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Air Pollution, Global Warming and Difficulties to Replace Fossil Fuel with Renewable Energy

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Abstract

Since the Industrial Revolution, greenhouse gas (GHG) emissions have greatly increased with the increased use of fossil fuels, leading to air pollution and global warming. We present the researches on air pollution and the use of fossil fuels in north China, the economic zone of Changsha-Zhuzhou-Xiangtan and the economic zone of the Pearl River Delta region. Researches indicate that the use of fossil fuels has been the main source of air pollution in the three regions. We present researches on global mean surface temperature (GMST) with the rise of carbon dioxide concentration (CDC) and global fossil fuel consumption (GFFC); researches indicate that the rise in CDC can account for 91% of the rise in GMST, and GFFC can account for 90% of the rise in GMST. We analyse the factors that bring about air pollution and temperature rise, they are the use of fossil fuels and deforestation. It is critically important to replace fossil fuels with clean energy, but renewable energy has also disadvantages. The world faces difficulties in solving air pollution and global warming, so governments of the world should cooperate to solve the technologies of clean energy, and preserve the forests and the natural environment.

Keywords

Air Pollution, Global Warming, Fossil Fuel, Renewable Energy

1. Introduction

Anthropogenic air pollution is becoming serious in winter in big cities, such as New Delhi, Karachi, Lima, and Beijing. 150 million tons of SO_2, 53 million tons of nitrogen oxides, 20 billion tons of CO_2, millions of tons of fluorinated substances, mercury, freon and other toxic pollutants are released into the air every

year [1]. 90% people of urban areas are exposed to air pollution with PM2.5 above the standard of the WHO air quality of 10 μg/m^3. In 2013, international agency for cancer research classified outdoor air pollution as a human carcinogen. Acute and chronic respiratory disease, stroke, lung cancer, heart disease are associates with poor air quality and air pollution. 7 million people died from household and ambient air pollution in 2016 [2]. About 2.5 million people die each year worldwide from indoor air pollution [3].

75% of global greenhouse gas emissions are from the use of fossil fuels, and large amount of local air pollution is brought about by the use of fossil fuels, which leads to 5 million premature deaths each year [4]. Steam engines and diesel engines have been the main driving forces for most industries after the Industrial Revolution, and fossil fuels have been the dominant energy sources. From 2000 to 2019, global CO_2 emission accounted for 30.7% of global cumulative emissions, the growth of CO_2 emission during this period is the fastest in human history [5].

The regions with the highest annual mean levels of urban PM2.5 are in South-East Asia with a PM2.5 concentration of 57.3 μg/m^3, followed by the Eastern Mediterranean Region with a PM2.5 concentration of 54.0 μg/m^3 [2]. Owing to poor ventilation, the solid fuels in stoves do not burn efficiently, producing large amounts of black carbon and other harmful gases that pose great harm to the health of children and women in rural areas. There are 3 billion people cooking with polluting fuels worldwide, especially in African Region [2].

There is observational evidence that global mean surface temperature (GMST) has been rising, and this rising trend has been very obvious since 1950. GMST was −0.16˚C in 1880, and it was 0.84˚C in 2021, thus an increase of 1.0˚C. The mean surface temperature of the Northern Hemisphere was −0.28˚C in 1880, and it was 1.14˚C in 2021, thus an increase of 1.42˚C. The mean surface temperature of the Southern Hemisphere was −0.04˚C in 1880, and it was 0.55˚C in 2021, thus an increase of 0.59˚C. GMST of 2020 was 1.02˚C, the highest temperature in history [6]. Due to the enhanced greenhouse effect, the growth rate of GMST nearly doubled in the past 50 years, GMST has increase by 0.6˚C - 0.9˚C from 1906 to 2005 [7]. The temperature rise in the tropical regions is also evident, although it has a lower temperature rise than most other regions [8].

The global average sea level rose by 248.92 mm from 1880 to 2021 [9]. There are 6200 Gt of glaciers lost from 1993 to 2019, which is equivalent to the rise of global sea level of 17.1 mm on average. The Greenland ice sheet has lost 4890 Gt from 1992 to 2020, which is equivalent to the rise of global sea level of 13.5 mm on average. The melting rate of the Greenland ice sheet is accelerating: the loss rate of ice sheet was 39 Gt/yr from 1992 to 1999, 175 Gt/yr from 2000 to 2009, 243 Gt/yr from 2010 to 2019. The Antarctic ice sheet lost 2670 Gt from 1992 to 2020, which is equivalent to the rise of global sea level of 7.4 mm on average. The melting rate of the Antarctic ice sheet is also accelerating: the loss rate of ice sheet was 49 Gt/yr from 1992 to 1999, 70 Gt/yr from 2000 to 2009, and 148 Gt/yr from 2010 to 2019 [8].

