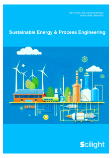
Scilight

Sustainable Energy & Process Engineering
https://www.sciltp.com/journals/sepe



Editorial

The Convergence of Energy and Process Innovation for a Sustainable Future

Shir Reen Chia [1] and Hwai Chyuan Ong [1,2,*]

[1] School of Engineering, Faculty of Engineering and Technology, Sunway University, Jalan Universiti, Bandar Sunway, Petaling Jaya 47500, Selangor, Malaysia
[2] School of Civil and Environmental Engineering, Faculty of Engineering and Information Technology, University of Technology Sydney, Sydney, NSW 2007, Australia

Received: 30 March 2026; Accepted: 30 March 2026; Published: 14 April 2026

How To Cite: Chia1, S.R.; Ong, H.C. The Convergence of Energy and Process Innovation for a Sustainable Future. *Sustainable Energy & Process Engineering* **2026**, *1*(1), 1.

The rapid depletion of fossil fuels and climate change have urged the development of energy and process innovation convergence as a blueprint for a liveable planet. In an era that demands radical rethinking, engineering stands at a critical juncture. A transition to net-zero economy through the methods of production, conversion and utilisation is a multidimensional challenge to achieve the goal. Given this challenging context, Sustainable Energy & Process Engineering (SEPE) defines its mission as a key channel for transformative research.

1. Integrated Paradigm: Beyond the Power Plant

To realise a successful sustainable energy transition, manufacturing plants such as power and chemical plant cannot be taken as solitary entities. The integration of renewable energy sources like solar, wind and hydrogen into the manufacturing processes is a pragmatic approach to overcome today's challenge. Our journal's scope lies in renewable integration, green process engineering (e.g., Carbon Capture, Utilisation, and Storage (CCUS) and circular economy strategies), sustainable materials, AI-driven process optimisation and policy pathways to drive decarbonization and efficient resource utilisation. With this approach, we can observe the shift driving from a linear model of resource consumption (take-make-waste) into the circular carbon economy model (closed-loop system) to mitigating carbon emissions and reduce energy footprints. By incorporating the concept of waste-to-resource conversion and AI-driven digital twins, the energy and material consumption are optimised for a sustainable and green future.

2. State of the Art: A Literature Review of Present Trends

To engineer sustainability, Sustainable Energy & Process Engineering is prioritising several high-impact emerging research fronts as listed. Each plays a focal role in accelerating global energy transition.

2.1. Sustainable Materials & Technologies

Recent literature underscores the importance of sustainable materials for energy production and efficiency. Bio-based materials are gaining attention for energy applications, especially as catalysts or lignin-derived ion-exchange membranes for biofuel enhancement of biofuel conversion, energy-efficient separations, or electrolysers. They can be synthesised from natural raw materials, including enzymes, plants or waste materials of plants [1], while offering renewability at scale for downstream processing. Building on this foundation, the development of hybrid catalysts like self-healing oxygen evolution catalysts (e.g., cobalt-, manganese- or nickel-based) enables scalable electrochemical and photochemical water splitting for hydrogen production [2]. Over 20% of solar-to-hydrogen efficiency is achieved via the usage of hydrogen evolution reaction catalyst $NiMo_4/MnO_{3-X}$ and monolithic perovskite/silicon tandem solar cell in producing clean energy [3]. Augmenting these advances, the next-generation materials for energy-efficient separations, including redox-copolymer for electrodialysis, and metal-organic frameworks for gas separation, adsorption heat pump and CO_2 adsorption to address the key challenges in water treatment, gas purification, environmental and air quality management [4–7].

2.2. Sustainable Energy Systems

The development of sustainable energy systems is achievable through several methods, one of which is the integration of renewable energy technologies, including solar, wind, bioenergy and hydrogen, which remain central to global advancement. Smart grids and energy storage technologies are applied to support the systems. For instance, Ding et al. (2026) have leveraged the power to ammonia (P2A) and electrical energy storage technologies to improve the efficiency of renewable energy utilisation within integrated energy system (IES) [8]. While Yan et al. (2026) have provided theoretical evidence that integrating thermochemical heat storage into IES could lead to significant reduction in electricity costs and carbon emissions [9]. Furthermore, the application of optimisation models is becoming common in supporting the decision making in industrial decarbonization. Shree Ram Senthil & Balamurugan (2026) have reported the enhancement of power quality and energy management in microgrid by using Artificial Rabbits Optimised Neural Network (ARONN) for predictive modelling and grid stability while using solar and wind sources to supply smart grid [10]. These advancements align with SEPE's focus on the integration of Life Cycle Assessment (LCA) and techno-economic modelling in early-stage research, which is vital for scaling sustainable energy systems.

