

Green engineering and sustainability

The future is going to be largely what we design it to be. Will the future be one of continued challenges from shortages of water, depletion of finite material and energy resources, and degradation of the environment, or one of effective and efficient systems that bring about concurrent environmental and economic prosperity for societal benefit? The role of engineers and designers on all scales—molecular, products, processes, and systems—is going to be central and essential in determining what tomorrow will look like. Green engineering—engineering for sustainability—uses the same traditions of brilliance, innovation, and creativity, which are the legacy of the engineering disciplines, within the context and perspective of environmental, economic, and social benefit. This new application of engineering excellence to sustainability is among the most complex and important challenges faced by science and technology.

While tremendous benefit has been derived from vision and value statements on the need for sustainability, scientists and engineers understand that change will only occur when sustainable technologies are implemented in industry and disseminated throughout society. The imperative of sustainability has been made clear over the past decade through studies, analyses, and political summits; however, the scientific and technological solutions to address this imperative are only in their most nascent stages. The vital and significant work in green engineering to date is a fraction of what is yet needed and realizable.

To accomplish this transition, industry, academia, and government need to engage with a sense of importance and urgency. Leading corporations, such as those represented in the World Business Council for Sustainable Development, are beginning to implement technologies that are not only more efficient, but more sustainable. Examples of academic research and educational initiatives for sustainability are becoming more common, such as the green engineering textbook published last year by Prentice Hall. Government plays a significant role in advancing green engineering through investments in research, such as the Technology for a Sustainable Environment program administered jointly by the U.S. EPA and the National Science Foundation. Several of these projects are featured in this issue. By engaging in these activities and continuing to raise the level of commitment, industry, academia, and government will further green engineering and move toward sustainability.

Environmental Science & Technology should be applauded for devoting a special issue to the Principles of Green Engineering, which highlights state-of-the-art research in engineering for sustainability. This is certainly a recognition that in order to meet the grand goals of sustainability, changes in the way we approach science and technology will be required. While we absolutely must have an understanding of our environment that can only be accomplished through monitoring, measurement, analysis, and characterization, this understanding alone is not enough. Solutions are needed. There are numerous examples of green engineering in industry, academia, and government, but the approaches used have not been applied either systematically or comprehensively across all disciplines and all scales. For this reason, a framework, the 12 Principles of Green Engineering, was constructed for engineers seeking to incorporate sustainability goals as design criteria (*Environ. Sci. Technol.* **2003**, *37*, 94A–101A). These engineering principles are largely a systematized reflection of the collection of excellent work in engineering for sustainability in a wide variety of applications.

This special issue includes both feature articles and technical papers that exemplify the Principles of Green Engineering. The approximately 100 contributing authors representing industry, academia, and government on three continents come from many disciplines, including civil, mechanical, environmental, chemical, electrical, and systems engineering. It is a challenge for the mere language in the Principles of Green Engineering to transcend discipline-specific terminology and be universally understood. However, this special issue serves to illustrate the application of green engineering principles to a broad array of real-world engineering challenges to advance the goal of sustainability.

Many thanks to all the contributing authors, my co-editors Joan Brenneke and Steven Skerlos; the staff at *ES&T*, especially Barbara Booth, Rachel Petkewich, and Alan Newman; and Editor Jerry Schnoor for making this special issue on the Principles of Green Engineering a reality.



Paul T. Anastas
White House Office of
Science and Technology Policy