Forum: United Nations Environmental Programme (UNEP)

Issue: Generating solutions to reduce the negative impacts of renewable energy

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Introduction

In the past few years, the global shift towards renewable energy has intensified in response to environmental degradation and governmental regulations. From 2011 to 2021, the utilization of renewable energy has increased by over 10%, rapidly becoming a more significant contributor to global energy production. Common sources of renewable energy that are quickly proliferating include (1) solar energy, (2) wind energy, (3) hydropower, and (4) geothermal energy. While the adoption of renewable energy is crucial, it is also imperative to acknowledge then address the potential negative impacts associated with these implementations.

A notable concern regarding renewable energy is its environmental footprint. For instance, the production and disposal of photovoltaic panels significantly contribute to pollution. These panels include heavy metals and hazardous chemicals such as silver, lead, and cadmium that can detrimentally contaminate natural habitats and resources. Furthermore, renewable energy installations, such as wind farms and PV power stations, require substantial land, leading to disruptions in land use and natural habitats. For instance, although wind turbines do not release harmful emissions, they can significantly affect aerial animals within the local population.

Moreover, although renewable energies come from inexhaustible sources, they are heavily criticized due to their intermittency. They are heavily dependent on weather conditions, temperature, and ecological factors, posing a significant problem for their effectiveness. For instance, wind farms rely completely on the amount of wind present while hydroelectric power plants require an abundant amount of water. This is problematic because it's highly unstable, causing global energy production to decrease drastically after abnormal natural changes. Additionally, the variability of renewable energy makes it challenging to establish energy stations in certain locations, causing inconvenience for local populations.

Definition of Key Terms

Renewable energy

Renewable energy is the type of sustainable energy produced from natural resources, including solar, wind, hydropower, and geothermal that can be reutilized as a higher form of energy. Unlike non-renewable energies and fossil fuels, renewable energies are considered eco-friendly. Adopting renewable energy contributes to reducing greenhouse gas emissions and supports the global effort to combat climate change.

Carbon Footprint

A carbon footprint is the index of the total amount of greenhouse gasses created by our actions. Worldwide, the total carbon footprint exceeds 35 billion tons; and in the United States, one of the countries that produces the highest rates in the world, is producing 6340 tons of carbon footprint. Due to the high amount of carbon footprint produced, professionals expect that, in order to reduce the global temperature, each person should aim to reduce their carbon footprint to 2 tons by 2050.

Energy Efficiency

Energy efficiency is the measure of how effectively energy is used to perform a specific task or produce a desired output. The higher energy efficiency, the lower the demand for energy imports and the fewer greenhouse gasses emitted. This is crucial because adopting higher energy efficiency systems can not only positively impact the environment but also the economy.

Environmental Impact Assessment (EIA)

Environmental Impact Assessment (EIA) is a type of assessment that aims to identify the environmental, social, and economic impacts of a project before decision-making. Using EIA can benefit both the environment and the economy, reducing cost and time of project implementation and design, and avoiding treatment and clean-up costs, as well as impacts of law and regulations.

Biodiversity

Biodiversity, often referred to as biological diversity, is the variety of life on Earth and the natural patterns it forms. In our contemporary world, human influence is also a significant factor affecting biodiversity.

Biodiversity Breakdown

Biodiversity breakdown is the loss of biodiversity; specifically, it involves the loss of biodiversity. Many species, especially due to human activity, face the risk of extinction. This problem is significant because according to the scientific community, biodiversity breakdown is implicated in several issues

such as the planetary crisis of climate change, pollution and waste, and the transformation of nature and ecosystems.

Wildlife Conservation

A wildlife conservation is a project which aims to protect plant and animal species as the human population encroaches on their resources. This involves implementing strategies to preserve natural habitats, managing ecosystems sustainably, and promoting awareness about the importance of biodiversity.

Photovoltaic Technology (PV Technology)

Photovoltaic technology is a technology that utilizes photovoltaic cells, commonly known as solar cells, to convert sunlight into electricity. By absorbing the photons from the photovoltaic cells, PV technology can efficiently convert solar energy into usable renewable energy.. PV technology is particularly beneficial in regions lacking power lines and conventional electricity distribution systems.

Grid Management and Integration

Grid management and integration comprise the coordination and control of the electrical grid, which is utilized to deliver electricity. Managing and integrating it into a more efficient electrical grid can yield positive implications. This includes reducing electricity demand, preventing overload of electricity, establishing a more efficient delivery system for electricity. By employing these strategies, it minimizes the energy loss and prevents unnecessary energy consumption.

