

Chapter 27

How Can Chemical Engineers Best Impact Societal Issues?

*By Liang-Shih Fan, Judy Raper, Emmanuel Dada,
Pete Ledeman, Norman Li, Jeff Sirola, and Dale Kearns*

For professionals in the chemical engineering discipline, the answer to the question “How Can Chemical Engineers Best Impact Societal Issues?”, may seem self-evident—something that is naturally intuited by those of us who apply our work to pressing societal issues and problems directly and indirectly every day. This is a question that AIChE has actively and effectively taken the lead in addressing as part of its 2007 Long-Range Strategic Plan. Its subcommittee concerned with societal impact issues was chaired by L.S. Fan with Emmanuel Dada, Peter Ledeman, Norman Li, Judy Raper, Darlene Shuster, Jeff Sirola, Dale Kearns, and Tim McCreight as its members. This committee tackled the issue of the societal impact of chemical engineers, identifying and outlining the issues and offering specific recommendations for the role of AIChE on this important and pressing issue.

The question of *how* can chemical engineers best impact societal issues almost immediately seems to generate other related queries. *What* are the societal issues, challenges and problems that chemical engineering as a discipline is best suited to tackle? *What* are the social problems that chemical engineering can and should contribute to solving, and what are the technologies and foci within the discipline that intersect with these societal concerns? *Where* will the expertise and influence of chemical engineering and chemical engineers be brought to bear on these issues? *Who* are we as a discipline in the early years of the 21st century and *how* does our changing face speak to our involvement in these societal questions? Finally, *on whom* should we focus to ensure the efficacy of our attempts to have a societal impact? It is only by sketching out some tentative answers to these questions that we can begin to offer our response to “how can chemical engineers best impact societal issues?”

Accordingly, this chapter begins by identifying those issues that are of the most relevance and applicability for chemical engineering. It should be emphasized, however, that the issues that we focus should not be construed of as an exhaustive list although they are admittedly among the most important. A consideration of these issues and those chemical engineering technologies best suited to make a decided societal impact is then situated in the broader context of sustainability, globalization and diversity before we conclude with considerations of how effective governmental relations and improved K-12 outreach efforts can ensure the effectiveness and pervasiveness of chemical engineering’s societal impact at present, in the near future, and for decades to come.

Improving the Quality of Life

Four of the greatest challenges facing society today are the provision of food, clean water, health care and energy. It is in these areas and others that chemical engineering can make a significant and lasting set of contributions that will help solve these problems and improve the quality of life. This is, in a sense, already well under way, as recent studies have indicated that more than half of recent graduates of American chemical engineering programs are working in nontraditional industries such as the biotechnology, pharmaceutical and nanotechnology fields,

contributing to these vital challenges. All of these involve products and processes, “bread and butter” areas for chemical engineers. Among numerous reasons why chemical engineering is poised to make significant societal impact, perhaps the most fundamental is the very nature of the discipline itself. The traditional foundations of chemical engineering science in chemistry, physics, mathematics, as well as systems and multiscale approaches, in recent years, have embraced the realization of the importance of biology as another, and previously largely unacknowledged, pillar of chemical engineering science. This exciting combination of the continued strength of traditional chemical engineering interests and their integration with emergent trends bode well for the impact that chemical engineering make on those and other challenges.

One of the greatest global societal problems is the availability of and access to food in the face of an exponentially expanding world population. This multifaceted challenge includes the development of fertilizers, pesticides and preservatives in concert with processes that will facilitate the “the production, processing, storage, distribution and consumption of high-quality plant and animal foodstuffs to meet the needs of present and future populations” (AIChE Strategic Report on Societal Impact, 2007). Chemical engineering and chemical engineers play a role in helping to design the same products and processes.

A related issue is that of the increasing paucity of clean water. Given the importance of separation processes in cleaning water so that it is free of sediment, organisms and contaminants, and fit for either human consumption or agricultural use, chemical engineers are at the forefront of such activities. These two basic human needs of food and water are perhaps the areas where chemical engineering technologies can have the broadest and most pervasive societal impacts.

While food and water are important, they do not in themselves offer a guarantee of good health, and when it comes to health care and its ancillary fields, chemical engineering continues to play an important role. Beyond their understanding of organic and inorganic materials and their “unique perspective on complex system dynamics” (AIChE

Strategic Report on Societal Impact, 2007), chemical engineers are often intimately involved in the creation of products and development of processes that diagnose, treat, cure, and mitigate a broad spectrum of medical conditions and diseases. Further, the pharmaceutical industry benefits from the expertise of chemical engineers who work with both the material composition of pharmaceuticals and the processes by which such products are combined, tested, and produced.

