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THE DETRIMENT OF THE AIR CONDITIONING UNIT AND WAYS TO IMPROVE VENTILATION IN TROPICAL AND ARID ARCHITECTURE

EL DETRIMENTO DE LA UNIDAD DE AIRE ACONDICIONADO Y FORMAS DE MEJORAR LA VENTILACIÓN EN ARQUITECTURA TROPICAL Y ÁRIDA

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Abstract
The invention of the AC Unit by Willis Carrier changed how billions of people live worldwide. The commercialization of this invention led to the designing of architecture dependent on the AC Unit throughout tropical and desertic countries. Globalism introduced to developing nations the illusion of modernity, which led to the construction of unsustainable skyscrapers and shopping malls common in many countries. With the threat of climate change looming, passive ventilation and Vernacularism provide solutions that can create a more sustainable architecture.

Keywords: ventilation, air conditioning unit, architecture, modernity, vernacularism

Resumen
La invención del aire acondicionado por Willis Carrier cambió la forma en que viven miles de millones de personas en todo el mundo. La comercialización de este invento llevó al diseño de arquitectura dependiente de la unidad de aire acondicionado, aun en países tropicales y desérticos. El globalismo introdujo en las naciones en desarrollo la ilusión de la modernidad, lo que llevó a la construcción de rascacielos y centros comerciales insostenibles, comunes en muchos países. Ante la amenaza del cambio climático, la ventilación pasiva y el vernacularismo brindan soluciones que pueden crear una arquitectura más sustentable.

Palabras claves: ventilación, unidad de aire acondicionado, arquitectura, modernidad, vernacularismo

Introduction

One of the most important factors when creating the design of a new building as an architect, architectural designer, or engineer is ensuring the client's steady access and flow of fresh air within the building while protecting them from the elements. For these reasons, humans have devised solutions to keep either cold or warm in their buildings. As new technologies emerge, systems have been created to simulate cool or warm environments in places where such temperatures are virtually impossible. Architects foresaw the advent of these systems and designed buildings that require an A/C or HVAC system, especially in tropical countries. With the rejection of vernacular practices in favor of modern international architecture unsuitable for local climates worldwide, mechanical ventilation systems have become the standard for countries submitted to the illusion of modernity.

History of Ventilation in Warm Climates

The first form of ventilation appeared in ancient times as people needed to find a way to get rid of smoke created by fires in their huts to keep themselves warm. The most notable ancient climate control system being the radiant heating systems of ancient Rome, in which hollow tiles under the floor transmitted heat from stoves located in the peripheries of the building to smokestacks (Janssen, 1999). Most tropical and desert-based civilizations developed ways of combating the scorching heat by building structures that responded to the elements of their climate, leading to the development of vernacular architecture. As European countries occupied territories worldwide, architects began to adapt European design standards to make living more comfortable for the new occupants. Such examples may be observed in colonial architecture around Asia, Africa, the Caribbean, and the Southern US. In these houses, ' designs were adapted and built with front porches, large windows, and high ceilings, and coated with white paint or plaster to keep fresh air in an inhospitable climate due to heat or humidity. Nobody expected that design would be changed with the invention of a machine that changed how humanity lived.

The Invention of the AC Unit

The first air conditioning unit was patented by Willis Haviland Carrier in 1902. It was originally conceived to solve a humidity problem at a printing plant in New York City. This first air conditioning unit turned hot air into cool air by sending it to coils of cool water while removing moisture to control humidity. Later, as

technology advanced, the Carrier Air Conditioning of America would create a model that would serve as the basis of modern-day air conditioning units (Varrasi, 2011). These new units use electricity to power these devices, turning hot air from outside into cool air. The fact that new technology was created to prevent hot air from ever entering a building while keeping its interior as cool as its owner sees fit revolutionized the way humans settled and developed architecture in the twentieth century and beyond.