Background Information

Environmental Footprint (Land use and habitat destruction)

The environmental footprint is defined as the total impact a person, activity, or organization has on the environment. Lowering the environmental footprint means reducing the detrimental effects certain actions may have on our environment. Generally, renewable energy sources have a much smaller environmental footprint compared to fossil fuels and other sources; they produce less greenhouse gasses and chemical waste. However, renewable energy sources can still detrimentally harm our environment when implemented incorrectly.

For instance, while hydroelectric power stations do not produce carbon emissions, they can have consequential environmental impacts. At the end of the penstock, the rapidly spinning turbines can extensively disrupt the natural flow of the river, causing the mass destruction of local habitats and fish populations. Moreover, these power plants can also drastically damage the land around them. Through

continued cycles of water transfer, water quality degrades and hazardous chemicals can contaminate water. Furthermore, hydropower stations flood land to build reservoirs, which heavily disrupts land use.

The carbon footprint of building these power-generating machines is also massive. The manufacturing process for wind turbine components requires heavy energy consumption and raw materials. An onshore wind turbine with a capacity of 2.5 MW requires over 1500 tons of concrete for the foundation and 355 tons of steel for the tower and turbines; the production of one ton of steel releases approximately 1.8 tons of CO2 emissions. Hydropower dams also use extremely large amounts of cement; for example, the Three Gorges Dam used over 27.2 million cubic meters of concrete in its construction. The manufacturing process of solar panels also involves the use of materials including silicon, glass, and aluminum. The production of silicon for solar cells is energy-intensive; estimates suggest that 20 to 70 grams of CO2 are generated per kilowatt-hour of electricity generated over the panel's lifetime. Another notable example is Geothermal Power stations; the extensive drilling and exploration cause detrimental environmental impacts, deteriorating surrounding lands.

Photovoltaic cell technologies can also bring significant harm to the environment. Photovoltaic panels rely on heavy metals and chemicals, thus requiring professional management. These panels are composed of semiconductor materials like crystalline silicon, which has severe environmental drawbacks. Furthermore, the production of crystalline silicon requires high-energy demanding tasks, including mining quartz and refining heavy metals. Additionally, hydrochloric acid and hazardous emissions are utilized when manufacturing these solar panels, significantly contributing to pollution. Many companies also incorporate cadmium telluride or copper indium gallium selenide, which are toxic substances, to increase the efficiency and capacity of the solar panels.

Implementation Cost

The implementation of renewable energy technologies often comes with a significant financial burden. The construction cost of large-scale hydroelectric projects can be exorbitant, as seen with examples such as the Three Gorges Dam in China, which cost over 28 billion USD, and the Belo Monte Dam in Brazil, with a total construction cost of over 18 billion USD. Offshore wind farms, due to the complexity of installations, also require significant investments. The Block Island Wind Farm in the US had a construction cost of over 300 million USD for only five turbines. The installation cost of solar photovoltaic (PV) systems varies based on factors like location and capacity. The Solar Star project in California had a construction cost exceeding 2 billion for a capacity of 579 MW.

Government aid is often critical to support investors financially. The Investment Tax Credit (ITC) in the United States offers a tax credit of 26 percent for qualifying solar projects. Other governmental regulations promote the adoption of renewable energies by providing financial incentives or material support.

Stability and Reliability

While renewable energy sources can generate large energy supplies, they are highly unstable and intermittent, due to their heavy dependance on environmental factors.

Solar power stations utilize photovoltaic cells to convert solar radiation into direct forms of energy. These stations can produce large quantities of energy. However, they are highly unreliable because the production of energy is purely based on the sun. Unlike traditional power stations, solar power plants can not be adjusted to meet the demands. Therefore, the amount of electricity generated can become detrimentally unbalanced, resulting in energy shortages from time to time.

Wind power, on the other hand, relies completely on factors including wind speed, direction, and turbulence. Without wind, the turbines will not move and thus no energy will be produced. Furthermore, wind patterns are inherently variable, and fluctuate beyond human control. These variables make it difficult for countries and companies to rely heavily on wind power, emphasizing the importance of backup power sources and storage.

Grid management strategies are effective methods that can reduce the instability associated with these renewable energy sources. They use advanced technologies such as Energy Storage Systems (ESS) like batters and pumped hydro storage to store excess energy generated. Smart grids are also used to enable real-time monitoring of renewable energy systems. Advanced forecasting is also employed to generate predictions that allow companies and countries to more accurately understand the supply and demand chain regarding these renewable sources of energy. Energy Management Systems (EMS) are used for monitoring and optimization. These methods and technologies can be used together to ensure a more comprehensive renewable energy system.

