HUM 321

Engineering Ethics and Environmental Protection

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Engineering and the Environment

Main Ideas:

- The modern environmental movement began in the 1960s and 70s. It has not only influenced law and policy throughout the world but also engineering practice.
- Life cycle analysis (or life cycle assessment) (LCA) is a useful basis for many types of engineering that affect the environment.
- Many formulations of the ideal of sustainability mandate care for the earths resources for the sake of present and future generations and a economic development in less economically developed societies. Business firms exhibit a variety of attitudes toward environmental concerns, but some give evidence of a genuinely progressive attitude.
- The professional virtue of respect for the natural world should be cultivated, because it can motivate environmental concern on the part of engineers. Student members of organizations such as Engineers for a Sustainable World have probably already developed this virtue.

DEVELOPMENT OF THE MODERN ENVIRONMENTAL MOVEMENT

Silent Spring and Earth Day

There is some dispute about how and when the modern environmental movement began, but few dispute that Rachel Carson's Silent Spring, published on September 27, 1962, was one of the early landmarks in the movement. The opening chapter, A Fable for Tomorrow, tells a fictional story of an idyllic community in rural America affected by DDT. The residents lived a wonderful life until a pesticide invaded their world.

ENVIRONMENTAL LAW AND POLICY

Engineering concern for the environment must take into account the framework of the law. Engineers have a self-interested reason to know something about environmental law: to stay out of trouble. But they have a professional reason as well: to frame their work relating to the environment in an appropriate way. In the United States, state environmental law varies from one state to another, so we shall focus on federal law. Here is a brief summary of some of the major themes in federal environmental law in the United States.

Most federal environmental law focuses on diminishing or preventing pollution.

One of the best-known mandates of the law is an environmental impact assessment, which is now required of federal agencies when their decisions affect the environment. The assessment is both complex and comprehensive, covering almost every imaginable way that a project could affect the environment. Contrary to widespread impressions, it covers the impact of a project on both the natural environment and the built environment. It mandates analyses of the impact of a project on air and water supplies and quality, on the production of hazardous wastes, on energy, plants and animals, endangered species, floodplains, coastal areas, geology, and wetlands. It also requires assessments of impacts on historic and archaeological sites, economic issues, neighbor hoods, noise, and traffic.

One other environmental law merits special attention. The Pollution Prevention Act of 1990 established pollution prevention as a national objective. The act requires the EPA to develop and implement a strategy to promote reduction of the pollutants source. This law is in sharp contrast to most environmental protection laws, which simply attempt to manage pollutants once they have been created. This act establishes pollution prevention as the most desirable practice, followed by recycling, treatment, and disposal, in descending order of preference.

Faced with the challenge of interpreting environmental laws, the courts have usually adopted a middle path between extremes. On the one hand, as the famous Supreme Court decision regarding allowable levels of benzene in the workplace shows, safe does not mean risk free. On the other hand, as the 1986 decision of the Circuit Court in the District of Columbia shows, some costs to industry can be tolerated for the sake of environmental protection as long as they are not grossly disproportionate to the level of safety achieved.

International Environmental Policy and Law

Many environmental issues cannot be resolved by individual countries, but require concerted action by many countries and preferably all of the earths people. Examples are population, biodiversity, global climate change, ozone depletion, the fate of Antarctica, pollution of the oceans and threats to marine life, transboundary air and water pollution, and the growth of deserts. Concern for these issues began at the same time that environmental consciousness was rising in the United States.

The modern international focus on environmental issues can probably be dated from the United Nations Conference on the Human Environment, which the United Nations convened in 1972 in Stockholm and which is now annually celebrated as World Environment Day. At that time, Sweden was experiencing environmental pollution coming from other countries. The Stockholm conference emphasized principles such as producing renewable resources and sharing nonrenewable ones, safeguarding wildlife, and producing pollution only to the extent that the environment can clean itself. Another important conference was the United Nations Conference on the Environment and Development, held in Rio de Janeiro, Brazil, in 1992. Among major themes were sustainable development, environmental impact assessment, and the principle that the polluter should bear the cost of the pollution. The World Summit on Sustainable Development, held in Johannesburg, South Africa in 2002, reaffirmed a commitment to sustainable development. Another conference in Rio in 2012 reaffirmed yet again a commitment to sustainable development and also to a green economy.

In addition to these major conferences, the number of multilateral environmental agreements has more than doubled since the Stockholm conference. Developments in international dispute settlement, especially in the field of trans frontier river pollution, have also taken place. Environment-related disputes have also been arbitrated under the General Agreement on Tariffs and Trade (GATT), including a dispute between Mexico and the United States (the Tuna-Dolphin case) and a dispute over environmental damages from the Gulf War.1

Applying Environmental Laws Clean Enough?

