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COMMENTARY

Opportunities in crisis to decarbonize the energy system

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INTRODUCTION

Large amounts of CO_2 emissions from the fossil fuel combustion are the primary source of anthropogenic climate change and the main long-lived climate forcers.[1] Under the Paris Agreement, member nations agree to restrict global warming to well below 2°C by 2100, with 1.5°C as the target.[2] However, given the most recent rebound in the global CO_2 emissions, it becomes hard to keep the global warming well below 1.5℃ or even 2°C by just following the Nationally Determined Contributions (NDCs) emission trajectory.[3] With the rising demand for electricity consumption, the decarbonization of the power sector becomes crucial in the global climate mitigation. Under the 1.5°C (2°C) scenario, the IPCC Sixth Assessment Report projects that the global CO_2 intensity of electricity must be lowered by 75% (60%) by 2030 and by 100% (95%) by 2050 relative to 2019 with urgent actions.[4] We need an immediate, pronounced, and rapid energy transition in the power system to be in line with the proposed climate targets.

The global crisis or recession as an external shock provides opportunities to accelerate the decarbonization of global energy system. Understanding the changes in energy use patterns helps us to clarify the successful emission-reducing actions during the global crisis. In this perspective, we take the world's largest emitter in industrial sector as an example to investigate the impacts of global financial crisis on its energy use dynamic. This paper reveals the breakthroughs in the recent global energy transition and sheds light on the potential CO_2 mitigation strategies and decarbonization pathway of energy system in the post-Covid-19 era.

CHANGES IN ENERGY USE IN THE POST-FINANCIAL CRISIS

Figure 1 illustrates the changes in sub-fuel choices in the global power sector in the post-financial crisis era (see Figure 1B & D). Between 2000 and 2007, global fuel choice shifted away from low-carbon fuels (a 5% decrease in total share of nuclear and hydropower) towards carbon-intensive fuels (a 5% increase in total share of gas and coal). Thereafter, a progressive decarbonization process has emerged since 2007. Multiple shifts in the sub-fuel

