Reducing CO_2 in Passivhaus-Adapted Affordable Tropical Homes

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On average, houses including those in the tropics are responsible for almost 39% of the global carbon emission caused by non-renewables, first and foremost by fuel. Looking at the worldwide map of residential buildings' contribution compared with commercial, the worldwide national maximum of 33.5% CO_2 of housing is caused by residential buildings in Uzbekistan. In an overwhelming number of most countries, their values are significantly lower, due to comparably lower energy demand than commercial buildings and because affordable homes increasingly use small PV to cater for their own basic needs. However, with the rising temperature and a likewise growing imperative to cool homes from about 30 °C onwards basically by split-unit air conditioners, the residential houses' portion of CO_2-emission might dramatically increase to survive such more common hot periods in the future. In combination with air conditioners needing some airtightness, the first purpose of this entry is to show that by 2050 in tropical regions, there will be no alternative to relatively airtight houses if the temperatures rise at the present speed. This is one alternative to an uncontrollable and life-threatening migration of millions of people to cooler but still livable regions in 2050. To trigger necessary changes toward homes that can better avert the heat, using the method of qualitative comparative content analysis, passive houses (PH) have emerged as adaptations to the tropical climate. Therefore, the second purpose of this in-depth study with the perspective of social science, is to reveal a comparative closer qualitative look at the tropicalized PH-approach. It is probably the most civilized building energy-saving strategy on the planet and can systematically keep the threatening increasing heat outside. However, before utilizing the concept, herein need to investigate why PH-technology as a whole concept with all its modules discussed earlier has been very slow to "go South" into the tropical region (the original PH will be referred to as "PH1"). The reason is that some qualitative differences of the more affordable and more simplistic tropicalized "PH2" make it easier and more realistic to penetrate the market, without letting go meaningful R&D-insights of PH1. As a probably facilitating future solution, the result is the triple-tabled option to utilise more synergies between the usually closed PH1 and the more open and flexibly naturally ventilated PH2. Unlike the PH-platform, ZEMCH is a related concept which tries to cater specifically to the significantly growing market for lower-income homes to go for carbonless energy. The conclusion is that scaling for residential buildings as mass products using passive house technology in combination with ZEMCH could turn out to become an important topic. It comprises the question in how far low or no carbon affordable homes based on the PH-concept in combination with ZEMCH-applications also may come into play as standard and to help mother Earth's struggle for survival.

Keywords: climate change ; Passivhaus ; ZEMCH ; affordable housing ; synergies

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In building science, and logically in everyday life, a building anywhere on the globe, is an "environmental separator between inside and outside" [1]. Green buildings attempt to reduce carbon against the hotter years to come. They firm up under different concepts and strategies, such as low and zero energy houses, zero energy buildings, nearly zero-emission building (NZEB), zero-emission buildings to name a few prominent ones. Some of these green building concepts are to be implemented in the EU between 2020 and 2030.

Among these strategies, worldwide, the most energy efficient concept is the Passivhaus. It will be using and tabling two slightly differing passive house concepts, PH1 and PH2, applying three comparative content analyses as methodology that is widely used in social science. In the tradition of the sociologists Emile Durkheim and Max Weber, this is a kind of a bird's-eye view perspective and method of comparing the two contents with the "idea of uncovering and discovering new ideas about them" [2].

Applying this methodology, it seems consensual that passive basically means that the indoor climate is separated by the building envelope against an unhealthy or uncomfortable outdoor climate for humans. This counts also vice versa: If the outdoor conditions are more comfortable and healthier compared with indoor, why not open windows and perhaps even doors?

However, based on the methodology of comparative content analysis, “passive house technology” generated by concepts in building science has two different meanings. From a social science perspective, the content analysis of “passive” will be used in the tradition of relationism and phenomenology as the “discipline of phenomenology that may be defined initially as the entry of structures of experience, or consciousness” [3]. Literally, phenomenology is the entry of everyday life “phenomena,” which states that different actors even like architects or building scientists might have different perceptions. This will depend on how science teaches to experience passive as part of the own social community and how different perspectives can work together. Accordingly, phenomenology describes and analyses the appearances of things, as they appear in experience, “the study of phenomena (= things that exist and can be seen, felt, tasted, etc.) and how experience them [4].

Hence, based on qualitative phenomenological studies, our first look will be at PH from five different perspectives; out of four principal ways how to build homes, looking at mainstream and three passive strategies, and within two concepts for passive houses:

- **Conventional house**. Nothing is optimized. Buildings are just cheap and fast focusing only on fast ROIs. These houses stack the heat. Its type A works with relatively energy saving fans (50%), type B with A/C, at least in the master sleeping room. Type B compared to type A is characterized by a high carbon footprint.

