Through my artwork, I explored the concept of sustainable architecture and the use of shipping containers in houses. I achieved this by designing a shipping container house and evaluating the work, time, cost, and overall sustainability of the structure.

I first began looking into the positives of the container houses. The method upcycles old containers. Shipping container houses are also often cheaper than the equivalent "normal" house. Additionally, the small size of the shipping container reduces the carbon footprint. Shipping containers are also very light which reduces carbon emissions from transportation. A large part of their appeal is also the diverse designs achieved due to their block structure.

My design consists of a green roof for insulation and sustainability. Solar panels are installed on the roof to make the house energy efficient. The structure is above a lake to allow for passive air conditioning. The project would hypothetically cost only slightly less than its traditional counterpart, and the extensive remodeling would add to the time needed to build the structure making it a longer process than that of a "normal" house for the buyer/owner of the house.

Though I thoroughly enjoy the aesthetic of the shipping containers and the creativity they permit, questions remain. Are shipping containers the best option? Are they a genuinely sustainable housing solution? How can we build a better home for people and the planet?

Zoé M.
California

The Future And Sustainable Architecture

Zoé M.

Dear Diary,

Today is October 8th, 2017. It was a long day of school finished off by strenuous physical activity at track practice. Dinner was excellent: we had chicken and pasta. Today was surprisingly sunny for October, but, I mean, I am not complaining! Before I set down my phone for the night, I saw a couple videos of a fire on Snapchat. It seems like a house fire, so I am not too worried. I hope nobody gets hurt!

Dear Diary,

Today is October 9th, 2017. It was a weird and stressful day. I woke up with a bad feeling that intensified when I looked out my window. The sky was orange as though it was covered in Cheeto dust and the sun was so red it seemed to be covered in blood. The scene was unnatural and it gave me the shivers. When I got out of my bed, I smelt it: burnt wood. The smell permeated my surroundings, I raced to the kitchen in a panic to check that the stove was off. It was on my way to the kitchen that I learned what had happened. Mom said that a wildfire was currently surrounding Napa and that her and Dad had been up all night monitoring the situation.

Looking around I saw the evidence of my parents' sleepless night. Beneath the front door, a thick layer of blankets was stuffed in an attempt to keep the smoke out of the house. On the kitchen table, gas masks were thrown in a haphazard pile. In the home office, all the computer screens were running various local news channels.

Today consisted mostly of packing my belongings in case of the need to evacuate as well as texting all my friends and family to see if they were ok. Many had to evacuate. They do not know if they will have a house when they return.

Dear Diary,

Today is October 10th, 2017. Day two of the fires. We almost got evacuated today. My friend thinks her house burned down. California is in a state of emergency. The death toll keeps rising. Why is this happening?

Dear Diary,

Today is October 20th, 2017. The past week has been emotionally and physically draining. Many of my friends' houses burned down. We started GoFundMe pages so they can get new clothes and other personal items. I worked at shelters all week where families upon families stood huddled with all of their belongings. The air quality is still awful. Everyone walks around in gas masks. It feels like the apocalypse. I miss the blue sky and the smell of fresh air.

In 2017, the fires in California burned down more than 1.2 million acres of land killing at least forty-six people.[1] Though the source of flame has yet to be determined, the reason for the fires' widespread destruction is well known:

Climate change caused a drought. The drought led to dry brush --a dry brush that is plentiful and extremely flammable. In other words, the ruination of the natural environment and human life was caused by global warming. It was global warming that evaporated all the water out of the ground and shortened if not completely canceled the rain season. It was global warming that beat down on the grass turning it brown and fragile. It was global warming that stole my friends' houses, burned our beautiful Napa Valley, and took human life.

People blame global warming on factories and developing countries, shrugging off any personal responsibility, and yet, their house, their offices, their supermarkets, are all exacerbating global warming. Buildings are currently a significant contributor to carbon emissions. An analysis of global carbon emissions showed that buildings are responsible for 40 to 50 percent of emissions.[2]

The knowledge of the harm caused by buildings to the planet, paired with the economic and ecological crises of the 1960s and 1970s led to the development of sustainable or green architecture. Sustainable architecture became more formally known in the 1990s with the formation of the Committee on the Environment by the American Institute of Architects (AIA) in 1989 and the launch of the ENERGY STAR program in 1992, to name a few.[3] Sustainable architecture quickly reached such importance that the United Nations' World Commission on Environment and Development defined it as the design of a structure that "meets the needs of the present without compromising the ability of future generations to meet their own needs."[4] Though seemingly focused on the wellbeing of humans rather than that of the environment, the United Nations' definition of sustainable development highlights the inherent connection between the survival of the planet and the survival of humans and the role of architecture in it all. All of this leads to the need to question the role of "normal" architecture in its aid in the degeneration of the environment and human health, and to investigate the impact of sustainable architecture in reversing the aforementioned adverse effects.

