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| RESEARCH ARTICLE

Greenhouse Gases and their Role in Air Pollution and Global Warming

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| ABSTRACT
Today, one of the most significant global challenges is the increase in climate change due to the excessive emission of greenhouse gases. Carbon dioxide gas, resulting from the combustion of fossil fuels, and methane are recognized as the primary greenhouse gases and the foremost contributors to climate change. Population density, increased vehicular traffic, industrial factories, and neglect of environmental concerns are major factors influencing the concentration of greenhouse gases in the atmosphere. Recent global studies indicate that since the onset of the Industrial Revolution—a period marked by a significant rise in fossil fuel consumption—human activity has played a crucial role in the process of climate change and global warming through the production and emission of greenhouse gases. Understanding how these types of pollution evolve requires attention to the various factors affecting their emission. Accordingly, this study collects and examines data obtained from library-based research using a descriptive-analytical method. Consequences of the greenhouse effect include flooding, reduction in potable water and agricultural products, increased soil erosion, the extinction of some plant and animal species, and the migration of certain population groups. These consequences underscore the necessity and importance of focusing on the use of renewable energy sources.

| KEYWORDS
Pollution, Renewable Energy, Carbon Dioxide, Greenhouse Gases, Environment.

| ARTICLE INFORMATION

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1. Introduction

Industries in any country serve as the backbone of economic activities and are central to the growth and prosperity of that nation. Naturally, alongside the production activities of these industrial centers, the generation of waste and by-products, both solid and liquid, and the pollutants emitted from factory smokestacks and households, are of particular importance (Yadegarnia Naeini, Azimzadeh, & Kiani, 2017). Air pollution is one of the major issues arising from urbanization, industrial growth, and transportation development. Poor air quality due to pollution poses a significant threat to the environment and human health, potentially leading to respiratory diseases, cardiovascular conditions, and lung cancer. Air pollution also results in reduced lifespan, increased medical expenses, and decreased economic productivity (WHO, 2010). Among the various factors contributing to air pollution, greenhouse gases are one of the most significant.

The emission of greenhouse gases and their effects have become a key focus in environmental issues. An increase in their concentration in the Earth's atmosphere, beyond natural levels, leads to further warming of the climate, the depletion of the Earth's protective layer against harmful solar radiation, and the endangerment of all natural life (Delangizan, Khanzadi, & Heydarian, 2014).

Today, one of the most pressing global problems is the rise in climate change due to excessive greenhouse gas emissions. Climate change, particularly global warming caused by the increase in carbon dioxide concentrations in the atmosphere, has drawn significant attention to this issue.

Greenhouse gases are a collection of gases that, by ascending into the Earth's atmosphere and trapping solar energy, contribute to the warming of the planet and its surrounding atmosphere. These gases include carbon dioxide, methane, nitrogen oxides, and hydro fluorocarbons (Mousavi & Falahatkar, 2020).

Power plants, deforestation, oil and gas production, fertilizer and pesticide use, the steel industry, waste production, agriculture, sewage, and waste disposal are considered the largest global sources of greenhouse gas emissions (Moezafari, Parhizkari, Heidarian Khodadadi, & Parhizkari, 2015).

In recent years, both developed and developing countries have paid significant attention to renewable energy sources. Utilizing these sources can reduce dependence on fossil fuels, decrease pollutant emissions from energy production and consumption, and lower greenhouse gas emissions, which play a crucial role in global warming (Daneshvari & Salatin, 2020).

This study examines the causes of pollution at the urban level and, considering the main factors contributing to air pollution and their effects on human health and disease occurrence, proposes suitable solutions and recommendations for addressing these issues.

2. Statement of the Problem

The increasing emission of greenhouse gases and related phenomena are significant factors contributing to air pollution. These gases, as they ascend into the Earth's atmosphere, trap a substantial amount of solar energy, leading to global warming. While a small amount of these gases naturally exists, population density and human activities, particularly those related to fossil fuel consumption, have artificially elevated greenhouse gas levels in urban areas, resulting in air pollution and global warming (Moezafari, Parhizkari, Heidarian Khodadadi, & Parhizkari, 2015). Today, there is a growing concern that human activities may drive the Earth, our habitat and arable land, towards destruction. This issue becomes a widespread concern, especially as pollution levels escalate in major cities at the onset of winter, potentially leading to a surge in various diseases among the population. This research aims to explore solutions for reducing greenhouse gas emissions and mitigating air pollution through optimized energy consumption.

