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Reducing Environmental Impact Through Optimized Non-renewable Resource Management: A Systematic Review of Technological Advances

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Abstract

The term "optimized use of non-renewable resources" describes the prudent management and optimization of limited natural resources that are difficult to replenish or regenerate quickly. Minerals, nuclear fuels, and fossil fuels (coal, oil, and natural gas) are examples of resources that are not renewable. The abstract idea is to minimize waste, the impact on the environment, and the pace of depletion while optimizing the utility obtained from these resources. Advanced technologies such as resource recovery, intelligent waste management, lowering energy demand, and optimizing the use of non-renewable resources will be discussed in our suggested review paper. According to the survey, material efficiency is essential for improving global waste statistics as well as reducing damage and pollution. The most important way to address many sustainability issues, such as the supply chain and the climate crisis, is through resource recovery. Second, smaller-scale adjustments include things like utilizing energy-efficient appliances, installing solar panels, and driving electric and hybrid cars. To lessen the effects on the environment, public education, and knowledge of the characteristics of non-renewable resources should be increased. Reducing the overall demand for resources can be achieved by promoting sustainable consumption habits, direct financial support for the advancement, and application of renewable energy technology. Investigate energy alternatives to non-renewable resources. With the advancement of renewable energy technologies like hydroelectric, solar, and wind, dependency on fossil fuels can be reduced. Climate-neutral and sustainable energy systems can result from increased industrial process energy efficiency. Improved living standards, lower greenhouse gas emissions, and greater energy and financial savings are all possible outcomes of energy-efficient buildings. We can therefore conclude our suggested study that sustainable development depends on the efficient use of non-renewable resources and that reducing, recycling, and using remote sensing are important ways to lessen the impact on the environment.

Keywords: Resources, energy, waste, fossils, coal, recovery, technologies

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INTRODUCTION

Any resource that "does not form or replenish in an extended amount of time" is considered non-renewable. The most prevalent non-renewable materials include nuclear energy from uranium and fossil fuels such as coal, natural gas, and crude oil. The depletion of biodiversity and global greenhouse gas emissions threaten environmental sustainability. One of the main challenges facing growing economies is to achieve sustainable manufacturing and greener growth. Economic growth continues to be uneven and insufficient, as environmental externalities result from both financial development and energy consumption, as shown in Figure 1.

Owing to their comparable formation through geological processes spanning millions of years, they are occasionally regarded as non-renewable resources. Conversely, renewable resources consist of wind, the sun, and responsibly sourced wood. They are renewable because they can be produced or harvested within a reasonable amount of time to meet the demand. In essence, everything that cannot be replenished naturally to meet human needs is a non-renewable resource. Non-renewable resources can also be viewed as finite resources because we are now unable to easily produce more coal or oil for use. These limited resources are currently the primary sources of power on the planet. Our world still relies heavily on non-renewable energy sources because of their high energy content, relative affordability, and existing systems. However, this cannot persist indefinitely. Fossil fuels are scarce and have negative environmental impacts such as climate change. Fossil fuels will become costlier and less available as they grow increasingly limited.

Eco-innovation has been suggested as a useful tool and solution to assist businesses in minimizing adverse environmental effects to achieve sustainability. However, as technology develops, the reach of eco-innovation broadens and becomes more intricate. Very few papers in the past have addressed the development of technologies involving eco-innovation in an integrated and methodical manner. It is worthwhile to conduct a thorough analysis of the state-of-the-art cleaner technology, a rise in the demand for renewable energy, and more economical utilization of natural resources all help economies achieve their environmental sustainability goals. In an endeavor to protect its natural and economic resources for future generations, the Chinese economy is no exception. This can be achieved through cooperative efforts to adopt greener energy sources, cleaner technologies, and resource conservation management. Power plants are presented to optimize the net profit of all parties involved in the coordinated operation of dispersed energy resources while considering uncertainties.

RELATED STUDIES

Ramzan et al. examined how trade openness, financial development, information, and communication technologies (ICT), and fossil fuel energy contribute to Pakistan's growing ecological footprint [1].

