

# FUNH5000 Essay2

## The Fundamental Solution to Climate Change: Reducing and Recycling Greenhouse Gases

**Abstract**—This article briefly introduces how greenhouse gases have become the main cause of climate change, and proposes some novel climate change solutions from the perspectives of energy conservation and recycling.

**Keywords**—greenhouse gases, gene editing, new energy

### I. INTRODUCTION

In recent years, climate change has become a global focus of attention. The frequent occurrence of extreme weather events, glacier melting, and rising sea levels indicate that the Earth's climate system is undergoing significant changes.



Figure 1. Melting glaciers.

Comprehensive interdisciplinary evidence shows that human activities since industrial civilization, especially greenhouse gas emissions, are the fundamental cause of current climate change, with an impact rate 10-100 times faster than natural processes [1].

#### 1. Core driving factor: intensification of greenhouse effect dominated by human activities

Since the Industrial Revolution, the widespread use of coal, oil, and natural gas has released massive amounts of carbon dioxide ( $CO_2$ ). According to data from 2023, approximately 75% of global  $CO_2$  emissions come from energy production and transportation [2].



Figure 2. Industrial emissions of greenhouse gases.

For example, power plants and automobile exhaust directly inject  $CO_2$  into the atmosphere, and its concentration

has increased from 280 ppm before industrialization to over 420 ppm currently [2].

On the other hand, human changes in land use are also an important cause of climate change. Forests are important carbon sinks, but about 10 million hectares of forests are destroyed each year, which is equivalent to reducing the ability to absorb 2 billion tons of  $CO_2$ . In the process of urbanization and agricultural expansion, activities such as wetland landfilling and grassland cultivation release carbon stored in the soil and weaken the regulatory function of ecosystems [3].



Figure 3. Destructive lumbering.

The emissions from animal husbandry are also a significant factor that cannot be ignored. The greenhouse effects of methane ( $CH_4$ ) and nitrous oxide ( $N_2O$ ) produced by animal husbandry are 28 times and 265 times that of  $CO_2$ , respectively. About 14.5% of global greenhouse gases come from animal husbandry, mainly from ruminant digestion and manure management [2].

#### 2. The auxiliary role and limitations of natural factors

Although natural factors such as solar activity, volcanic eruptions, and changes in Earth's orbit have played a role in historical climate fluctuations, their contribution to climate change over the past century is far less than that of human activities.

The explanatory power of changes in solar radiation for global warming is extremely low. Over the past 50 years, the intensity of solar radiation has only increased by about 0.1%, while the global average temperature has risen by 1.1 °C during the same period, indicating that changes in solar activity are not sufficient to explain the current trend of climate warming [4].

Although volcanic activity can temporarily lower global temperatures through the eruption of aerosols (such as the 1991 Pinatubo volcanic eruption causing a global temperature

drop of about 0.5 °C), this cooling effect only lasts for a few years and has a weak overall impact, which cannot explain long-term climate change [5].



Figure 4. Volcano eruption.

As for the changes in Earth's orbit, such as the Milankovitch cycle, they can indeed drive the alternation of ice ages and interglacial periods, but such changes typically require a time scale of tens of thousands of years, and the current rapid warming clearly exceeds this time frame. Therefore, these changes in natural factors cannot reasonably explain the global warming phenomenon over the past century. In contrast, human activities such as fossil fuel burning and deforestation have a more significant dominant role in climate change [5].

### 3. Dispute and Complexity Analysis

In the current society, there is a clear feedback mechanism that amplifies the conditions between human activities and climate change. For example, when the Arctic ice sheet melts, the decrease in ground reflectance accelerates heat absorption, and the unsealing of permafrost releases methane and  $CO_2$ , further exacerbating the greenhouse effect [4].



Figure 5. Energy saving and emission reduction.

In front of us, although some viewpoints believe that technological innovations such as carbon capture can alleviate the problem, the mainstream scientific community emphasizes that emission reduction is fundamental. For example, the International Energy Agency (IEA) points out that even with the full deployment of existing technologies, the 2050 carbon neutrality goal cannot be achieved if fossil fuel consumption does not decrease.