The Post-War, Suburbanization, and Modular Low-Cost Housing

As the Second World War concluded, many Western countries, specifically Europe, began constructing buildings in glass and concrete to reconstruct major European cities from the devastation caused by the war. This new architecture was made of cheap materials that retained heat, only released at night, creating an Urban Heat Island Effect (EPA 2023). These structures were also built with low ceilings, which prohibits air from going up to a higher place, trapping the heat inside the structure, which is a problem as, in the future, both America and Europe will suffer warmer summers. The decrease in window sizes was also present, prohibiting the entry of cool air. As a result, buildings would have to be cooled in the summers and warmed in the winters using artificial systems. As the Cold War advanced and new economic theories were created, modernist architecture gained traction throughout the many countries of the developing World.

Globalism and the Illusion of Modernity

During the end of the twentieth century, the old ideologies of the Second World War died out as the Socialist Bloc collapsed, starting with the fall of the Berlin Wall in 1989 and the Collapse of the Soviet Union in 1991. This led the Western Capitalist nations to gain a world hegemony and spread neoliberalism throughout the World. This led to the development of a new global supply chain, as large corporations outsourced their manufacturing jobs to low-income countries, bringing in new wealth for many people. The agricultural and medical revolution of the mid-twentieth century led to an exponential growth in the population of these territories, as people in low-income countries produced more offspring as they became healthier, had better access to food, and gained sexual consciousness.

Most of these new infrastructures built in developing countries were designed in the international and post-modern styles, ignoring their locations' climactic and environmental conditions. For example, the large glass structures seen in desert cities such as Dubai and tropical cities such as Singapore and Kuala Lumpur attract

heat as it gets trapped in the glass that makes up the facade of the building, thus making its surrounding area hotter than the actual climate of the city, causing the Urban Heat Island Effect (EPA, 2023). This predicament calls for mechanical ventilation, which led to the introduction of AC units to these buildings to keep a cool microclimate inside these steel and glass furnaces.

These structures were erected as developing countries fell into the illusion of modernity, which implies that, for a country to be considered modern or “developed," its infrastructure should resemble the infrastructures of economically dominant nations for further development and economic progress. This way of thought is partly true, as many countries that have adopted modern structures have gained global popularity due to this practice and a large influx of tourists and businesses that have helped diversify their respective economies and create jobs. On the other hand, this is just an illusion that tries to hide the large economic disparity in the developing World, as many people crowd themselves into slums surrounding large cities. At the same time, the wealthy minority lives in luxury apartments situated in glass and steel towers. This means that many people living below the poverty line were not able to afford AC units, instead having to resort to living in dense slums that don’t have electricity services to run any type of artificial ventilation due to population increase and taxpayer refusal to subsidize electricity for the poor (Rutu et al., 2019). This practice of cookie-cutter housing is also commonplace in suburban development projects in Latin American countries such as Puerto Rico, where low ceilings, small windows, and heat-attracting cement have made it virtually impossible to enjoy good ventilation, thus creating the necessity of air conditioning units inside residential structures, which come at a hefty price for the electric bills of many.

High Electricity Consumption

World's population is happening mainly in developing countries, which means that most of the planet’s people are dependent on artificial cooling systems that are powered by electric energy, even in portions of developed countries such as most of Australia and the American states of Arizona, New Mexico, and Southern California. This means that, as more people live in humid climates such as those of India and Southern China and arid climates such as most of the Middle East and Northern Africa, more people will pay copious amounts of money for electricity to keep their homes cool. If one were to run a window AC unit at total capacity, the cost could range from six to thirty-six cents an hour, with an average of ten cents. Monthly, the costs would add up from $3.82 to $35.57 per month, which makes for an annual cost of $46.50 to $432.75 a year. It is estimated that in the US, air conditioning usage

comprises 8.2% of the average household's electric bill (James, 2023). Suppose one considers the significantly lower income in less-developed countries, which are majorly located in the hotter, more humid, and arid southern hemisphere. In that case, this expense is an economic burden to the primarily low-income households that inhabit these territories.