- **House with element(s) of passive technology**. Architects try to educate people to use more passive modules based on natural ventilation, which as a minimum requirement just means opening windows all day and night long to save CO_2: “The most important passive design strategy in the tropics is to open up houses as much as possible, even during the heat of the day, to achieve maximum cross ventilation and convective air flow” [5]. This is a common behaviour for most households in warm and hot conditions like in the tropics.

- **PH1,** as presented below, was developed and marketed from the cold hemisphere (Central Europe, Sweden, USA/Utah), following their credo with meticulously defined necessities of insulation and airtightness with software like PHPP which restricts the user’s calculation to a clear standard saves enormously carbon.

- **PH2** resembles PH1 but looks in depth at tropical adaptations. It is a combination of daytime closed and nighttime open windows, which is unsuitable for PH1 under tropical conditions of high temperature and absolute => relative humidity. It can lead to more RH if is it not controlled, and it may lead to higher “adaptive” temperatures of occupants. Therefore, tropically adapted Passive Houses (PH2) can accept higher temperatures. with set points up to 28 °C and any humidity. Hence, it will be seen more energy saving than the conventional PH1-standards with their maximum allowable temperature of 25 °C and 60% relative humidity integrated in the software tool PHPP.

- In addition, the **ZEMCH** network products are not a derivation of 3 or 4 but could be closely related to one of them, making use of passive technology. ZEMCH is not restricted to its features. Its application might also be more related to nearly zero-emission building (NZEB).

Option 1 is still common but is not a not subject in this contribution, as looking towards more carbon-free solutions. Both 1 and 2 have no radar for real passive sustainability, as the house remains hot. Option 2 is just patchwork and does not lead to CO_2 saving targets like the PH 1 and 2, along with ZEMCH buildings.

Before applying phenomenology as a tool to compare the two remaining Passivhaus concepts (1) in the colder hemisphere and (2) its potential in the tropics, looking at different passive strategies to achieve more conducive thermal comfort. In the decades of approaching global warming catastrophes, this can be seen as a “higher” reason to assist to reduce climate change in the building sector. In the case of passive technology and how to achieve thermal comfort for occupants, it is about the (non-) interaction of two basically latent controversial standpoints passive technology and the renowned PH1. (Especially PH2 as a potential further development of the PH with ZEMCH which stresses on scalable affordable mass homes will follow later).

Comparing 2. Passive technology and 3. Passive Houses from the phenomenologist’s perspective are like asking two building scientists who more unconsciously but inadvertently refused talking about the generic meaning of “passive” to each other. Decades to communicate and exchange ideas have passed by since the word ever occurred, probably independently, in tropical and colder climate origins.

The first one promoting passive technology will be called the “classical tropical” type approach that even at certain times maximises natural ventilation and the second one “passive” PH1 using the building envelope as a basic fortress against the heat. At certain “hot” times, air conditioning and in less hot cases cool-water-based cooling ceilings or walls are needed, protected by a closed-up building envelope. In this entry, by qualitative content analysis, the second meaning of passive related to PH1 and PH2, and, by the applied analysis will be pursued, try to reconcile both.

Since 1991, the State of the Art Passivhaus in the traces of type PH1 follows five principles. Instead of heat recovery, compulsory cooling recovery is suggested for tropical buildings and those in the colder hemisphere during the hot season. In cold regions like Iceland, back in the Middle Ages, dwellers started to build passive-like turf houses after wood became scarce [6]. It requires artificial cooling in residential buildings under hot conditions usually performed by air conditioners as clear separator between inside and outside climate was laid out around 1980 in Utah/USA by its fundamental DIYS-inventor, Amory Lovins [7]. Wolfgang Feist (formerly Institute for Housing and the Environment, /Institut Wohnen und Umwelt Darmstadt/Germany) and Bo Adamson (Lund University, Lund/Sweden) introduced and further developed the concept in Europe. The emerging "Passive House standard" originated from a conversation in May 1988 between Adamson and Feist, but was much more than a new label for a green building. Its founders agreed on strict criteria to make it the most radical "green" version of a thermally comfortable low energy house. Apart from any consumable energy, it is defined by extremely low heating and, likewise if applicable, cooling demand [8]. It results in the fact that (apart from other energy efficient features) necessary warmth or coolness can be implemented primarily by the supply of an (active) mechanical ventilation system. Adamson's idea of mechanical instead of sometimes not working natural ventilation was first rejected by Feist but was soon understood as a necessity to make PHs a reality with basic airtightness plus outside air if necessary [9]. When 90% less energy was consumed in the world's first passive residential house at Kranichstein/Darmstadt in 1991, experts said to Feist that it must be an error, but obviously it was not: Even by 2021, 30 years after the first building was set up, no decrease in terms of this 90% less energy performance could yet be reported, with still low maintenance efforts [10].

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