RAND

Next Generation Environmental Technologies

Benefits and Barriers

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Preface

Next Generation Environmental Technologies (NGETs) focus on the redesign, at the molecular level, of manufacturing processes and products so as to reduce or eliminate the use of hazardous materials. The potential for such technologies suggests that they may play an important role in a new approach to environmental protection. NGETs thus raise important policy questions, including the range of benefits such technologies have already provided and may in the future provide and the types of actions commensurate with these benefits that policymakers might take to encourage their development and adoption. This report examines 25 case studies of such Next Generation Environmental Technologies to begin to address such questions.

For readers unfamiliar with NGETs, this study will provide a survey of their promise and weaknesses. For researchers and practitioners creating new NGETs, this study aims to provide a broader context for their efforts. For policymakers, this study aims to provide the raw materials for a systematic assessment of the range of potential benefits of NGETs and the portfolio of policies needed to move them forward.

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Summary

Next Generation Environmental Technologies (NGETs) represent a set of advanced manufacturing technologies that have the potential to produce environmentally benign products and processes. These technologies offer a new approach to environmental protection: Rather than focusing on the cleanup and control of waste and hazardous materials, they involve the redesign of industrial products and processes to reduce the quantity of material inputs required and to eliminate broad classes of environmentally detrimental outputs. When successfully implemented, NGETs offer the promise of substantial new advances in environmental protection often at low cost and even with a net economic benefit. They also raise important policy issues related to the magnitude and importance of the benefits that can be realized and the types of actions that might be taken to encourage their development and diffusion.

This report examines 25 existing NGETs to begin to address these issues. The technologies considered span the range of development from early research to full deployment in profitable businesses. Those that have been commercialized are offering benefits in a variety of areas, including the environment, national security, occupational safety and health, and the economy. Others that are still in various developmental stages offer similar promise.

Most of the technologies reviewed here draw on applications of the emerging science of green chemistry, an important source for NGETs. For each case study, we describe the underlying chemistry, the commercializing firm(s), the incentives that caused those firms to adopt the technology, and the role played by government support. Particular attention is paid to the identification of both near- and long-term benefits as well as to any barriers to technology adoption.

These case studies provide a review of the benefits and problems associated with NGETs. Taken together, they demonstrate the following:

1. NGETs can provide significant benefits to society in all the areas considered in our study: the environment, national security, occupational safety and health, and the economy.

2. NGETs can in some cases eliminate the use and generation of hazardous substances at little or no additional cost.

3. NGETs can be adopted by businesses for a variety of different reasons: to meet environmental regulations in a cost-effective way; to provide environmentally benign products economically; or to develop profitable new products in new and environmentally beneficent ways. NGETs provide new approaches to competitive advantage.

4. The barriers to the widespread use of NGETs can be technical, economic, and/or societal in nature.

This report represents a first step toward assessing the potential benefits of NGETs, reviewing the barriers to their successful deployment and pointing out where government actions have supported their successful adoption. Our case studies indicate that although green chemistry can be a powerful source of environmentally and economically beneficial technologies, its development is still in its infancy. Substantial work is needed both to create new NGETs and to encourage demand for their use. Much also remains to be learned about the basic science and practical application of green chemistry principles.

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The statements and conclusions contained in this report are still the sole responsibility of the authors.

Acronyms

ABS	Aqueous biphasic systems
ACQ	Alkaline copper quaternary
ADPA	Aminodiphenylamine
AND	Adiponitrile
AO	Advanced oxidation
AOX	Absorbable organic halides
API	Active pharmaceutical ingredient
BAC	Benzyl ammonium chloride
Btu	British thermal unit
CCA	Chromated copper arsenate
CDI	Capacitive Deionization
CFC	Chlorofluorocarbon
Cl_2	Elemental chlorine
CO_2	Carbon dioxide
CPA	Chloropropionic acid
DDAC	Dodecyl dimethyl ammonium chloride
DMC	Dimethyl carbonate
DME	Dimethyl ether
DOE	U.S. Department of Energy
DSIDA	Disodium diimindociacetate

ECF	Elemental chlorine free
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
FDA	U.S. Food and Drug Administration
GDP	Gross domestic product
GI	Glyphosate intermediate
GSC	Green and Sustainable Chemistry Network
GSK	GlaxoSmithKline
GWP	Global warming potential
H_2O_2	Hydrogen peroxide
HCF	Hydrofluorocarbon
HF	Hydrofluoric acid
HTI	Hydrocarbon Technologies, Inc.
IBB	Iso-butyl benzene
kg	Kilogram
lbs	Pounds
MCF	Methyl chloroform
MPa	Megapascals
MTBE	Methyl tert-butyl ether
N_2	Elemental nitrogen
NASH	Nucleophilic aromatic substitution for hydrogen
NESHAP	National Emission Standards for Hazardous Air Pollutants
NGET	Next Generation Environmental Technology

NIH	National Institutes of Health
NO_x	Nitrogen oxides
NSF	National Science Foundation
O_2	Elemental oxygen
OECD	Organisation for Economic Cooperation and Development
PAA	Polyaspartic acid
PCE	Perchloroethylene
PDC	Polycrystalline diamond compact
PEG	Polyethylene glycol
PET	Polyethylene terephthalate
PLA	Polylactic acid
PMN	Premanufacture notices
PO	Propylene oxide
psi	Pounds per square inch
R&D	Research and development
RCRA	Resource Conservation and Recovery Act
SCF	Supercritical fluid
SCI	Chemical Specialties, Inc.
SIC	Standard Industrial Classification
SO_2	Sulfur dioxide
TCF	Totally Chlorine Free
TRI	Toxics Release Inventory
VOC	Volatile organic compounds