The following part of the paper is arranged in this way: the second part of the paper is air pollution and fossil fuel in China; the third part is global warming and greenhouse gas emissions; the fourth part is disadvantages of renewable energy; the fifth part is discussion, we discuss the situation of global greenhouse gas emissions and deforestation; the sixth part is conclusion.

2. Air Pollution and Fossil Fuel in China

The North China region includes Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia, Shandong, Henan, and part of Liaoning Province. There are many heavy industrial bases in Beijing, Tianjin, Hebei, and Shandong. The energy base of China is Shanxi. There is serious air pollution in this area, and pollution can spread rapidly from province to province. China's sandstorm is from Inner Mongolia Province. There are many industries that use fossil fuels as the main energy or raw materials, such as thermal power plants, steel plants, coke plants, metallurgical plants, cement plants and petrochemical plants. Coal is widely used in this area, and it is the main source of pollution. In 2003, the use of coal caused significant pollution in North China, coal-fired pollution accounted for 13.6% of PM10 emissions, 14.1% of PM2.5 emissions, 64.1% of the nitrogen oxide (NO_x) emissions, 99.0% of sulfur dioxide (SO_2) emissions, 1.5% of non-methane volatile organic compounds (NMVOCs) emissions and 57.5% of carbon monoxide (CO) emissions.

In 2000 in the North China, among the 254 cities monitored, the pH values of precipitation ranged from 4.10 to 7.70, and 157 cities had acid rains, accounting for 61.8% [10]. Many cities suffer from severe NO_x pollution, excessive ozone concentrations and photochemical smog [11]. Inhalable particulate matter has become the primary air pollutant in the cities in northern China. In major cities in North China, such as Beijing, Tianjin, and Shijiazhuang, the annual emission of PM10 is 50 t/km^2. In some heavily polluted cities, or cities in winter with severe air pollution, the annual emission of PM10 is 200 t/km^2. In lightly polluted cities, the annual emission of PM2.5 is 20 t/km^2. In some heavily polluted cities, or cities in winter with severe air pollution, the annual emission of PM2.5 is 100 t/km^2 [12].

In lightly polluted cities, the annual emission of NO_x is 20 t/km^2, while in heavily polluted cities, the annual emission is 100 t/km^2. In lightly polluted cities, the annual emission of SO_2 is 10 t/km^2, while in heavily polluted cities, the annual emission is 100 t/km^2. In lightly polluted cities, the annual emission of CO is 50 t/km^2, while in heavily polluted cities, the annual emission is 200 t/km^2. In lightly polluted cities, the annual emission of NMVOCs is 10 t/km^2, while in heavily polluted cities, the annual emission is 100 t/km^2. In lightly polluted cities, the annual emission of ammonia (NH_3) is 10 t/km^2, while in heavily polluted cities, the annual emission is 50 t/km^2 [12].

In 2003, in the North China region, the emissions of atmospheric particulate matter of PM10 were 10.46 million tons, of which 21.2% were from the use of

fossil fuels. The emissions of PM2.5 were 5.48 million tons, of which 24.4% were from the use of fossil fuels. The emissions of NO_x were 5.3 million tons, of which 94.9% were from the use of fossil fuels. The emissions of SO_2 were 9.58 million tons, of which 99% were from the use of fossil fuels. The emissions of CO were 46.73 million tons, of which 79.8% were from the use of fossil fuels. The emissions of UMVOCs were 3.85 million tons, of which 56.2% were from the use of fossil fuels. The emissions of MH3 were 5.3 million tons, of which 1.3% were from the use of fossil fuels [12].

In 2013 in the economic zone of Changsha-Zhuzhou-Xiangtan, the emissions of atmospheric particulate matter of PM10 were 113981.99 tons, of which 22.19% were emitted from the use of fossil fuels. The emissions of PM2.5 were about 56610.53 tons, of which 32.17% were from the use of fossil fuels. The emissions of NO_x were 144071.14 tons, of which 73.52% were from the use of fossil fuels. The emissions of SO_2 were 132559.08 tons, of which 73.81% were from the use of fossil fuels. The emissions of volatile organic compounds (VOCs) were 158255.69 tons, of which 25.73% were from the fossil fuels. The emissions of NH_3 were 75512.6 tons, of which 0.8% were from the fossil fuels [13].