3. Need for Research

The environmental crisis has become a serious issue, resulting from the irrational exploitation and use of natural resources by humans. This concern has prompted scientists to seek solutions for its mitigation. The increase in greenhouse gases beyond natural levels has led to both pollution and global warming. Urban living presents its own unique challenges. Air pollution, traffic congestion, noise pollution, and the proliferation of high-rise buildings that create visual obstructions are just a few of these challenges that warrant research and solutions.

4. Research Objectives

4.1 **General Objective** To examine the impact of environmental pollution caused by fossil fuel combustion on public health.

4.1.1 Specific Objectives

- To investigate the effects of environmental pollution on physical and mental health.
- To analyze the factors contributing to global warming.

5. Research Methodology

This research employs a descriptive-analytical approach based on data and information obtained from library sources and relevant documents. The gathered data is analyzed to reach conclusions and propose solutions to address the identified deficiencies.

6. Literature Review

While there are no directly related studies in the current research area, several relevant studies on related topics have been conducted, summarized as follows:

Sohrab Delangizan (2014) conducted a study on greenhouse gases, focusing on the impact of fuel price changes on greenhouse gas production. The study highlighted that air pollution arises from the émission and leakage of pollutants from fossil fuel combustion, including sulfuroxides, nitrogenoxides, carbonmonoxide, particulate mâter, and hydrocarbonés. Carbone dioxide is one of the primary greenhouse gases entering the Earth's atmosphere due to energy sector activities, particularly hydrocarboné

fuels. Lin and Mubarak (2013) investigated carboné dioxide émission changes related to energy consumption in the textile industry in China. They concluded that industrial activity changes were the main factor behind the increase in carbon dioxide emissions, with energy intensity fluctuations showing variability over the study period. Ghatars and Barati (2013) found that fossil fuel consumption in the transportation sector affects carbon dioxide emissions. Factors studied included economic activity, emission intensity coefficients, fuel composition, transportation methods, structural effects, and population growth. Their results indicated that changes in economic activity, structural effects, and population growth had the most significant impact on carbon dioxide emissions in the transportation sector. Abadollahan Koych and colleagues (2015) studied factors influencing carbon dioxide emissions in Iran's non-metallic minéral industries. They identified that the lack of modern, low-emission technologies, increased production from high-emission groups, and decreased fuel quality were major reasons for the rise in carbon dioxide emissions in these industries. Salar and colleagues (2014) addressed factors affecting gas production at landfill sites, identifying méthane as a greenhouse gas directly related to global warming. Although methane is not a toxic and dangerous gas, its migration to the upper layers of landfill soil replaces oxygène, and methane oxidation in soil reduces oxygen levels and increases carbon dioxide concentration. Mousavi and colleagues (2020) investigated the role of wind currents in the origin of carbon dioxide greenhouse gases at the provincial level. They found that carbon dioxide exhibits seasonal variations and changes due to geographical factors. The study also noted that various human and natural factors, including fossil fuel consumption, land use changes, volcanic activity, photosynthesis, and respiration, contribute to carbon dioxide inputs and outputs. Climatic factors such as precipitation and wind crurent Play a crucial role in the dispersion of this greenhouse gas in the atmosphere.

7. Air Pollution, Greenhouse Effect, and Its Consequences

In recent decades, air pollution has emerged as an unwanted byproduct of industrial societies. The primary causes of air pollution are the release of hydrocarbon molecules, nitrogen oxides, and sulfur oxides (McMurry & Robert C., 2007).

The addition of any substance alters the physical and chemical properties of clean air to some extent; therefore, such substances are considered air pollutants. Pollutants are typically classified as substances that have significant effects on humans, animals, plants, or materials (Dabiri, 2010).

In fact, humans are the only beings who consciously and unconsciously harm the environment. The consequences of human activities not only threaten human life but also jeopardize the natural habitats and lives of other creatures on this planet. Deforestation, depletion of production resources, improper waste disposal, and increased industrial activities have created a polluted environment that has made life on Earth difficult for all living beings.