Buildings are important contributors to global carbon emissions and thus play a significant role in the degeneration of the planet's air. From the exhaust of the trucks and boats who carry building materials from one continent to another, to the excessive use of heating and cooling to make the spoiled first world population even more comfortable, structures are expelling foul gases that turn the blue skies yellow and make breathing an increasingly difficult task. Air is vital in supporting life, and as of this moment in time, it is still being treated as an infinite resource. Adverse air quality holds a myriad of negative impacts from respiratory irritation to increased heart

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[1] Johnson, Kirk. "What Started the California Fires? Experts Track the Blazes' Origins." *The New York Times*, The New York Times, 15 Nov. 2018, www.nytimes.com/2018/11/15/us/camp-fire-paradise-cause.html.

[2] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

[3] *EPA*, Environmental Protection Agency, archive.epa.gov/greenbuilding/web/html/about.html.

[4] Federal Office for Spatial Development ARE. "1987: Brundtland Report." *Bundesamt fÃ¼r Raumentwicklung ARE*, www.are.admin.ch/are/en/home/sustainable-development/international-cooperation/2030agenda/un-_-milestones-in-sustainable-development/1987--brundtland-report.html.

and cardiovascular issues.[5] These examples are simply on the human end. For the environment, noxious air harms tree growth and causes soil contamination among many other effects.[6] Even so, a grand majority of humans fail to see that maintaining air quality by cleaning the air they pollute or even better not emitting in the first place is their responsibility. As long as the air remains uncleaned and polluted continuously, the environment and human health will continue to deteriorate making green architecture more crucial than ever in the future success of the planet and its inhabitants.

Herbert Girardet, in his book *Creating Sustainable Cities,* creates a metaphor of a city as an organism with a "definable metabolism." He explains how the metabolism consists of a "flow of resources and products through the urban system."[7] These products, having gone through the urban system have outputs such as airborne emissions and sewage. According to Guy Battle, the co-founder of Battle McCarthy Consulting Engineers & Landscape Architects, approximately 70% of the waste produced by cities is returned to the biosphere untreated.[8] Not only is such a large percentage of waste untreated, but the waste is in such large quantity that nature's processes of purification are overwhelmed. To make matters worse, these processes are themselves further degraded by the pollutants which cause deforestation, soil life loss, and destruction of biodiversity. All of the carbon emitted then goes to warm the environment thus throwing everything off balance, from submerging cities underwater to causing massive wildfires.

The IPCC (Intergovernmental Panel on Climate Change) states that humans have twelve years before the damage of climate change is permanent.[9] The time crunch set by the IPCC makes change even more critical, especially in the world of architecture that has been causing so much damage. Because of this, sustainable architecture has revisited significant aspects of structures, from the air to the materials. Sustainable architects are even going so far to visit the social aspect of buildings, all in a bid to create structures that are beneficial to both humans and the planet.

Human and non-human life are significant factors to value when designing a structure. Buildings who value these factors, otherwise known as green structures, are critical for the future of human health and climate change in the industrializing world. A main consideration in such green buildings is air. From the insulation of ice and snow by the Eskimos in the Arctic to the ventilation of stilted and minimally partitioned houses in Malaysia, even early architecture existed to create comfortable living conditions. Sometimes, however, the quest for the most comfortable condition holds more negatives than positives.

Problems began with the creation of buildings such as the Home Insurance Building in Chicago. These buildings were taller than ever before, and the question of ventilation, daylight, and large occupancy plagued the engineers. One day, however, an engineer by the name of Willis Carrier invented air-conditioning which allowed for a far more controlled environment. Initially

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[5] "Air Quality." *Spare the Air*, www.sparetheair.org/stay-informed/air-quality-and-your-health.

[6] "Ambient Air Quality and Environmental Health." *EnvironmentalScience.org*, www.environmentalscience.org/ambient-air-quality-and-environmental-health.

[7] Girardet, Herbert. *Creating Sustainable Cities*. Published by Green Books for the Schumacher Society, 2001.

[8] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

[9] Watts, Jonathan. "We Have 12 Years to Limit Climate Change Catastrophe, Warns UN." *The Guardian*, Guardian News and Media, 8 Oct. 2018, www.theguardian.com/environment/2018/oct/08/global-warming-must-not-exceed-15c-warns-landmark-un-report.

adopted by factories, air-conditioning quickly became a standard in office buildings and schools. By the end of World War II with the market for personal comforts booming, air-conditioning became what it is today: widespread as it is used to keep cars, houses, food, and stores cool.[10] But it all comes at a price.