## II. INNOVATIVE GREENHOUSE GAS RECOVERY METHODS

Modern science is attempting to use gene editing to provide solutions for reshaping ecosystems. Here are some examples [6]:

### 1. Super Absorbent Plants

Through gene editing techniques such as CRISPR, scientists are attempting to modify plant roots to enhance their carbon sequestration capabilities [7]. For example:

**Root expansion:** Adjust plant root growth related genes (such as WOX11 or ARF) to make the roots deeper and denser, thereby increasing soil organic carbon storage.

**Carbon transport enhancement:** Edit plant metabolic pathways to convert absorbed  $CO_2$  into stable compounds such as lignin or lipids, and store them in deep soil layers through root exudates to avoid re release.



Figure 6. Plants that have undergone gene editing.

Previous studies have developed rice varieties with a 50% increase in root biomass through gene editing, which may be extended to wetland plants such as mangroves in the future to enhance the "blue carbon" ecosystem [7].

### 2. Methane Devouring Bacteria

The greenhouse effect of methane is 28 times that of  $CO_2$ , with wetlands and rice fields being its main sources of emissions. Gene editing proposes the following solutions [7]:

**Targeted gene design:** Modify the metabolic pathway of methane producing bacteria by inserting methane oxidase genes (such as pmoA) to convert methane into  $CO_2$  and water.

**Synthetic microbial community:** constructing a symbiotic system containing methane oxidizing bacteria and electricity producing bacteria, generating electricity while decomposing methane, achieving the dual benefits of "negative carbon + production capacity".

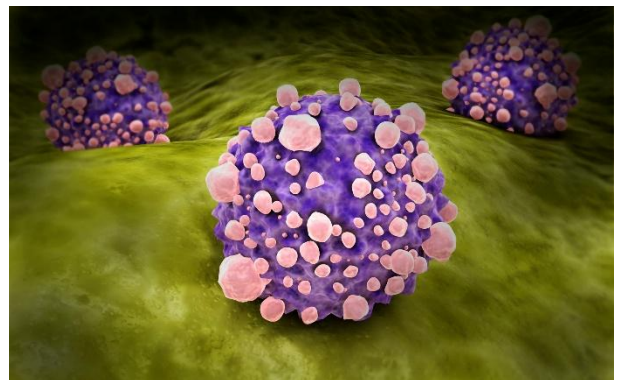


Figure 7. Bacteria that have undergone gene editing.

However, it is worth noting that such synthetic microorganisms may disrupt the original ecological balance



and their spread needs to be limited through "gene driven inhibition" technology [8].

### 3. Blue Carbon Gene Bank

Marine ecosystems such as mangroves and seagrass beds are efficient natural carbon sinks, and their carbon sequestration capacity can be further enhanced through gene editing [7]:

**Growth acceleration:** Edit genes that control plant cell division (such as CYCD3) to double the growth rate of mangroves and rapidly form a carbon sequestration network.

**Enhanced resilience:** Introducing gene modules for salt alkali tolerance (such as SOS1 gene) and pollution resistance (such as P450 enzyme system) to help marine plants survive in acidic or polluted waters.

**Collaborative repair:** Design genetically modified algae that can secrete chelating agents to adsorb heavy metals in seawater and fix  $CO_2$  through photosynthesis, forming an integrated solution of "purification - carbon sequestration".

### 4. Potential Risks and Ethical Challenges

**Ecological irreversibility:** Gene edited organisms may affect wild populations through hybridization or horizontal gene transfer, such as super plants invading native ecosystems [8].

**Technology abuse:** The popularization of low-cost CRISPR tools may lead to blind experiments by non-professionals, resulting in uncontrollable gene contamination [8].



Figure 8. CRISPR gene editing schematic.

**Governance gap:** There is currently no international regulatory framework for environmental gene editing globally, and unilateral actions may trigger geopolitical conflicts (such as a country releasing genetically modified organisms without authorization, affecting the ecology of neighboring countries) [8].

## III. INNOVATIVE EMISSION REDUCTION METHODS

As mentioned earlier, although these advanced greenhouse gas recovery technologies can alleviate the problem, the fundamental improvement of climate change still lies in reducing emissions. In this field, China has achieved some results [9], and the following will explain the distance:

### 1. Smart Energy System

The intelligent transformation of the energy industry is accelerating through LLM models and digital twin technologies. The simulation model proposed by *Xiniao* Group can map physical energy systems to the digital world, achieving real-time optimization decision-making [10], such as:

**Dynamic energy regulation:** By predicting the output fluctuations of photovoltaic and wind power through AI, dynamically adjusting energy allocation based on energy storage and grid demand, and improving the consumption rate of renewable energy.