Environmental pollution has become a global problem; however, despite significant investments in this area, toxic compounds in various forms are increasing in the environment, making environmental pollution a serious and tangible threat to the survival of living beings. Consequently, we are witnessing chronic diseases, including respiratory issues due to air pollution, internal infections resulting from water pollution and solid waste, and psychological disorders stemming from physical pain as direct impacts of environmental pollution (Salar, Moattar, & Khazri, 2014).

The origins of air pollution during the early industrial revolution were primarily industries and coal fuel, and in the twentieth and twenty-first centuries, urban transportation has been responsible for air pollution in cities. Fossil fuels used in transportation and industry, on one hand, and industrial processes involving raw materials and manufactured products, on the other hand, are major sources of pollution with non-natural origins (Solgi, 2005).

Today, one of the most significant problems the world faces is the increasing instability of the global climate due to the excessive emission of gases or the greenhouse effect (Mousavi & Fallah-Tekeh, 2020). The primary concern regarding the greenhouse effect is the fear that human activities in the past and present may have disrupted Earth's delicate thermal balance. One component of this balance is the solar radiation received at Earth's surface, a portion of which is radiated back into space as infrared energy. Although most of this energy passes through the atmosphere, some of it is absorbed by atmospheric gases, particularly water vapor, carbon dioxide, and methane. This absorbed radiation warms the atmosphere and stabilizes Earth's temperature at a relatively constant level. An increase in absorbed radiation leads to a rise in atmospheric heat and an increase in Earth's temperature (McMurry & Robert C., 2007).

The increasing emission of greenhouse gases and remote phenomena are among the factors influencing the speed of climate change (Kaltsas et al., 2007). Greenhouse gases include a range of carbon dioxide (CO_2), nitrogen oxides (N_2O), methane (CH_4), ozone (O_3), chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs), which, by ascending into Earth's atmosphere and trapping solar energy, contribute to the warming of the planet and its surrounding air (Mozafari et al., 2015). Among these gases, carbon dioxide is recognized as the most important greenhouse gas and the primary factor in climate change, accounting for 50 to 60 percent of the greenhouse effect (Yhe et al., 2015). Although a small amount of these gases naturally exists

in Earth's atmosphere, human activities and the resulting pollution have unnaturally increased their levels, trapping heat or thermal radiation from the sun in the atmosphere and consequently raising Earth's temperature (Mozafari et al., 2015).

According to reports from the Intergovernmental Panel on Climate Change (IPCC), the iron and steel industry and waste production are identified as the largest global sources of greenhouse gas emissions from human activities. The World Resources Institute (WRI) also identifies the energy, industrial, agricultural, forestry, and waste and sewage sectors as the major producers of various greenhouse gases worldwide. Figures 1 and 2 illustrate the share of each of these sources and sectors in global greenhouse gas emissions (IPCC, 2007).

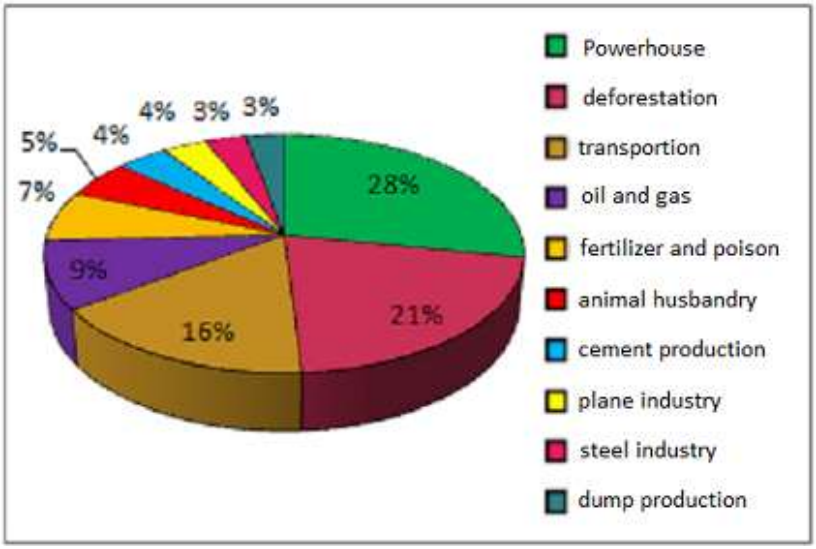

Figure1. Percent share of the largest global emission resources of greenhouse gases ((IPCC), 2007)

