The Zero Energy Building: A Driver of Change Towards Environmentally Focused Technologies

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

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Spring, 2020

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The Climate Catastrophe

Earth is on the verge of a climate catastrophe. Humankind has only 10 years before facing irreversible damage to the environment and the planet, according to experts at the Intergovernmental Panel on Climate Change (IPCC) (General Assembly, 2019). The IPCC also claims that at its current rate, global climate change will cause the extinction of humankind (IPCC, 2018). In order to prevent this irreversible damage, humans must reduce their waste, pollution, and carbon emissions. There is no single solution to the problem of global climate change, but every contribution to lower overall carbon emissions matters. One technology that is helping to decrease carbon emission output that comes from houses and buildings is the zero-energy building. The zero-energy building is a type of building designed specifically to benefit the environment by reducing its carbon emissions and energy usage drastically while creating its own clean, renewable energy. This technology is so important because it is one of the first technologies to consider global climate change as its highest priority in the design process. The zero-energy building is a prime example for the design process of new technologies. A design process focused on its environmental impact should be one that becomes the standard for new technologies, marking a paradigm shift towards environmentally conscious technologies. This paradigm shift is effectively the only complete solution to the issue of global climate change.

Research Question and Approach

How does the zero-energy building demonstrate the paradigm shift from energy inefficient technologies to energy efficient technologies? This question will be addressed in this paper through documentary research and case studies. These methodologies are the most effective approach to the given research question because there is a plethora of existing research in the field of climate change. Using the documentary research methodology, it is easier to utilize this pre-existing information in order to create an argument and support these claims. Case studies aid in proving the concept and the effectiveness of zero-energy buildings. For these reasons, documentary research and historical case studies are the most useful methodologies to answer this research question. The documentary research in this paper is organized by topic and specification. Different categories of research are used in order to provide insight and evidence into the arguments that are presented. Some case studies based on the progress of the zero-energy building are used to support the claims made in this paper. Using these methods, the paradigm shift from energy inefficient technologies to energy efficient technologies is explored in great depth. This paradigm shift "[provides] model problems and solutions for a community of researchers" who are involved in designing new technologies (Kuhn, 2012). Ultimately, this paradigm shift creates massive changes in the design of new technologies.

The Zero-Energy Building

Climate change has rapidly grown into an extremely pressing issue. Without interference, Earth will face a climate catastrophe that will cause irreparable damage to the planet within the next 12 years (IPCC, 2018). The causes of climate change have evolved over time to become

more human-centric. The Intergovernmental Panel on Climate Change's (IPCC) 5th Assessment Report, published in 2014, states that climate change is extremely, about 95%, likely caused by humans (IPCC, 2014). A supporting report states that there is "no convincing alternative explanation" to humans causing climate change (USGCRP, 2017). This issue is dangerous because it is urgent and caused by humankind. There is no doubt that climate change is an issue that must be resolved now. One technology that is helping to solve the issue of climate change is the zero-energy building.

The zero-energy building is a building design that aims to generate as much renewable, sustainable energy as it uses, therefore netting a zero-energy usage. This is done in several ways, including generating as much renewable energy as possible using wind, water, and solar energy technologies. Zero-energy buildings seek to reduce their energy usage in every way possible, such as airflow, insulation, and lighting through innovations in design and implementations of new technologies (Torcellini, Pless, & Deru, 2006). These buildings have more efficient heating and cooling systems, more efficient water usage in plumbing systems, eco-friendly insulation, and much more, which all contribute towards decreasing the overall energy usage of the building. These buildings use a combination of all these technologies to drastically reduce carbon emissions compared to regular building designs. This is especially beneficial in densely populated urban cities that contain lots of closely-packed housing and large commercial skyscrapers that release huge amounts of carbon emissions (Center for Climate and Energy Solutions, 2020). The zero-energy building greatly improves the carbon emissions in these places. The one disadvantage that the zero-energy building has is its cost. Of course, to design and build such efficient buildings, it costs a lot more than a regular building upfront (Petersen,

2018). However, the cost is alleviated by the fact that the building provides its own energy, reducing the building's operating costs greatly. These buildings are undoubtedly a great technological solution to reducing carbon emissions and therefore fighting global climate change.

The adoption of these buildings is still not universal. The upfront cost has proven too much for many parts of the world (Petersenn, 2018). However, over time, the number of zero-energy buildings is increasing steadily. Eventually, all buildings will be much more energy efficient than they currently are, and the carbon emissions produced by buildings will be incredibly small. More importantly, though, is the adoption of the design philosophy behind the zero-energy building. Climate change is a global issue that does not just have one solution. It takes a cultural change in order to fight the effects of climate change. Therefore, adopting the zero-energy building globally is not enough. What is more important is the adoption of a design philosophy that is focused on being environmentally-friendly. Once this philosophy is adopted globally, all technologies will be influenced more greatly by their environmental impact than previously. This is the key shift that needs to occur in order to fight climate change, and it is explored thoroughly further in this paper.

