construction process understand the principles and why it is important to adhere to the specifications.
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- Used as a tool for teaching, through lectures and their practical application, the students got a deeper understanding of the Passivhaus principles.

4. INTERNATIONAL WORKSHOP

The delivery of the net-zero future is not the responsibility of one country but needs to be a collective, global effort. Supported by the findings of the LatamHaus Network, an exploration of international and cross-country projects to deliver a net-zero future is a clear next step. With this activity, we seek to identify and engage with critical organisations, industrial partners and academics to build international collaborations.

To boost these interdisciplinary and intercontinental collaborations, we identified Passivhaus projects across Latin America, either built or under construction. The aim here is to map potential case studies. It has already enabled the

authors to identify and engage with key industry actors, academics and national funding bodies. Further research will help shape national net-zero policies supported by world-leading studies that push the boundaries between the current building stock and the net-zero future in different countries.

The international workshop seeks support from industrial partners and academics from Argentina, Brazil, Chile, Colombia and Mexico. Additionally, we seek support from academics within Latin America, the UK and EU, as well as support from international funding bodies such as Latin American Research Councils (i.e. CONACyT, COECYT), UK Research and Innovation (UKRI) and the UK PACT, among other venues of funding to establish international collaborations.

Given that this activity is still to be delivered at the time of writing, there are no lessons learned or specific outcomes from this workshop. Nonetheless, we have had talks with the industrial partners and academics to develop a draft idea of how these collaborations may look. We hope to attract the required funding to develop different strategies that will support the Passivhaus development in Latin America.

The LatamHaus Network suggested several courses of action. For example, while several Passivhaus projects are under development, only residential buildings have been the focus of scientific scrutiny. Hence, there is a need to conduct a large-scale, cost-effective analysis of different Passivhaus case studies identified throughout Latin America[, such as office blocks…?]. Another course of action relates to the natural environment and its capacity to sequester CO2 emissions in Latin American countries. Therefore, looking at how Passivhaus buildings can be supported through natural building materials to reduce even further their CO_2 footprint.

5. DESIGN RESEARCH ROLE

Design research methods have allowed us to shape the net-zero agenda for our project. The use of research methods has been invaluable during the planning process to do the following:

- understand the current state of net-zero buildings in Latin America,
- respond through multidisciplinary approaches,
- shape the situations into something that everyone can understand it, and
- design outcomes and activities supported by the findings.

More importantly, design research allows us to better understand particular communities' needs and shape the research around that. In other words, we want to conduct research that crosses the traditional research boundaries with a bottom-top approach where the research question comes from the community. Hence, these research projects are informed by the activities of the LatamHaus Network.

Another crucial role of using design research methods to conduct and plan this kind of research project is that they provide the flexibility to incorporate both qualitative and quantitative research approaches and bend the traditional research boundaries to establish interdisciplinary research for all. Design research also enables academics to translate the research outcomes into tangible actions that can be applied and implemented at local, regional and national levels so that the research becomes an actor of change.

5. CONCLUSION

This paper presented a framework that can be exploited to introduce and start the discussion of the net-zero future in the built environment, considering social and academic aspects. The critical role of this framework developed through research design methods is summarised in three key points: 1) networking & capacity building, 2) engagement activities, and 3) research.

Networking & capacity building provides the basis for the research activities. The main task here is to build a network of people interested in working together and support them to develop the necessary skills to become actors of change within their reach.

Engagement activities provide the outreach for the research outcomes, but more importantly, open the science in a lay language that everyone can understand, helping so that they can be gradually absorbed in day-to-day life.

Research provides interdisciplinary project development and rigorous testing of ideas to be incorporated into the net-zero building industry.

Finally, the role of research design is to close the gap between academics and the general public, taking a bottom-top approach and translating the research outcomes into tangible actions for local communities.

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