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The Ethics and Economics of the World's Energy Consumption

For over 150 years, fossil fuels have helped build the world economy to the success that it boasts today. Fossil fuels are formed from the fossilized, buried remains of plants and animals that lived millions of years ago (National Resources Defense Council, 2018). This includes coal, natural gas, and crude oil. What this resource has enabled our world to achieve is remarkable. While the efficiency of burning fossil fuels has allowed for notable industrial prosperity over a relatively short period of time, our planet's constant economic growth has led these fossil fuels to become primary contributors towards air pollution and climate change. It relies on individuals, businesses, and governments to collaborate and explore alternative energy sources that can still suffice the needs of our expanding economies, while mitigating carbon emissions and air pollutants to better preserve our planet's wellbeing for generations to come. In the year 1870, the world gross domestic product peaked at $1.92 trillion. With the help of these fossil fuels, the world economy was able to grow exponentially. Our world economy posted a GDP of over $108 trillion in 2015 (Our World in Data, 2019). Businesses produced more and more each year. Vehicles were mass produced and normalized. The standard of living and life expectancy both escalated; the bar was raised because these fossil fuels were able to push the limits of the economy every year. In that same year of 2015, where the world's GDP was over $100 trillion the world consumed 129,916 terawatt-hours, which is a unit of energy equal to the output of one trillion watts in one hour (Our World in Data, 2019). Because of the massive amounts of fossil

fuels that were consumed by that year, the world was able to reap huge economic success. But, over years and years fossil fuels have also displayed concerning negatives that have large impacts on the environment and the economy. And now as fossil fuels are being burned in higher numbers every year, these issues are coming to fruition in front of our eyes.

The consumption of fossil fuels is a very difficult force to stop. One of those reasons is because of population growth. Every human is going to consume energy, so as the population grows so will energy consumption. A study was conducted in 2009 by Paul Murtaugh and Michael Schlax outlining the relationship between population growth and global warming. It determined that the 'carbon legacy' of one child will produce more greenhouse gases than twenty people who drive a high-mileage car, recycling, using energy-efficient appliances and light bulbs, etc. (Murtaugh & Schlax, 2009) The study concluded that, "Clearly, the potential savings from reduced reproduction are huge compared to the savings that can be achieved by changes in lifestyle." It's an unfortunate reality, but one individual is going to be responsible for a whole lot more carbon emissions than one individual will be for being energy efficient. The United States is a country that is subject to rapid population growth, and they are seeing that side effect. "Its 300 million inhabitants produce greenhouse gases at a per-capita rate that is more than double that of Europe, five times the global average, and more than 10 times the average of developing nations. The U.S. greenhouse gas contribution is driven by a disastrous combination of high population, significant growth, and massive (and rising) consumption levels, and thus far, lack of political will to end our fossil-fuel addiction." (Center for Biological Diversity). In a country like America, there is nothing to do about the high population, any solution for that is hard to reason with. As far as the rising consumption levels, it is becoming a habit and there are no clear-cut

solutions for that either. The only route that can be taken is to de-escalate the use fossil fuels. There won't be such a problem if the energy consumed is clean.

Ultimately, the mass adoption of renewable energy is reliant on three groups: governments, businesses, and individuals. It is the easiest for individuals to take the initiative and make decisions that cut out the use of fossil fuels. They can choose to buy cars that are electric or hybrid. They can choose to buy solar panels so their day-to-day home activities are being powered by clean energy. These actions are investments in the environment. They are investments that will pay off over generations. And the prices are become more and more appealing as technology costs drop every year. Governments can also help this mass adoption even without putting mandates or requirements in place to convert the population. They can instead do this through incentives. The United States has some incentives in place. They have tax credits, grants, and loan programs available for qualifying renewable energy technologies and projects. That way, those who chose to switch will be rewarded. The goal is that individuals can form a movement large enough to put the government in the position to apply regulations to businesses. Because businesses are the more difficult of the three to convert. If the cost of building new renewable energy plants to compensate for all their current energy demands is too expensive compared to just continuing to pay operating costs on their current fossil fuel plants, then most businesses are not going to be willing to switch. But individuals can take action to the point where government bodies begin to step forward as well.

