Creating a More Environmentally Friendly Energy Plan

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Thesis

How we produce energy is one of the largest causes of global warming, and right now UNI is over contributing to that problem. The goal of my panther ovation is to create a hypothetical Energy plan to spark more discussion on the matter and visualize how we could help fight the colossal global warming problem. In this paper I will discuss the purpose of my project, why I included nuclear, and how I created the energy plan.

The Purpose

Throughout the semester we have learned the importance of a civilization maintaining its resource base. Jared Diamond lists environmental damage as one of the five factors of civilization collapse. Through attempting to move UNI away from depleting coal resources we can help improve our sustainability. Renewable resources allow us to maintain our current resource base. Another one of Jared Diamon's factors was global warming and climate change. According to NASA, the largest contributor to global warming is the burning of fossil fuels. This means moving away from fossil fuels whatever chance we get can help two major factors attributing to the eventual collapse of our civilization at once.

We must take lessons from past civilizations like the Roman Empire and apply them to our current situation. One of the core problems that caused the Roman Empire to collapse was overexpansion, and the subsequent inability to grow enough food. Modern civilization very rarely avoids expansion, and as such our energy costs continue to grow. Unlike the Roman Empire, we need to find ways to minimize our use of energy resources to match the pace at which we industrialize.

Why include nuclear?

One of the largest motivators for why I chose this as my project was the reopening of the Cedar Rapids nuclear power plant. I am personally very pro-nuclear despite it being nonrenewable, which at first seems in contrast with the purpose of my project to help with resource sustainability. Instead, I see it in line with the need for cooperation discussed over the semester. As was mentioned during energy week, one of the problems with renewable energy is battery storage. This is because renewable energy plants typically have a lower capacity factor than their fossil fuel counterparts. Normally this means that grids with renewable energy are typically supplemented during times of low energy output with fossil fuels. As an alternative, we could use nuclear energy instead, which has the highest capacity rate of any energy source (Department of Energy). According to the Scientific American, if we used all sources of uranium, we could supply power for 60,000 years. This will outlast our civilization and when it does, give the earth time to cover up traces of our uranium consumption.

Nuclear Energy is not without downsides as well, most notably its production of nuclear waste and potential for disasters. Nuclear waste is not as much of a problem as it originally seems though, as Fast Neutrons Reactors are able to reuse nuclear waste until toxicity reaches a level safe for disposal (World Nuclear Association). These reactors exist in a limited fashion today but are not prevalent due to politics and costs. In an ideal scenario, the government would take short term financial hits to set up the infrastructure necessary for long term power sustainability. Meltdowns and other nuclear disasters remain a large problem with nuclear energy, but modern nuclear reactors are much safer than they were in the past. Notably, Chinese researchers have created a nuclear reactor capable of cooling down when about to meltdown, effectively becoming “meltdown proof” (ANS).

Creating the Energy Plan

When I first set off to create my energy plan, I needed benchmarks and goals to surpass. To do so, I had to gather information on the current UNI power plant. Data publicly available on UNI's website is limited. Luckily, The Environmental Protection Agency has a database updated once every few years that provides crucial information about all active power plants in the country (UNI's power plant data was updated in 2023). The mapping tool was specifically helpful as it allowed me to find details on all power plants near UNI.

The first important statistic to consider is nameplate capacity. This is the maximum amount of power a plant can output given optimal conditions. UNI's current power plant has a nameplate capacity of 7.5 megawatts. When creating the energy plan, I wanted the total nameplate capacity to be the same as UNI's power plant, even though it is not indicative of actual power output.

The other variable that controls energy output is Plant Capacity Factor. The P.C.F. is the average rate of energy production in relation to the nameplate capacity, typically measured by year. UNI's P.C.F is 35%, which means that on average it generates around 2.63 megawatts of electricity. P.C.F variates highly between different energy sources, particularly lower in renewable sources like wind and solar. Since the nameplate capacity of my plan was set to be the same, a core goal of the project was to ensure the average P.C.F. was greater than it is currently, hopefully preventing power outages.

Megawatt-hours (MWh) were another important statistic. This is the physical amount of energy produced because of the two previous variables. Throughout my plan I measured it frequently by annual output. This stat was especially useful in finding out prices of the different energies as they are normally priced by cents/KWh. UNI's yearly generation in 2023 was 22,708 MWh, so I set a benchmark for 25,000, allowing for yearly growth and fluctuations.

Energy costs proved to be the most speculative variable of them all, only publicly disclosed for the local solar farm. To estimate UNI's energy cost I took the MWh value from 2023 and multiplied it by the average cost of coal power in Iowa. Since the primary reason we still use coal energy is its affordability, I knew the revised energy plan would have a higher cost, but I set a goal of maintaining similar pricings.

Lastly, the most important variable for my plan was the C02 emissions. The EPA measures by pounds per MWh, but other sources, particularly ones related to renewable energy, measure it in grams per KWh. UNI was one of the few plants in the area that had a public emission rate. It measured in 2023 at 689.77 lb/MWh, below the regional average of 936.5 lb/MWh. This was surprising to me because the plant is over 40 years old so I assumed it would be above the average if anything. I set out to half the current emission rate.

Now that I have dictated core goals and the means of measuring them, I set out to search for different plants in the area that could be integrated into the power plan. One problem I ran into is that the majority of power plants in the area do not deal directly with clients but instead sell to utility companies like Alliant Energy. Customers are then supposed to contract through utility companies through documents called Power Purchase Agreements. Instead of simply changing our power plan to something like Alliant Energy's renewable energy program, I instead choose to model my energy plan around a situation where UNI directly buys power from local plants, much like how Google plans to do with the nuclear reactor in Cedar Rapids.

Once I had created a variety of potential energy sources, I manipulated using different percentages of each type of energy until I landed upon one that met all goals I created. Despite being nonrenewable, the high-capacity factor of nuclear energy and its zero carbon emissions made it a key factor to manipulate, resulting in it providing the brunt of the MWh's. I also decided to keep the coal power plant running, albeit at a reduced rate in order to prevent Job loss, however if deemed necessary that percentage of the power could be diverted to either nuclear or wind.

I had to use a variety of calculations to get the values not outright listed. To get the annual MWh I inferred the proportion shown below:

$$\frac{Power\ Used\ in\ Plan}{Total\ Plant\ Capacity} = \frac{Annual\ MWh\ in\ Plan}{Total\ Annual\ MWh}$$

For pricing I used Levelized costs of energy generation and multiplied it by the estimated annual MWh calculated above:

$$Total\ Cost = Annual\ MWh * Avg. Cost\ of\ Energy\ source\ in\ MHw$$

CO2 emissions were found by researching and converting average rates to lb/MHw to match the EPA's measuring system.

Conclusion

Especially in recent years the relationship between energy and my study of Computer Science has become blindingly apparent. Doing this project and exposing myself to this area when I had next to no knowledge has helped highlight its grave importance not just to my field but civilization. Moving forward, I must balance my personal ambitions with the realistic power costs and weight it will have on the environment to ensure continued prosperity.

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