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Environmental Impacts of Solar, Wind, and Hydropower Technologies: A Comparative Lifecycle Analysis

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Abstract: The research study examines the environmental effects of solar, wind, and hydropower energy, with a comparative examination of each. The paper begins with a brief overview of renewable and non-renewable energy sources, followed by a thorough examination of the environmental implications of energy collection. This study implies that if collecting energy in sustainable ways emits so many greenhouse gases, what is the difference between using non-renewable and renewable energy sources?

IndexTerms –

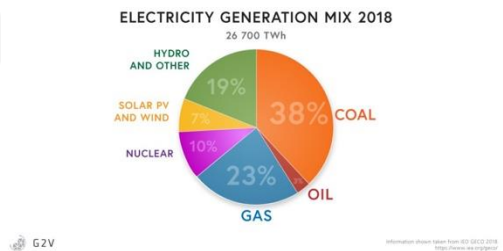
I. INTRODUCTION

INTRODUCTION

Before we get started on renewable energy, let's first define energy. Energy is defined as "the ability to do work," or the ability to exert force to induce displacement of an item. When I consider the conversational law of energy, it is quite intriguing. It states that "energy can neither be created nor destroyed but it can be only transformed from one body to another". This law is vital to remember since without it, we wouldn't comprehend how energy works.

Energy generation is currently in high demand around the world. Energy is required to run vehicles, power houses, and operate all modern equipment. There are two ways to generate energy: non-renewable techniques and renewable techniques. Non-renewable techniques are methods of generating energy (mostly electricity) from sources that may be replaced over time, whereas renewable techniques are methods of generating energy (primarily electricity) from sources that cannot be replenished over time.

There are numerous ways to generate energy using non-renewable techniques. The three most popular resources utilized to generate energy are coal, gas, and oil. Oil is primarily utilized for transportation, whereas coal and gas are primarily used to provide electricity and heat. There are several renewable energy sources available, including solar, hydropower, and wind, all of which use natural components such as the sun, water, and air to generate electricity. The majority of these renewable methods are utilized to generate power.



Based on the definitions and examples of renewable energy, it appears to be an excellent approach to generate energy while minimizing environmental impact. This is where individuals make a mistake by believing that these sources can provide energy without affecting the environment.

Let's get into the specifics.

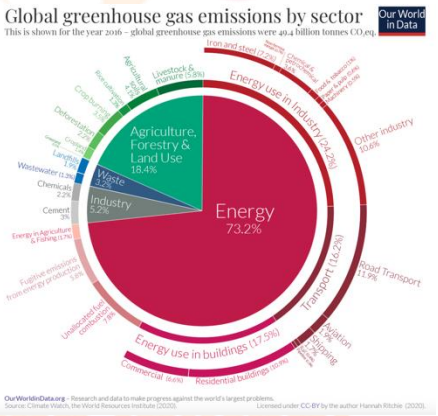
SOLAR ENERGY:

Starting with solar energy. Solar energy is widely used in most places to generate electricity. Solar panels extract solar energy and convert it to electricity. This is accomplished by employing photovoltaic cells to absorb solar energy and then convert it to electrical energy. 95% of photovoltaic cells marketed include a significant amount of silicon, which aids in the efficient conversion of light into energy through the production of the crystal lattice structure generated by silicon atoms.

Silicon is the second most abundant resource on Earth, which makes it easy for people to find, but it is also abundant because silicon is required for the earth's lithosphere. Silicon plays an important part in many natural processes and ecosystems. Its fundamental necessity is to ensure the proper minerals in the earth's soil since it creates silicate elements, which make up a large portion of the earth's makeup. Silicate elements are essential for plant strength and survival, allowing them to be protected from pests and disease. Intricate silica based cell walls play a huge role in diatoms which help the marine ecosystems food sources like the food source of a plankton.
The silicon cycle has a vital role in marine ecosystems because it provides food for little fish, which in turn provide food for big and medium-sized fish. Because little fish in marine habitats and soil need silicon in large quantities for nutritional value, a high content in the crust is critical. When we remove silicon to make solar panels, we create an imbalance in the marine and land ecosystems, which could lead to a serious calamity in the near future.

Aluminium is the second most abundant element used in solar panels for the metal frame, which helps prevent corrosion and provides strength to the panel. Aluminium and silicon are extracted by mining. Aluminium is taken from bauxite ore, whereas silicon is derived from quartz, both of which are obtained through mining. This causes a significant release of carbon dioxide, which affects the level of greenhouse gases in the atmosphere.