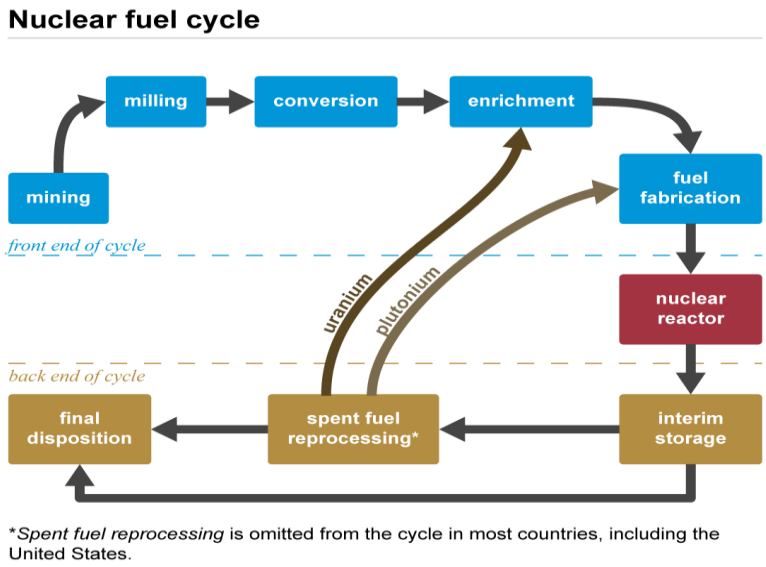
An alternative energy source that governments can selectively utilize is nuclear energy. The creation of nuclear energy is unbelievably efficient, but it has a collection of red flags that come with it. Just to get an idea of the efficiency that nuclear energy offers, the US Energy Information Administration states, "In 2017, 31 countries had commercial nuclear power plants,

and in 15 of the countries, nuclear energy supplied at least 20% of their total annual electricity generation." The EIA also explains that as of January 1, 2020, 96 nuclear reactors were operating at 58 nuclear power plants in 29 states. Nuclear power plants have supplied about 20% of total annual U.S. electricity since 1990 (EIA). Under 100 nuclear reactors have been able to account for about a fifth of America's annual electricity for the past thirty years. When looking at a 2015 analysis of how the US generates its electricity from the Washington Post, it illustrates just how efficient these nuclear reactors are. Between natural gas-powered, coal-powered, and oil-powered electric plants there are 3,269 in total. And these thousands of plants powered by fossil fuels make up roughly 65 percent of our nation's energy generated in the year before this was released. So, for less than 100 nuclear reactors to generate 20 percent of America's annual electricity, it is quite apparent what nuclear electric plants are capable of. And the remarkable feat that nuclear energy boasts is that when nuclear energy is being created, there are no carbon emissions released as a byproduct. These CO2 emissions are part of the reason that the planet can't keep up the high rate at which fossil fuels are being burned. So, with how much more efficient nuclear energy is compared to fossil fuels, and with nuclear energy not releasing any greenhouse gas, nuclear energy looks like a very attractive alternative. It's environmental benefits and remarkable efficiency will allow governments to shift away from fossil fuels and the detriments that come with them.

But nuclear energy has an array of its own unique limitations that would make it challenging to push nuclear energy to the forefront of energy consumption. It's a very demanding energy source, so not every country will be fit to transition. Nuclear energy is a quality option when being used at the conservative volume that the planet is currently using it at. Shifting nuclear energy into a more primary source of energy is a much more demanding task for

a majority of countries. First off, nuclear reactors have complex safety and security features. It's essential that nuclear power plants are running and operating flawlessly and that requires a lot of resources and human contribution (EIA, 2020). The chances of an uncontrolled nuclear reaction happening from a reactor in the United States is quite unlikely because of the amount of safety systems that are in place in these power plants. And because of this, America has the luxury of having nearly 100 nuclear reactors producing 20 percent of their economy's energy (EIA, 2020). It's because America has highly trained and skilled workers who operate and monitor the reactor. They also conduct thorough testing and maintenance activities along with regulatory requirements and oversight of the U.S. Nuclear Regulatory Commission (EIA 2020). With each and every one of these safety and security protocols in place, nuclear energy can be safely produced, and its benefits can be enjoyed. Without all these factors in place there is much more significant room for error; and when it comes to nuclear reactors, any sort of error cannot be afforded. A reactor meltdown causes nuclear radiation to escape from the reactor and be released into the environment. This makes any area exposed to this radiation unlivable for humans and animals (EIA, 2020). Because of the risk that comes with nuclear reactor malfunction, creating nuclear energy is extremely threatening. Some countries, like the United States, are fortunate enough to be able to safely expand nuclear energy production to over 90 reactors; but those countries that have the means to provide trained and skilled workers, thorough and honest testing and maintenance, security to keep the place safe, etc. are few and far between. If any country attempted to expand nuclear energy creation significantly further than what they are currently sustaining and move it into a more primary source of energy, they would be taking dangerous risks by assuming none of the new reactors would ever malfunction. With everything that goes into nuclear power plants staying safe and operational, a majority of countries would not be in

