Clean Technology for Resource, Energy and Environment

jcleantree.com

Editorial Article

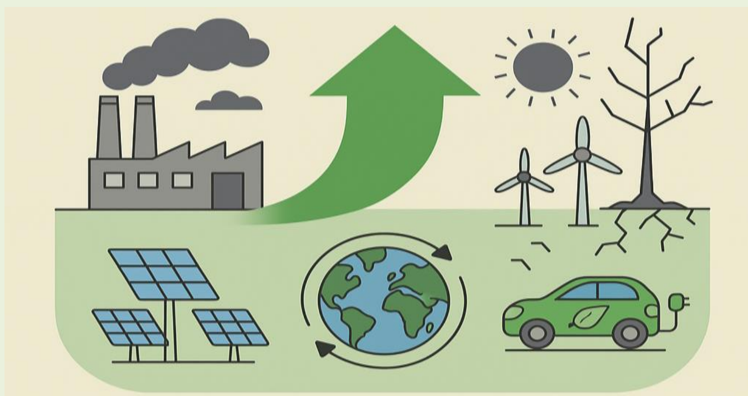
Clean Technology for Resource, Energy and Environment: Driving Innovation for a Resilient Future

Zhijie Chen

School of Civil and Environmental Engineering, University of New South Wales, Sydney, NSW 2052, Australia; E-mail: Zhijie.chen1@unsw.edu.au; chenzj1019@outlook.com

Cite This: https://doi.org/xxxxx-xxxxx-xxxxx

Read Online



Graphical Abstract

ABSTRACT: The global pursuit of sustainability has never been more urgent. Climate change, resource scarcity, and environmental degradation are accelerating, threatening the foundations of ecosystems, economies, and communities. In this context, clean technology has emerged as a transformative enabler—offering integrated solutions to decarbonize energy systems, recover valuable resources, and protect the environment. The launch of *Clean Technology for Resource, Energy and Environment (CTREE)* marks a timely milestone in fostering cross-sectoral innovation and knowledge exchange at the heart of this transformation.

CLEAN TECHNOLOGY: CONNECTING RESOURCE UTILIZATION, ENERGY TRANSITION, AND ENVIRONMENTAL PROTECTION

Clean technology encompasses a wide array of innovations designed to reduce environmental footprints while maximizing the value of natural and anthropogenic resources. Its essence lies not only in decarbonizing energy but also in decoupling growth from resource extraction, enabling a circular, efficient, and low-waste future.

In the resource domain, clean technologies offer transformative approaches for the extraction, recovery, and reuse of critical materials from a wide variety of sources—including natural ores, electronic waste, industrial effluents, biomass residues, saline water,

Received: May 29, 2025
Accepted: June 19, 2025
Published: July 22, 2025

mining tailings, and municipal solid waste. A growing suite of technologies—from conventional flotation [1], leaching [2], and electrochemical extraction [3] to solvent-free separation [4], biorefinery integration [5], and waste-to-product conversion [6]—is unlocking new value chains and reducing reliance on virgin feedstocks .

For instance, rare earth elements and critical metals are now being recovered from end-of-life electronics and industrial by-products using greener, more selective techniques [7, 8]. Agricultural residues and plastic wastes are converted into biochar, platform chemicals, or carbon-negative building materials [9-11]. Nutrients such as phosphorus and nitrogen are reclaimed from wastewater and returned to the food system [12], contributing to both environmental health and food security. These innovations not only address material scarcity and supply chain risks, but also promote resource circularity, intergenerational equity, and localized resource sovereignty.

In the energy sector, the expansion of renewable sources—solar, wind, geothermal, and green hydrogen—is reshaping global energy infrastructure. Clean technologies such as high-efficiency photovoltaics, photothermal systems, water electrolysis, and thermal energy storage are enabling the transition toward decentralized, low-carbon energy systems [13-17]. Energy storage innovations—including lithium-ion batteries [18], supercapacitors [19], and hybrid technologies [20]—are essential to balance supply and demand, support grid resilience, and facilitate renewable integration.

The environmental dimension of clean technology encompasses air and water purification, soil remediation, greenhouse gas mitigation, and pollution control. Advanced oxidation processes [21], membrane separation [22], catalytic conversion [23], and artificial intelligence (AI)-enhanced sensing [24] are being deployed to restore ecological functions, ensure regulatory compliance, and protect public health.

What unites these domains is a growing system perspective: clean technologies are no longer viewed in isolation—they are increasingly recognized as interconnected tools within a resource–energy–environment nexus. Realizing their full potential requires integrated solutions that optimize resource flows, minimize emissions, and regenerate natural systems.

CHALLENGES AND OPPORTUNITIES IN CLEAN TECHNOLOGY DEPLOYMENT

Despite its promise, the deployment of clean technology at scale still faces formidable challenges. Many resource recovery and circular economy solutions remain at pilot scale, hindered by limitations in selectivity, cost-effectiveness, or process complexity. Infrastructure lock-in, fragmented regulations, and uneven access to financing further constrain progress, especially in low- and middle-income regions.