The earlier phases of the environmental movement often focused on various kinds of environmental pollution, such as toxins in the earth, air, and water. When rivers were catching fire because of pollution, as the Cuyahoga River in Ohio did in 1969, it is understandable that citizens would have demanded action to clean up the environment. This raises the question of when the environment is acceptably clean a question of great importance in the application of many environmental laws. Several criteria have been offered, all of them having a certain common-sense plausibility. We favor the last one.

(1) According to the ***comparative criterion***, an aspect of the environment is sufficiently clean if and only if it imposes no greater threat to human life or health than do other risks that most people might consider reasonable. This is a defective criterion. It may often be the case that the public does not understand the seriousness of certain risks they accept. Furthermore, data about comparative risks are often difficult to obtain.

(2) According to the ***normalcy criterion***, an aspect of the environment is sufficiently clean if and only if any pollutants present in it are normally present in it to the same degree. However, if the pollutants present in a river or the air are normally present, they could still pose a threat to human and animal health.

(3) According to the ***optimal pollution reduction criterion***, an aspect of the environment is sufficiently clean if and only if funds required to reduce pollution further could be used in other ways that would produce more overall human well-being. According to this criterion, if funds necessary to make the Cuyahoga River sufficiently clean (e.g., by one of these criteria) could be better used to remediate an environmental problem somewhere else, the Cuyahoga River should be left in its present condition. This seems unsatisfactory.

(4) According to the ***maximum protection criterion***, an aspect of the environment is sufficiently clean if and only if any identifiable risk from its pollution that poses a threat to human health has been eliminated, up to the limits of technology and the ability to enforce. This criterion could require all available funds to be spent on a single environmental remediation project if it were serious enough, leaving many other problems unaddressed.

(5) According to the ***demonstrable harm criterion***, an aspect of the environment is sufficiently clean if and only if every pollutant that is demonstrably harmful to human health has been eliminated. Still stronger than the previous criterion, this criterion eliminates not only considerations of cost but also considerations of technical feasibility. It also requires proof of harm to human health, which is sometimes difficult to obtain. The criterion thus seems to be unrealistic.

(6) According to the ***degree of harm criterion***, an aspect of the environment is sufficiently clean if and only if cost is not a factor in removing clear and pressing threats to human health, but when the degree of harm is uncertain, economic factors may be considered. This criterion may suggest the best balance of cost and health considerations and seems to be the closest to the position taken by many court decisions.

LIFE CYCLE ANALYSIS

LCA has many uses. It is often used by business as a basis for a claim that their products are green because they have minimal negative effects on the environment. It is also considered an essential tool in comparing environmental impacts of various products and processes, such as carpet tile versus vinyl tile, or polystyrene versus paper coffee cups, or diesel engines used on a bus fleet driven under urban conditions and diesel engines used in a truck fleet driven mainly on highways. The main goal in the last example was to determine whether it is beneficial from the environmental standpoint to use e-diesel fuels that contain ethanol rather than traditional fuels. In another LCA, steel and plastic packaging were compared to determine which packaging has less environmental impact, what happens to the packaging after delivery to the end user, and what the differences are between packaging in Sweden and the rest of the world.

Many environmentally concerned scientists and engineers believe that merely keeping environmental pollution within what some would consider acceptable limits does not go far enough in protecting the environment. Environment-friendly manufacturing must be based on a determination of the environmental effects of the materials or products being used, as well as the environmental effects of the manufacturing processes themselves. A useful method to this end is life cycle analysis (LCA) also called life cycle assessment.11 LCA is a cradle-to-grave analysis of the environmental impact of a product or a process. It covers the life history of a product or process from the extraction of raw materials from the earth, through manufacture and use, to its final disposal. According to one evaluator of LCA, it is not possible to make rational judgments on the relative environmental impact of various products, or the case for or against their recycling apart from the formal tool of LCA.12

Four Phases of Life Cycle Analysis

1. ***Goal and Scope.*** Defining the product or process, the context of the assessment, the boundaries of the analysis (geographical area, temporal boundaries of the study, and boundaries between this analysis and related life cycles of other systems), and the environmental effects.

2. ***Inventory Analysis.*** Relevant inputs and out puts of a product or process in terms of the energy, water, and materials used and identification and quantification of releases.

3. ***Impact Assessment.*** Identification and quantification of the most significant envi ronmental impacts associated with the product, including resource use, human health and ecological consequences, and greenhouse gas emissions.