2.3. Green Process Engineering and CCUS

Carbon capture, utilisation, and storage (CCUS) technologies are recognised as key technologies and vital climate solutions to mitigate CO_2 emissions from primary sources. Recent reviews show that standalone CCU faces high energy penalty, operating costs and limited availablility of H_2 from renewable sources [11]. The integration of green technological principles is required to overcome these barriers. Besides, the approaches such as process intensification, includes hybrid thermochemical methods, and waste-to-resource conversion, aid in the reduction of industrial equipment size [12]. By improving the process throughput and energy efficiency through optimal resources utilisation, these approaches demonstrate cost efficiency while maintaining or enhancing product yield. SEPE also covers circular economy strategies especially designed for chemical, manufacturing and materials industries that are primary CO_2 sources. Further enhancement could be done through the AI-driven process optimisation and digital twins to ensure the technological breakthroughs are grounded in environmental and economic reality.

3. Nexus of Advanced Materials to Sustainable Future

In parallel, advances in functional materials are essential to enhance the performance, lifespan and stability of the technologies. Table 1 shows the advanced materials enabling sustainable energy technologies. The improvement of catalyst materials for energy conversion and the membrane materials permits less dependency on noble metals for the former and better operational durability for the latter. Latest development of high-performance perovskite-based solar cells, solid-state batteries and nanomaterials like cellulose nanocrystals-based materials for battery components fabrication and boron nitride-decorated TiO_2 nanotubes demonstrate the escalating importance of advanced materials in bridging the performance gaps of conventional systems. Therefore, SEPE is committed to highlighting these fundamental breakthroughs enabling high-efficiency applications in energy and processing fields.

Table 1. Recent development of advanced materials in sustainable energy innovation.

Materials	Examples	System/Technology	Contribution to Deployment	Ref.
Halide perovskite semiconductors	$MAPbI_3$, $CsPbI_3$, $FAPbBr_3$	Solar cell	High power conversion efficiency due to highlight absorption coefficient, bandgap tunability and long diffusion length, cost efficient	[13]
Solid-state electrolyte	Halide-based	Solid-state batteries	High ionic conductivity, exceptional electrochemical stability, improved energy density, enhanced safety and lower cost for moderate temperature fabrication	[14,15]
	Polymer-sulfide composites		High ionic conductivity with low grain-boundary resistance and good moisture resistance, allowing good interfacial processing	[15]
	Oxide-polymer composite		High chemical and electrochemical stability, good mechanical strength and mechanical flexibility for high-voltage application	

Table 1. *Cont.*

Materials	Examples	System/Technology	Contribution to Deployment	Ref.
Carbon-based nanomaterials	Graphene, carbon nanotubes	Electrocatalysts	Efficient electron transfer, high surface area for reactant adsorption, good stability under harsh conditions	[16]
Biomass-derived nanomaterials	Cellulose nanocrystals, lignin-derived	Electrodes, electrolytes, and separators	High mechanical strength, aqueous assembling ability, and tuneable surface chemistry	[17]
Membrane materials	Nafion (perfluorosulfonic acid, PFSA)	Fuel cell	Exceptional proton conduction capabilities and electrochemical stability, minimal fuel crossover	[18]
	Poly(fluorene)-based, full-carbon chain poly(aryl quinuclidinium) anion exchange membrane	Fuel cell, batteries and water electrolysis	Use non-noble catalyst, cost effective, high current density and good durability	[19]

4. Conclusions: A Call to Action

A transformation from sustainable energy innovations into real-world applications demands more than technological breakthroughs. It involves the convergence of advanced materials, smart digital tools/platforms, or circular engineering strategies with a broader system-oriented framework. With such integration, the “green transition” can progress beyond aspiration and pave a scalable way to achieve global decarbonization goals.

Sustainable Energy & Process Engineering (*SEPE*), launched under Scilight Press, is uniquely positioned to bridge the persistent gap between fundamental discovery and real-world industrial deployment. This journal serves as an interdisciplinary hub to conceive innovations and further translate them into impactful and practical panacea. We invite researchers, engineers, and policymakers to contribute their visionary, rigorous and application-driven work to shape the next generation of sustainable solutions. Through your contributions, we can step up the advancement of resilient and carbon-neutral systems, ensuring a sustainable future for generations to come.

Conflicts of Interest

The authors declare no conflict of interest. Given the role as Editor-in-Chief of Sustainable Energy & Process Engineering, Hwai Chyuan Ong had no involvement in the peer review of this paper and had no access to information regarding its peer-review process. Full responsibility for the editorial process of this paper was handled independently by another editor of the journal.