Kuo et al. presented a comprehensive picture of the technological advancements that have advanced the realization of sustainability during the last two to three decades. To find technologies involving eco-innovation, 55 research review papers were first chosen and examined for their study. Four technology-based eco-innovation components are identified: hybrid model construction and optimization, green marketing and sustainable consumption, business model integration, and green/sustainable product creation. Five case studies from a previous study were reassessed using aspects of technology-based eco-innovation. The results showed that most companies were good at creating green and sustainable products. To strengthen the other three dimensions, businesses require new technologies and strategies [2]. Bhuiyan et al. demonstrated that while the use of renewable energy (at the threshold level) does not affect economic growth in developed nations, it does not impede economic growth in emerging or developed nations [3].

Figure 1. Non-renewable resources examples.

Shaheen et al. used quarterly data for the Chinese economy from 2000Q1 to 2020Q4 to investigate how cleaner technology, green energy sources, and natural resource management affect the reduction of greenhouse gas emissions. The results support the idea that "green is clean" energy development by showing that the rising demand for green energy lowers greenhouse gas emissions. Furthermore, the "resource cleaner blessing" theory is supported by the fact that optimal resource use improves environmental quality [4].

Focusing on their use in Turkey, Acar and Dincer provided a comparative environmental effect assessment of potential hydrogen production techniques from renewable and non-renewable sources. The goal is to evaluate the economic, social, and environmental effects of various hydrogen production techniques by comparing and analyzing their performance. The techniques considered in their study include high-temperature electrolysis, thermochemical water splitting utilizing Cu–Cl and S–I cycles, biomass gasification, coal gasification, natural gas steam reforming, and water electrolysis using solar and wind energy [5].

To find the best combination of renewable and non-renewable energy sources for Romania, Tudorică et al. presented a unique method based on Particle Swarm Optimization (PSO). Their research, which considered cost, generation capacity, and environmental impact, determined the most efficient combination of energy sources using data from January 2019 to August 2022. Six different optimization algorithms are compared with PSO: CUKO search, mayfly algorithm, harmony search, genetic algorithm, flower pollination method, and grey wolf optimizer. The suggested mix was 20% coal, 2.74 percent oil and gas, 18.92 percent hydro, 12.20 percent nuclear, 24.05% wind, 26.09% solar, and 15.09 percent biomass [6].

Rahimi et al. constructed a stochastic scheduling problem for a virtual power plant to satisfy thermal and electrical loads while considering network security constraints, wind speed, solar radiation, market pricing, and uncertainties of the electrical and thermal loads. A virtual power plant is composed of boilers, energy storage devices, wind turbines, photovoltaic-thermal panels, combined heat and power, and conventional generators [7].

By examining the effects of globalization, natural resources, financial development, and the use of renewable and non-renewable energy on the ecological footprint of nations with abundant natural resources between 1990 and 2018, Usman et al. provided empirical evidence in favor of their theoretical claims. The substantial cross-sectional dependence across cross-sections was confirmed by the empirical results. The second-generation panel data technique was used to provide reliable and trustworthy results. The results indicated that non-renewable energy, natural resources, and financial development had positive effects, whereas globalization and renewable energy reduced the ecological footprint in these countries. It has been established that using renewable energy sources in conjunction with natural resources and integrating financial development with globalization can both slow environmental degradation [8].

Amin et al. concentrated on the production of hydrogen using traditional and non-renewable sources, including coal, natural gas, nuclear power, and thermochemical processes, as well as renewable sources, such as biomass, solar, wind, geothermal, and algae. In addition, a cost analysis of hydrogen production from each energy source was conducted. Finally, a summary of the environmental effects and ramifications of different hydrogen-generating technologies is provided [9].

Sikiru et al. compared fossil fuels and renewable energy sources to investigate the potential of hydrogen as an energy storage option. It outlines the advantages and disadvantages of each approach and assesses its effects on the economy, technology, and environment. Although it faces obstacles to its broad use, hydrogen has potential applications in industry, transportation, and power generation. To fully realize the low-carbon and environmentally benign potential of hydrogen, the assessment underlined the necessity for continued research, development, and cross-sector collaboration [10].