The Environmental Paradigm Shift

Climate change is a topic that is deeply embedded in STS. One of the most important factors in many engineering endeavors is considering its effect on the environment because climate change has become as urgent as it is. Therefore, the field of STS is heavily influenced by the issue of climate change and the solutions that revolve around climate change. The

zero-energy building, one of many helpful solutions to climate change, is a building that has brilliant engineering designs and ideas in every single facet. The zero-energy building takes concepts from several different engineering practices and creates an incredibly efficient and ethical design. The design of this type of building is one that puts the environment first, therefore putting STS principles first. The zero-energy building is one that marks a paradigm shift behind the design choices of new technologies.

The one to formally identify and define the paradigm shift was Thomas Kuhn in 1962, who defined a paradigm shift as "a fundamental change in the basic concepts and experimental practices of a scientific discipline" (Kuhn, 2012). The concept of the paradigm shift has received some criticism in its time. For example, one criticism by Martin Cohen claims that Kuhn did not fully understand his own concept well enough to argue its merits (Cohen, 2015). Most other criticisms focus on Kuhn's explanations for what causes a paradigm shift and why paradigm shifts happen. However, in general, the core concept of the paradigm shift itself is well accepted by scholars, with many tangible examples available throughout history. The transition from an Earth-centered universe to a Sun-centered universe, the revolution from goal-directed evolution to Darwin's theory of natural selection, and the discovery of quantum mechanics are all direct examples of paradigm shifts in the sciences (Kuhn, 2012). All of these examples have key discoveries that lead to a drastic change in how future science is done. With such strong examples like these, it is hard to argue against the core idea of the paradigm shift.

The paradigm shift is important to the zero-energy building because the discovery driving this paradigm shift is more subtle than some of these previous examples. To examine the paradigm shift that the zero-energy building represents, it is important to find the discovery that

drives it. Once this paradigm shift is fully fleshed out, it is much easier to understand the importance of the zero-energy building and the example it sets for other technologies. Using the paradigm shift, it will be possible to understand the reasons that climate change is not being fixed quick enough and what is necessary to change how quickly humankind acts on climate change.

The Effects of the Zero-Energy Building on Climate Change

The zero-energy building demonstrates the paradigm shift from energy inefficient technologies to energy efficient technologies through two factors: the design philosophy behind creating a zero-energy building and the success of the zero-energy building in areas that it has been well-implemented. This research overwhelmingly shows that zero-energy buildings are successful by saving those that implement them massive sums of money, such as one healthcare company in Wisconsin, which has saved an estimated $3 million every year. (Freeark, 2018). Furthermore, the environmental effects from the zero-energy building show drastic improvements to those of regular buildings while maintaining comparable efficiency in building conditions (Irfan, 2018). Therefore, the zero-energy building is able to improve environmental conditions without sacrificing comfort or convenience.

The problems that climate change presents are becoming more and more ominous over time. Humankind has affected climate change in all sorts of ways, including overconsumption, increased carbon emissions, and pollution (Brown, 2009). New technologies are constantly created that benefit the environment. Fuel-efficient cars, efficient renewable energies, and many other new technologies help slow down the negative changes that our environment is suffering

from. However, there are also many new technologies that work against this effort. These technologies increase creation of waste and pollution levels when this is something actively being worked against. A large portion of carbon emissions comes from a small number of big corporations; 71% of all global emissions come from only 100 companies (Riley, 2017). It is up to those companies to reduce their own emissions. As a society, there are other aspects to focus on to reduce emissions. It is extremely important that individuals not only reduce the carbon emissions they release, but also that individuals instill a change in culture about climate change. Big cities play a major role in creating carbon emissions. Large, urban areas with skyscrapers and densely packed buildings allow for more carbon emissions per square foot than more spread-out, rural areas. Therefore, it is essential to focus on these areas as areas where large improvements can be made. The more these improvements are made, the more this sense of culture will be installed throughout the world, ultimately improving the state of the environment.