Major Countries and Organizations Involved

International Renewable Energy Agency (IRENA)

The International Renewable Energy Agency (IRENA) is a global intergovernmental organization comprising 168 countries and the European Union (EU). IRENA is dedicated to facilitating energy transformation on a global scale. IRENA contributes to various facets of energy transformation, including establishing energy platforms for international cooperation, assisting countries in their energy transitions, and providing comprehensive analysis and data on energy technology. IRENA's goal is to promote awareness and adoption of sustainable renewable energy sources, encompassing bioenergy, geothermal, hydropower, solar, and wind energy. Additionally, IRENA is committed to fostering

developments in accessibility, security, and economic and social prosperity, all within the framework of a sustainable and green world.

United Nations Framework Convention on Climate Change

United Nations Framework Convention on Climate Change (UNFCCC) is one of the headquarters of the United Nations, established in 1992 with the participation of 198 nations. The primary focus of the UNFCCC is to tackle issues related to climate change, particularly following the adoption of the Kyoto Protocol and the Paris Agreement. Alongside this, UNFCCC aims to stabilize greenhouse gas concentrations in the atmosphere which can give detrimental impacts to humans, while simultaneously, ensuring the sustainable development of nations. The UNFCCC achieves these objectives through several initiatives, such as the Conference of the Parties (COP) and Rio convention.

World Bank

The World Bank is a global financial institution that provides loans and grants to governments. The role of the World Bank extends beyond offering financial assistance; it also provides support in the form of technical expertise, monetary resources, and collaboration with governments. The influence of the World Bank is notable in issues related to renewable energy development, as it stands as a major sponsor supporting the transition from non-renewable to renewable energy sources.

United States of America

The United States has been a leading nation in the development and utilization of renewable sources. With the use of 20 percent renewable energy, the United States demonstrates a strong commitment to environment sustainability and reducing reliance on non-renewable sources such as fossil fuels. Various policies and investments have been implemented to develop and promote the adoption of renewable technologies including solar, wind, and hydropower. This success is attributed to technological advancements and economic development, enabling the United States to adopt renewable technologies effectively. However, the country also experiences several side effects of using renewable energy sources, including the contamination of natural resources, unequal geographical distribution of renewables, habitat disruption, and more.

China

Contributing to 27 percent of global carbon dioxide emissions and a third of the world's greenhouse gasses, China has emerged as a prominent nation in the field of renewable energy and environmental sustainability. With a substantial number of industrial factories and a concentrated workforce, China currently produces 11.5 billion metric tons in industrial sectors, a situation that poses significant environmental issues. However, recognizing these challenges, China has set a pivotal goal to transition from non-renewable to renewable energy sources. Setting goals such as doubling the renewable

capacity and generating 1,200 gigawatts of energy through wind and solar power by 2050 will not only make China more environmentally friendly, but also positively impact our world by reducing carbon dioxide emissions through implementing these sustainable solutions.

Germany

By aiming to replace 80 percent of its energy with renewables by 2030, Germany is emerging as a global leader in sustainable energy adoption. As of 2022, Germany has already made substantial progress with renewable energy accounting for 46 percent of its total energy consumption. German corporations such as ABO Wind and Senvion, are collaborating with other international and intranational companies to achieve its goals of transitioning to renewable energy.

Timeline of Events

Date	Description of event
July, 1887	The first wind turbine was invented by James Blyth. This was the significant historical event which marked the inception of renewable energy generators capable of harnessing electricity from wind power.
1927	The commercialization of the first wind turbine occurred in the United States. This event was noticeable as this event triggered the interest among the public in renewable energies.
1978	This was the year when an entire village used solar energy. The Tohono O'odham Reservation in Arizona became the world's first solar-powered village, which symbolized a pivotal movement in the global adoption of solar energy.
September 16th, 1989	197 nations had ratified the Montreal Protocol. The Montreal Protocol is to protect the ozone layer by preventing the production of numerous substances that contribute to ozone depletion.
May 19th, 1992	The United Nations Framework Convention on Climate Change (UNFCCC) was founded, which had become an organization combating international environmental issues including climate change.
March 28th, 1995	The first Conference of the Parties (COP) was held in Berlin, Germany. It was marked as the first UNFCCC conference dedicated to monitoring the implementation of various conventions and agreements aimed at preventing climate change issues.