A COMPREHENSIVE REVIEW OF FOSSIL FUELS: USAGE, DEPLETION RATES, AND ENVIRONMENTAL IMPACT

This article examines fossil fuels, such as coal, oil, and natural gas, emphasizing their methods of extraction, applications in the generation of energy, effects on the environment, and difficulties brought on by their limited supply. We also discuss how fossil fuels contribute to global warming through carbon emissions.

Oil

Crude oil is an energy source used to generate asphalt, heating oil, lubricating oils, diesel fuel, jet fuel, and petrol. This non-renewable resource is a liquid removed from tar sands, sedimentary rocks, and subterranean reservoirs. After transportation to refineries, crude oil is converted into petroleum-derived goods.

Natural Gas

Drilling into rock structures containing natural gas deposits yields natural gas. Natural gas can be found at several locations:

- Conventional natural gas is discovered in vast fissures and gaps in rock formations.
- Tiny pores in rocks contain shale gas, often known as unconventional natural gas.
- Natural gas, which is present in crude oil resources, contains natural gas liquids (NGLs), including ethane, propane, butanes, pentanes, and water vapor.

The NGLs were separated from methane in the processing facilities using wet natural gas. Fuel is produced from the methane found in natural gas.

Coal

Carbon and hydrocarbons are found in coal, which is a sedimentary rock. Fossil fuels contain plant-stored energy, which has been produced over millions of years. Coal comes in four different varieties. The metals sector uses anthracite, which has the highest heating value and contains 86–97% carbon. The most common coal type in the US, bituminous coal, has 45–86 percent carbon and is used to produce steel and iron, as well as to generate electricity. Of the four coal varieties, subbituminous coal had the lowest heating value and contained 35–45 percent carbon. Of the four forms of coal, lignite, which is used to generate power, has the highest moisture content and lowest energy value. It also contains 25–35 percent carbon. This article discusses the extraction and processing of uranium as a non-renewable resource for nuclear energy. It might examine nuclear waste sustainability issues, storage options, and nuclear technological developments for increased effectiveness.

Uranium

Despite being a widespread non-renewable resource, uranium is not a fossil fuel. U-235 is a very rare type of uranium, although uranium is a common metal found in rocks. Uranium is processed to produce U-235, which is then utilized as fuel for nuclear fission in nuclear power plants. There is a wide range of applications for non-renewable energy sources. Non-renewable resources provide more than 70% of the energy utilized in industrial operations, and fossil fuels are utilized in many domestic applications. Non-renewable resources have far-reaching economic effects that go well beyond their direct role in energy production. The discovery, extraction, refinement, and distribution of these resources form the foundation of the world economy and generate a diverse range of jobs in several industries. The sector sustains millions of livelihoods globally, ranging from geologists and engineers involved in the extraction process to workers in refineries and power plants. Additionally, non-renewable resource income is crucial to the national budgets of resource-rich nations because they finance the creation of infrastructure and public services. Plant biomass is the primary energy source in most human history. Burning biomass provided light and warmth, cooked food, and animals that were utilized for plowing and transportation. In the early 19th century, non-renewable energy began to replace most renewable energy in the US, and by the early 1900s, fossil fuels controlled the energy scenario. In rural areas,

biomass was still mostly utilized to heat dwellings; in urban areas, it was used to supplement heat to a lesser degree. The use of biomass and other renewable energy sources started to rise in the 1980s, mostly because of incentives for their usage, particularly in the production of electricity.

THE STAGES OF THE NUCLEAR FUEL CYCLE

From uranium extraction to fuel disposal, multiple phases exist in the nuclear fuel cycle. Every stage has a unique effect on the environment.

Mining and Milling Uranium

- The process of uranium mining entails removing uranium ore from the ground and then milling it to produce a concentrated form called "yellowcake."
- *Environmental Impact:* Water contamination, radioactive waste production, and landscape disturbance are all consequences of mining operations. Furthermore, mining uses a large amount of energy and releases greenhouse gases, particularly when open-pit mining is employed.
- *Health Impact:* Radiation exposure increases the risk of cancer in workers and surrounding communities.