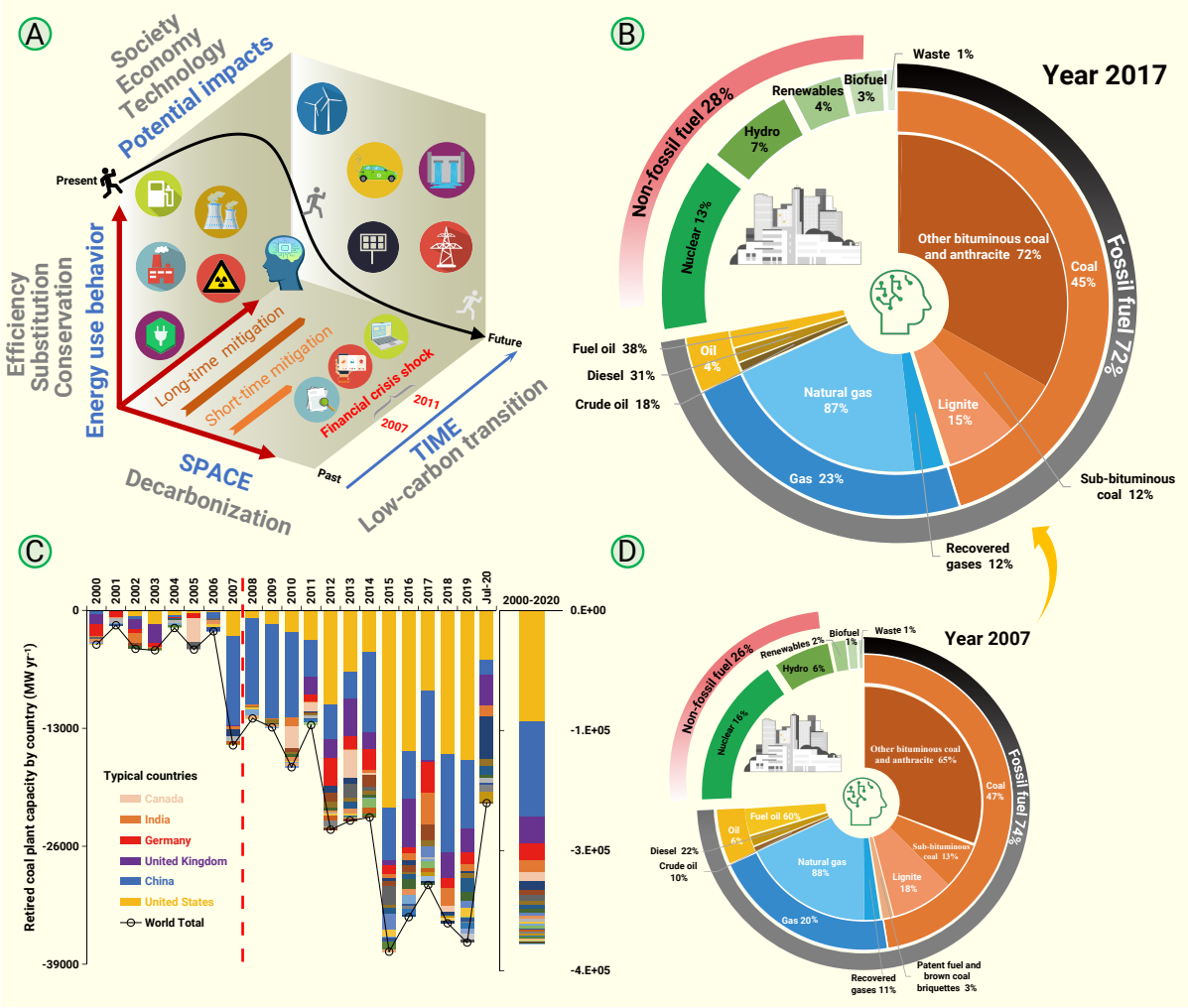

Figure 1. Global changes in energy use patterns (A) Decision-making and policy planning for energy system during the global crises; (B) Global shares of fuel input for electricity production in 2017; (C) Retired capacity of coal power plants by country; (D) Global shares of fuel input for electricity production in 2007. **Note:** The units in (B) and (D) are oil equivalent. The coal capacity data is collected from Global Coal Plant Tracker in (C). This data includes 108 countries, and we show the most affected countries in the legend. Default carbon content value is from IPCC 2006 Guidelines.

choices consistently exerted a downward influence on the global CO_2 intensity of electricity. The fuel type and volume evolved and became more efficient. For non-fossil fuels, hydropower increased by 1% and the total share of biofuels, wind, solar, and geothermal, etc. increased by 5%, while nuclear share declined from 16% in 2007 to 13% in 2017. For fossil fuels, gas increased from 21% in 2007 to 23% in 2017, while coal and oil both declined by 2% in this period. Gas is a cleaner fuel compared to coal and oil. Thus, the substitution of gas for coal and oil benefits the global decarbonization of the power sector. Specifically, gas fuel has not changed its structure so much since 2000. Natural gas accounts for ~87% of gas-fired electricity generation. Improvement in coal quality contributes to CO_2 reduction. High-carbon-content coal (for example, lignite (27.6 kgC/GJ) and sub-bituminous coal (26.2 kgC/GJ)) has been replaced by low-carbon-content coal (other bituminous coal (25.8 kgC/GJ)). Likewise, the improvement in oil quality also reduces CO_2 emissions. The high-carbon-content oil (for example, heavy fuel oil (21.1 kgC/GJ)) is replaced by light-carbon-content oil (diesel (20.2 kgC/GJ) and crude oil (20 kgC/GJ)).

Coal-fired power plants are the largest CO_2 emitters in the power sector. Figure 1C shows that large amounts of coal capacity have been retired since 2007. The global financial crisis provided triggers to reshape the energy system from production to end use. Specifically, the small, inefficient coal units are replaced by high efficient ultra-supercritical units in China. In the United States, the retired coal-fired power plants are substituted by natural gas and renewable power plants. This gas-for-coal substitution also benefits CO_2 mitigation in the power sector.[5] Overall, the United States and China cumulatively eliminated 223GW coal capacity from 2000 to 2020. These energy substitutions largely improved the coal-fired efficiency in the global power sector.

LEVERAGING THE OPPORTUNITIES IN CRISIS TO ACCELERATE THE GLOBAL GREEN TRANSITION

The global crisis delivers a shock, and this might lead to structural changes to the global economies. During a global recession induced by an economic crisis or an event like the Covid-19 pandemic, several economic and social factors are typically impacted. We could find a sharp contraction in economic output with disrupted supply chains. In response to a recession, consumers experience a shift in their spending habits and prioritize essential goods and services, which eventually reduces the total social demand. Governments introduce green stimulus packages to support economic growth, for example, financial assistance, unemployment benefits, tax cuts, and investment supporting programs. As a result, energy use patterns have largely changed within the major countries.

Policymakers have a unique opportunity to integrate low-carbon solutions into economic recovery plans in the post-crisis era (see Figure 1A). The investment of next-generation clean technologies (for example, advanced battery storage, carbon capture and storage, and sustainable materials) using green financing tools (for example, green bonds, subsidies, and low-interest loans) from both public and private sectors will provide long-term benefits to support a green economic growth. We should pay close attention to the deployment of low-carbon infrastructure in economic recovery, including smart grids, electric vehicle charging stations, electrified transportation, and energy-efficient buildings, et al. A robust, long-term, and deep mitigation pathway is needed to decarbonize the existing global energy system. Additionally, public policy support can scale these green technologies, create new industries, and diversify economies. With critical thinking, we could accelerate the global transition to achieve a more sustainable, inclusive, and resilient economy in the future.

CONCLUSIONS

The global crisis brings a significant decline in business activities, and this short-term economic pain might lead to far-reaching effects on economies. Meanwhile, the structural changes in economic growth provide a window of opportunity for global climate mitigation in the energy system. For example, the global power sector has increased its share of non-fossil energy consumption for electricity production since 2007. The deployment of renewable energy, phase out of fossil feedstock, and improvement in energy efficiency accelerated its decarbonization during the crisis. Given the limited carbon budget available under global climate targets, we should overcome the existing technological bottlenecks and introduce more clean technologies into the energy system to accelerate progress towards future decarbonization.

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AUTHOR CONTRIBUTIONS

All authors contributed to the manuscript and approved the final version.

DECLARATION OF INTERESTS

The authors declare no competing interests.