We can see that in the economic zone of Changsha-Zhuzhou-Xiangtan, in 2013, the main polluting sources were from the use of fossil fuels, they can be divided into the following categories: 1) fixed-point combustion of fossil fuels, such as power plants; 2) moving vehicles, such as cars and trucks; and 3) stored diesel and gasoline or diesel and gasoline in transportation. The monitoring data of urban environmental air quality from 2014 to 2017 indicated that the vast majority of heavy air pollution in the economic zone of Changsha-Zhuzhou-Xiangtan occurred from mid October to mid March of the following year, about five months [14]. In fact, in northern China, during this period, it is relatively cold. Cities are mainly heated by the use of coal and natural gas, and the use of fossil fuels will increase sharply, resulting in severe air pollution. Many elderly people pass away during this period in China.

In 2012, in the economic zone of the Pearl River Delta region, the annual emission of PM10 was 495,200 tons, of which 37.08% were from the use of fossil fuels. The emissions of PM2.5 were 192,300 tons, of which 59.8% were from the use of fossil fuels. The emissions of NO_x were 942,800 tons, of which 99.19% were from the use of fossil fuels. The emissions of SO_2 were 466,100 tons, of which 97.86% were from the use of fossil fuels. The emissions of CO were 4,626,600 tons, of which 88.23% were from the use of fossil fuels. The emissions of VOCs were 864,000 tons, of which 40.51% were from the use of fossil fuels. The emissions of NH_3 were 190,300 tons, of which 6.57% were from the use of fossil fuels [15].

The Pearl River Delta region is an economically developed area in China. A large amount of fossil fuels are used by thermal power plants, industries and vehicles. This place is densely populated, with a large number of industrial enter-

prises and motor vehicles. Therefore, the pollution is relatively serious in this region, the main pollutant is PM2.5. In 2014, the annual average concentration of PM2.5 was 22 μg/m^3, and the annual average concentration of PM10 was 61 μg/m^3. There were 298 days that met the air quality standard, accounting for 81.6% of the year.

We can see that the situation of air pollution in north China was serious in the 2000s, air pollution was all year around, and winter was the worst. In the economic zone of Changsha-Zhuzhou-Xiangtan, air pollution is serious from mid-October to mid-March of the following year, air pollution is relatively not serious in the remaining 7 months. The situation of air pollution in the Pearl River Delta region is much better than that in north China, it is also better than that in the economic zone of Changsha-Zhuzhou-Xiangtanin. Its main pollution sources are thermal power plants, light industrial enterprises, and various vehicles.

3. Global Warming and Greenhouse Gas Emissions

The use of fossil fuels releases greenhouse gas (GHG), which pollutes the air and leads to the rise of GHG concentration, more GHGs trap more solar energy and lead to the rise of surface temperature. The use of global fossil fuels was 2575 TWh in 1880, and 136,761 TWh in 2019, thus an increase of 52.11 times [16]. Global CO_2 emissions were 85,371 million tons in 1880, 36441.39 million tons in 2019, thus an increase of 41.69 times [17]. From 1750 to 2009, the carbon dioxide concentration (CDC) has risen by 38%, and the concentration of methane has increased by 148% [7]. The atmospheric CDC was 287.77 ppm in 1880, and it was 417.65 ppm in 2022, thus an increase of 45.13% [18]. We can see that the growth rate of CDC in recent decades is a little faster than that before the 1960s. We conduct regression analysis with GMST as dependent variable [6], and with CDC as independent variable [18], the time is from 1880 to 2019. We present the outcome in **Table 1**. We can see that t-Statistics are significant at 5% confidence level; F-statistic is also significant, which means that the positive relationship between GMST and CDC is robust. R-squared is 0.91, which means that the changes of atmospheric CDC account for 91% of the rise of GMST.

To know the effect of fossil fuel consumption on global warming, we also conduct regression with GMST as dependent variable [6], with global fossil fuel consumption (GFFC) as independent variable [19]. Fossil fuels include oil, gas and coal, the units are exajoules. The time of the data of GFFC is from 1965 to 2022. The outcome is presented in **Table 2**. We can see that there is a positive relationship between GMST and GFFC, changes in GFFC can account for 90% of the rise in GMST. t-Statistics are significant at 5% confidence level, F-statistic is also significant. We conduct pairwise Granger causality tests between GMST and GFFC, the outcome indicates that GFFC does Granger cause GMST, while GMST does not Granger cause GFFC. These outcomes indicate that GFFC has intensified the greenhouse effect, and brought about global warming.