Enrichment and Conversion

- *Procedure:* Following milling, uranium was converted to uranium hexafluoride gas, which was subsequently enriched to increase the percentage of fissile isotope U-235.
- *Impact on the Environment:* Enrichment facilities use a lot of energy, which is often obtained from fossil fuels. This process also produces chemical and radioactive byproducts.
- *Health Impact:* Although these facilities are monitored, accidental release of uranium hexafluoride gas can pose chemical and radiological hazards.

Fuel Fabrication and Reactor Use

- *Process:* Enriched uranium is converted into fuel pellets and loaded into fuel rods used in nuclear reactors.
- *Impact on the Environment and Human Health:* Nuclear reactors produce very little greenhouse gases during operation. However, spent fuel is highly radioactive and poses storage and handling risks.

Spent Fuel Management and Disposal

Process: After use, spent nuclear fuel requires long-term storage and disposal. Storage solutions include onsite pools, dry casks, or deep geological repositories.

DIFFERENT METHODS FOR OPTIMIZED USE OF NON-RENEWABLE RESOURCES

Urbanization and population increases have significantly impacted the world's energy needs. Air pollution, acid rain, greenhouse gas emissions, global warming from CO_2 emissions, depleting energy supplies, and environmental deterioration that result in climate change are all consequences of using non-renewable fossil fuel-based energy infrastructure. These elements necessitate the investigation of alternative renewable-energy-based sources. Hydrogen has become a viable alternative fuel to satisfy energy demands. In recent years, green hydrogen generation, which produces no carbon emissions, has attracted scientific attention (Figure 2).

Reducing, Reusing, and Recycling

In an era of rapid urbanization, industrial growth, and increased consumption, the demand on Earth's natural resources has reached unprecedented levels. The maxim "Reduce, Reuse, Recycle" has become a key strategy for promoting sustainability as humanity confronts environmental challenges such as climate change, biodiversity loss, and overflowing landfills. These three principles offer practical approaches to reducing waste, conserving resources, and minimizing the ecological footprints of individuals and communities.

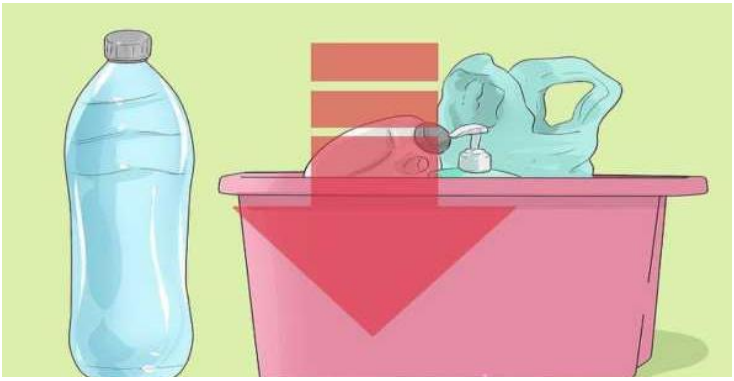

Figure 2: Reduction of use of Plastic.

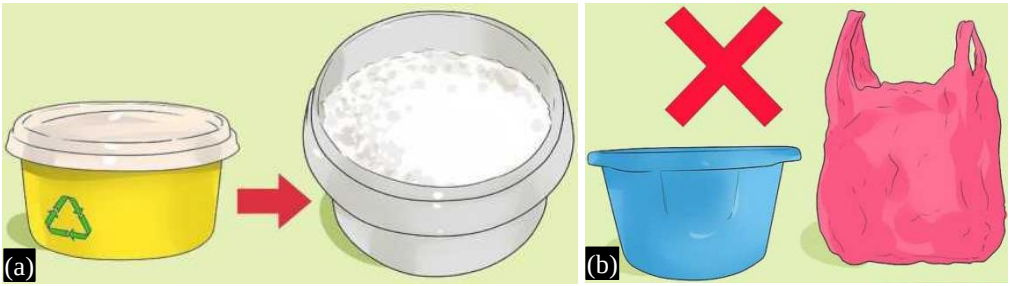

Figure 3. (a) Use Reusable food containers, (b) Stop single-use plastic.