**Process optimization:** In the manufacturing industry (such as printing and dyeing factories), AI reduces energy consumption by 25% and improves product qualification rates by predictive adjustment of dyeing temperature curves.

**User side energy efficiency management:** The hotel industry adjusts the operation strategies of air conditioning and refrigeration units through AI, dynamically optimizes energy consumption based on pedestrian flow and environmental parameters, and achieves a 20% energy efficiency improvement.



Figure 9. Xiniao's solution sharing.

The core of these technical solutions lies in the "selection and training" framework based on large models, that is, selecting general AI models and combining them with energy industry mechanism data to train professional models, reducing knowledge acquisition and decision-making costs, and enabling ordinary employees to have expert level decision-making abilities.

### 2. Breakthrough in Energy Storage Technology

The innovation of energy storage systems is a key support for China's energy revolution:

**Distributed energy storage system:** The new distributed energy storage system launched by Xi'an *Jdenergy* significantly reduces deployment costs and improves response speed by optimizing the communication timing synchronization between energy storage inverters. Its patented technology, such as SOC balancing control, can extend battery life and support efficient energy management for microgrids and electric vehicles [11].



Figure 10. Xi'an Jdenergy Co., Ltd.

**Virtual Power Plant (VPP):** Aggregate distributed energy storage, photovoltaic, and load resources, participate in electricity spot trading through AI algorithms, and achieve peak shaving and valley filling. It is expected that the market

size of virtual power plants will exceed 80 billion yuan by 2025, and the synergy of software and hardware will promote the maturity of business models.

### 3. Nuclear Revolution

China's innovation in the field of nuclear energy is attracting global attention:

**Nuclear battery technology:** By utilizing nickel-63 isotope decay and diamond semiconductor technology, clean energy supply without charging can be achieved for 50 years. Its decay product is non-radioactive copper element, which can be safely used in medical devices (such as pacemakers) and deep-sea sensors, subverting the traditional battery dependent charging mode.

**Reuse of nuclear waste:** Transforming nuclear power plant waste into radioactive isotope batteries (such as plutonium-238 batteries) to provide zero carbon electricity for remote areas and solve the problem of nuclear waste disposal.

### 4. Energy Structure Transformation

The "three transformations" of the power system (cleanliness, marketization, and digitization) are reshaping the energy landscape:

**Increase in the proportion of clean energy:** The energy structure dominated by wind power and photovoltaics is facing the challenge of uneven spatial and temporal distribution, and it is necessary to adjust the supply-demand mismatch through the electricity spot market mechanism.

**Intelligent distribution network:** Investment in distribution networks below 110kV is accelerating, and AI models are empowering grid inspections, load forecasting, and trading decisions. For example, Huawei Cloud Pangu model optimizes the accuracy of new energy power forecasting.

**Ultra high voltage transmission network:** Supporting the power transmission of the wind and solar power base, the demand for ultra-high voltage equipment will enter a peak period from 2024 to 2025.

### 5. Future technology foresight

Although the current technology is not yet mature, the following directions may become the next stage of the energy revolution:

**High altitude wind powered kite:** Utilizing stable strong winds at a height of one kilometer to generate electricity costs only one-third of offshore wind power, and requires breakthroughs in material and transmission technology bottlenecks.

**Geomagnetic dynamo:** Based on the Earth's rotation cutting the geomagnetic field to generate electricity, it is theoretically possible to achieve infinite clean energy, but energy extraction efficiency and engineering feasibility issues need to be addressed.

In the future, the energy system will shift from "centralized supply" to "decentralized autonomy", and AI and IoT technologies will be deeply integrated to form a "source - network - load - storage" full chain intelligent collaborative

network, ultimately achieving zero carbon closed-loop energy production and consumption.

## IV. CONCLUSION

Climate change is not only an environmental crisis, but also a fundamental challenge to the development model of human civilization.



Figure 11. Environment protection.