However, the field is rapidly evolving. The global shift toward circular economy principles and net-zero commitments is catalyzing demand for clean and efficient technologies. Breakthroughs in nanomaterials, green chemistry, digital twins, and AI-guided optimization are accelerating the development of next-generation solutions across the resource–energy–environment continuum [25, 26].

For instance, waste-derived materials—once discarded—are now reimagined as high-value functional components such as chemicals, catalysts, fuels, membranes, and adsorbents [27-30]. Such innovations close the loop between waste and utility, turning liabilities into assets. Moreover, clean technology plays a vital role in promoting resource justice, ensuring that access to clean energy, materials, and environmental services is equitable, inclusive, and globally distributed. Decentralized systems, local resource utilization, and community-driven innovation are particularly promising for empowering sustainable development in the Global South.

CTREE: A PLATFORM FOR KNOWLEDGE INTEGRATION AND IMPACT

Clean Technology for Resource, Energy and Environment (CTREE) is launched as an interdisciplinary journal committed to advancing the science, engineering, and policy of sustainability. Our mission is to catalyze frontier innovation, support real-world deployment, and promote systems-level thinking across domains.

We invite contributions that span, but are not limited to:

- Circular resource recovery and waste valorization
- Renewable energy generation and energy storage
- Environmental remediation and pollution control
- Sustainable materials and process intensification

- Electrochemical, photochemical, thermochemical, biological, and hybrid clean technologies
- Techno-economic analysis, life cycle assessment, and environmental impact modeling
- Digital, AI-enabled, and autonomous systems for sustainability
- Policy, equity, and global transitions toward net-zero and resource-secure futures

By fostering collaboration across disciplines and sectors, CTREE aims to become a central hub for innovative solutions and interdisciplinary dialogue.

JOIN US IN ADVANCING CLEAN TECHNOLOGY

The transition to a resilient, resource-efficient, and environmentally sustainable future demands collective action across disciplines, industries, and borders. CTREE welcomes researchers, engineers, innovators, and decision-makers to contribute original research, insightful reviews, case studies, and forward-looking perspectives.

We especially encourage submissions that address interfaces and synergies between resource, energy, and environment domains—such as mining–waste–energy integration, circular urban metabolism, or agro-industrial symbiosis. These complex, interconnected challenges require integrated thinking and cross-sectoral collaboration.

CTREE is not only a scholarly journal—it is a growing community dedicated to accelerating clean technology innovation and implementation worldwide. By contributing to CTREE, you join a global network of thought leaders and changemakers working to reshape how we manage resources, produce energy, and protect our environment.

We look forward to your participation. Together, let us define the science, systems, and stories that will power a cleaner, more equitable, and more sustainable future.

CONFLICT OF INTEREST

The author discloses no conflicts of interest or potential biases related to the paper.

REFERENCES

[1] Jia W, Li J, Shen C, Li G, Li H, Fan G, *et al*. Research advances in phosphogypsum flotation purification: Current status and prospects. Sep Purif Technol. 2025; 354: 129244.

[2] Zhu R, Wang S, Chen Y, Xiang D, Zhang L, Liu J, *et al*. Ultrasound enhanced in-situ chemical oxidation for leaching Ag from zinc leaching residue and response surface optimization. Chem Eng J. 2024; 489: 151243.

[3] Lin T, Chen T, Jiao C, Zhang H, Hou K, Jin H, *et al*. Ion pair sites for efficient electrochemical extraction of uranium in real nuclear wastewater. Nat Commun. 2024; 15: 4149.

[4] Huskić I, Halasz I, Friščić T, Vančik H. Mechanosynthesis of nitrosobenzenes: a proof-of-principle study in combining solvent-free synthesis with solvent-free separations. Green Chem. 2012; 14: 1597-1600.

[5] Tofani G, Jasiukaitytė-Grojzdek E, Grilc M, Likozar B. Organosolv biorefinery: resource-based process optimisation, pilot technology scale-up and economics. Green Chem. 2024; 26: 186-201.

[6] Chojnacka K, Mikula K, Skrzypczak D, Izydorczyk G, Gorazda K, Kulczycka J, *et al*. Practical aspects of biowastes conversion to fertilizers. Biomass Convers Biorefin. 2024; 14: 1515-1533.

[7] Jyothi RK, Thenepalli T, Ahn JW, Parhi PK, Chung KW, Lee JY. Review of rare earth elements recovery from secondary resources for clean energy technologies: Grand opportunities to create wealth from waste. J Clean Prod. 2020; 267: 122048.

[8] Ye Q, Wang D, Wei N. Engineering biomaterials for the recovery of rare earth elements. Trends Biotechnol. 2024; 42: 575-590.

[9] Sikiru S, Abioye KJ, Adedayo HB, Adebukola SY, Soleimani H, Anar M. Technology projection in biofuel production using agricultural waste materials as a source of energy sustainability: A comprehensive review. Renew Sustain Energy Rev. 2024; 200: 114535.

