

Editorial

Evolution and Future Horizons of Chemical Engineering: Introducing the Updated Aims and Scope

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1. The Role of Modern Chemical Engineering in Addressing Global Challenges

Chemical Engineering stands at the forefront of addressing some of the most pressing challenges facing humanity. As the world strives toward a more sustainable, resilient, and resource-efficient future, the discipline plays a pivotal role in translating fundamental scientific discoveries into scalable technologies and industrial solutions. The foundations of Chemical Engineering are extensively documented in numerous reference books [1–5]. These works, representing only a few examples among many significant contributions, not only compile the fundamental principles of the discipline but also, through continuous updates and new editions, reflect the ongoing evolution of a field that is constantly advancing. From the production of clean energy and sustainable fuels to carbon capture, utilization, and storage, circular manufacturing, water purification, advanced materials, process intensification, chemical engineering provide the scientific and technological foundation required to design, optimize, and implement transformative solutions across multiple industrial sectors.

Beyond developing innovative processes, modern chemical engineering embraces a systems-oriented perspective that integrates reaction engineering, transport phenomena, process design, data science, and life-cycle thinking to maximize efficiency while minimizing environmental impact at competitive cost. The increasing convergence of digitalization, artificial intelligence, automation, and micro-/nano- scale engineering is reshaping the discipline, enabling the development of more adaptive, and highly efficient processes capable of responding to rapidly evolving industrial demands. These advances position chemical engineering not only as a driver of technological innovation but also as a key enabler of the global transition toward sustainable production, energy security, and climate neutrality.

To better reflect this evolving landscape and to facilitate the dissemination of cutting-edge research, *ChemEngineering* has updated its editorial scope through six thematic sections (Table 1) that encompass the breadth and diversity of contemporary chemical engineering. These sections are designed to provide a clear and comprehensive framework covering both established research areas and rapidly emerging fields, while fostering interdisciplinary collaboration and innovation.



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Table 1. Thematic sections and their scope.

Sections	Scope
Process and reaction systems engineering	• Design, modelling, and optimization of industrial process. • Chemical and catalytic reaction engineering. • Separation and purification operations. • Process intensification and energy-efficient technologies. • Adsorption processes driven by pressure, temperature, or electric fields. • Advanced process control, automation, and real-time optimization. • Transport phenomena: fluid dynamics, heat transfer, and mass transfer. • Thermodynamics of multiphase and reacting systems.
AI and data science	• Virtual sensors, process monitoring, and predictive maintenance. • Fault detection and intelligent control strategies. • Machine learning for optimization and decision-making. • Big data analytics for process and product development. • Digital twins and cyber-physical systems. • Computational fluid dynamics and multiscale simulation.
Molecular and product engineering	• Molecular design and simulation of materials and interfaces. • Design of advanced functional products and formulations. • Pharmaceutical, food, and fragrance engineering. • Microencapsulation and controlled release technologies. • Lignin and biomass valorization into high-value chemicals. • Development of new devices and smart chemical products.
Materials and nanostructured systems	• Synthesis and characterization of advanced materials. • Materials for catalysis, sensing, and energy applications. • Biomaterials and sustainable composites. • Membranes and hybrid materials for clean separation processes. • Materials for multicomponent (e.g., CO₂, CH₄, etc.) separation and storage.
Energy, environment, and biochemical engineering	• Renewable and clean energy technologies. • Hydrogen production, storage, and conversion systems. • Thermo-, photo-, sono- and electro-catalytic processes. • Mechanochemical schemes and mechano-, tribo- and piezo-catalytic processes. • Bioenergy production and biorefinery design. • Pollution control, waste valorization, and resource recovery. • Environmental bioprocesses and water treatment technologies.
Sustainability, safety, and industrial systems	• Circular economy and life-cycle assessment. • Process integration for sustainability and resource efficiency. • Techno-economic analysis and scale-up methodologies. • Safety engineering and risk management. • Sustainable process design and eco-efficient manufacturing. • Engineering leadership, innovation, and education for global challenges.

2. The Six Sections of the Updated Aims and Scope

Section: Process and Reaction Systems Engineering

This section considers high-impact research on process and reaction systems engineering, spanning fundamental principles and their modern industrial applications. In an era defined by the need for unprecedented efficiency and sustainability, the scope includes, but is not limited to, the design, modelling, and optimization of industrial processes, which constitute the foundation of next-generation manufacturing; advances in chemical and catalytic reaction engineering aimed at accelerating chemical transformations; and innovative separation and purification technologies to achieve high-purity products.

In response to the global transition toward decarbonization, particular emphasis is placed on process intensification, energy-efficient technologies, and novel adsorption processes driven by pressure, temperature, or electric fields, offering low-energy alternatives to conventional methods. To address the ongoing digital transformation of the sector, the section also encompasses advanced process control, automation, and real-time optimization, connecting fundamental theoretical developments with intelligent industrial operations. These topics are underpinned by the study of transport phenomena, including fluid dynamics, heat transfer, and mass transfer, together with investigations into the thermodynamics of multiphase and reacting systems.

Section: AI and Data Science

This section is dedicated to publishing high-quality research at the intersection of artificial intelligence, data science, and industrial engineering, encompassing both foundational methodologies and real-world applications. As industries undergo rapid digital transformation, computational intelligence has become essential for improving efficiency, safety, and innovation. The scope includes, but is not limited to, the development of virtual sensors, process monitoring, and predictive maintenance to enhance operational reliability, together with robust fault detection and intelligent control strategies for complex industrial systems.