According to Tatiana Schlossberg, a writer for the New York Times, air conditioning units in America release 100 million tons of carbon each year and run the risk of leaking HFCs (hydrofluorocarbons, a gas that traps thousands of times more heat than carbon dioxide) into the atmosphere.[11] Overly air conditioned places are one of the culprits for Sick Building Syndrome which has a wide array of symptoms varying from headaches to personality changes.[12]
Air-conditioning has also allowed architects to build more closed buildings which have less ventilation than before which leads to the average air in an office building being 3X worse than noxious urban air.[13] The bad air in buildings is another cause of Sick Building Syndrome. In other words, the air quality within and outside buildings is the culprit of not only environmental degradation, but also that of human health. It goes to say how the two, environmental and human health are linked.

The situation of the air within buildings is one of the main concerns of sustainable architects. Green architects are now combining traditional wind-powered ventilation systems with new building management technologies to create highly efficient buildings. The architects begin by studying a detailed analysis of the behavior of the air in the space. Ideal ventilation is achieved through mathematical modeling called Computational Fluid Dynamics (CFD) paired with wind tunnel analysis.[14] An example of a successful ventilation device is the modern wind tower. Inspired by the vernacular architecture of the Middle East, it is highly effective in powering ventilation systems. Combined with solar energy, wind towers become even more powerful. With strategic positioning, solar energy can make air rise faster displacing the air from below at a quicker rate.

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[10] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

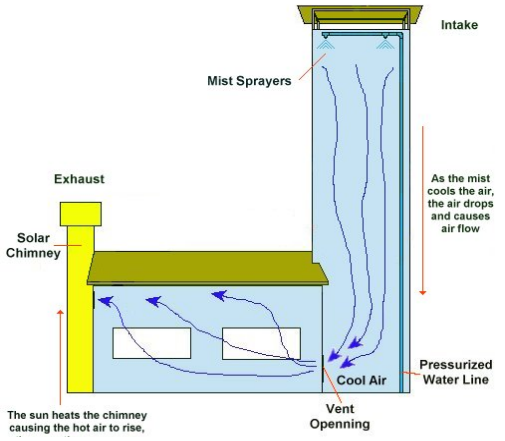
[11] Schlossberg, Tatiana. "How Bad Is Your Air-Conditioner for the Planet?" *The New York Times*, The New York Times, 20 Jan. 2018, www.nytimes.com/2016/08/10/science/air-conditioner-global-warming.html.

[12] Joshi, Sumedha M. "The Sick Building Syndrome." *Indian Journal of Occupational and Environmental Medicine*, Medknow Publications, Aug. 2008, www.ncbi.nlm.nih.gov/pmc/articles/PMC2796751/.

[13] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

[14] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

Additional methods such as the double skin have also been invented. Double skins consist of two skins or facades superimposed to allow for air to flow in the intermediate cavity.[15] Doubles skins can be further strengthened by the use solar energy. During the winter, double skins serve as a thermal buffer between the outdoors and indoors which reduces the need for space heating. They also allow for much more sunlight and provide extra acoustic protection. During mid-season, the skins can be opened thus allowing for natural ventilation and blinds can be adjusted to let in or shut out the light. During the summer the skin is sealed, and blinds can be used to provide solar control.



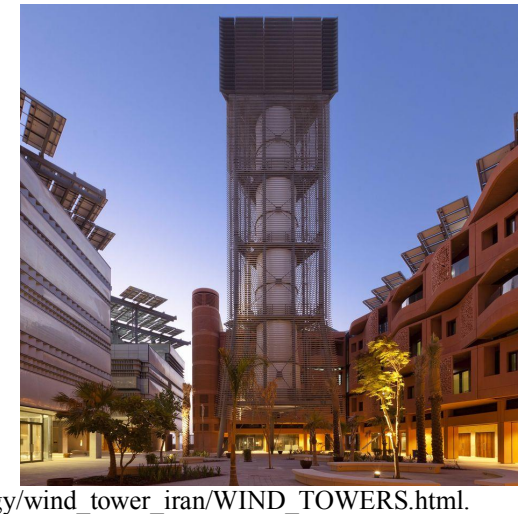
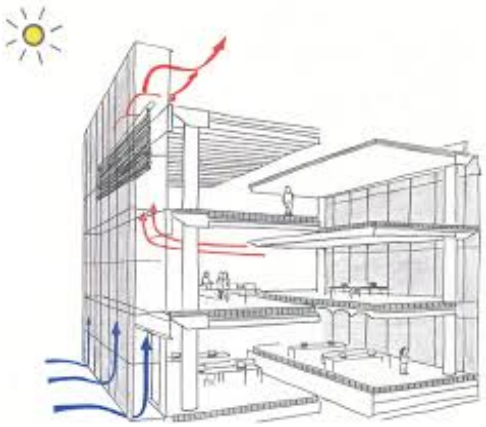


Fig. 1 *WIND TOWERS*, earthsci.org/mineral/energy/wind_tower_iran/WIND_TOWERS.html.