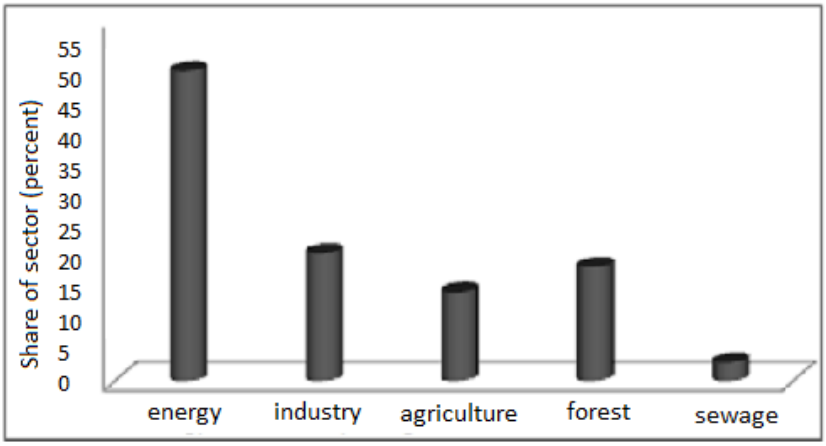

Figure2. Percent global emissions of greenhouse gases separately for Sections ((IPCC), 2007)

8. Effects of Air Pollution

The effects of air pollution on human health, animals, plants, and the degradation of cultural heritage have been subjects of extensive discussion and research. In recent decades, issues such as acid rain, the ozone layer, global warming, and their impacts on ecosystems and ultimately on humanity have been studied and debated by scientists (Solgi, 2005).

Fossil fuels, which are consumed in large quantities in urban and industrial activities, contain various heavy metals such as lead, zinc, mercury, and arsenic (Ozaki, Watanabe, & Kuno, 2004). Traffic pollution contains toxic elements such as cadmium, lead, and zinc, which pose serious risks to human health and the environment (Duran & Gonzalez, 2009). These particles mainly enter the human body through the respiratory system and have negative effects on health (Grimm, Faeth, Golubiewski, & Redman, 2008). Heavy metals such as arsenic, iron, zinc, lead, cadmium, chromium, copper, manganese, and nickel can enter the human body through three main routes: inhalation, ingestion, and skin contact. They can lead to issues such as kidney disease, nervous system

disorders, endocrine system dysfunction, urinary system disturbances, and developmental problems in children (Yang, Ge, Lu, & Long, 2010).

Recent studies in several major polluted cities have examined the relationship between pollution levels and mortality rates, and these findings will be discussed further (Solgi, 2005).

8.1 Carbon Monoxide (CO)

This is a colorless and odorless gas produced by the incomplete combustion of fuel materials. Vehicles and transportation machinery are the primary sources of this type of pollutant. Carbon monoxide is toxic because it binds with hemoglobin in the blood, preventing oxygen from reaching the body's tissues. Hemoglobin in the lungs absorbs oxygen and releases it to the tissues to aid in food oxidation. When hemoglobin interacts with carbon monoxide, it forms a more stable complex than oxyhemoglobin, making carbon monoxide a toxic gas (Mortimer, 2009).

The oxygen deficiency caused by carbon monoxide leads to dysfunction in sensory and muscular functions, such as those in the brain, heart, blood vessel walls, and platelets. The affinity of carbon monoxide for hemoglobin is approximately 220 times greater than that of oxygen, so carboxyhemoglobin levels rise rapidly in polluted environments. When carboxyhemoglobin levels reach 50%, the body's oxygen-carrying capacity decreases, and its effects on the heart become clearly evident (Solgi, 2005).

8.2 Sulfur Oxides (SO_2 and SO_3)

Sulfur is considered an environmentally harmful element, often present in coal at levels exceeding standards. A relatively high sulfur content in coal results in significant sulfur dioxide (SO_2) emissions (Yazdi, 2007). Sulfur dioxide from coal combustion is slowly oxidized by atmospheric oxygen into sulfur trioxide (SO_3). Water on Earth converts SO_3 and SO_2 into sulfuric acid (H_2SO_4) and sulfurous acid (H_2SO_3), respectively. These substances are highly corrosive and are the principal acids in acid rain (Mortimer, 2009). Even low concentrations of SO_2 can cause respiratory distress in individuals, with severity depending on the exposure level. Sulfur dioxide, combined with particulate matter, has a synergistic effect because of its solubility in water and, consequently, its greater impact on the upper respiratory tract (Solgi, 2005).