December 11th, 1997	The Kyoto Protocol was adopted by 192 nations. The Kyoto Protocol mainly aims to assist countries in adapting to the effects of climate change. It facilitates the development and deployment of technologies that can help increase resilience to the impacts of climate change.
December 12th, 2015	At the 21st COP, the Paris Agreement was ratified. This Agreement mainly focuses on limiting global temperatures enhance global efforts for sustainable development

Relevant UN Resolutions and Treaties

- Promotion of new and renewable sources of energy (**A/RES/69/225**)
- Promotion of new and renewable sources of energy (**A/RES/67/215**)
- Promotion of new and renewable sources of energy, including the implementation of the World Solar Programme 1996-2005 (**A/RES/60/199**)
- UNFCCC Summary of **Global Climate Action at COP 28**
- Ensuring access to affordable, reliable, sustainable and modern energy for all (**A/RES/71/233**)
- **Montreal Protocol on Substances that Deplete the Ozone Layer**, 16 September 1987.
- **Kyoto Protocol** to the United Nations Framework Convention on Climate Change, 11 December, 1997.
- The **Paris Agreement**, 12 December 2015.

Possible Solutions

Grid management strategies

The grid management strategies have been used by many companies, countries, and organizations to successfully reduce the variability of renewable energy sources. **This system integrates various renewable energy sources while utilizing an organized system to closely monitor and predict the supply and demand of the power stations.** It uses the energy management system (EMS) as the central station, controlling and optimizing energy generation. It also employs smart grid technologies that adjust the renewable sources to meet the supply and demand. Furthermore, advanced storage systems are also used to significantly reduce the intermittency associated with renewable energy sources. This management strategy is highly effective because it ensures real-time monitoring and the interconnectedness of different renewable sources, reducing the intermittency of the sources. However, the initial implementation cost can be high, and it may be extremely complex if not

implemented correctly. This management system is suitable for large-scale corporations or countries but unsuitable for local businesses because of the high implementation requirements.

Advanced technological deployment (Artificial Intelligence & Machine Learning)

Artificial Intelligence (AI) and Machine Learning (ML) models can be employed to more effectively predict future environmental trends to comprehensively understand energy supply and demands. These models are highly effective in terms of data organization, analysis, and management. They successfully detect patterns to produce comprehensive forecasts and responses. AI and ML model technologies can be implemented in three main ways: (1) Forecasting, (2) Monitoring, and (3) Optimization.

ML Models can analyze historical weather/temperature data to predict renewable energy generation from sources like solar and wind, reducing the *variability* in renewable energy sources. Furthermore, these models can also analyze supply and demand trends, providing more reliable responses to energy consumption fluctuations. AI technologies can also be used to monitor and maintain renewable energy infrastructures based on real-time data, which can more efficiently ensure the sources are well maintained. Moreover, ML can significantly optimize renewable energy storage systems, such as batteries, ensuring efficient use of stored energy and minimizing reliance on non-renewable backup sources.

However, while AI and ML models can dramatically facilitate these basic organizations and implementations, they present issues such as (1) data bias, (2) security problems, and (3) ethical concerns. Because these models rely heavily on data and algorithms, data bias can lead to unfair or discriminatory outcomes. Furthermore, these models are considered “black boxes” because their decision-making processes cannot be easily interpreted, posing issues related to security and ethics.

Questions for Further Research

1. How can we comprehensively assess and mitigate the potential negative environmental impacts associated with the production and use of renewable energy sources?
2. What strategies can be employed to integrate renewable energy sources into existing infrastructure without including any inefficiencies?
3. How can technological advancements and innovations contribute to minimizing the carbon footprint created by renewable energy technologies?
4. In what ways can communities be actively involved in the planning and implementation of renewable energy projects to address and alleviate social concerns and consequences?
5. How can we ensure the economic viability of renewable energy solutions while simultaneously creating job opportunities and supporting local economies?

6. What measures can be taken to enhance the management of power grids when relying on intermittent renewable energy sources, and how can energy storage technologies be optimized for better efficiency?
7. How can we effectively tackle the challenges associated with land use for large-scale renewable energy projects, considering the ecological and agricultural consequences?
8. What role do policy and regulatory frameworks play in promoting responsible and sustainable deployment of renewable energy, and how can they be improved to address potential negative impacts?
9. How can public perception of renewable energy be positively influenced, and what educational initiatives are needed to dispel myths and misinformation regarding potential negative impacts?
10. To what extent should there be international collaboration and information-sharing to address global challenges related to the negative impacts of renewable energy, and what mechanisms can facilitate such cooperation?

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