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Short Communication

Reducing CO^2 in Passive House Adapted Low-cost Tropical Homes?

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Abstract

The background of this novel study is how to apply an empirically adjusted Passive House concept in the tropics - beyond its otherwise prevailing global standards. Even though well-insulated houses have been on the planet since people settled down in some of their first dwellings, passive in the 21st century is different. It includes strict rules for airtightness and fitting of windows along with a sophisticated concept for artificial ventilation. Fresh air reachable from outside by filtered ventilation with heat recovery describes the heart of the system - if natural outside air is not preferable, it is convenient just in seasons with thermal comfort.

Hence, the purpose and aim of the study presented here is to use a less common and at the same time more cost-saving approach: It might seem that the modern type of passive house entails the same standards that have been developed firmly on its own global market niche. However, this article tries to contribute toward a new development of modern passive homes for low-cost affordable tropical and subtropical houses in their entirety.

As a concluding note, the author states that nobody has ever disproven this evolving concept as a combination of airtightness and a new way of forced ventilation without heat- or coolness recovery which is highly applicable for low-cost residential areas in tropical countries. By generating lower temperatures, it can help to surpass the overheating caused by climate change in certain tropical climate zones in higher altitudes and during cooler seasons. The condition is that the occupants are willing to accept a thermal comfort of up to 28 °C and humidity in its 70s and 80s.

More Information

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Introduction

The stereotypical discussion about climate change, whether a dangerous increment of "CO^2 and other worldwide hazardous gases" exists since the industrial age with an increasing threat potential for the whole planet, or not, is no longer relevant. Whatever web page one opens, it is clear that climate change continuously was caused by humans and is threatening our planet severely.

What should be clear to everyone: the post-World War II ff. generation must leave their children and grandchildren with as much of an environmentally protected planet as possible. Can stakeholders do anything about climate change (which the international "community" obviously cannot do anything much until the IPCC-envisaged threshold year 2030)? [1] Despite various official statements and activities, we are dealing with a long-term unnatural warming of the earth. This does not do anything immediately in the midst of other hot political issues that have cascaded down to business. Concrete statements can be found and derived about environmental and climate protection, which has been largely ignored, but what the about three equal polluters can do, each segment individually: industry, transport, and buildings. This article will only deal with the 30% - 40% CO^2 causes of climate change undeniably produced by buildings – their making, their dwelling all the way down their life cycle until their destruction.

The *Passive House approach* is the best-known and most renowned concept in the world promising to reduce global warming by 90% mostly for non-commercial buildings. There are meticulous calculations, the plausibility of which will not be discussed here [2]. Instead of relying on simulations, the writer of this contribution would rather dare a comparison with these classic passive houses in tropical climates, where a larger and even growing number of people live. Are these suitable for competing on a large scale with conventional ways of building houses, or offer an alternative? Passive houses are often the structural paradise – the "number 1" – for their residents. Moreover, for most representatives of this approach, there is no doubt. However, with the growing influence of architecture, this is contradicted by the non-affordability of passive elements: the higher the budget for a living space, the more original passive house elements can be included in the planning on the strive for survival strategies in the age of climate change. But by strict definition, it will be shown that these not complying with certain regulations may no longer be entitled to carry the name "*certified* passive houses". Below, the strict worldwide standards will be questioned, but in addition, rather the search for realistic bridges to the No. 1 in ecological house building of the future, where the budget is too tight.

To comprehend passive houses and try to adapt them at the same time, here are the 5 summarised main credos or core parts of the classic passive house approach, which cannot be questioned by the user, because they are fixed assets within the globally valid certified Passive House (PHPP) software [3]: All of their credos are therefore scientifically mandatory. The resulting standards that must be strictly adhered to for building projects are in the Passive House software which is authorized for certification, but not for any new discussion. As the author had between 05 and 08/2021 with the co-founder and still leading figure of the Passive House, Wolfgang Feist.

1. Insulation: In the author's opinion and experience, it makes no sense to demand 100% perfect standards because of density. 0.6 1/h for airtightness at a pressure difference of 50 Pascal is the maximum acceptable for the Passive House software, regardless of the location, whether it is Melbourne, Prague, or Kamtschatka. That means that the building envelope needs a thickness of almost 40 cm, and the triple-glazed windows must be connected in an airtight manner. Conversely to this software-driven standard, for a tropical passive house, the requirements are different. Together with a Central European provider, [4] it is calculated by a light-weight concrete house the external walls of this typical European manufacturer should be 22 cm, but not the 40 cm required by the passive house standard and its software. This is logical because at 22 cm a house will still remain cool enough - if the other tropical standards described below are met. As a test, the layperson can point to experiments that indicate that well-insulated thermos flasks keep filled liquids warm or cold much longer than uninsulated insulation material.