the position to increase the production volume of nuclear energy and expect nothing to go wrong. Another complication with nuclear energy is fueling the reactor. The nuclear reactor is fueled by uranium. While uranium isn't a very scarce raw material, to mine and refine it takes a large amount of fossil fuel energy (EIA 2020). On top of that, the construction of nuclear power plants requires loads of metal and concrete which will also take a large amount of energy to obtain. While no carbon emissions are released when nuclear energy is being created within the reactor, the overall process of producing nuclear energy still entails the use of fossil fuels because of the requirements to build a plant and fuel it. So, although creating nuclear energy is much more efficient than burning fossil fuels, it isn't necessarily a direct substitute. I expect nuclear power to continue to play a role in providing the world's energy needs for decades to come; but because of the economics of uranium mining, power plant construction and the challenges of sustaining and operating nuclear power plants, it would be difficult for most countries to expand nuclear energy to a primary source of energy. Aside from those economic obstacles, there is a major underlying environmental concern when it comes to producing nuclear energy. Yes, nuclear energy does not release carbon emissions, but it does produce radioactive waste. And that byproduct can be just as problematic. The radioactive waste is what really complicates the nuclear fuel cycle.



This is a visual representation of the nuclear fuel cycle (Pennsylvania State University Radiation Science and Engineering Center). The entire 'back end' of the cycle is dedicated to overcoming complications involving radioactive waste because of how careful one must be when dealing with this problem. It's a major environmental concern because these items that have become radioactive through the nuclear energy creation process can remain dangerous to human health for thousands of years (EIA, 2020). The radioactive waste needs to be precisely handled, transported, stored, and disposed to keep our health and our environment safe. When I initially researched nuclear energy and radioactive waste, I had the impression that the waste was some sort of goop that was created as a byproduct from nuclear reactors. But radioactive waste is just objects that have been subject to radiation. The waste gets classified in two categories: low-level radiation and high-level radiation. Low-level radioactive waste are objects like tools, protective clothing and other disposable items that have been exposed to small amounts of radioactive dust. And these items are preciously handled and disposed so they don't come into contact with the outside environment. While these procedures are pretty routine and easy to execute, dealing with high-level radioactive waste is more concerning. This consists mostly of spent nuclear reactor

fuel. For these reactors to be decommissioned they need to be removed and stored underwater in 'spent fuel pools' for several years. "Even though the fission reaction has stopped, the spent fuel continues to give off heat from the decay of the radioactive elements that were created when the uranium atoms were split apart. The water in the pool serves to both cool the fuel and block the release of radiation." (EIA, 2020) After years of decaying, the spent reactors are moved to outdoor concrete or steel containers with air cooling at the power plant site. For the United States, who has the most active nuclear reactors of all countries, that is as far as they've come in the disposal process even though it is still interim storage. That's where it can become an environmental problem. From 1968 through June 2013, 241,468 fuel assemblies had been discharged and stored at commercial nuclear reactors across the United States (EIA, 2020). Now in 2020 with over a quarter million spent reactors, if nuclear energy were to attempt to expand into a more prominent energy production role there needs to be a structured plan for these irradiated reactors. The plan that the US currently has is to dispose of them into a permanent underground repository; and a plan is all that it is because the US does not currently have any of those repositories built. Executing this final depository step could be quite the economic hurdle. There would be many complications to deal with, and when dealing with radiation that is a threat to human health and environmental wellbeing there is little room for error. The reactors must be safely transported. The repositories have to be absolutely safe and monitored. Resources will be used to build these repositories. And if nuclear power continues to be consumed then these storages will have to keep up. Nuclear energy has loads of potential, but it is only a realistic option for a small percentage of countries.