Table 1. Regression output between GMST and CDC.

independent variables:	coefficient:	t-Statistic:	R-squared: 0.91
C	−331.53	−32.75	F-statistic: 1152.36
CDC	1.03	33.95	D-W statistic: 1.19

Note: here *C* is the intercept.

Table 2. Regression output between GMST and GFFC.

independent variables:	coefficient:	t-Statistic:	R-squared: 0.90
C	−57.2	−12.88	F-statistic: 5152.0
GFFC	0.3	22.69	D-W statistic: 1.52

Note: here *C* is the intercept.

Figure 1 is changes in the global mean concentration of carbon dioxide above the ocean surface from 1959 to 2021, the units are ppm [20]. The x-axis represents the rise of the concentration of carbon dioxide in ppm, and the y-axis represents the time in years. We can see that the upward trend of global mean concentration of carbon dioxide is clear from 1959 to 2021, of course, it is full of fluctuation.

4. Disadvantages of Renewable Energy

Renewable energy has been replacing fossil fuels across the world, but renewable energy has also disadvantage. First, renewable energy is susceptible to weather, which makes them intermittent and unreliable. For example, solar power generators do not work at night, wind turbines cannot generate electricity when the wind speed is lower than the critical values, the hydroelectric facility will generate little or no electricity if the water level is too low and the water flow is slow. Second, renewable energy sources are unreliable without large-scale storage facilities, electric fluctuations can damage appliances and cause losses to users, economical and practical energy storage facilities are necessary for the large-scale application of renewable energy. A battery system for an ordinary family is around $5000 or even more. If installing a power storage system is beyond your budget and the power generation system cannot generate electricity due to weather, you will have no power available. Third, renewable energy is currently impractical for the transport and aviation sectors with current technology. The technology for large-scale storage facilities is not mature and it does not have economic advantage. Finally, large dams and reservoirs affect geological structures, generate earthquakes, and alter the ecological environment.

Wind power generation increases with the cube of wind speed, therefore wind turbine generators should be installed in areas with high wind speed, such as seashores, plains and mountain passes. If wind farms are far away from cities, transmission lines need to be built to deliver electricity from wind farms to cities, which add cost to wind electricity. Wind power is seasonal, wind turbines

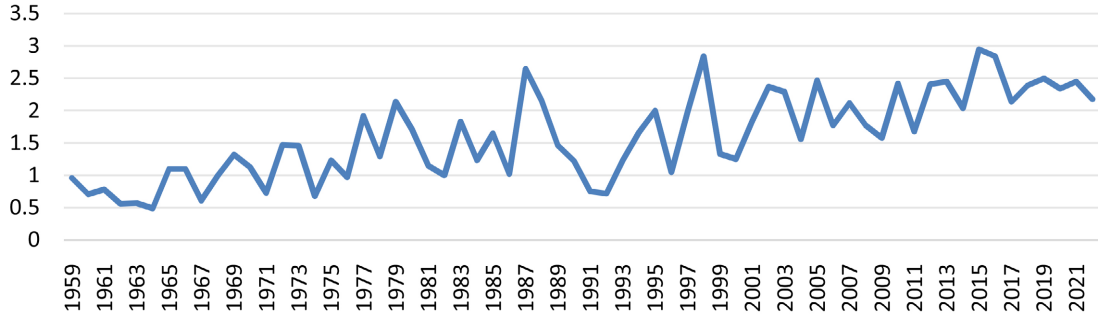

Figure 1. Changes in the global mean concentration of carbon dioxide above the ocean surface from 1959 to 2021. The x-axis represents the rise of the concentration of carbon dioxide in ppm, and the y-axis represents the time in years.

work at full capacity in seasons of strong wind. Wind turbines generate much less electricity in seasons of low wind speed. Wind turbines produce broadband noise, which is harmful not only to birds, but also to human health. Birds are killed if they fly into rotating turbine blades, so rotating wind blades change local habitats and affect certain birds.

The embankment of a dam cannot be built anywhere, it must be environmentally sustainable. The construction of a dam generally takes a lot of investment and time. During dry seasons, the water level is low, and the hydro power plant cannot generate electricity at full capacity. Fish habitats are formed by water level, water flow speed, access to food, and the possibility of shelter. Hydro power plants change the ecosystems, and these changes could be disastrous for certain fish species. In fact, building a dam not only change the animal habitats, but also the human habitats. Cities and towns may be wiped off the map when a big hydro power plant is built, people will have to resettle elsewhere.

