

Energy Landscapes Under Climate Change: Transformations, Explorations, and Challenges

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In 2023, the 28th Conference of the Parties (COP28) to the United Nations Framework Convention on Climate Change marked the first global consensus under the Paris Agreement, calling for nations to shift from fossil fuels to renewable energy sources like wind, solar, and biomass in a more equitable, orderly, and rational manner. Energy landscapes refer to the processes through which the human use of natural resources results in the transformation of surface space. The concept not only reflects the profound impact of energy development on landscapes^[1], but also is an essential component in achieving the energy transition as a goal of socially sustainable development.

Energy landscapes emphasize the transformation of local and regional landscapes through an energy transition perspective, highlighting humans' demand for energy as a key driver of landscape transformation^[2]. For a long time, energy landscapes have been broadly categorized under cultural landscapes, given the interventions and impacts of human activities on land and nature^[3]. Scholars have defined them as cultural landscapes characterized by substantive, spatial, and temporal qualifications^[4]. Moreover, energy landscapes inherently reflect diverse resource types and their complex, ongoing development processes across physical, social, ecological, and economic dimensions. These include historical and cultural landscapes with traditional wind and water power plants, fossil energy landscapes,

renewable energy landscapes, post-industrial landscapes, and brownfield landscapes^{[5][6]}.

At present, energy landscapes have attracted attention across interdisciplinary fields, prompting proactive cross-regional and cross-disciplinary research collaborations among scholars worldwide. Key research topics cover the global trends of energy landscapes in urban and rural spatial development, planning, and design; post-industrial city and coal-mining region regeneration; ecological restoration of industrial wastelands; and renewable energy infrastructure construction such as wind, solar, and biomass power. Additionally, discussions on the identity and aesthetic value of energy landscapes, as well as initiatives for reducing carbon footprints, are gaining importance. Exploring energy landscapes from different perspectives underscores the role of "landscape" as an essential approach for systemic design and innovation, aiming to: 1) guide multi-scale energy landscapes to unlock site potential in the global resource transition; 2) forge robust connections between energy infrastructure and local planning systems; 3) maximize the positive effects of renewable energy, including its spatial added value; and 4) mitigate the impacts of energy infrastructure on both the natural environment and ecological systems.

In the future, the development of China's energy landscapes will face significant challenges in research, design, and practice,

mainly in the following four aspects.

First, formulating spatial planning and design standards. Energy landscapes introduce new research and practice challenges to the field of planning and design. It is crucial to establish corresponding professional norms and technical standards to define the connotation and potential of energy landscapes, clarify the spatial planning and design frameworks and methods for land use transformation, and lay the foundation for achieving the essential task of energy transition.

Second, conducting integrated assessments of impacts on landscapes. The construction of energy infrastructure will inevitably impact ecosystems, biodiversity, and landscape quality to varying degrees. Research and practice must implement integrated assessments based on multivariate data, including potential analysis, resource analysis, typological study, and visual impact evaluation, to minimize the adverse effects of energy facilities on landscapes and the natural environment.

Third, comprehensively considering public acceptance. Public attitudes toward energy landscapes evolve over time, making public acceptance a complex and uncertain factor in the energy transition. Energy landscape development must involve continuous discussion, coordination, and guidance with stakeholders throughout all stages of planning and design to achieve high-quality landscape development.

Last, safeguarding, sustaining, and shaping landscape diversity. While protecting natural resources, energy landscapes should also coordinate the relationship between humans and nature, effectively integrate energy infrastructure into urban and rural spaces, and continuously strengthen the diversity of local landscapes.

Energy landscapes represent a complex and globally challenging issue. We hope this special edition will inspire more scholars to engage in transnational and interdisciplinary research on the present and future of energy landscapes, gradually refining the theoretical and practical foundations of energy landscape transitions within urban and rural spatial development and landscape planning and design.

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气候变化下的能源景观：转型、探索与挑战

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2023年,《联合国气候变化框架公约》第二十八次缔约方大会首次就《巴黎协定》达成全球共识,呼吁各国以更加公正、有序和合理的方式实现化石燃料转型,提高风能、太阳能和生物质能等可再生能源在整体能源结构中的占比。能源景观指人类利用自然资源致使地表空间发生改变的过程,这一概念不仅体现了能源发展对景观的深远影响^[1],还将成为推动能源转型、实现社会可持续发展目标的关键组成。

能源景观关注能源转型视角下地方及区域景观的变化,并强调人类对能源的需求是景观变迁的核心驱动力之一^[2]。长久以来,鉴于人类活动对土地、自然的干预及影响,能源景观更多地被纳入广义的文化景观范畴^[3]。有学者将其定义为一种兼具物质性、空间性和时间性特征的文化景观^[4]。同时,基于物质、社会、生态和经济层面,能源景观揭示了不同资源类型复杂且长期的发展历程,包括以传统风力、水力发电设备为要素的历史文化景观、化石能源景观、可再生能源景观、后工业景观和棕地景观^{[5][6]}。

当前,能源景观作为多学科交叉研究的重要议题,吸引了广泛关注。各国学者正积极展开跨区域、跨学科研究与合作,主要涉及城乡空间发展及规划设计领域的全球能源景观发展趋势,去工业化城市更新与采煤矿区转型,棕地生态修复与风能、太阳能、生物质能等基础设施构建,以及能源景观认同、景观美学与低碳行动等。不同视角下的能源景观探索表明,“景观”已成为系统性设计与创新的重要方法,旨在引导多尺度能源景观在全球资源转型中激活场地潜能,构建能源基础设施与地方规划系统的紧密联系,发挥可再生能源的积极作用(包括其空间附

加价值),以及缓解能源基础设施对环境和生态的影响。

未来,在研究、设计和实践中,中国的能源景观发展也将面临巨大挑战,主要体现在以下四个方面。

1) 制定空间规划设计标准:能源景观将给规划设计领域带来新的研究与实践课题,需建立相应的行业规范和技术标准,以明确能源景观的内涵、要义和潜力,以及用地转化过程中的空间规划设计框架与方法,为实现能源转型奠定基础。

2) 综合评估对景观的影响:能源基础设施的建设将在不同程度上影响所在地区的生态系统、生物多样性和景观质量。在研究与实践中,需基于多元数据,通过潜力分析、资源分析、类型分析和视觉评价等方式对地表空间实施综合评估,以减少能源设施对景观与自然环境的破坏。

3) 全面考虑公众接受度:社会对能源景观的态度会随时间推移而变化,公众接受度因此成为能源转型过程中一个复杂且不确定的影响因素。在规划设计的各个阶段,能源景观的发展需持续与各利益相关者进行讨论、协调和引导,以实现高品质景观发展目标。

4) 保护、维护和塑造景观多样性:在保护自然资源的基础上,能源景观应协调人与自然的关系,将能源基础设施与城乡空间有效整合,延续和强化多样化的地域景观特征。

能源景观是一个复杂且极具挑战的全球性议题,期待本期专刊能够激发更多学者围绕能源景观的现状与未来展开跨国、跨学科研究,并逐步完善其在城乡空间发展和景观规划设计领域的理论和实践基础。