Fig. 2 Firth, Peter, and Robin Key. "Green Utopia: World's First Clean-Tech City Takes Shape." *LS*, www.lsnglobal.com/news/article/3694/green-utopia-world-s-first-clean-tech-city-takes-shape.



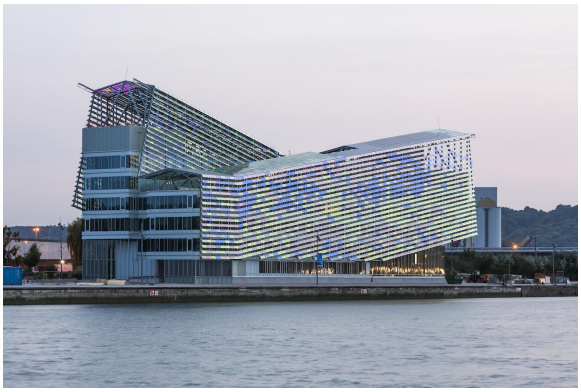


Fig. 3 Poirazis, Harris. *Single and Double Skin Glazed Office Buildings*. 2008, pp. 1–1, *Single and Double Skin Glazed Office Buildings*.

Fig. 4 Wang, Lucy. "Iridescent Monet-Inspired Métropole Building Catches the Light on the River Seine." *Inhabitat Green Design Innovation Architecture Green Building*, Inhabitat, 30 Oct. 2017, inhabitat.com/iridescent-monet-inspired-metropole-building-catches-the-light-on-the-river-seine/.

[15] Robins, Mark. "Dual-Skin Façades." *Metal Architecture*, 5 Oct. 2017, www.metalarchitecture.com/articles/dual-skin-fa%C3%A7ades.

According to research by Battle McCarthy in association with Franklin Andrews for the United Kingdom Department of Environment, Transport, and Regions, double skin buildings can reduce energy use and running costs by 65 percent and can decrease carbon dioxide emissions by 50 percent in the cold temperate climate of the UK.[16]

Reducing energy usage and emissions, however, is not the end goal. Sustainable architects want to leave the environment better than it was before they built their structure thus giving future generations with brighter prospects. Sustainable architects are striving to create a new kind of architecture that treats its waste and cleans the air of its cities. A leading architecture with this mindset is Kenneth Yeang. Yeang has, over the years, built himself an articulate philosophy. He believes in not only integrating air cleansing and recycling, but also water conservation, recycling, and reuse, on-site waste management systems, passive solar design, and on-site renewable energy generation.[17] Some of Yeang's core values could be realized through methods as simple as the inclusion of plants and gardens into architecture. Plants clean the air of pollutants such as carbon dioxide and create more serene atmospheres for the building's occupants. For example, deciduous climbing plants not only help clean air but they also protect from the sun during the summer, and shedding leaves provide for maximum sunlight during the winter. Though the air is just one of the main focuses of sustainable architecture, all of these methods are vital and should be utilized.

Another critical factor to consider when designing a building is the materials used. After all, new construction accounts for 40 percent of the raw stone, gravel, and sand use each year as well as 40 percent of processed materials such as steel and one-quarter of the world's world harvest.[18] Due to the extent of materials used and their dispersion around the world, a building's footprint extends far beyond its square footage. For example, the use of a precious cabinet wood in NY may trigger deforestation in Brazil, and the use of marble for a countertop in California may cause toxic mine tailings in Italy. All of these examples go to show that an informed material choice can do an enormous amount of damage to the environment. For those, however, who cannot bring themselves to care enough about the environment to change their actions, it is important to know that the material choice in buildings can also influence human health.