8.3 Nitrogen Oxides (NO and NO_2)

These oxides are produced from the reaction of oxygen and nitrogen in the air at high temperatures, such as during thunderstorms with lightning. Significant amounts of NO are generated by vehicle engines and power plants. NO_2 is produced as NO reacts with oxygen in the air. Nitrogen dioxide is more toxic than nitrogen monoxide. The concentrations of these gases are generally quite low, and their direct effects are not highly significant. However, their importance lies in their role in the formation of other dangerous pollutants.

$$NO_{2(g)} \rightarrow NO_{(g)} + O_{(g)}$$

Oxygen atoms interact with atmospheric oxygen to form a compound known as ozone:

$$O_{(g)} + O_{2(g)} \rightarrow O_{3(g)}$$

Ozone is highly reactive and combines with certain hydrocarbons to produce oxygenated compounds. Since this process is initiated by sunlight, its products are commonly referred to as photochemical pollutants. These substances are toxic and cause irritation to the eyes, skin, and respiratory system; they severely damage crops and degrade materials. Such substances are also known as photochemical smog (Mortimer, 2009).

Ozone, although considered one of the dangerous pollutants on Earth, plays a beneficial role in the upper atmosphere by absorbing harmful ultraviolet (UV) radiation from the sun. The ozone layer acts as a shield to prevent high-energy solar radiation from reaching the Earth's surface.

The increasing levels of greenhouse gases have raised significant concerns about the depletion or thinning of the ozone layer. The primary cause of ozone layer destruction is the presence of chlorofluorocarbons (CFCs) such as CF_2Cl_2 and $CFCl_3$ in the atmosphere (McMurray & Robert C, 2007).

The formation of holes in the ozone layer is associated with numerous environmental and human health risks. Without this layer, life on Earth would be endangered. Environmental impacts of ozone layer depletion include disruption and fragmentation of food chains in terrestrial and marine ecosystems, increased incidence of eye diseases such as cataracts, and other ocular conditions. Additionally, there is a rise in various types of skin cancers, loss of marine and fish populations, destruction of plants and trees,

and an increase in infectious diseases due to a weakened immune system. These are all consequences of the loss or degradation of the ozone layer (Bameh, 2015).

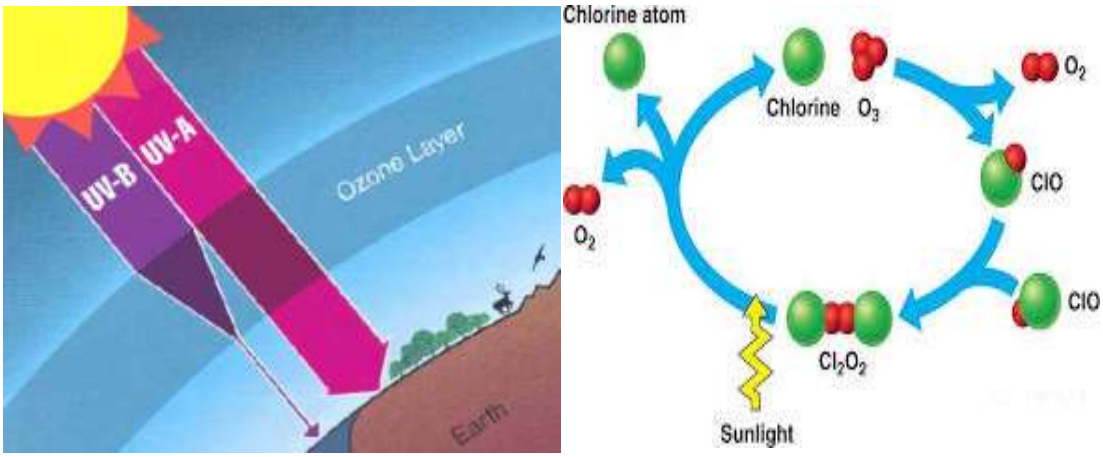

Figure 3. Ozone Layer Depletion by Chlorine and Other Greenhouse Gases.