Why this experiment is primarily of central importance for the external walls, can be seen in the opening of non-insulated, NOT state-of-the-art, leaky private houses with, unfortunately, typically only 10 cm of standardized concrete or brick construction of the external walls.

Imagine one lives in a house like this with a balcony and sits down there for dinner in the evening at 28°C and a humidity of 77%. Typically, one does not keep the balcony door into the house closed. How long does it take for the house, which is "naturally ventilated" at almost 30 °C through non-density inlets, to reach the slightly lower outside temperature? The answer, based on the previously mentioned thermo-flask or spoon experiment [5], is shockingly simple: due to the inertia of the heat stored in the walls, cooling takes a very, very long time. Even at sunrise, during the coolest temperatures of the day, hardly anything has changed. Of course, the perceived temperature can be reduced by supplying (pretended cold) air from conventional fans or by air conditioning systems - but these isolated climatic solutions cannot produce a single cubic cm of fresh outside air.

2. Furthermore, at this point, it would be feasible to just take a quick look at the windows, the most expensive and at the same time most vulnerable modules in most houses. In the globally valid passive house approach, there is no alternative to triple-glazed windows with a high heat transmission (U - value) and a low g - value [6]. In tropical terms, this would imply that, on the one hand, shading should be optimal. Nevertheless, when it comes to glazing, very expensive mandatory triple glazing like requested by the Passive House software hardly makes sense for any tropical homeowner - unless he or she is aiming for certification in conformity with the software. Correct positioning along the sun's path, shading, and white roofs, on the other hand, is a simple, cost-effective job. The g - value (solar transmittance) drops, depending on the season in the then-generated heat of the sun, could be up to 0% if simple shading tools are used instead of complex triple or double glazing. And the U - values can be higher because of shading, in addition to the windows. Therefore, the 60% g-value rule of the PHPP cannot be transferred to a tropical environment.

3. Ventilation: Cross ventilation is one of the most effective ways of naturally cooling a house [7], even in hot and humid climates. *Forced cross ventilation* (as found for passive house technology) is a type of building ventilation system that uses fans or blowers to provide fresh air to rooms when the forces of air pressure and gravity are not enough to circulate air through a building [8].

The concept presented here, however, uses forced drawn-in and at the same time released ventilation instead of more sophisticated heat or coolness recovery duct solutions for centralised aircon to provide them with fresh and filtered air. For split units, as they are typical for residential areas, fresh air is contradictory as it opposes the generation of cool and dehumidified air which is exactly the task of the decentralised air cons, alongside the coolness recovery tool of the mandatory Passive House equipment [9].

Hence, in the case of our concept, outside air is actively drawn into the room or, at a larger scale, into the entire building. Moisture (eventually in the longer run followed by mould) with free ventilation from outside is no longer considered an issue for humans and the building structure, as the incoming humid air is being exchanged by the immediate extrusion of the cross ventilation, drawing out the air on the other side. This principle is widely acknowledged in Central Europe and North America, but it contradicts the Passive House strategy [10].

If one is a follower of the climate change theory in the wake of Al Gore [11], Harald Lesch, or most radical Jeremy

Bendell [12], they will certainly be initially convinced by air conditioning systems with PV on the roof and coolness recovery mode for fans including air conditioning. (Heat pumps are in vogue in cooler areas, but the required pumps are difficult to present in tropical high-rise buildings without a base from the 1st floor onwards due to a lack of space.) Therefore, if a Passive House client favors the "other" modified passive house theory, and has the "luxury" of one if they cannot or do not want to afford a passive house with these advantages, then there is a simple alternative. This is based on the principle of the much unknown active mechanical night cross-ventilation with conventional ventilation such as in the bathroom or as an extractor hood - both with an external connection.