The maintenance and improvement of living standards require the continued and increased consumption of energy. Because of the finite supplies and the environmental concerns of greenhouse gas emissions, reliance on fossil fuels is neither practical nor desirable in the short or long term. Long a player in the development and production of petrochemicals, chemical engineering has begun and will continue to be involved with both the development of alternative energy sources, and the increased efficiency and less environmentally-damaging use of traditional fossil fuel sources. As the AIChE Long Range Strategic Plan accurately points out, “The challenges of alternative energy production and carbon dioxide capture and sequestration are perhaps the greatest mankind has ever faced in terms of economic and societal impact” (AIChE Strategic Report on Societal Impact, 2007).

We would be remiss if we did not factor the contributions of biotechnology, nanotechnology, and electronic materials in considering the specific ways and means by which the chemical engineering discipline can have an impact on society. The use of the different aspects of living organisms, the exploitation of energy, and the ability to manipulate and control the scale, at the molecular level, of matter have important roles to play in refining the processes and developing the products by which chemical engineering can contribute, not just to the issues of food, clean water, health care and energy, but the whole panoply of social concerns and challenges that may fall within our purview.

Sustainability

In addition to the four areas delineated above, environmental issue must be considered both in the sense of how it imbricates with the

issues of food, clean water, health care and energy and how it stands independently as a problem in need of the insights of chemical engineering. The points of intersection between environmental concerns and the previously discussed areas of societal impact are, perhaps, obvious. For example, the development and production of large quantities of foodstuffs to which chemical engineers can contribute raise the specter of potential large-scale and lasting damage to various land and marine ecosystems. Chemical engineers have the opportunity to help mitigate and minimize these effects even as they contribute to addressing the questions of the quality and quantity of food supplies around the world. The same conscientiousness can and must be brought to bear on the other aforementioned challenges of clean water, health care and, perhaps most urgently, energy where the environmental issue is inextricable from the problem of energy supply and consumption. Chemical engineers have important contributions to make in helping to lessen or even reverse the ecological footprint of human-created biological and physical processes. Indeed, chemical engineering systems approaches can address these problems both beforehand and as they emerge, and not solely when the problem has reached a critical stage. Furthermore, the use of biodegradable materials wherever possible is of critical importance. The rising profile of biology within chemical engineering suggests the prime role that chemical engineers can and will play in addressing the serious problem of environmentally destructive, nonbiodegradable materials from coating solvents to packaging and containers, as well as the future design of biodegradable products and processes.

Environmental considerations that must accompany any discussion of how the products, especially chemical engineering processes, can impact the societal issues brings us to the importance of sustainability. AIChE has been actively involved, through grassroots efforts, in developing the following definition of sustainability that would be appropriate and effective for the discipline of chemical engineering: "Sustainability is a path of continuous improvement, wherein the products and services required by society are delivered with progressively less negative impact upon the Earth." In the spirit of such a definition, the AIChE Societal Impact report argues that sustainability is best viewed as "a

path that should be followed in providing technological solutions to societal problems as well as all engineering processes and product design and development” (AIChE Strategic Report on Societal Impact, 2007). As the chemical engineering community addresses energy problems with an awareness of environmental considerations, a commitment to sustainability will provide the atmosphere in which the scientific solutions to societal problems (including those of chemical engineers) are both enduring and responsible technically, socially and economically. As the authors of the AIChE Societal Impact report point out, “Chemical engineering has three core concepts that are essential to the implementation of sustainability: systems thinking, material and energy balances, and the use of metrics for total costing approaches” (Societal Impact 25). Many technical solutions to social problems have not met sustainability standards historically, but chemical engineering is well positioned to ensure that these are not repeated, and to continue the implementation of sustainable solutions to social problems in the years to come.

Global Issues

In light of the above discussions on the societal impact of chemical engineering, we would like to address the questions of where this societal impact will occur, who we are as individuals within the discipline, and how the face of those who make up the chemical engineering discipline will continue to evolve in the coming years. The short answer to where chemical engineering’s impact on society will be found is everywhere. We are in the era of globalization, which poses opportunities for the wide-ranging societal impact of chemical engineering, as well as new problems and challenges. Some of the very societal problems that chemical engineering can contribute to solving—global warming, resource scarcity, and environmental degradation—are themselves partially a consequence of globalization itself.