Did the Three Gorges Dam cause the Wenchuan earthquake and the Ya an earthquake? The Wenchuan earthquake occurred on May 12, 2008 in Sichuan Province, with a magnitude of 8.0. It caused a total of 69,227 deaths, 17,923 missing, 374,643 injured to varying degrees, 19.93 million people lost their homes, and the total affected population reached 46.26 million [21]. The Ya an earthquake occurred on April 20, 2013, with a magnitude of 7.0, also in Sichuan Province. It caused a total of 196 deaths, 21 missing, 11,470 injured, and 1.52 million people affected [22].

Research [23] indicated that the impoundment of the Three Gorges Reservoir leads to changes in the gravity field in the western region of Sichuan, and brings about earthquakes. As time goes on, the change in gravity field becomes increasingly significant. Therefore, long-term energy accumulation will lead to large-scale earthquakes. Empirical researches indicate: 18 years after the construction of the Three Gorges Reservoir, the frequency of earthquake in the western region of Sichuan has significantly increased compared to 18 years before the construction of the Three Gorges Dam. Wanli Huang, one of China's leading experts on hydraulic engineering, once said that the Three Gorges Dam would change the geological structure and bring ecological disaster.

5. Discussion

5.1. Developing Countries Have Become Major Emitters in CO_2 Mission, the Consumption of Fossil Fuels Is Still Growing

From 1850 to 2005, the total CO_2 emissions in developed countries accounted for 60% - 80% of the world total, and developing countries accounted for 40% - 20% [24]. In 2004, CO_2 emissions in the non-OECD countries were 13626.7 million tons, exceeding that in the OECD countries (13,450 million tons). Since then, CO_2 emissions in the non-OECD countries have been more than that in the OECD countries, and the trend has continued to the present with no sign of decline [25]. In 2020, the total CO_2 emissions in the OECD countries was 10778.1 million tons, accounting for 33.3% of the world's total, the average annual growth rate was −0.4% from 2009 to 2019 [26]. In non-OECD countries, the total CO_2 emissions were 21540.5 million tons in 2020, accounting for 66.7% of the world's total, the average annual growth rate was 2.5% from 2009 to 2019 [26]. Developing countries have been the major emitters in CO_2 emissions.

In 2005, China's CO_2 emissions were 6098.2 million tons, surpassing the United States and becoming the first country. In 2020, its CO_2 emissions were 9899.3 million tons, accounting for 30.7% of the world's total [26]. China's fossil fuel consumption was 41.89 Exajouls in 2001, 122.67 Exajouls in 2020, thus an increase of 1.93 times. In 2020, China's fossil fuel consumption accounted for 84.33% of its total primary energy consumption [26]. Renewable energy consumption in China was 2.79 Exajoules in 2001 (including hydroelectricity), 19.53 Exajoules in 2020, thus an increase of 6 times. In 2020, China's renewable energy consumption accounted for 13.43% of its total primary energy consumption, with an annual average growth rate of 31.58% from 2001 to 2020 [26].

The United States is the second largest country in CO_2 emissions, and its CO_2 emissions were 4457.2 million tons in 2020, accounting for 13.8% of the world's total. Fossil fuel consumption in the United States was 81.87 Exajouls in 2001, 71.69 Exajouls in 2020, thus an decrease of 12.43%. Fossil fuel consumption in 2020 accounted for 81.66% of its total primary energy consumption [26]. Renewable energy consumption in the United States was 2.97 Exajoules in 2001 (including hydroelectricity), 8.71 Exajoules in 2020, thus an increase of 1.93 times. In 2020, renewable energy consumption accounted for 9.92% of its total primary energy consumption, with an average annual growth rate of 10.17% from 2001 to 2020 [26].

India is the third largest country in CO_2 emissions, its CO_2 emissions were 2302.3 million tons in 2020, accounting for 7.1% of the world's total. India's fossil fuel consumption was 12.49 Exajouls in 2001, 28.71 Exajouls in 2020, thus an increase of 1.3 times. The fossil fuel consumption in 2020 accounted for 89.78% of its total primary energy consumption [26]. Renewable energy consumption in India was 0.76 Exajoules in 2001 (including hydroelectricity), 2.88 Exajoules in 2020, thus an increase of 2.79 times. In 2020, renewable energy consumption accounted for 9.01% of its total primary energy consumption, with an average

annual growth rate of 14.68% from 2001 to 2020 [26].