Renewable energy is another likely alternative energy source that can better de-escalate the world's heavy usage of fossil fuels because it is a suitable alternative for more countries. And

this type of energy can be easily adopted by individuals and businesses. Renewable energy is energy that is collected from resources that are naturally replenished. Energy generated from sunlight, wind, rain, or tides are considered renewable because of that very reason (National Geographic, 2019). So there is no barrier to entry like there is with the resources and workers that it takes to create nuclear energy. One of the main reasons that renewable energy is so valuable is its unmatched sustainability. Renewable energy will never run out because these resources such as wind, heat, sunlight, etc. do not have a limited supply. Natural gases and petroleum are not unlimited resources; and with worldwide energy consumption increasing every year (Our World in Data, 2019), more of these resources are annually consumed and the cycle continues. There is no way to tell exactly how much fossil fuel we have left, but with the rate of consumption increasing every year the inevitable date is only getting closer. It will take an estimated ten million years to replenish the fossil fuels that have been used in the past century and a half (Environmental Science Organization, 2020). So, it's in our best interest to leave whatever crude oil is left in the ground because it’s not sustainable. These ideas have been backed by research for decades. In the 1950’s, geologist M. King Hubbert published a graph showing the predictable trajectory of oil reservoirs from discovery to depletion. It illustrated that once oil is discovered, production from the reservoir continues to increase until it reaches its maximum output. After that, production plateaus, then begins to decline. Once it declines, production continues downward until the reservoir is depleted. If you take that predictable behavior from individual oil reservoirs and compare it to the total oil supply of the planet, you get the theory of ‘peak oil;’ this is when demand outstrips supply. Since oil is nonrenewable, the Earth’s combined oil supply should follow this bell curve to the point where it begins to decline forever. And many experts agree that we have already hit this peak/plateau as early as 2008, with

only external factors creating fluctuation in supply and demand (Environmental Science Organization, 2020). This can't be one hundred percent confirmed, but by assuming we are at this peak production, very concerning economic issues will follow. According to the peak-oil bell curve, after oil production peaks it will plateau and then behind to decline. With continued population and economic growth every year it is also expected that the annual energy consumption demands will increase with it. So, once the end of that plateau is reached and production of these fossil fuels begins to decline the demand will remain just as high while the supply slowly drops, and a shortage will be created. A shortage of fossil fuel production would cause sizable economic losses and countries that are heavily reliant on these fossil fuels are going to suffer the most. China, for example, has fossil fuels responsible for over 85 percent of their total energy consumed in 2018 (BP Statistical Review, 2019). In that year they consumed 33,512 terawatt-hours (Our World in Data, 2019). For a country like China to be faced with a shortage of fossil fuels would prove to be very detrimental to their economy. The level of production that the country is accustomed to would not be achievable, and it would leave both the consumers and the producers insufficiently satisfied.

Renewable energy, on the other hand, has no expiration date or limit. Energy can be farmed from wind, heat or sunlight forever. And what compliments renewable energy incredibly well is energy storage. It's not an energy source itself, it simply stores energy that's been created to then be used in the future. "Energy storage can revolutionize the how we use energy. It lets us produce clean energy when it's cheapest, store it, and put it back into the electricity grid when needed. Using storage in conjunction with solar and wind energy helps ensure that power is available even when the sun isn't shining and the wind isn't blowing." (Union of Concerned Scientists, 2020) This method of storing clean energy makes renewables even more