Other than the high costs that come with high electricity consumption levels, it also places a heavy burden on many countries' electric infrastructures. It is said that central air conditioners and mini split AC units can consume from 0.48kW/h to 5.14kWh. Larger, 6-ton or SEER AC Units can consume up to 3.75kWh of electricity (Poed & Learn Metrics, 2022). That does not sound like much, but when those numbers are added up to a large population, billions upon billions of kilowatts are wasted due to electricity consumption from AC units. It is estimated that in the United States, 235 billion kWh were used by American households (Poed & Learn Metrics, 2022). This is worrying because most electric systems in developing nations are not on par with the needs of their population, as they do not have enough resources as developing nations have and do not have enough spending power to implement new energy-efficient technologies that can help sustain a robust electric system. For this reason, these countries have no choice but to use cheap sources such as coal and natural gas to power up their already small and feeble electric systems—which leads, in turn, to the creation of fossil fuels that harm the planet.

Climate Change

High energy consumption levels exacerbate the climate crisis the globe is currently facing, as most countries are still using fossil fuels to power up their homes and businesses. Even though the planet's population has lowered its fossil fuel consumption, from 94.5 percent in 1970 to 79.7 percent in 2015 (World Bank, 2014), there is still a way for humanity to reach a sustainable carbon footprint. Coal, oil, and gas are still primarily used, as 77 percent of the planet’s energy consumption was sourced from these materials in 2021 (Truman, 2023). Combined with other environmental and behavioral factors, these fuels create a significantly hotter environment, as heat waves of record temperatures have been plaguing temperate countries, which means that people in hotter climates will suffer more in these heat waves. These heat waves have also catalyzed many more severe health problems.

The increase in hot temperatures throughout the planet also contributes to the melting of ice caps and glaciers in the northern and southern poles, which lead to rising sea levels. One city suffering from this effect is Miami, Florida, which has built a metropolis of concrete, glass, steel, wood, and gypsum board on terrains six

feet or less below sea level, making up 56% of Miami-Dade County's land. The Southeast Florida Regional Climate Compact warns that in the next century, sea levels can rise from three to eight feet, making over half of the land in the county uninhabitable (Rivero, 2023). This is due to poor infrastructure practices, such as changing the local terrain to fit humanity's needs by building canals, highways, large suburbs, and other unsuitable projects for tropical climates. This includes houses and buildings built from the perspective of Northern, cooler climates that rely on air conditioning to function in the area. Rising sea levels are not the only threat to the quality of life in these warm climates, as rising heat also accompanies increased natural disasters.

Natural disasters and extreme weather events have increased in severity as the planet suffers from man-made climate change. Hurricanes, typhoons, and rainstorms become more severe, causing billions of dollars in damage costs. The World Meteorological Organization has reported that a total of 3.6 trillion US dollars have been lost due to damage costs related to natural phenomena and a total of 2,064,929 deaths related to natural disasters (WMO, 2021). Many of the structures in these disasters are often lost to mass floodings and large gusts of wind. As a result, their inhabitants may need more than water and electricity to live through prolonged amounts of time. These problems are rooted in how people design their living spaces, as they might design structures unsuitable for resisting the elements and surviving the aftermath of such catastrophes. For these reasons, there must be an overhaul in how ventilation is considered in the architectural design of the places suffering the worst of the climate crisis.

Humanity must change how they live and consume water, food, and, most importantly, electricity if the climate crises are to be subverted. The first way to change people’s lifestyles is to transform the spaces that humans live in into spaces more suitable for nature, climate, and people's overall health. The first step that should take place is to completely reform how the modern man ventilates his buildings, from switching from electricity-dependant AC units and HVAC systems to forms of natural ventilation to better suit his climate. Many natural, historical, and vernacular solutions can serve as a guide to reform the ventilation design in spaces, especially in countries and regions with hot and arid climates.