In 1970, the total global consumption of fossil fuel was 53,381 TWh, accounting for 93.74% of global total primary energy, and it was 136,761 TWh in 2019, accounting for 84.32% of primary energy [27]. The average annual growth rate of fossil fuel consumption was 1.96% from 1970 to 2019. The total global electricity generation from renewable energy sources was 2057.64 TWh in 1985, and 7492.51 TWh in 2020, thus, an increase of 2.64 times, and the average annual growth rate was 7.55% [28]. Global renewable energy accounted for 6.81% of primary energy consumption in 1985, and 11.41% in 2019, thus an increase of 4.6% [29]. The share of renewable energy in primary energy is small, and the share of fossil fuel in primary energy is much larger, only that renewable energy grows faster than fossil fuel.

5.2. Deforestation

Trees absorb CO_2 in the air and convert it into wood. Therefore, deforestation leads to the rise of CDC and drives the rise of surface temperature through the greenhouse effect. Human activities have raised the concentration of GHG in the air by the use of fossil fuel and deforestation over the past 250 years [7]. There is a strong feedback between the biosphere and solar radiation in moderately wet regions, proper precipitation and solar radiation are conducive to vegetation growth, which in turn enhances heat transfer and increases the thickness of clouds and the height of atmosphere. The feedback between biosphere and solar radiation is globally widespread, they account for up to 30% changes of precipitation and surface radiation [30]. The atmospheric extension can effectively buffer extreme weather such as too cold or too hot, and makes the surface temperature more suitable for human survival.

There were 1474.53 million people in the world in 1880 [31], 7794.8 million in 2020 [32], an increase of 4.29 times. From 1950 to 1990, the growth rate of human population is the fastest since the Revolution Industry, with an average annual growth rate of 1.88% [31]. Population growth has led to continued urbanization and deforestation, which lead to increased use of fossil fuel and environmental degradation. Deforestation rate was 16 million hectares per year in the 1990s, 10 million hectares per year from 2015 to 2020. Since 1990, 420 million hectares of forest were converted to other land uses and more than 80 million hectares of primary forest have been cut down [33].

In 2020, there are more than 37,400 species of animals and plants that are list as extinct species, accounting for 28% of all assessed species. Among them, 41% of amphibians, 26% of mammals, 34% of conifers, 14% of birds, 36% of sharks and rays, 33% of reef corals, and 28% of selected crustacean, are listed as threatened species by IUCN [34]. It is necessary for human beings to establish national parks and ecological reserves to preserve plants and animals. Vegetation is the natural basis of human sustainable development in the future. We should preserve plants and animals, protect ecosystems and avoid the loss of biodiversity to achieve sustainable development.

6. Conclusions

Clean energy is badly in need, and solar power is the most abundant energy resource, but the huge cost of the investment of the up-front infrastructure is an obstacle to its rapid growth. As prices continue to fall, solar energy is becoming more and more competitive. Hydrogen is a clean energy, it is a secondary energy, easy to carry, and safe to store. We can use renewable energy to generate electricity, and then produce hydrogen with electricity. Thus, we can solve the problem of intermittency and unreliability of renewable energy by converting it to hydrogen.

Since the beginning of the 2000s, half of the growth of renewable energy generation in the United States is attributed to the state renewable energy requirements—Renewable Portfolio Standards [35]. Researches indicated that Renewable Portfolio Standards are more cost-effective in promoting the development of renewable energy than the Production Tax Credit or the cap-and-trade policy [36]. Technology innovations in clean energy reduce GHG emissions and the cost of environmental policies. Therefore, clean energy is pushing countries that have not joined the climate treaties to voluntarily adopt clean energy to reduce GHG emissions [37].

Forests are home to many wild animals and plants, and half of wild species reside in tropical forests, habitat loss is the leading cause of global biodiversity loss. Deforestation not only leads to the rise of atmospheric GHG concentration, but also to the decrease of wildlife in species and quantity [38]. 10,000 years ago, 57% of the world, 6 billion hectares of land, were covered by forests, and now there are 4 billion hectares of forests, one-third of forests have been lost. Half of the forests were lost from 8000 BC to 1900, the other half were lost in the 20th century. The net loss rate of forests was 4.7 million hectares per year from 2010 to 2020, and 10 million hectares of forests are cut down each year [38]. Therefore, the momentum of deforestation must be reduced, and forests should be preserved.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Ivanova, V.R. (2020) The Anthropogenic Air Pollution and Human Health. *Journal of IMAB*, **26**, 3057-3062. https://doi.org/10.5272/jimab.2020262.3057