[10] Paudel PP, Kafle S, Park S, Kim SJ, Cho L, Kim DH. Advancements in sustainable thermochemical conversion of agricultural crop residues: a systematic review of technical progress, applications, perspectives, and challenges. Renew Sustain Energy Rev. 2024; 202: 114723.

[11] Chen Z, Wei W, Chen X, Liu Y, Shen Y, Ni B-J. Upcycling of plastic wastes for hydrogen production: Advances and perspectives. Renew Sustain Energy Rev. 2024; 195: 114333.

[12] Starck T, Fardet T, Esculier F. Phosphorus recycling from human excreta in French agroecosystems and potential for food self-sufficiency. Nutr Cycl Agroecosyst. 2024; 129: 411-425.

[13] Wang O, Chen Z, Ma X. Advancing sustainable end-of-life strategies for photovoltaic modules with silicon reclamation for lithium-ion battery anodes. Green Chem. 2024; 26: 3688-3697.

[14] Lv W, Tan Y, Guo C, He X, Zeng L, Zhu J, *et al*. Triple regulation of water molecules behavior to realize high stability and broad temperature tolerance in aqueous zinc metal batteries via a novel cost-effective eutectic electrolyte. Adv Energy Mater. 2025; 15: 2403689.

[15] Huang Y, Li X, Shen PK, Yang C, Zhu J. High-performance MoP-Mo2C/C heterogeneous nanoparticle catalysts for alkaline hydrogen evolution and oxidation reactions. ACS Mater Lett. 2024; 6: 1678-1685.

[16] Ali HM, Rehman T-u, Arıcı M, Said Z, Duraković B, Mohammed HI, *et al*. Advances in thermal energy storage: Fundamentals and applications. Prog Energy Combust Sci. 2024; 100: 101109.

[17] Zeng W, Ye X, Dong Y, Zhang Y, Sun C, Zhang T, *et al*. MXene for photocatalysis and photothermal conversion: Synthesis, physicochemical properties, and applications. Coord Chem Rev. 2024; 508: 215753.

[18] Zheng M, You Y, Lu J. Understanding materials failure mechanisms for the optimization of lithium-ion battery recycling. Nat Rev Mater. 2025; 1-14.

[19] Shin SJ, Gittins JW, Balhatchet CJ, Walsh A, Forse AC. Metal–organic framework supercapacitors: challenges and opportunities. Adv Funct Mater. 2024; 34: 2308497.

[20] Yang Y, Wu Z, Yao J, Guo T, Yang F, Zhang Z, *et al*. An overview of application-oriented multifunctional large-scale stationary battery and hydrogen hybrid energy storage system. Energy Rev. 2024; 3: 100068.

[21] Shang W, Wang L, Chen Z, Cheng D, Liu H, Ngo HH, *et al*. A novel layered porous Fe, Cu dual-loading biochar

heterogeneous catalyst to guided non-free radical pathway for peroxymonosulfate activation. J Colloid Interface Sci. 2025; 689: 137262.

[22] Huang Z, Zhao DL, Shen L, Lin H, Chen C, Xu Y, *et al*. Mxenes for membrane separation: from fabrication strategies to advanced applications. Sci Bull. 2024; 69: 125-140.

[23] Liu J, Burciaga R, Tang S, Ding S, Ran H, Zhao W, *et al*. Heterogeneous catalysis for the environment. Innov Mater. 2024; 2: 100090.

[24] Nkinahamira F, Feng A, Zhang L, Rong H, Ndagijimana P, Guo D, *et al*. Machine learning approaches for monitoring environmental metal pollutants: Recent advances in source apportionment, detection, quantification, and risk assessment. TrAC Trends Anal Chem. 2024; 117980.

[25] Lüer L, Peters IM, Smith AS, Dorschky E, Eskofier BM, Liers F, *et al*. A digital twin to overcome long-time challenges in photovoltaics. Joule. 2024; 8: 295-311.

[26] Verma C, Chauhan DS, Aslam R, Banerjee P, Aslam J, Quadri TW, *et al*. Principles and theories of green chemistry for corrosion science and engineering: design and application. Green Chem. 2024; 26: 4270-4357.

[27] Chen Z, Wei W, Ni B-J. Prioritizing capture and utilization for microplastic management in water systems. Nat Rev Clean Technol. 2025; 1-3.

[28] Davidraj JM, Sathish CI, Benzigar MR, Li Z, Zhang X, Bahadur R, *et al*. Recent advances in food waste-derived nanoporous carbon for energy storage. Sci Technol Adv Mater. 2024; 25: 2357062.

[29] Deng G, Dong Z, Jiang L, Zhang F. Selective conversion of polyolefin waste to light olefins by tandem catalytic cracking and isomerizing ethenolysis. Green Carbon. 2025.

[30] Xu Y, Wei C, Xu Y, Zhang H, Su L, Tan C. Treating waste with waste: New insight into phosphorus removal by graphitic carbon nitride modified water treatment sludge-based ceramsite. Environ Funct Mater. 2024.