To conclude, mechanical cross ventilation uses a simple device to draw fresh, cooler, usually filtered, but also more humid air into the building at night as soon as the outside temperature is lower in the evening or at night. Opening a window will help the tropical temperature to dissipate very slowly, and rather invite mosquitoes and other animals to enter the room. The temperature difference between inside and outside is much smaller in non-urban regions than in cooler climates, where simply opening the windows often brings comfort with temperature differences of up to 10 °C. Open doors supply fresh air, but a bit cooler air from outside alone will not reduce the nighttime temperature unless it rains heavily.

In the tropics, the smaller temperature difference is still very helpful for cross-ventilation. A typical example from a longitudinal study 2015f., demonstrates this on average days. In many shaded rooms, the internal temperature is typically approximately 29 °C with a produced humidity between 70 and 75%, if the air con is not operated. Gabriele Arese, a technical student from Torino, resident in Malaysia 6 months in 2015, reports about this typical "behavior" of his room which was located in a condominium in the heart of Kuala Lumpur. In case it is switched on, the system "smartly" automates the otherwise dormant air conditioning system to the "On" mode to return to a maximum of 28 °C, or in the economy version of a house it turns on the indoor fans targeting the residents' skin.

Of course, moisture is also attracted during the cooler night, but the simple, flexible system of cross ventilation, if necessary with a pollution filter, transports it right away back out. During times of very high nocturnal humidity, over the course of 3 months of the rainy season, a little mold appeared in the experimental bedroom due to "forced" cross ventilation, but at first, it was only easy to wash off on rubber or belts. And if a little mold should appear on the walls or, typically, the corners of the ceiling, there are enough ways to combat it quickly. And if one is a supporter of Spengler's doomsday theory [13] (or like Bendell's), then it does not matter how much relative humidity the building absorbs by 2040 or 2050, since everything should then come to an end anyway, at least tropical areas will then become uninhabitable due to the extreme heat, and the cross ventilation might be history, if not moved to a cooler, then still habitable regions.

4. Payback period: 30 years or 5 years? These obviously arguable figures make a huge difference in making a buy decision into passive or not. According to detailed calculations, potential passive house buyers usually have to anticipate a very long RoI (return on investment) of 30 years. They might be common in architecturally sophisticated houses [14]. The genuine advantage of an affordable tropical Passive Home in any place of the world, however, is mere functionality– and not any appealing architecture. For such standard passive homes, including a minority of different architects, the payback period compared to a conventional house is only about 5 years [15] compared with typical standardized concrete houses [16]. The alternative would be accepting the architectural sins that are still prevailing in the style of the 1970s and 1980s without the application of tropically adapted passive house knowledge.

5. The author assumes therefore that the worst enemy of a real sustainable innovation that would be necessary, more than ever in the Anthropocene age [17], is the mindset of the experts, who discharge the term passive house with the comment "not applicable to us" (iron it out) or until the standard for certification fits [3]. Although the passive house only found a smaller number of supporters in absolute and relative terms than in any other climate, - as explained above - large parts of the approach are climate-protecting, budget-saving, and, last but not least, compatible with most existing and yet to be built buildings. These are not patchworks like the buzzword "passive designs", which only mean isolated solutions such as insulation, double glazing, or location in a (still) tree-rich environment. Passive house, whether classic with a maximum of 25 °C inside temperature and a maximum of 10% deviations upwards, means in the tropics a useless restriction taken from cooler climates applied for any other climate. It further means an integrated approach of all its modules, but for reasons of environmental protection mentioned above, with the inclusion of a maximum temperature that since Brager's publications (e.g.1999) tropically adapted people are prepared to endure ("adaptive thermal comfort") [18]. The most challenging issue that has become debatable by Brager's and De Dear's work assigned by ASHRAE is that "Thermal comfort must be met for all living areas during winter as well as in summer, with not more than 10 % of the hours in a given year over 25 °C" [19]. These requirements are not doable when it comes to a tropical building that uses the cross-ventilation system derived above.

Conclusion

Anyway, for affordable houses free cross ventilation without the more sophisticated coolness recovery system can become an alternative. Climate change is actually as brutal as hypothesized by the IPCC with already debated 2 °C more heat forecast by 2050. Subsequently, the adapted passive house may provide another option for protection without the large-scale use of air conditioning systems, which unfortunately increases the CO^2 level (that was supposed to be reduced) as well. In comparison to the universal passive house approach, opening the strict standards offers an opportunity to at least delay a mass exodus from tropical climes in a hotter and hotter environment that is becoming increasingly inhospitable. In line with what was written above, solutions that are much more compatible with nature and people are to be found.

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