[2] WHO (2019) World Health Statistics 2019: Monitoring Health for the SDGs, Sus-

tainable Development Goals. World Health Organization, Geneva.
https://www.who.int/publications/i/item/9789241565707

[3] National Geographic (2022) Air Pollution.
https://education.nationalgeographic.org/resource/air-pollution

[4] Ritchie, H., Roser, M. and Rosado, P. (2022) Renewable Energy. Our World in Data.
https://ourworldindata.org/renewable-energy

[5] Zhou, M.Z. (2021) Global CO_2 Emissions and China's Challenges.
http://www.china.org.cn/opinion/2021-05/08/content_77475411.htm

[6] NASA (2022) Annual Mean Land-Ocean Temperature Index in 0.01 Degrees Celsius. GHCN-v4 1880-08/2021 + SST: ERSST v5 1880-08/2021. Using Elimination of Outliers and Homogeneity Adjustment, Base Period: 1951-1980.
https://data.giss.nasa.gov/gistemp/tabledata_v4/ZonAnn.Ts+dSST.txt

[7] Riebeek, H. (2010) Global Warming.
https://earthobservatory.nasa.gov/features/GlobalWarming

[8] IPCC (2021) Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.
https://doi.org/10.1017/9781009157896

[9] EPA (2022) Climate Change Indicators: Sea Level.
https://www.epa.gov/climate-indicators/climate-change-indicators-sea-level

[10] Ministry of Ecology and Environment of the People's Republic of China (2000) China Environmental Status Bulletin in 2000.
https://www.mee.gov.cn/gkml/sthjbgw/qt/200910/t20091031_180765.htm

[11] Ministry of Ecology and Environment of the People's Republic of China (2003) China Environmental Status Bulletin in 2003.
https://www.mee.gov.cn/gkml/sthjbgw/qt/200910/t20091031_180756.htm

[12] Zhao, B. (2007) The Research of Air Pollution Source Emission for the North China. Chinese Academy of Meteorological Sciences.
https://kns.cnki.net/kcms2/article/abstract?v=CvQ6TjzSIZwvRaBYTfzTORbhH3r_aUfN2jedlpOjGHQE0VM0v2dcM7u9VV5XNL3saNIoSOlMis0JDAXADMq_R80ArWKqDSVv8jxyZoUNRMNaUeyo1y6FKoeQ1pATmIwGImghu3Flt1KsaqF-Ny-bXg==&uniplatform=NZKPT&language=CHS

[13] Li, B. (2016) Pollution Sources Emission Inventory Research of Changsha-Zhuzhou-Xiangtan Urban Agglomeration. College of Environment and Resources, Xiangtan University. 1994-2022 China Academic Journal Electronic Publishing House.
https://kns.cnki.net/kcms2/article/abstract?v=3uoqIhG8C475KOm_zrgu4lQARvep2SAkueNJRSNVX-zc5TVHKmDNkl1Mhi69FwJqRDgbkBdIdm-oTJf3ADe3IOzIr4Qk7Gtp&uniplatform=NZKPT

[14] Yueyang City Qu Yuan Administration District Administration Committee (2017) Hunan Implements the Special Protection Period Plan for Air Pollution Prevention and Control in Changzhutan.
http://www.quyuan.gov.cn/31137/31140/content_1203080.html

[15] Yang, J. (2015) A Study on Refining Temporal and Spatial Allocation for the 2012-Based Air Pollutant Emission Inventory in the Pearl River Delta Region. School of Environment and Energy, South China University of Technology, Guangzhou.
https://kns.cnki.net/kcms2/article/abstract?v=32zMbNrZv2CmMpL_MeTqutEeOkn2v3UX-xHIcKDKF5Kmu59XdjNUuHPQ0lo6dk_AvREsEfuK1hC9u5c1_b_977iA35-lN8yoUFHx5HyW_dsjZ0i2IUMLYQ3bK4YuqraNoVizbDJyBdTDMVVFM7Brnw

==&uniplatform=NZKPT&language=CHS

[16] Ritchie, H. and Roser, M. (2020) Global Fossil Fuel Consumption 1800-2019. https://ourworldindata.org/fossil-fuels

[17] Ritchie, H., Roser, M. and Rosado, P. (2020) CO_2 and Greenhouse Gas Emissions. https://ourworldindata.org/co2-and-greenhouse-gas-emissions