Looking at the overall actions undertaken to construct, manufacture, and extract materials for a solar panel, different industries contribute a total of 36.2%. (Industrial sector (5.2%), energy use in the industry (24.2%), shipping (1.7%), aviation (1.9%), and garbage (3.2%). This data demonstrates that the manufacturing and production of solar panels contributes to the bulk of the sectors that generate significant amounts of greenhouse gases.



Additionally, when maintaining solar panels, the panels must be clean. To ensure cleanliness, 20 gallons of water are utilised each megawatt per hour. On average, 30,000 gallons of water are consumed each year to keep the solar panels clean. Naturally, this figure varies according on geographical location and the amount of dust in the atmosphere of each place.

With all of the waste water, greenhouse gas emissions, and silicon extraction, would solar panels be renewable? Given the frequency with which silicon is taken, it is possible that the planet could face a silicon shortage in the coming years, and the use of compounds such as aluminium and steel are limited and not abundant. Furthermore, there is a significant amount of water wasted when maintaining solar panels. This has numerous negative consequences for the environment, and viewing solar panels as a clean way to generate electricity is erroneous.

The Solution:

Well, there is no real solution as whatever we do, with this infrastructure, we are going to harm the climate. A better way to harness the sun's energy is by exploring the process of how plant's absorb heat energy from the sun. If we try to replicate such biotechnology, there would be minimal impact on the environment. However, this is not a real solution as there still would be certain impacts to the environment, but this would have the most minimalistic damage to the environment.

WIND AND HYDRO POWERED ENERGY:

Wind and hydropower energy employ the similar concept of harnessing the kinetic energy of different elements (wind and water). In hydropower, water is first held in reservoirs and dams, and then a turbine is installed at the end of the dam near a detachable hole that connects the reservoir to the turbine. When enough water is gathered, it is discharged, causing the turbine to rotate and generate kinetic energy, which can then be transformed into electrical energy. When dams or reservoirs are built, a large quantity of pollution is emitted. Since the structure is often a reinforced wall, it requires the use of numerous construction trucks, cement, and other minerals produced through polluting activities such as mining.

Not only that, but the movement of the structure's components and vehicles produces a significant quantity of pollution. Furthermore, constructing a structure that disrupts the water flow of a body of water may cause numerous ecosystem changes and an imbalance in the ecosystem as a result of the impact of fish migration patterns and breeding. Reservoirs also emit methane and carbon dioxide as a result of the decomposition of organic materials in water. This may vary depending on the reservoir's location, plant species, and depth, but the process is prevalent in most reservoirs.

When manufacturing turbines for hydropower facilities, a massive process of material extraction, manufacturing, and transportation is necessary. When extracting materials, an average hydropower station requires around 300 tonnes of steel for the turbines, as well as a modest amount of copper and other alloys. This emits around 600 tonnes of CO2 into the atmosphere. While manufacturing and producing, a massive process of melting, forging, and casting is carried out, which consumes a lot of energy. If this energy is derived from fossil fuels, it will be around 275 tonnes. This would imply that the total quantity of CO2 emitted into the environment from simply constructing a hydropower station, which includes turbine production, energy use, and material procurement, is around 260,000 tonnes.

Please note: This estimate does not take into account all of the parameters involved in the construction and operation of a hydropower dam; therefore, the amount may be higher.

Wind energy's turbine structure is like hydropower's. It's just that wind turbines don't require turbines, which makes them slightly better than hydroelectric. However, steel and rare earth materials are frequently used in the manufacture of wind turbines. Because these materials must be extracted, there will be greenhouse gas emissions from mining, in addition to an imbalance in the environment because a rare resource, which may be required for balance, must be mined. Manufacturing a single wind turbine might produce approximately 500 tonnes of CO2. When constructing a wind turbine in a wind farm, several building tasks are carried out to ensure that the wind turbine will last for a long time. This also produces a lot of greenhouse gases in the process. Recycling wind turbines after they have been used can be a huge difficulty because the blades are non-biodegradable, making the procedure complex and inefficient.

This demonstrates that constructing a 20 wind turbine farm generates a large quantity of garbage and emits around 18,000 tonnes of CO2 into the atmosphere.

The Solution:

Using water reservoirs for hydropower would be more detrimental to the environment and cause more issues than the benefits it provides. An easy answer would be to find an alternate material that is strong but does not require mining and is readily available to manufacture smaller versions of these turbines. These turbines might be installed on various natural rivers to generate electricity while not disrupting the ecosystem or migration patterns. It would take some time to locate an alternate material, but with future technical breakthroughs, one could be discovered.

The same material might be utilised for wind, and transportation greenhouse gases could be reduced by using newly hydrogen-powered automobiles.

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