Mechanisms for Gaining the Benefits from NGETs

The case studies demonstrate that NGETs offer potentially significant benefits over a wide variety of applications, recognizing the uncertainty in any forecast of the ultimate range and scope for any specific technology. This report describes current benefits and then the possible longer-term benefits that depend on further technology advances.

We now look at the mechanisms by which the benefits are delivered.

Mechanisms

A review of our case studies and the literature on environmental technologies suggests that the invention, design, and deployment of NGETs offer four types of benefits—environmental, economic, security, and health and safety. These benefits are delivered by three mechanisms: cost reduction, risk reduction, and broad technology transfer or spillover effects.

Cost Reduction

NGETs can reduce the costs of providing the various benefits. The classic model derived from welfare economics provides a way of thinking about how NGETs might enable a new approach to environmental protection. In this model, one can estimate the costs associated with emitting some pollutants. One also knows the potential costs of reducing these emissions. With this information, policymakers can choose the level of environmental regulation so that the marginal cost of reducing emissions is just balanced by the marginal benefit of further reductions. At this optimal level of reductions, society as a whole has gained a benefit equal to the reduced level of environmental impact less the cost of achieving the necessary reductions.

In this model, technological innovation can play a role by lowering the costs of reducing emissions. Policymakers are then able to choose a higher level of regulation, with an overall increase in the net societal gain. In this model, such research can play its most important role when the current costs of reducing some pollutant are sufficiently high that the optimal level of regulation leaves the pollutant untouched. An opportunity is created for research to make significant cost reductions compared to the alternatives.[16] In cases where costs are already low compared with benefits, innovation may provide little additional gain. Only in cases where innovation makes dramatic improvements in relative costs can it fundamentally change the regulatory calculus.

[16] Ian Parry, William A. Pizer, and Carolyn Fisher, "How Important is Technological Innovation in Protecting the Environment?" Resources for the Future Discussion Paper 00-15, March 2000.

Many of today's environmental challenges represent cases where the current costs of reductions are high compared with the perceived benefits. One example might be the sequestration of greenhouse gases from electric power generation facilities, where current costs may be high because of the limited or untested technological options available for reductions. NGETs may significantly change the situation by providing technological options that dramatically reduce the costs of reductions relative to the derived social benefits. In such cases the government can set new regulatory standards and achieve previously unavailable social benefits. NGETs may also significantly change the situation if they can lower costs of reductions sufficiently so that firms will make these reductions without the need for traditional regulatory stimulus. This latter case represents the situation where NGETs can indeed provide a new approach to environmental protection.

Risk Reduction

Many of today's environmental challenges also represent cases where the potential benefits of addressing the problem are sufficiently uncertain that it becomes difficult to justify a traditional regulatory remedy. NGETs may provide a powerful tool for managing such risks. For instance, there may be many emerging environmental hazards of which we are only dimly aware. An estimated 100,000 chemicals are used in commerce worldwide, and more than one new chemical[17] is introduced every day, not all of which may be harmless. In addition, the volume of many existing pollutants grows yearly.

The "precautionary principle" represents one approach to addressing such uncertain environmental risks. This principle, embodied in many of the environmental policies of the European Union, suggests that human activities with a potential for serious environmental harm should be limited even in the absence of full scientific certainty.[18] For instance, the principle suggests that some new chemicals ought not be used until proved completely safe. Industry and some policymakers in the United States generally oppose this concept because it can increase the risks to economic growth in exchange for an uncertain benefit. Such growth can create additional wealth that can help pay for enhanced environmental protection, and is a valuable end in itself. To preserve economic growth, many experts argue that hazardous substances should not be regulated until the benefits of doing so clearly outweigh the costs. However, some environmental dangers may not become certain until damages are already significant and emissions control and cleanup have become expensive.

NGETs may help serve as a bridge between these two positions by making a different wager. NGETs can reduce environmental risk by eliminating broad classes of potentially dangerous substances from products and processes. The principles of green chemistry guide firms in designing new products and processes in such a way that their impact on the environment is

[17]These include industrial chemicals, polymers, pesticides, pharmaceuticals, and food additives. Four times as many premanufacture notices are submitted as chemicals commercially produced.

