



# Editorial: Upscaling Low-Carbon Energy Resources: Exploring the Material Supply Risk, Environmental Impacts and Response Policies

Jianliang Wang<sup>1\*</sup>, Fan Tong<sup>2,3</sup> and Mikael Höök<sup>4</sup>

<sup>1</sup>School of Economics and Management, China University of Petroleum, Beijing, China, <sup>2</sup>School of Economics and Management, Beihang University, Beijing, China, <sup>3</sup>Lawrence Berkeley National Laboratory, Berkeley, CA, United States, <sup>4</sup>Department of Earth Sciences, Uppsala University, Uppsala, Sweden

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## Editorial on the Research Topic

### Upscaling Low-Carbon Energy Resources: Exploring the Material Supply Risk, Environmental Impacts and Response Policies

## INTRODUCTION

Continued reliance on high-carbon fossil fuels in the face of increasing climate change casts a grand threat for modern society (Le Quéré et al., 2021). The global society has joined forces to address climate change, showcased by the UN Sustainable Development Goals and ambitious efforts to mitigate climate change stated in the Nationally Determined Contributions (NDC) for the Paris Agreement. Major countries have agreed to embark on a transition towards sustainable energy systems, where high-carbon fossil fuels would be replaced by low-carbon alternatives to reach carbon neutrality eventually. Although the development and deployment of low-carbon energy resources and technologies have achieved considerable success in the past decades, the scale to achieve carbon neutrality worldwide requires a rapid upscaling of low-carbon energy resources and technologies at speed unseen in human history (World Economic Forum (WEF), 2019).

The transition to sustainable energy systems is not an easy road, as broad and complex social and environmental implications would emerge during the transition. In particular, material supply risk and environmental impacts are the most significant challenges. In this Research Topic, we selected nine recent studies investigating environmental and social impacts caused by the development of low-carbon energy resources and proposing policy suggestions to address these challenges in the transition towards low-carbon energy systems.

## Material Supply Risk

Raw materials, including heavy-metal elements such as Lithium and Cobalt, are essential inputs for developing low-carbon energy resources and form the bedrock of low-carbon energy systems. The upscaling of low-carbon energy resources and technologies would induce exponential increases in material demands, which has led to uneven price dynamics and elevated supply risks. For example, Liu's work *Renewable Energy and Material Supply Risks: A Predictive Analysis Based on An LSTM Model* (Liu et al.) points out that improving the energy density of metals plays a crucial role in China's transition to a low-carbon energy system. Furthermore, Hu's work *An Explanation of*

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### \*Correspondence:

Jianliang Wang  
wangjianliang305@163.com

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*Energy Return on Investment From an Entropy Perspective* (Hu et al.) finds that improving resource extraction efficiency would facilitate renewable energy development. Finally, Wang's work *Accounting and Management of Natural Resource Consumption Based on Input-Output Method: A Global Bibliometric Analysis* (Wang et al.) presents a systematic review of recent natural resource consumption accounting and management studies. This overview clearly shows the increasing research interest and upward trend of research outputs related to upscaling low-carbon energy resources.

## Environmental Impacts

The upscaling of low-carbon energy resources and the transition to sustainable energy systems is crucial to address the global sustainability challenges but may also bring unexpected environmental impacts if managed poorly. For instance, natural gas is a low-carbon energy resource when replacing coal but could induce methane leakage, water pollution, and landscape impacts (Qin et al., 2018). Fu's work *Identifying and Regulating the Environment Risks in the Development and Utilization of Natural Gas as a Low-Carbon Energy Source* (Fu et al.) analyzes the environmental risks in the whole process of natural gas exploitation to utilization and put forward policy recommendations to manage these risks. The water-energy-carbon nexus has attracted increasing interest as these environmental impacts are intertwined, and no single solution could solve it all. Li's work *Water Use for Energy Production and Conversion in Hebei Province, China* (Li et al.) quantifies the relationship between energy production and water consumption in a Chinese province in the context of three future emissions reduction scenarios. On the other hand, well-designed low-carbon energy systems have the potential to mitigate carbon emissions as well as other environmental impacts. Xue's work *Environmental Benefit and Investment Value of Hydrogen-Based Wind-Energy Storage System* (Xue et al.) estimates the environmental benefits of hydrogen-based wind-energy storage systems, promoting renewable energy integration.

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**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Response Policies

Researchers have investigated response policies to support the low-carbon energy transition to address the material supply risks and the environmental impacts that may impede the upscaling of low-carbon energy resources. Wang's work *China's Energy Transition Policy Expectation and Its CO<sub>2</sub> Emission Reduction Effect Assessment* (Wang et al.) estimates carbon emissions reductions from China's energy transitions. Zhang's work *Analysis of Performance Deviation of Wind Power Enterprises in China* (Zhang and Qi) disentangles the impacts of policy measures and market conditions in the dynamics between carbon reduction efficiency and the financial performance of wind power enterprises. Finally, Hu's work *The Impact of Policy Intensity on Overcapacity in Low-Carbon Energy Industry: Evidence From Photovoltaic Firm* (Hu et al.) investigates the overcapacity issue (i.e., the bust-and-boom cycle) in the photovoltaic industry in China and examined the role of government subsidies and policies in the development of the low-carbon energy industry.

## CONCLUSION

A rapid and large-scale upscaling in developing and deploying low-carbon energy resources and technologies is essential to address climate change. Findings from studies in this Research Topic would help industry and governments better understand and manage the material supply risks and environmental impacts in the process of upscaling low-carbon energy resources. As highlighted by the selected studies, cross-discipline experts and practitioners need to work together to address the multi-dimensional challenges in the transition to sustainable energy systems towards carbon neutrality.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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