Reduce Plastic Reduce Pollution

Reduce Your Use of Plastic

Use Less Plastic

Plastic is derived from petroleum unless it is labeled as "compostable." It can linger in the environment for hundreds of years without completely degrading or contaminating the soil and groundwater. When plastics are not properly disposed of, animals that mistake them for food are killed.

- To help stop this from occurring, you can:
- Purchase or produce reusable containers. To shop, leave a couple in a car or bike. Place a small one in your purse for impromptu grocery shop visits.
- Recycled paper bags or boxes made from cardboard are used in place of plastic bags in your neighborhood supermarket.

Even "biodegradable" plastic bags may wind up in landfills due to improper decomposition. As a result, they are as dangerous as regular plastics.

Reuse Plastic Containers to Store Food

The resin identification code, which is the number inside the recycling arrows, is either two or five when storing food in plastic containers, as shown in Figure 3. These codes are often located on underside containers. Reusing plastics with these codes to store food is generally safe. Any other figure is either dangerous or not strong enough to be reused. You can recycle plastic or use it for crafts if it is not thought to be safe for food. For instance, plastic buckets work well to hold water in paintbrush rinses.

Refuse Plastic as Often as Possible

When you go shopping, spend some time looking at the packaging. If possible, they should stay away from products that are packaged in plastic, particularly polystyrene. Make the most of your grocery store's bulk goods sales by filling your containers. Use paper bags if you cannot decide between them. Of course, bringing your luggage would be even more beneficial. You can bring your food containers to some eateries and takeout establishments.

Recycle What You Cannot Reduce or Reuse

Making new containers and paper products requires more fossil fuels than recycling old ones. Look up your local recycling center's rules online. Find out what they will and will not discard. The sorting specifications are verified. For instance, most recycling facilities do not recycle polystyrene, waxpaper, or tissues. Paper, plastics, glass, and metals probably need to be separated unless they provide single-stream recycling. Aluminum cans are exchanged for cash at recycling facilities in several locations. To determine whether this service is offered in your city, it is checked online. If so, learn what types of aluminum cans are permitted. For example, some establishments accept beverage cans but not pet food cans. Choosing Transportation Wisely.

CHOOSE ZERO-CARBON TRANSPORTATION

To get there, try to walk or ride a bike. They are the most eco-friendly forms of transportation because they do not use fossil fuels. Look for bike lanes or pathways whenever possible. Compared to dealing with cars and getting struck in the face due to pollution, they are safer. Get in touch with your municipal council and advocate for the addition of bike lanes or bikeways if your neighborhood lacks them. Remember to practice good safety habits. Wearing a reflector will help cars and other vehicles notice if they are traveling in dark areas. Wear a helmet when you bike.

LOOK INTO HYBRID OR ELECTRIC CARS

Depending on the location, these alternatives can significantly lower the emissions from fossil fuels. Electric vehicles (EVs) operate entirely on electricity. When the battery in a hybrid car is low, the gas engine steps in as backup. Conventional hybrids are charged using an on-board generator, whereas plug-in hybrids are charged by connecting them to a wall. You will still be utilizing fossil fuels to power your car if you reside in an area where electricity is generated using coal. However, this influence can be decreased by charging overnight when the grid is not under as much strain.

USING RENEWABLE ENERGY

Many home equipment, including televisions and lights, are powered by fossil fuels such as natural gas and oil. However, many greenhouse gases are released into the atmosphere by non-renewable energy sources. I think about using alternative energy sources to power your house while they are more widely available and simpler to use. For example, adding solar panels to rooftops is a terrific way of capturing solar energy. Making the switch from non-renewable to renewable energy can have a significant impact.

CONCLUSION

We may therefore conclude that non-renewable energy sources cannot be renewed in the future based on our study and research. Non-renewable resources, which can be supplied far more slowly than they can be consumed, are a source of non-renewable energy. Non-renewable energy sources include nuclear energy, coal, natural gas, and oil. Because most of our energy needs are currently met by these resources, humanity faces a significant issue because they cannot be restored once they are exhausted.

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