One technology that is helping to alleviate the effects of climate change is the zero-energy building. The goal of the zero-energy building is to reduce the emissions produced by a building, one of the biggest sources of emissions in a large city or a rural area through the use of electricity and heating (Center for Climate and Energy Solutions, 2020). Buildings create large amounts of emissions from utilities like heating, cooling, lighting, and electronics. Buildings with heavy use of these utilities are a huge energy drain that is especially amplified in densely populated areas. These densely populated areas with heavy use of energy-draining utilities are an area in need of major improvement in terms of reducing emissions. In order to reduce emissions in buildings, their energy consumption levels must be reduced. To accomplish this reduction in energy consumption, zero-energy buildings seek to reduce the energy usage of

buildings in every way possible, such as airflow, insulation, and lighting through innovations in design and implementations of new technologies (Torcellini, Pless, & Deru, 2006). Zero-energy buildings aim to reduce their net energy consumption to zero. Effectively, the building should create as much renewable energy as it uses. The effects of these buildings are incredibly extensive. In major cities, the use of these buildings cuts emissions immensely. Not only will major cities and urban areas improve from the implementation of this technology, but the entire planet will benefit from this reduction of carbon emissions. The design and creation of these buildings is one that is completely focused on the impact it has on the environment.

The success of the zero-energy building is a question many people have had for several years. Critics of the concept believe that there is no real benefit gained from the zero-energy building. After all, it does cost more to construct a building like this, and it is incredibly more complicated to perfect than an average building. In the past few years, the concept has been thoroughly proven successful. For example, one healthcare organization in Wisconsin is saving $3 million every single year since converting to a zero-energy building system (Freeark, 2018). The New Buildings Institute (NBI) tracks research and case studies into zero-energy buildings in great depth. They have found much the same story. The NBI has discovered that not all targets for the zero-energy building are equal. Although the zero-energy building can be beneficial for anyone, it is extremely beneficial for certain target groups. Some of the best examples of this are schools and hospitals. These large buildings that require lots of concentrated energy save the most money from converting to zero-energy because the energy consumption in these buildings are so exhaustive. For these types of buildings, as well as commercial buildings, the reduction in carbon emissions is massive (NBI, n.d.). Not only does the zero-energy building save money, but

it does it in an environmentally beneficial way. The zero-energy building is a massively successful concept, but it still has not been adopted globally.

Since the zero-energy building is clearly a successful concept, why is it not already extremely prevalent throughout metropolitan areas? The concept is still relatively new; the idea of the zero-energy building has only been strongly considered possible for the last 10-15 years. It is also an expensive endeavor. For example, a 1200-1500 square foot home in Oregon could cost an additional $50,000 to be considered a zero-energy building. In Massachusetts, a similar home costs an additional $40,000 (Zero Energy Project, n.d.). These are large upfront costs to create a zero-energy building. However, it has already been demonstrated in this paper that the savings from the zero-energy building can be highly lucrative. The upfront cost provides a barrier to these savings for most common people in the world. Regardless of this barrier, the increase in zero-energy buildings is still quite steep. In the United States and Canada, the number of zero-energy buildings has increased by tenfold since 2010. Zero-energy buildings also take up over 80 million square feet of commercial buildings (NBI, n.d.). This rapid growth of zero-energy buildings is a clear indicator that this trend is both desired and highly successful. Over an extended period of time, zero-energy buildings will overtake normal buildings as the standard of building design and construction. This continuous and rapid rise in demand for zero-energy buildings demonstrates a clear paradigm shift towards conscious design towards the environment.

Considering the environmental impact of a technology is an interesting phenomenon that does not occur often in the creation of new technologies; the design process of a new technology rarely examines its effects on the environment. In today's society, considering the environmental

impact of a technology is a necessary step in the design process that often gets looked over. In order to improve the conditions of the environment and the earth, every technology should work towards benefitting the environment as opposed to hurting it. This paradigm shift is well-exemplified in zero-energy buildings. When new technologies create an emphasis in their designs for environmental benefit, the environment will benefit. If this paradigm shift could be extrapolated to the design and creation of all technologies, the problems climate change poses will be drastically reduced and much easier to approach. Thus, the shift towards environmentally-focused technologies is an extremely important one, and new technologies should follow the example set by the zero-energy building to consciously design towards the benefit of the environment.

The Future of the Zero-Energy Building

Zero-energy buildings demonstrate a paradigm shift towards energy efficiency through the core concepts behind their design philosophy and the clear success of the zero-energy buildings that have already been designed and built. These findings prove that this technology and the philosophy behind it can cause great improvements in the health of the environment. Adopting this environmentally-focused philosophy in other technologies will follow this paradigm shift and create even greater improvements in Earth's climate. The problem that climate change presents is one that does not have a single, fix-all solution. Instead, it requires a total reconstruction of the way we think and design technologies. The only way to improve our climate is through a paradigm shift like the zero-energy building demonstrates. The research

presented in this paper proves that a design philosophy like this one can be highly successful and sustainable. Extending this research into other fields of technology is essential to quickly reducing the problems that climate change presents to the world.

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