8.4 Methane (CH_4)

Methane is a colorless, odorless gas that produces 252 kilocalories of thermal energy per cubic foot when burned. This value is substantial compared to other fuels and particularly significant when considering gases resulting from biological processes in landfills. A key advantage of methane over other fuels is that it does not produce the toxic and dangerous carbon monoxide when combusted.

Methane is a greenhouse gas directly linked to global warming. A portion of Earth's warming is attributed to the accumulation of various greenhouse gases in the atmosphere, with methane and carbon dioxide being the most prominent. Although methane itself is not a toxic or dangerous gas, its migration upward through the layers of soil in landfills replaces oxygen. Besides the oxidation of methane in the soil, this reduction in oxygen and increase in carbon dioxide concentration adversely affects plant growth by reducing the oxygen available near the roots, thereby hindering plant survival (Salar, Motahar, & Khazri, 2014).

9. Effects of Greenhouse Gases on Natural Systems

Rising temperatures lead to reduced rainfall, increased evaporation and transpiration, altered wind patterns, changes in crop patterns, decreased agricultural output, more frequent droughts, expansion of arid regions, and alterations in surface and groundwater resources (Mofidi et al., 2015). Studies show that the average surface temperature of the Earth and its atmosphere has risen over the past century, with the 2000s being the warmest decade since 1880. Climate change and global warming have the most significant impact on dry and semi-dry regions, including Afghanistan. Various factors influence the distribution of carbon dioxide in the atmosphere, such as topography (due to greenhouse gas transfers and interactions with surface features), rainfall (which washes gases and transfers them to underground areas), air currents, and wind. For instance, an increase in wind speed to 2 meters per second can help disperse and dilute surface carbon dioxide (Mousavi & Flahati, 2020).

10. Transition to Renewable Energy Sources

The use of fossil fuels such as oil and gas as primary energy sources has resulted in irreparable damage to humanity. To mitigate these adverse effects, it is crucial to transition to renewable or environmentally friendly energy sources such as solar, wind, and hydropower. The energy crisis of the 1970s was a major impetus for the global shift towards these inexhaustible resources (Moeini & Dehghan Manshadi, 2010). Additionally, biogas and hydrogen are other renewable sources that warrant attention for maintaining environmental health and replacing fossil fuels (Bagheri, Emteyazi, & Jalili, 2022). These renewable energy sources, aside from being cleaner than fossil fuels, offer attractive options for economic growth, energy needs, job creation, and the establishment of production and service industries, especially in developing countries (Pfeiffer & Mulder, 2013).

Renewable energy sources have a long lifespan and natural cycles, unlike non-renewable energy sources such as fossil fuels, which are finite. This ensures the sustainability of energy consumption for future generations. Renewable energy sources, particularly wind and solar energy, due to their abundance and favorable geographical conditions, have significant potential for energy production. Utilizing these sources can reduce dependence on fossil fuels, decrease emissions of pollutants from energy

production and consumption, and mitigate the release of greenhouse gases that contribute to global warming (Daneshvari & Salatin, 2020).

11. Conclusion

Human activities generate greenhouse gases, and their impact on climate change is well-documented, with energy use being the largest source of these emissions. The entry of gases such as carbon dioxide, methane, and nitrogen oxides into the atmosphere which are also naturally present, leads to their heat being trapped, resulting in Earth's warming and climatic changes. Various human and natural factors, including fossil fuel consumption, land use changes, volcanic activity, photosynthesis, and respiration, affect the levels of carbon dioxide in the atmosphere. One of the most fundamental and crucial measures to reduce greenhouse gas emissions and carbon dioxide is decreasing energy consumption, which directly correlates with the amount of these gases released into the atmosphere. Furthermore, expanding the use of renewable energy as a clean energy source can play a significant role in reducing environmental pollution and major pollutant emissions, such as carbon dioxide and other greenhouse gases, thus preventing substantial societal costs. Therefore, addressing the excessive environmental degradation, thinning of the ozone layer, climate changes, seasonal rhythm shifts, global warming and reduction in agricultural areas underscores the necessity and importance of adopting renewable energy.

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