economically efficient. The sun is not always shining, and the wind is not always blowing, so by storing energy we can ensure power is available even if it's demanded when it can't be created. Large scale storage operations are still relatively rare, so as clean energy starts to become a more prominent source it is important that these energy storages also begin to scale up. The expansion of renewable energy can also be economically beneficial because of the jobs it can create. In America, there were four million clean energy jobs in 2018 (Environmental Defense Fund, 2018). And the number of clean energy jobs will increase annually because as time goes on, the technology costs of these renewable energy generators become cheaper. According to the 2014 report of the Intergovernmental Panel on Climate Change, since 2007 many renewable energy technologies have demonstrated substantial performance improvements and cost reductions, and a growing number of renewable energy technologies have achieved a level of maturity to enable deployment at significant scale (IPCC, 2014). "The most rapid renewable energy job growth has come from the solar and wind sectors, which rose by 24.5 percent and 16 percent, respectively, from 2016 to 2017. Solar and wind energy jobs outnumber coal and gas jobs in 30 states, including the District of Columbia." (EDF, 2018) This growth needs to continue. The better we can expand and grow renewable energy as a majority source of energy will lead to reduced environmental determinants caused from the release of carbon emissions when burning fossil fuels. The bigger problem that comes with moving away from fossil fuels as a means of producing energy is the economic disruptions that it can cause. But with the marginal costs of renewable energy continuing to decline it is constantly making it easier to shift more and more towards renewable energy. It must be understood that this movement of converting to renewable energy is inevitable. Not only will fossil fuels cause unignorable environmental issues in the near future, but there will also come a time where fossil fuels begin to deplete. And when the resource

becomes scarce enough, the extraction cost will be higher than renewable energy (David Timmons, 2014). So, it is important for businesses to begin converting more of their energy production into renewable energy, and for individuals to reduce their personal fossil fuel consumption.

The undeniable truth is that fossil fuels are terrible for the environment and human health over time. From the harvesting of the resource to the burning of it, the entire process is detrimental to our planet and our wellbeing. The unearthing, processing, and moving of underground oil, gas, and coal deposits take an enormous toll on our landscapes and ecosystems. The fossil fuel industry will decimate stretches of land to use for facilities, waste storage, waste disposal, or other infrastructure. “In the case of strip mining, entire swaths of terrain—including forests and whole mountaintops—are scraped and blasted away to expose underground coal or oil. Even after operations cease, the nutrient-leached land will never return to what it once was” (NRDC, 2018). All that land was previously wildlife habitat. And the animals that were pushed out now have to suffer and compete with existing wildlife for their resources. Renewable energy is generated from movement of water, wind, sunlight, etc. Landscapes will never have to be destroyed to farm renewable energy. Also, when fossil fuels are burned, they emit large amounts of carbon dioxide into the air as a byproduct. Renewable energy only creates emissions in the process of building the generator. Once it is built and operating it gives off little to no emissions. This dynamic is what’s driving the current global warming crisis. Carbon is a greenhouse gas, which means this gas stays in Earth’s atmosphere and when it’s released it absorbs infrared radiation from the sun (American Chemical Society, 2020). As a result of this process, Earth’s global temperature slowly rises. Because of human activities producing these greenhouse gases the temperature has risen from past decades to now; and it will continue to rise unless steps are

taken to reduce emissions. NASA scientists have recorded this annual increase in global temperature. They've also identified concerning trends such as the intensity and frequency of hurricanes will continue to increase, the sea level is rising an average 3.3 millimeters per year, and 148 billion metric tons of ice melting in the arctic each year. All recorded via satellite (NASA, 2020). The effects of these trends are not visibly noticeable, but over decades and generations the numbers will continue to add up and create serious environmental and economic problems. And not only will converting to renewable energy avoid economic disasters in the future, but it will also most likely be in your best interest today. With technology cost falling every year, unsubsidized renewable energy is now most frequently the cheapest source of energy generation (James Ellsmoor, 2020). New solar and wind installations will increasingly undercut even the operating-only costs of existing coal-fired plants. In addition, maintenance requirements are much lower. These machines don't rely on flammable, combustible fuel sources to operate. Solar panels and wind turbines don't have that many moving parts so there's not going to be as big of a need for maintenance, and that equals time and money saved. So businesses can take initiative and switch to renewables without having to suffer financially.

Without a doubt, there have been miraculous opportunities that have been achieved strictly because of fossil fuels. The daily life that I have grown accustomed to living would not be possible without the economic prosperity that fossil fuels have created. But, because of economic growth, population growth, and increasing energy demands, the world economy is on a path that it cannot sustain forever. Environmental issues are already upon us, and scientists only project them to get worse. Whether it is from the limited resources of fossil fuels or from the global changes that carbon emissions will cause over future generations, there will also be economic difficulties. Countries need to turn to alternative energy sources that can reduce carbon

emissions and innately reduce global warming. It is on the shoulders of individuals, government, and businesses. Everyone is responsible for the future of the planet.

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