The societal problems that chemical engineering can help to address are global in scope. For example the National Academy of Engineering estimates that about 1.1 billion people do not have access to clean water and 2.6 billion people lack adequate sanitation (AIChE Strategic Report

on Societal Impact, 2007). Food shortages throughout the developing world, the various pandemics ravaging Africa, spiraling health care costs in the United States, the exploding amounts of energy consumption by India and China, and the intersection of current and future geopolitical considerations with energy resource availability in the Middle East and elsewhere all suggest something of the breadth and variety of the global reach that chemical engineering can have. While the size and number of societal problems created or intensified by the era of globalization can be somewhat daunting, the converse is also true. The era of globalization offers tremendous and positive opportunities for collaboration and consultation, if we are prepared to act proactively. The technological and communication revolution in recent decades has shrunk our world, but we must be prepared to exploit this to open up more effective lines of communication among societies such as AIChE and its international counterparts, to rethink the education of tomorrow's chemical engineers in the context of globalization, and to promote a spirit of cosmopolitanism in diversifying the membership of the AIChE along international lines.

Diversity is another important dimension to the impact that chemical engineers can have on societal issues. Globalization, shifting demographic patterns, and the changing nature of American higher education are coming together to create an environment where issues of diversity will assume a particularly high profile. People involved in the discipline of chemical engineering is changing along the lines of gender, race, religion, age, physical condition, nationality and sexual orientation, but this change can be accelerated and promoted by those currently in or connected to our discipline. Current efforts to promote the increased participation of women and minorities, as well as the creation of a culture in which all are valued equally for their skills, abilities, unique perspectives, and experiences must and will continue if the U.S. and the American chemical engineering community are to retain its economic and intellectual preeminence. Further, these efforts must pervade all sectors of our discipline from industry and academia (both with respect to faculty and student populations) to professional societies such as AIChE (which has been active in promoting diversity for several decades). One of the paradoxes of globalization is that in drawing us together it has

revealed our global diversity and the variety of the problems that exist. Likewise, chemical engineering is united in its efforts to positively impact societal problems on local, national and international levels even as the chemical engineers who are and will be doing this important work are an increasingly diverse group of talented and committed individuals.

The societal impact of chemical engineers and chemical engineering brings together consideration of two very disparate groups that are crucial if this impact is to be positive now and in the future. The first of these groups are politicians and government officials at the local, state, and particularly federal level given the global reach and scope of the societal issues. Chemical engineering as a discipline, through the auspices of its various professional organizations such as AIChE, must play multiple roles, including that of an educator for those involved in the decision-making process. The discipline must also simultaneously be an effective advocate and active partner with the federal government and its agencies. AIChE, for example, has a long history of working successfully with all levels of government to promote the interests of chemical engineers on a variety of issues. However, given the complexity and range of problems raised by globalization and the urgency and importance of chemical engineering's continued and potential contribution to the solution of such problems and challenges, we need to recommit the discipline to partnering with the various legislative and regulatory bodies for a fruitful and productive relationship.

The dissemination of information about the role that chemical engineering can play when it comes to the challenges of providing clean water for over a billion people or the importance and feasibilities of carbon capture from flue gases—to take two very different examples—is a crucial educative mandate that must work in concert with other governmental activities. Chemical engineers through organizations such as AIChE must communicate with the Congress in a variety of ways and establish the discipline as an integral, indispensable and impartial resource for that deliberative body. Failure to take such practical steps might undermine all of the potential and expertise on the technological contributions that the discipline can make.

Education

We would like to emphasize the importance of K-12 chemical engineering education in the light of the impact the discipline can make with regard to societal problems and challenges. They are the future chemical engineers who will both inherit and grapple with the societal problems and challenges that the discipline of chemical engineering is now addressing. It will be their accomplishments and contributions that will form much of the content for this chapter in the bicentennial edition of this book in 2108. How K-12 education can be enhanced in ways that will ensure that the momentum and promise generated by current efforts in addressing societal problems will not be squandered, but rather developed and extended? In introducing the discipline to these students the applied nature of chemical engineering should be emphasized and reinforced through curricular revision to increase the emphasis on technological design and problem-solving in addition to the traditional theoretical foundations of the discipline.

There is little question that chemical engineering can and does have a significant impact on societal issues, but the nature of that impact is currently being redefined as the discipline of chemical engineers evolves from within and is rethinking and reassessing its impact in the context of sustainability, globalization, governmental relation, diversity, K-12 education, and innovation.

