The National Academies of | SCIENCES ENGINEERING MEDICINE

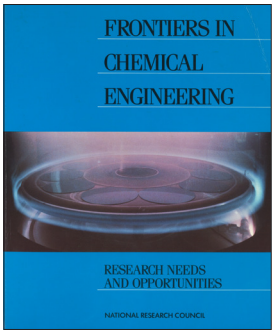
BOARD ON CHEMICAL SCIENCES AND TECHNOLOGY

Chemical Engineering in the 21st Century: Challenges and Opportunities

The National Academies of Sciences, Engineering, and Medicine is planning to conduct a study that will outline a vision for the chemical engineering discipline and point the way for research, education, workforce development directions over the next 25 years. The National Academies is reaching out to the chemical engineering community both to participate in the study and to help support it.

Motivation

Chemical engineers apply molecular sciences to create life's essentials and enhance life's quality. Using not only the chemical sciences, but also mathematics, physics, materials, biology, and data science, chemical engineers play key roles in such areas as health care, energy development, waste management, food processing, and national security. The 2015 American Chemistry Council estimated that the breadth of chemical industries contributed nearly 26% of US GDP ($4.6 trillion) while supporting over six million jobs.



In 1988, the National Academies laid out an important vision for the field. *Frontiers in Chemical Engineering: Research Needs and Opportunities*, also known as the "Amundson Report," outlined a roadmap for turning promising research opportunities into reality, while guiding university educational efforts to embrace new frontiers. It also highlighted the remarkable potential of the profession to affect many aspects of American life and "promote the scientific and industrial leadership of the United States." The study is widely recognized as having been a key driver for many advances in chemical engineering over the past 30 years.

In future decades, the discipline must continue to evolve to address the rapidly changing needs of society while taking advantage of new scientific capabilities. Specific changes that affect how we might view research priorities, education, and the practice of chemical engineering include:

- Advances in computing power and communications technologies that have changed how we model, predict, manage data, publish results, and design, monitor, control, and protect manufacturing processes and products;
- The growing transdisciplinary nature of the field and what that means for education, training, and workforce development;
- The advent of data science and analytics, machine learning, and artificial intelligence and its implications for research and process design and management;
- The revolution in biology, including the fast-changing field of synthetic biology;
- The growing focus on sustainability in process design and manufacturing;
- Changes in feedstocks; particularly the boom in hydraulic fracturing and availability of natural gas;
- The advent of process intensification, requiring innovation in integration and operations.

A New Vision for the 21st Century

At a 2016 American Institute of Chemical Engineers (AIChE) Roundtable, leaders from the chemical engineering profession reached a major conclusion: chemical engineering needs a new vision for the 21st century. Participants at that meeting, including both current and former AIChE Presidents, underscored

the transformative and lasting impact of the Amundson Frontiers report, unanimously supporting the need for a new report. As emphasized by Professor Alexis Bell of the University of California, Berkeley, one of the co-authors of the 1988 report, "A new report will influence and transform the chemical engineering profession in today's world, as did the original Amundson Report 28 years ago."

The aspiration for a new report, *Chemical Engineering in the 21st Century: Challenges and Opportunities,* will be to articulate and transform the chemical engineering profession, guiding its vision of future research, innovation, and education. It will recognize the changing needs of industry in the 21st century; develop ways to more effectively engage with and learn from related fields; anticipate potential consequences affecting society and the environment; strengthen diversity within the chemical engineering community; point the way to a modern educational curriculum; and encompass the international sweep of the profession.

Work Plan

This study will be organized and managed by the National Academies' Board on Chemical Sciences and Technology in collaboration with the National Academy of Engineering. It will be conducted by an ad hoc volunteer committee of 12-15 members, with additional expertise brought in as needed. Committee members will be selected to ensure a balance across specific expertise areas and sectors. The project will solicit broad input from the chemical engineering community through workshops, town halls, professional meetings, solicitation of white papers, and electronic media. Depending on available funds, the study is expected to begin in Fall 2018, with a final report being delivered in Fall 2020.

Supporting the Study

The total cost of the project is estimated at $1.1 M; commitments from agencies so far suggest that approximately half the funds will be provided by the federal sector, with the remaining balance to be covered by the academic and private sectors. We are seeking contributions from the chemical engineering community, including academia, industry, professional associations and societies, and individuals.

Study Planning Committee

Joan F. Brennecke, University of Texas; Jennifer Sinclair Curtis, University of California, Davis; Sharon C. Glotzer, University of Michigan; Alexander Orlov, State University of New York, Stony Brook; Joseph B. Powell, Shell; and Phillip R. Westmoreland, North Carolina State University.

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Visit our website at **nas.edu/chemengineering** to make a contribution to help this important study begin.

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