An Engineers Responsibility: Preparing for Global Warming and Climate Change

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Since the industrial boom of the late 18th century to the early 19th century, machinery and factories have been creating by-products. For any given coal burning power plant these by-products can include emissions and solid wastes. The emissions of coal combustion are as follows: H2O, CO2, and reduced amounts of SO2, NOx, and Pm (University of Kentucky). As for solid waste, boiler slag and bottom ash are both produced in this process. In the scope of global warming the emission that draws the most focus is carbon dioxide. A heat trapping (greenhouse) gas which is created in the burning of coal (as mentioned) as well as oil and natural gas. Carbon dioxide may also be emitted naturally from natural disasters such as forest fires and volcanic eruptions, though such events may be exacerbated by humans (NASA). Since the beginning of the industrial revolution the level of atmospheric carbon dioxide has risen by a staggering fifty percent, resulting in an overall increase of one hundred and fifty percent more carbon dioxide compared to before the industrial revolution began (NASA**).** This proves to be a worrying factor, as such an upsurge in carbon dioxide is unprecedented in the lifespan of Earth. The only other time similar levels of carbon dioxide were observed was nearly twenty thousand years ago, near the end of the last ice age, and even those values pale in comparison to our contemporary situation (NASA**)**. Carbon dioxide is not the only major factor in global warming, however. Surprising to some, even the way in which our very cities are constructed has contributed to this through a variety of factors. Major cities around the world have become what experts call a "heat island". A heat island is an urban area that is recorded as having warmer temperatures than the less populated areas that surround it (EPA**)**. This is due to modern cities basically being concrete jungles containing buildings, pavement, and an overall lack of trees present. These factors lead to less reflection and more absorption of the sun's rays, which in turn leads to warmer temperatures. Another contributing factor towards global warming is an increase in the use of aerosols. An aerosol is a microscopic particle that remains suspended in the atmosphere for an extended period (days or weeks). These aerosols are consequential by-products of the burning of both fossil fuels (coal, oil, natural gas) as well as biomass (wood, fruit waste, garbage). According to research, not all aerosols are harmful to the environment, in fact some can reflect sunlight, leading to a cooling effect. On the other hand, black carbon (a part of soot) has a plethora of harmful effects. Black carbon can absorb both incoming and reflected sunlight as well as infrared radiation. After black carbon falls from the sky, it can land on snow and ice, increasing the absorption of sunlight, directly leading to a stark increase in melting (EPA). Of course, there have also been natural factors contributing to the warming of the Earth. One factor completely out of human control is changes in the Earth's rotation and orbit. Changes in orbit and rotation cause certain portions of the Earth to experience more direct sunlight than they would have before. There have also been natural changes in carbon dioxide concentrations, though it can be argued that humans have had an overall impact on the values over time. As a society we must step back and take into consideration the overall impact our choices have had on our environment and global warming.

Moving forward, the new generation of engineers and politicians must consider alternative ways to mitigate the effects of climate change. The foundation for a cleaner, more efficient world exists if we take the time to not only expand on technologies available to engineers, but also leave other technologies in the past in favor of newer technologies. Technologies and methods that we can use to combat climate change include alternative energies, new vehicle engines, and overall improvements in the overall efficiency of homes and buildings.

For as long as fossil fuels have been used engineers have sought out alternatives to this process. The key to a sufficient alternative energy is not only that it be considered "clean" energy, but that it is renewable and accessible. One solution, which has existed seemingly longer than the use of fossil fuels, is hydropower. Hydropower is the process in which the natural flow of moving water is used to generate electricity. One of the most well-known examples of hydropower is the Hoover Dam, located in Nevada. According to energy.gov, hydropower makes up about thirty one percent of renewable electricity generation, and about six percent of the United States total electrical generation (Energy.gov**)**. Furthermore, only two states do not take advantage of hydropower, those being Delaware and Mississippi (Energy.gov). With renewable energy being this widespread there are bound to be some major disadvantages. Askari Mohammad Bagher outlines these advantages and disadvantages in one of his published papers. Two major disadvantages revolve around the cost of construction/maintenance and the limited number of reservoirs available for hydroelectric power generation (Bagher). Another common source of alternative or "clean" energy is wind, which is generated through wind turbines. As is true for most renewable energies, wind is highly dependent on the environment that it is being generated in. Despite these shortcomings, there are still major benefits when considering the use of wind energy. One of these is that it ends up being a highly clean form of energy where the only emissions are during the building and transportation process. In the past few years there have also been major advancements in their design, leading to greater levels of efficiency. A slightly less efficient type of alternative energy is solar. Solar energy takes advantage of the energy provided by the sun and its solar rays. As an overall form of energy, it proves to be highly inefficient in current times, with an efficiency rate of only around ten to twenty percent (Engineering Challenges). This does not necessarily constitute abandoning this form of energy, as if it is utilized correctly solar could prove to be one of the, if not the, most lucrative forms of renewable energy. This could be accomplished in a variety of ways. One method would be having solar panels installed on roofs of buildings in large cities, which would not only increase the amount of energy yielded, but also lessen the amount of heat that is absorbed by buildings. Another major type of "clean" energy is nuclear energy. The electricity created by nuclear energy comes from the process of nuclear fission, the splitting of atoms to release energy. This released energy creates heat, which then creates