Particular emphasis is placed on machine learning for process optimization and decision-making under dynamic operating and market conditions, as well as on big data analytics for process and product development. The section also covers digital twins and cyber-physical systems that integrate physical assets with their virtual counterparts, supporting the next generation of intelligent manufacturing. In addition, contributions combining data-driven approaches with physics-based models, including advanced computational fluid dynamics and simulation, are within the scope of the section.

Section: Molecular and product engineering

This section focuses on impactful research on the bottom-up design of materials and the development of high-performance chemical products, bridging fundamental molecular science with commercial applications. In a market increasingly driven by tailored properties and high-performance functionalities, the scope includes, but is not limited to, the molecular design and simulation of materials and interfaces to predict and control macroscopic behaviour, together with the rational design of advanced functional products and formulations for a broad range of industrial applications.

Particular emphasis is placed on addressing key challenges in all industrial areas such as pharmaceutical, food, fragrance engineering, etc. In line with the global transition toward sustainability and the circular bioeconomy, the section also covers biomass valorization. In addition, research advancing the development of novel chemical products and next-generation devices capable of dynamically responding to environmental stimuli is within the scope, as well.

Section: Materials and nanostructured systems

This section features pioneering research on the synthesis, characterization, and application of advanced materials and nanostructured architectures, bridging fundamental materials science with innovative engineering solutions. As the demand for high-performance, multifunctional materials continues to grow across technological sectors, the scope includes, but is not limited to, the synthesis and characterization of nanostructured materials that enable unique properties, together with the development of advanced materials for energy storage, conversion, and energy saving, which are essential for the transition toward sustainable energy systems.

A strong focus is placed on catalytic materials for environmental and energy applications, as well as on polymeric and composite materials for advanced engineering technologies. The section also encompasses functional membranes for gas and liquid separation, together with advanced adsorbents for water treatment and gas purification, addressing critical challenges in separation science and environmental remediation.

Section: Energy, Environment, and Biochemical Engineering

This section is devoted to high-quality research addressing the global challenges of climate change, resource scarcity, and the energy transition, bridging biochemical engineering with sustainable environmental solutions. As society moves toward circular and low-carbon systems, the scope includes, but is not limited to, the advancement of renewable and clean energy technologies, together with the design of efficient hydrogen production, storage, and conversion systems.

Particular emphasis is placed on novel chemical and physical transformation pathways, including thermo-, photo-, sono-, and electro- catalytic processes, as well as innovative mechanochemical approaches and mechano-, tribo-, and piezocatalytic technologies for low-footprint chemical synthesis. The section also encompasses bioenergy production and biorefinery design. In addition, research on pollution control, waste valorization, resource recovery, environmental bioprocesses, and advanced water treatment technologies is within the scope of the section, reflecting the growing need for sustainable resource management and environmental protection.

Section: Sustainability, Safety, and Industrial Systems

This section addresses high-quality, forward-looking research focused on the systemic challenges of industrial operations, emphasizing the alignment of economic viability, environmental stewardship, and operational safety. As modern engineering evolves toward more holistic and responsible practices, the scope includes, but is not limited to, the implementation of circular economy principles and life-cycle assessment methodologies to evaluate long-term environmental impacts, together with advances in process integration for sustainability and resource efficiency aimed at minimizing waste and optimizing the use of energy and materials.

A key focus is placed on bridging laboratory-scale innovations with industrial implementation through techno-economic analysis, scale-up methodologies, and technology validation, ensuring that emerging processes are both technically feasible and economically competitive. The section also encompasses safety engineering and risk management, addressing strategies to prevent industrial hazards and enhance process resilience. In addition, research on sustainable process design and eco-efficient manufacturing is within the scope of the section, supporting the development of next-generation industrial systems. Recognizing that technological progress also depends on human capital and organizational excellence, the section welcomes contributions on engineering leadership, innovation, and education for global challenges.

3. Conclusions

Chemical Engineering has continuously evolved in response to the changing needs of society, expanding from its traditional foundations to encompass emerging technologies, digitalization, advanced materials, and sustainable manufacturing. To remain at the forefront of these developments, the journal has updated its editorial structure around six complementary sections that collectively reflect the breadth and future direction of the discipline. The new sections are intended to capture this diversity, spanning topics from process design, modelling, and optimization to artificial intelligence and data science, molecular and product engineering, advanced materials, energy and environmental

technologies, and sustainability, safety, and industrial systems. Together, they provide a coherent framework for publishing high-quality research addressing both fundamental scientific advances and industrial challenges. This renewed scope reinforces the journal's commitment to serving as an interdisciplinary platform where researchers from academia, research institutions, and industry can disseminate innovative solutions to global challenges related to energy transition, circular economy, digital transformation, sustainable manufacturing, and advanced process engineering.

The journal welcomes contributions from authors, reviewers, and the broader Chemical Engineering community to support this new editorial framework. It is expected that these updated sections will foster scientific excellence, encourage interdisciplinary collaboration, and promote impactful research that advances both the theory and practice of Chemical Engineering.

Conflicts of Interest: The author declares no conflict of interest.

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