Use of AI and AI-Assisted Technologies

During the preparation of this work, the authors used ChatGPT to improve spelling, grammar, clarity, and readability during manuscript preparation. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

References

1. Murthy, H.C.A.; Bhattacharya, T.; Kelele, K.G.; et al. Chapter 29—Biobased materials in sustainable development of catalysis. In *Advanced Applications of Biobased Materials*; Ahmed, S., Annu, Eds.; Elsevier: Amsterdam, The Netherlands, 2023; pp. 699–715.
2. Thorarinsdottir, A.E.; Veroneau, S.S.; Nocera, D.G. Self-healing oxygen evolution catalysts. *Nat. Commun.* **2022**, *13*, 1243.
3. Pan, S.; Li, R.; Zhang, Q.; et al. An over 20% solar-to-hydrogen efficiency system comprising a self-reconstructed NiCoFe-based hydroxide nanosheet electrocatalyst and monolithic perovskite/silicon tandem solar cell. *J. Mater. Chem. A* **2021**, *9*, 14085–14092.
4. Kim, N.; Elbert, J.; Kim, C.; et al. Redox-Copolymers for Nanofiltration-Enabled Electrodialysis. *ACS Energy Lett.* **2023**, *8*, 2097–2105.
5. Yang, Y.; Yuan, Y.; Sun, Y.; et al. Positively Charged Polymer-Brush MOFs for Large-Area, Pressure-Resistant Gas Separation Membranes. *Adv. Mater.* **2026**, e20099. https://doi.org/10.1002/adma.202520099.
6. Shamim, J.A.; Nawaz, K.; Hu, M.-H.; et al. Review of the potential and challenges of MOF-based adsorption heat pumps for sustainable cooling and heating in the buildings. *Energy* **2025**, *323*, 135846.

7. Batool, S.M.; Batool, S.S.; Aliashghar, B.; et al. Structural modifications in metal–organic frameworks for CO_2 adsorption and sensing through sustainable synthesis and emerging designs. *Mater. Today Sustain.* **2026**, *34*, 101321.
8. Ding, J.; Wang, J.; Zhao, N.; et al. Stochastic scheduling optimization of integrated energy system incorporating power and ammonia energy storages for cost-effective and flexible operation. *Int. J. Hydrog. Energy* **2026**, *197*, 152626.
9. Yan, J.; Cui, M.M.; Zhou, Y.K.; et al. Design and optimization of large-scale thermochemical heat storage reactor and its application in integrated energy system. *Energy* **2026**, *345*, 139936.
10. Shree Ram Senthil, S.; Balamurugan, R. Hybrid approach of energy management and power quality enhancement in smart grid-connected hybrid renewable energy system. *Sustain. Energy Technol. Assess.* **2026**, *85*, 104763.
11. Singh, H. Chapter 10—CCUS: Green technological solutions and research paths. In *Industrial Decarbonization and the Energy Transition*; Sundaramurthy, S., Sundaresan, S., Swain, S.K., Eds.; Elsevier: Amsterdam, The Netherlands, 2026; pp. 221–264.
12. Reddy, C.C.S. Chapter 2—Applications and Potential of Process Intensification in Chemical Process Industries. In *Control and Safety Analysis of Intensified Chemical Processes*; Wiley: Weinheim, Germany, 2024; pp. 15–46.
13. Krishna, B.G.; Sundar Ghosh, D.; Tiwari, S. Progress in ambient air-processed perovskite solar cells: Insights into processing techniques and stability assessment. *Sol. Energy* **2021**, *224*, 1369–1395.
14. Li, W.; Zhao, C.; Yu, C.; et al. Advanced batteries for sustainable energy storage. *Green Energy Environ.* **2025**, *10*, 2201–2258.
15. Liu, S.; Zhou, L.; Neyts, K. From Promise to Production: Strategy for Halide-Based All-Solid-State Battery Pilot Lines. *Adv. Energy Mater.* **2026**, *16*, e05286.
16. Negi, A.; Asim; Ringwal, S.; et al. Chapter 15—Advanced Carbon-Based NCs as Electrocatalysts for Sustainable Energy Systems. In *Carbon-Based Nanocomposites for Sustainable Applications, Volume III: Biomedicine, Electronics, and Catalysis*; Khanna, V., Ed.; Springer Nature: Cham, Switzerland, 2026; pp. 365–394.
17. Calle-Gil, R.; Castillo-Martínez, E.; Carretero-González, J. Cellulose Nanocrystals in Sustainable Energy Systems. *Adv. Sustain. Syst.* **2022**, *6*, 2100395.
18. Ma, L.; Liu, X.; Yang, R.; et al. Matrix to surface engineering of nafion membranes: Advanced modifications for high-temperature proton exchange membrane fuel cells. *Fuel* **2025**, *405*, 136789.
19. Wijaya, G.H.A.; Im, K.S.; Nam, S.Y. Advancements in commercial anion exchange membranes: A review of membrane properties in water electrolysis applications. *Desalination Water Treat.* **2024**, *320*, 100605.