[18]P. Sand, "The Precautionary Principle: A European Perspective," *Human and Ecological Risk Assessment,* Vol. 6, No. 3, 2000, pp. 445–458.

reduced. While reductions of many new effluents will have little ultimate consequence, NGETs may unknowingly eliminate some critical environmental problems before we ever learn that such problems exist.

Technology Spillover Effects—Technology Transfer

Finally, research on NGETs can have broad spillover effects that facilitate the development of subsequent NGETs in the same firm, or across an industry. It is widely understood that society's scientific and technological advances provide a stock of knowledge that can be repeatedly drawn on by those seeking new innovations. Early NGETs may have had a relatively sparse base on which to draw. As the body of research and practical experience grows, it will become easier and less expensive for firms to make progress in their particular applications. In addition, innovation in new technology areas can be subject to increasing returns. Scientists and engineers can draw more heavily on the principles and lessons of many NGETs and green chemistries as they become more familiar and proven. Constraints may ease as NGETs become more prevalent. Early research efforts can help create the knowledge and resources to make future projects easier and more likely to succeed. Spillover effects also occur when one firm installs technology eliminating a particular pollutant. Competitors may then be pressured through a variety of forces to at least reduce, if not eliminate, that pollutant.

The importance of spillover effects for the development of NGETs is increased by the wide variety of fields from which these technologies derive. Figure 1 shows how advances in many different scientific disciplines, including biochemistry, bacteriology, genetics, catalysis, mathematics, and electrochemistry, have contributed to green chemistry. Disciplines other than those shown can also play a role. These illustrative connections were generated by the authors, observing patterns of citations in the chemical sciences literature and individual histories of the developments in our case studies. This diversity underlies the great promise of NGETs, but it also stresses the difficulty of bringing together all the potentially relevant information while these technologies and their use remain relatively new and unexplored.

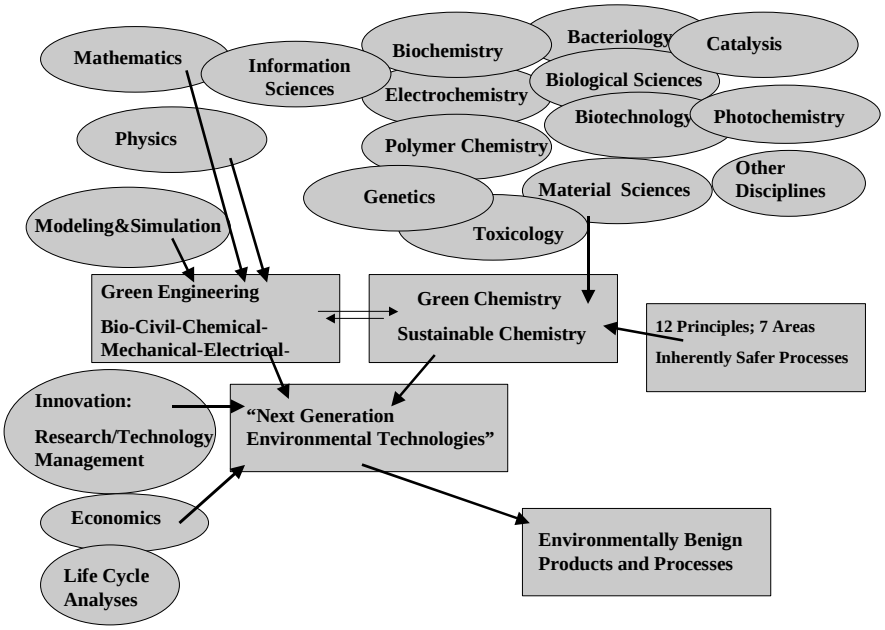

Figure 1. Science and Technology Landscape. (Influence diagram showing the information flow from scientific disciplines to green chemistry and engineering and then to NGETs and environmentally benign products and processes.)