The choice at this moment will determine whether we become the gravediggers of the last fossil civilization or the founders of interstellar ecological civilization.

## REFERENCES & STATEMENT

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What do you think is the main factor causing climate change?



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● 分析人类活动导致温室气体排放

The main factor causing contemporary climate change is **human activities**, particularly the emission of **greenhouse gases (GHGs)** such as carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O). Here's a breakdown of the key contributors:

1. **Fossil Fuel Combustion:** Burning coal, oil, and natural gas for energy releases vast amounts of CO<sub>2</sub>, the primary driver of global warming. This accounts for ~75% of global GHG emissions.
2. **Deforestation and Land Use:** Forests act as carbon sinks, absorbing CO<sub>2</sub>. Clearing them (e.g., for agriculture, logging) reduces this capacity and releases stored carbon, contributing ~10% of emissions.
3. **Agriculture and Livestock:** Methane from livestock digestion and rice cultivation, along with nitrous oxide from fertilizers, adds potent GHGs. Methane is 25–80 times more effective than CO<sub>2</sub> at trapping heat over 20–100 years.
4. **Industrial Processes:** Cement production, chemical manufacturing, and other industries release CO<sub>2</sub> and other GHGs directly.
5. **Waste Management:** Landfills and wastewater treatment produce methane and other emissions.

**Natural Factors** (e.g., solar variability, volcanic activity, orbital cycles) historically influenced climate but cannot explain the rapid, recent warming. The **scientific consensus** (e.g., IPCC reports) attributes over 95% of post-1950 warming to human activities, with CO<sub>2</sub> levels rising from ~280 ppm pre-industrially to over 420 ppm today—a pace unprecedented in geological records.

**Feedback Loops** (e.g., melting ice reducing reflectivity, thawing permafrost releasing methane) amplify warming but are secondary effects triggered by initial human-driven GHG increases. Thus, addressing climate change requires reducing emissions and transitioning to sustainable energy and land use practices.

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🔍 搜一下再回答

How can we reduce greenhouse gas emissions?

What are some sustainable energy sources?



Introduce me to some very innovative greenhouse gas recovery methods.



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介绍创新温室气体回收方法



以下是一些创新的温室气体回收方法：

### 碳捕获、利用与储存 (CCUS) 技术

- **燃烧后捕获**：在化石燃料燃烧后，利用化学吸收剂（如胺溶液）从烟气中分离出二氧化碳。这种方法技术相对成熟，适用于现有的燃烧设备，但能耗较高，需要进一步优化以降低成本和提高效率 。
- **富氧燃烧**：在燃烧过程中使用纯氧或富氧空气，使燃烧产生的烟气主要由二氧化碳和水蒸气组成，便于后续的二氧化碳分离和捕获。该方法可提高二氧化碳的浓度，减少后续分离的难度，但需要额外的氧气供应设备，且燃烧过程需要精确控制 。
- **膜分离**：利用具有选择性的膜材料，将二氧化碳与其他气体分离。膜分离技术具有能耗低、操作简单等优点，但目前膜的性能和成本仍需进一步改进，以满足大规模工业应用的需求 。

### 直接空气捕获 (DAC)

- **化学吸附**：通过化学吸附剂从大气中直接捕获二氧化碳。例如，利用氢氧化钠或氢氧化钾等碱性溶液与二氧化碳发生化学反应，生成碳酸盐，从而实现二氧化碳的捕获。这种方法可以捕获大气中低浓度的二氧化碳，但需要消耗大量的化学试剂，且再生过程能耗较高 。
- **固体吸附**：使用固体吸附剂，如金属有机框架 (MOF) 等材料，其具有高比表面积和可调节的孔隙结构，能够选择性地吸附二氧化碳。固体吸附剂可以通过加热或其他方法进行再生，实现二氧化碳的循环捕获。该技术具有吸附容量大、选择性高等优点，但吸附剂的成本和稳定性仍需进一步优化 。

### 生物转化

- **藻类光合作用**：利用藻类的光合作用吸收二氧化碳，并将其转化为生物质或生物燃料。藻类生长速度快，二氧化碳固定效率高，且可以通过收获藻类获得生物能源或其他有价值的产物。然而，藻类培养需要占用大量的土地和水资源，且受环境条件的影响较大，需要解决培养系统的优化和规模化生产等问题 。
- **微生物转化**：利用微生物将二氧化碳转化为有用的化学品或燃料。例如，某些微生物可以通过代谢途径将二氧化碳转化为甲烷、乙醇等有机化合物。这种方法具有环境友好、可再生等优点，但目前微生物转化的效率较低，需要进一步研究和开发高效的微生物菌株和转化工艺 。

Introduce some achievements China has made in the field of energy conservation and emission reduction in recent years.