Natural Ventilation

Understanding how natural ventilation works and behaves is an important step to improving the architecture of tropical and arid homes to break from the dependence on mechanical ventilation. There are two main types of natural ventilation. The first

one is wind Ventilation, in which wind forces and pressures are used to ventilate an architectural structure. This is achieved by openings in the building, such as windows and doors, strategically placed and scaled to get the maximum amount of fresh air. The other type of natural ventilation is buoyancy-driven, emphasizing the air density inside the structure. As cool air enters the building, it becomes less dense as it becomes separated from the exterior of the building, making it warmer, thus rising to a higher place in the building, which is supposed to have an exit for warm air, such as a clerestory or roof window, making the structure's interior cooler. There are many ways to design spaces that maximize natural ventilation to achieve a cooler building without artificial methods.

How windows are placed relative to a building's inner structure is one of the most important factors when designing buildings with natural ventilation, as designing larger windows and emphasizing window placement can help cool the house without any electricity. Shorter distances result in better ventilation, as if the space is too large, the wind will weaken before traveling from one side to another. It is best to have the large space be placed perpendicular to the prevailing wind and to have smaller room. An overlooked method for natural ventilation in modern architecture is the placement of a courtyard in the center of the house. This allows wind to travel shorter distances and hot air to escape the building through a central space.

The structure's height is also an important factor that can help cool a building without artificial ventilation. This can be achieved using high ceilings, which attract the warm air to the top of the structure as air density decreases, keeping heat from interacting with the cool air on the structure's floor (Holder, 2022). This practice has been made obsolete as cost-measuring standards have been put in place in many parts of the World. One solution is to increase height standards from eight to ten or twelve feet, as hot air can escape from the ground without interfering with the cool air below. Even with solutions that can be applied to modern styles popular around the World, there are local solutions that can help solve the ventilation dilemma.

Vernacular Solutions

As the illusion of modernity has plagued many developing countries, inhabitants of developing countries have started to abandon local solutions to deal with heat. Examples of vernacular practices worldwide exist within the original architecture of the many cultures that inhabit humid and arid climates. These solutions must apply to the design of new structures as a restoration of the local architecture or adaptation to fully fit modern style standards.

The Middle East and Northern Africa are some of the most arid regions on the planet, which require their people to design structures that would keep them cool in harsh environments. This adaptation resulted in the surge of the Malquaf in Egypt and Iran. The Malquaf comes in two forms: a triangular-shaped shaft spurting out of the building and the form of a tower topped with arches and wooden logs acting as vents. In a traditional Middle Eastern structure, cool air from the prevailing winds enters the windcatcher, another name for the structure, and travels to ground level like a chimney. Hot air comes out through clerestories located in a lower tower or a courtyard, using high ceilings and other practices to its advantage (Sakr, 2011). This form of ventilation is so sustainable that it has been adapted to use in modern architecture, as it has been implemented in arid areas in Australia, for example, and has been recovered in the Middle East.

Vernacularism holds sustainable solutions to the problem of modern ventilation dependency since such solutions respond to the area's local climate, as every part of the World has different climates, temperatures, wind directions, and ecosystems, to which each culture tries to respond. By combining vernacular solutions with other solutions mentioned before, such as the use of natural ventilation and developing new building standards, and the dependency on air conditioning units in tropical and arid lands will slowly die off in favor of more sustainable solutions.

Conclusion

As the climate crisis gets more severe, it is paramount that people be educated about the benefits of natural ventilation over the AC unit. This also must be addressed in higher institutions that influence architectural culture, such as academia and international architectural boards. Through adopting vernacular and passive solutions, changes in standards, and passive ventilation methods, dependency on the AC unit will decrease, and architectural ventilation in tropical and arid countries will find itself in a better position than it is today. By opening the minds of architects, architecture students, and other professionals alike, we can learn from our mistakes and work together to find solutions for a better, more sustainable future.

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