Certain ingredients in materials used in buildings can have invisible long term effects on humans, from those who occupy the building, to those who manufacture it, to those who dispose of it. Take polyvinyl chloride, used ubiquitously in PVC pipes and vinyl which are ingredients in windows, doors, flooring, and insulation. PVC has been known to contain toxic heavy metals that are carcinogenic and endocrine disrupting. Different ingredients such as formaldehyde, a toxin found in particle board and textiles, and other volatile organic compounds (VOCs) are equally as

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[16] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

[17] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

[18] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

standard and are suspected carcinogens and immune-system disruptors.[19] These chemicals, seep off or off-gas from the structural materials. The chemicals thus contaminate the air which is then tightly trapped in sealed buildings leading to accumulation. The seep off and off-gassing of materials is one of the main culprits of the noxious state of indoor air quality and costly human health issues associated with the already mentioned Sick Building Syndrome.
The consequences brought around by these materials and ingredients highlight the need for their phasing out of use in buildings. A new generation of architects are attacking this problem and have come up with several strategies. Some advocate retrofitting and reusing, others encourage the creation of efficiently constructed buildings, while others champion the use of lighter materials. These strategies, however, all have something in common: they all have the same chemistry of materials that cause such harm to humans and the environment. [20] Green design should be beneficial to the environment and to humans thus aiding in their longevity and future prosperity.

Ecologically intelligent design thus does not seek just efficiency; it also seeks rematerialization. The goal is to design healthy materials that can be safely circulated in closed-loop cycles thus integrating nature's nutrient and energy systems into buildings. Ecologically intelligent development seeks a positive footprint which produces more habitat, more clean water, more fresh air, and more biological and cultural beauty. Though there remain obstacles such as the fact that each year approximately 2,000 new chemicals are introduced without the need for approval, that is not an excuse. There is now enough knowledge to build using materials that are safe if not beneficial for the health of humans and the environment. Take the example of insulation. Usually made of fiberglass, rigid foam, cellulose, or polyurethane which all contain problematic substances, insulation can instead be made of rice husk. Rice husk is safe, effective, inexpensive, biodegradable, and produced with a renewable resource that does not displace food crops. Such intelligently harvested materials help preserve the financial, environmental, and social assets of communities, unlike other materials which spread destruction around the world.[21]

Materials should have safe chemistry and be recycled in a closed-loop. A closed-loop allows for materials to be infinitely cycled for the industry very much as how it works in nature where the "byproducts of one organism become[s] food for another."[22] The flow of materials through these cycles thus eliminates the idea of waste.

Lastly, sustainable architecture also considers the comforts of the occupants to be important when designing a building. The comfort of a person, after all, is indicative to a healthy mental state. A sustainable architect Kenneth Yeang asks a simple question that holds a deep meaning: "What kind of work gets done in a skyscraper?". Yeang suggests that built environments are

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[19] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

[20] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

[21] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

[22] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

organic ecosystems that must work interdependently with the existing social and political landscapes if it is to thrive. According to Yeang, without commitment to existing social ecology, even the greenest of green buildings will not be able to achieve its goals.[23] An example of an ideal sustainable building is the Biosphere III, a project financed by the Bass family in the late 1980s. The project combines an energy station, a research unit, an educational facility, and a living community. Biosphere III thus promotes socio-ecological symbiosis that is ideal for future green skyscrapers. Another example of a consideration taken to include the social aspect of life into sustainable architecture is seen in the access to light and air. Access to light and air has historically increased with a person's position in a company. The CEO would have a large office with floor to ceiling windows and plenty of ventilation while the lower level employees are in cubicles in small, darkly lit, stuffy rooms. Sustainable architects are now building large atriums within buildings and creating immense glass walls while making sure that all occupants have equal access to ventilation through regenerative energy systems that allow for each to control their surroundings air flow from solar-induced cavity ventilation. Not only does the increase of light and air decrease energy usage and costs, but it also diffuses social hierarchies.[24]

From air, to materials, to light, sustainable architecture helps not only the environment, but also the people. “Normal” architecture that has been demonstrated to be so extremely harmful to the Earth should not be allowed to continue in this age of global warming. Buildings are an important contributor to carbon emissions, and the role of carbon in today’s environmental crisis illustrates how vital sustainable architecture is for the future success of the environment and thus the success of humankind. Sustainable architecture is the architecture of the future, and its utilization would without a doubt set humans off the track of environmental destruction as predicted by the IPCC.

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[23] Yeang, Ken. *The Green Skyscraper: the Basis for Designing Sustainable Intensive Buildings*. Prestel, 2000.

[24] Gissen, David. *Big and Green: toward Sustainable Architecture in the 21st Century ; Published in Conjunction with the Exhibition "Big Et Green: Toward Sustainable Architecture in the 21st Century", Presented at the National Building Museum, Washington, DC, January 17 - June 22,2003*. Princeton Architectural Press.

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