Conclusions and Observations

This section presents conclusions based on our case study results and observations based on the analyses of barriers.

NGETs Can Provide Benefits in All Areas Studied

NGETs have the potential to make a significant contribution to a new approach to environmental protection. NGETs represent an important class of pollution prevention technology that redesigns products and processes at the molecular level to reduce or eliminate the use of hazardous materials. Our case studies demonstrate that NGETs have already provided a wide range of environmental, security, health and safety, and economic benefits. In some cases, NGETs can provide these benefits for no additional cost or even at a lower cost compared with today's practices. And because NGETs are relatively new technologies, they may help policymakers ensure environmental quality with less reliance on costly regulations as they mature.

The nation's economy increasingly relies on a wide variety of chemical products and processes. Progress in slowing the use of potentially hazardous substances has not kept pace with other positive environmental trends over the past 30 years. Finding new ways to ensure that needed chemicals pose no or little risk requires new thinking into the means by which they are produced and employed. Over the past decade, green chemistry, an important source of NGETs, has begun to provide alternatives to chemicals that are known to be dangerous or to potentially pose risks. The case studies suggest that green chemistry technologies also have potential to expand beyond their current niches and provide significant long-term benefits spanning the four areas highlighted in this study. NGETs may help eliminate emissions from broad classes of chemicals through inventive solvent choices; toxic reagents may be nearly completely displaced by an environmentally benign alternative; the security risks of dangerous chemicals may be avoided through the creation and adoption of less hazardous alternatives; and synthetic processes may be more readily adapted to take into consideration environmental concerns.

NGETs Can Address Uncertainties

In addition to addressing currently known risks, NGETs can also help address those that are imperfectly understood. The principles of green chemistry guide scientists and engineers toward processes that intrinsically embody more of the process inputs in the final product and thus are more efficient and generate less waste. Such principles can eliminate potential environmental problems before they arise.

Firms Adopt NGETs for a Number of Different Reasons

Driven by technology push alone, however, NGETs are unlikely to reach their full potential. The case studies demonstrate that firms adopt NGETs for many reasons, ranging from business decisions to pursue new production processes or product lines to the need to respond to regulatory pressures. Firms adopt NGETs because they are the most cost-effective means to meet some particular end. In each firm, however, NGETs must compete for resources with a host of other investment opportunities. To garner scarce investment dollars, it is rarely sufficient for a new technology to merely save the firm money. It must be among the options that move the firm most aggressively toward its corporate goals.

Policymakers Face a Number of Challenges

This report made no attempt to assess the need for or the types of policies the federal government might implement in response to the potential offered by NGETs and the barriers to their implementation. Nonetheless, the report suggests several observations about potential policy actions.

A number of different types of government policies can help NGETs reach their full potential. One such policy area is that of information dissemination. Our case studies suggest that there are important spillovers across and among different areas of green chemistry. Applications of broad processes such as biocatalysis in bioprocessing in one area may suggest applications in another. When a firm develops some new product or process, it does not generally scan the full range of possibilities but rather tends to scan a more narrow range close to current practice. In part, research and design is expensive, so innovators will focus the majority of their efforts on those design choices where they expect to find promising answers. Publicizing the scientific principles and successful applications of green chemistry may cause firms to guide their internal research toward innovations that become NGETs. Examples of such information dissemination policies include partnerships involving industry to develop environmentally benign processes, such as those with the Department of Energy's (DOE's) Office of Industrial Technologies; awards programs such as EPA's Presidential Green Chemistry Challenge Awards; fellowships and other funding for green chemistry at the nation's universities; and encouraging the work of professional, scientific, and engineering societies in education and training related to green chemistry.

The government also has an important role to play in supporting basic research. New areas of chemistry and other sciences, still in their relative infancy, may lead to significant changes in a vast number of processes across the economy. Basic research may help to unlock their potential. At present the federal government funds a range of research potentially relevant to NGETs such as the EPA / NSF (National Science Foundation) Technology for a Sustainable Environment program. (See Appendix B for a list of examples of federal policies that can affect the development and adoption of NGETs.) Additional relevant programs have been proposed. The

National Coalition for Advanced Manufacturing[55] has called for a three-year, $5 billion basic manufacturing science and technology initiative, which includes research on manufacturing technologies for energy efficiency and environmental quality. We have not made an attempt to survey what the government is funding relevant to NGETs and then to assess this funding against the most promising avenues and areas of greatest need. Such a complete survey of federal funding is difficult to do given the diverse funding sources, the variety of programs and objectives, and the uncertainty that energy, life sciences, or chemical engineering programs will result in green chemistry or NGET advances.[56]

Finally, the widespread diffusion of NGETs may require policymakers to also address demand pull by providing appropriate incentives for the adoption of NGETs. Crafting such incentives will be an important challenge. On one hand, NGETs present policymakers with questions common to environmental policy. For instance, NGETs may diffuse relatively slowly if internal cost savings are the only incentive the firms have to adopt them. Policymakers will need to determine whether the potential benefits of NGETs warrant other incentives to speed their adoption. However, there are opportunity costs to encouraging firms to allocate their capital and technical personnel to develop NGETs. Resources spent on such pursuits are not available to develop other products and processes. Policymakers will need therefore to gauge what level and type of effort seems appropriate to further the development of NGETs. Should the approach be technology push or demand pull, fund research, increase the extent of regulation, or some combination?

There are also some areas where NGETs pose particular challenges. These include the focus on process technology, the uncertainty of future process applications, and the extent to which technology spillovers broaden the adoption of new manufacturing processes. For example, the focus on process technology is often invisible to consumers and thus relatively decoupled from any emerging market demand for cleaner products. Many government policies also focus on industrial products rather than processes that produce them. For instance, the EPA premanufacture notices (PMN) required of chemical manufacturers focus on the potential toxicity and hazards of new products rather than the greenness of the process by which they will be made.[57]

NGETs also present policymakers with a problem of information asymmetry. There are a vast number of products and processes for which the adoption of NGETs might provide important environmental, security, safety, and economic benefits. Only firms have the information that can allow them to discover which products and processes offer the most gains from NGETs. But society as a whole may reap a large fraction of the gains from such applications. Some of these benefits come through reducing risks that are presently imperfectly understood or that seem too

[55] www.nacfam.org

[56] However, in discussions with the Office of Science and Technology Policy (on March 26, 2002) we estimated that green chemistry federal funding was most likely in the $20–100 million range with all manufacturing technologies about $100 million (database at www.imti21.org/); industrial R&D related to NGETs might be 1 percent of chemical R&D or $260 million per year.

[57] EPA had for a short period provided advice to PMN submitters on ways the processes could be made more environmentally benign; discussion with Richard Engler, EPA, December 3, 2002.

costly to control. Clearly, policymakers should not threaten to regulate in every area where NGETs might provide some benefits, but many potential benefits may remain undiscovered without some expression of societal demand. Thus, policymakers must devise means to appropriately enable and encourage chemists, chemical engineers, and other potential innovators to explore the effective new scientific tools at their disposal and bring them to bear most effectively on the array of applications for NGETs.