[18] NOAA (2021) Trends in Atmospheric Carbon Dioxide. https://gml.noaa.gov/ccgg/trends/gl_data.html

[19] BP Data (2022) BP Statistical Review of World Energy June 2022. http://www.bp.com/statisticalreview

[20] NOAA (2023) Trends in Atmospheric Carbon Dioxide. Globally Averaged Marine Surface Mean Growth Rates. https://gml.noaa.gov/ccgg/trends/gl_data.html

[21] Baidu Baike (2023) The Wenchuan Earthquake in 2008. Baidu Baike. https://baike.baidu.com/link?url=onsVtdyrxoaWMqdtVyskfZ_-FdfB9BJTME_PvfKs0ffrGY3IsTqKB1F9Kw9-b-TmKcOgBKBh7-1MEAQOilaHeCtfWxSQ4GBAqhczOm3ATGc5eGjfz_CHckZFoU0hMOiQgxq3qRaKZyaa9CIpXZZoTK

[22] Baidu Baike (2023) April 20th Ya'an Earthquake. https://baike.baidu.com/item/4%C2%B720%E9%9B%85%E5%AE%89%E5%9C%B0%E9%9C%87/2290997?fromModule=search-result_lemma-recommend

[23] Li, J. (2014) Research on the Influence of the Three Gorges Dam on Seismicity in Western Sichuan. School of Automation Engineering, University of Electronic Science and Technology of China, Chengdu. https://kns.cnki.net/kcms2/article/abstract?v=3uoqIhG8C475KOm_zrgu4lQARvep2SAk6nr4r5tSd-_pTaPGgq4znAs699xderZ4SGePwn3HEb7BjCAJ0YSJrrHm__gNd2M5&uniplatform=NZKPT

[24] Wei, T., Yang, S.L., Moore, J.C., Shi, P.J., Cui, X.F., *et al.* (2012) Developed and Developing World Responsibilities for Historical Climate Change and CO_2 Mitigation. *PNSA*, **32**, 120911-12915. https://doi.org/10.1073/pnas.1203282109

[25] BP Data (2020) BP Statistical Review of World Energy June 2020. https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

[26] BP Data (2021) BP Statistical Review of World Energy July 2021. http://www.bp.com/statisticalreview

[27] Ritchie, H. and Roser, M. (2021) Primary Energy Consumption from Fossil Fuels, Nuclear and Renewables World. https://ourworldindata.org/grapher/sub-energy-fossil-renewables-nuclear?country=~OWID_WRL

[28] Ritchie, H. and Roser, M. (2021) Renewable Energy, Our World in Data. https://ourworldindata.org/renewable-energy

[29] Our World in Data (2021) Share of Primary Energy from Renewable Sources. https://ourworldindata.org/grapher/renewable-share-energy

[30] Green, J.K., Konings, A.G., Alemohammad, S.H., Berry, J., Entekhabi, D., Kolassa, J., Lee, J.-E. and Gentine, P. (2017) Regionally Strong Feedbacks between the Atmosphere and Terrestrial Biosphere. *Nature Geoscience*, **10**, 410-414. https://doi.org/10.1038/ngeo2957

[31] Roser, M., Ritchie, H. and Ortiz-Ospina, E. (2019) World Population Growth. https://ourworldindata.org/world-population-growth

[32] Macrotrends (2021) World Population 1950-2021. https://www.macrotrends.net/countries/WLD/world/population

[33] FAO and UNEP (2020) The State of the World's Forests 2020. Forests, Biodiversity and People. Rome. https://www.fao.org/3/ca8642en/CA8642EN.pdf https://doi.org/10.4060/ca8642en

[34] IUCN (2021) The IUCN Red List of Threatened Species. https://www.iucnredlist.org

[35] NCSL (2021) State Renewable Portfolio Standards and Goals. https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx

[36] Palmer, K. and Burtraw, D. (2005) The Environmental Impacts of Electricity Restructuring. Discussion Paper: 2005 Resources for the Future. JEL Classification, Numbers: L51, L94, L98. https://media.rff.org/archive/files/sharepoint/WorkImages/Download/RFF-DP-05-07.pdf

[37] Di Maria, C. and Werf, E. (2008) Carbon Leakage Revisited: Unilateral Climate Policy with Directed Technical Change. *Environmental and Resource Economics*, **39**, 55-74. https://doi.org/10.1007/s10640-007-9091-x

[38] Ritchie, H. and Roser, M. (2022) Deforestation and Forest Loss. https://ourworldindata.org/deforestation