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In recent years, China has achieved remarkable accomplishments in the field of energy conservation and emission reduction, which are specifically reflected in the following aspects:

#### Energy Structure Optimization

- **Continuous Growth of Non-fossil Energy:** In 2023, the proportion of non-fossil energy in primary energy consumption will increase to around 17.5%, while the proportion of coal in primary energy consumption will decrease to about 55.2%, a year-on-year decrease of 0.6 percentage points [中国政府网](#). From the perspective of energy production, the proportion of raw coal in primary energy production will decrease by 0.9 percentage points in 2023 compared to 2020, while the proportion of primary electricity and other energy sources will increase by 1.5 percentage points [e9](#).
- **Stable Global Leadership in Clean Energy:** By the end of 2023, China's total installed capacity for renewable energy power generation reached 1.519 billion kilowatts, accounting for 52.0% of the country's total installed power generation capacity, nearly 40% of the world's total installed capacity for renewable energy power generation. Hydropower, wind power, and solar power generation have been the world leaders for consecutive years. Among them, hydropower has grown from 160,000 kilowatts in 1949 to 420 million kilowatts in 2023, with an average annual growth rate of 11.2%. The combined installed capacity of wind power and solar power exceeded 1 billion kilowatts, with wind power growing from 1.06 million kilowatts in 2005 to 440 million kilowatts in 2023, with an average annual growth rate of 39.8%, and solar power growing from 2.22 million kilowatts in 2011 to 610 million kilowatts in 2023, with an average annual growth rate of 59.7% [国家统计局](#).

#### Energy Efficiency Improvement

- **Continuous Decline in Unit GDP Energy Consumption:** Since the "Eleventh Five-Year Plan," cumulative energy savings have reached 43.8%, with an average annual decline of 3.1%. In 2023, the energy consumption per unit of GDP was 0.41 tons of standard coal per ten thousand yuan, a year-on-year decrease of 0.5% [e9](#).
- **Significant Reduction in Unit Product Energy Consumption:** By upgrading technologies and processes, renovating energy-consuming equipment, eliminating outdated production capacity, and promoting high-efficiency energy-saving technologies, the comprehensive energy consumption per unit product has been continuously reduced. Compared to 2012, in key energy-consuming industrial enterprises with an annual energy consumption of 10,000 tons of standard coal or more, the comprehensive energy consumption of papermaking and paperboard in 2023 decreased by 20.0%, caustic soda by 19.4%, calcium carbide by 15.5%, synthetic ammonia by 5.2%, cement by 10.2%, flat glass by 14.0%, steel by 6.7%, and the standard coal consumption for thermal power generation decreased by 6.0% [e9](#).

#### Energy Conservation and Emission Reduction in Key Industries

- **Steel Industry:** For example, Ningbo Iron and Steel Co., Ltd. implemented a 9.97-megawatt rooftop photovoltaic power generation project, saving over 3,000 tons of standard coal and reducing carbon dioxide emissions by over 7,000 tons annually. Through technical upgrades such as residual heat recovery from riser pipes, applying green electricity, and improving energy management levels, the company achieved unit product energy consumption better than the industry's energy efficiency benchmark level in 2022 [e9](#).
- **Aluminum Industry:** For example, Kaiman Aluminum Industry (Sanmenxia) Co., Ltd. replaced 179 high-energy-consuming motors with first-grade efficiency or permanent magnet energy-saving motors, saving over 3 million kilowatt-hours of electricity annually, equivalent to 370 tons of standard coal. Through energy-saving renovations such as filter press vacuum system upgrades, application of energy-saving motors, falling film evaporation technology, and aluminum hydroxide fluidized roasting technology, the company achieved unit product energy consumption better than the advanced value of national quota standards in 2022 [e9](#).