steam that is used to turn a turbine which outputs electricity (National Geographic). Nuclear energy is a highly efficient process with zero emissions. This does not mean that it has zero by-products, however, as nuclear energy produces the by-product of "nuclear poison" which are the elements left over after the fission reaction is completed. Nuclear power is not without its drawbacks, the largest of which being that it is a nonrenewable source of "clean" energy. Nuclear power plants also run the risk of experiencing meltdowns, an event that can prove catastrophic, as seen in the Chernobyl incident. This section has only scratched the surface of alternative and clean energies, but it shows that there are plenty of alternatives to fossil fuels that can become more efficient, if given proper attention.

Another way to combat global climate change is to remaster the transportation industry. One way in which this can be accomplished is through the switch from internal combustion engines (ICEs) to electric, or even possibly hydrogen fuel cells. A main concern of many climate change activists is the emissions created by ICE's, which has led to multiple laws being implemented that restrict emissions for vehicles, something that has had the overall effect of having car manufacturers research alternative types of engines. The most common is the hybrid or fully electric vehicle. An example of this type of engine can be found in one of the United States' so-called "Big Three", Stellantis. Stellantis claims to have four fully electric vehicles platforms coming soon, with the overarching goal of one hundred percent electric sales in Europe and fifty percent electric sales in the United States. The company also seeks to have different battery chemistries which will offer a low-cost option while also assisting with the build process of batteries (Stellantis). Stellantis has also made innovations towards hydrogen fuel cell technology. A hydrogen fuel cell is an electrochemical device that operates like a battery, though unlike a battery it requires re-fueling, not recharging. In its simplest form, this process is possible by having a constant flow of hydrogen to react with oxygen to produce electricity. (Berry). This type of fuel cell will provide a zero emission (with the only by-products being water and heat), long range, and fast refueling for light commercial vehicles.

In another vein, engineers can reconsider the way in which buildings are constructed to help combat carbon dioxide emissions. The development of homes and buildings that are more energy-efficient yields only net positives. For example, well-insulated homes reduce the required amount of energy for heating and cooling, which leads to cheaper energy bills for the consumer, and more importantly fewer fossil fuels being required to produce the energy for these homes. The same concept can be applied to larger buildings although such a task is made slightly more complex due to the sheer size and volume of certain structures. As with any solution to the climate crisis, it will require effort and attention from engineers to create an economically as well as physically viable process.

When discussing climate change and the responsibility of the next generation of thinkers and doers, we must recognize how we have reached this point. For as long as humans have been powering machinery, we have created some sort of by-products. The most common and harmful by-product is that of carbon dioxide, which is produced through emissions like coal burning power plants and vehicle emissions. To combat these emissions, engineers and lawmakers all over the world have been researching and developing unique solutions to these problems. These solutions are overarchingly based in discovering an alternative and renewable source of "clean" energy. So far engineers have harnessed nature to produce energy such as hydro, wind, and solar power, though these methods need further development before they can ever hope to become viable enough to replace fossil fuels. Furthermore, engineers have developed more involved solutions, such as nuclear and hydrogen-based energies, though these come with their own issues. With a non-fossil fuel-based energy solution, society can cut down on emissions and improve our power efficiency. This can be done in both transportation and construction using these improved forms of energy. Utilizing these building blocks, the new generation of engineers will be able to improve on the foundations that have been laid out by the ones before who were trying to solve these problems. Armed with this knowledge and the breakthroughs that will undoubtedly come to light within the next twenty years, the next generation of engineers will be able to combat the glaring issue of climate change confidently and effectively.

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