4. ***Interpretation.*** Evaluation of the results of the first three phases, along with evaluations of the assumptions made and the degree of uncertainty assumed. The best product or process is then selected.

Despite the need for a tool such as LCA, it has multiple weaknesses.
First, a proper LCA is a long and time consuming process. In the inventory analysis phase, the release of carbon dioxide and other greenhouse gases must be included. The data collection forms must be properly designed, and of course the data must be accurate. Data collection is the most resource-consuming part of the process. In the impact assessment phase, the potential human and ecological effect of the energy, water, and materials that are identified in the inventory analysis must be carefully addressed.

Second, there are many problems with obtaining useful and reliable data for an LCA. Only quantifiable data can be used. Critics argue that the data used in many LCAs can be questioned. Some times the data are obtained from confidential industry sources and are proprietary, so the sources are reluctant to give out full information. Assumptions about the life span of a product are often conjectural. Claims of accuracy are sometimes excessive. For example, some data are given with four decimal places usually far beyond verifiable accuracy.

Third, comparisons one of the most important uses of LCAs are often inconclusive. For example, according to one writer, disposable diapers produce 90 times more solid waste, but cloth diapers generate 10 times more water pollution and consume 3 times as much energy. How should one decide whether disposable or cloth diapers are more harmful to the environment? Despite these weaknesses, LCA is usually considered an essential tool in evaluating the environmental impact of buildings, products, and processes. The limitations, however, should be kept in mind.

SUSTAINABILITY: THE ENVIRONMENT VERSUS HUMAN DEVELOPMENT

Questions about environmental impact include not only questions about environmental damage and pollution but also, ultimately, about the effect on the long-term sustainability of human and nonhuman life. The effect on inanimate nature must also be considered. A major question here is: How can products and processes be improved from the standpoint of their demands on the resources of the earth? This brings us to the vexing and controversial, but nonetheless, vitally important, topic of sustainability.

Several engineering codes also mention the concept of sustainability. The code of the National Society of Professional Engineers (NSPE) says that Engineers are encouraged to adhere to the principles of sustainable development in order to protect the environment for future generations (III, 2, d). The first canon of the code of the American Society of Civil Engineers (ASCE) says that engineers shall strive to comply with the principles of sustainable development in the performance of their professional duties. While neither provision imposes an absolute requirement on engineers (they are merely encouraged or told they should strive), they do indicate a commitment to the ideal of sustainability in engineering work.

What is sustainability? In October 2009, the ASCE Board of Direction defined sustainable development as the process of applying natural, human, and economic resources to enhance the safety, welfare, and quality of life for all of society while maintaining the availability of remaining natural resources. 17 Notice that this definition reveals a tension between a concern for the environment and a concern for human development, a tension that pervades the discussions of sustainability.

The Brundtland definition of sustainable development can be seen as a political compromise between these competing groups and interests. The arguments on both sides have considerable moral weight.

Five Goals for Sustainable Development According to the Brundtland Report

1. Economic growth
2. Fair distribution of resources to sustain economic development
3. More democratic political systems
4. Adoption of lifestyles that are more compatible with living within the planets ecological means
5. Population levels that are more compatible with the planets ecological means.

Several additional comments should be made about the WCEDs definition of sustainable development and the associated goals.

First, one can ask whether sustainability and continued economic development are really compatible. As we have seen, the WCED attempted to combine the need of the developing world for continued economic development in order to raise their standard of living with the necessity of living in a way that is compatible with the limited resources of the earth and the needs of future generations. By combining the ideas of sustainability and development, the WCED implied that it is possible to have both sustainability for the sake of future generations and continued economic development for the sake of underdeveloped countries. Some have denied this possibility, even maintaining that the term sustainable development is a combination of two incompatible ideas.

Let us assume (as is surely the case) that the earth has a limited supply of non renewable resources, such as metals and oil, and that development implies increased use of these resources in order to supply the increasing needs of underdeveloped countries. We might also have to assume that the human population will continue to grow. Given these assumptions, how can development be sustainable? Indeed, how can any continued use of the finite supply of nonrenewable resources be sustained indefinitely?

Second, the reference to controlling population and changing lifestyles is idealistic and difficult to achieve. The best route to combining sustainability for future generations with improving the lot of the worlds poor might indeed be to limit or reduce the human population and to change our consumption-driven lifestyle and our present modes of manufacturing, so that, instead of needing to take new materials from the earth, old materials would be reused. These goals appear highly idealistic at present, but we shall see that some progress is being made with respect to

Third, why are equitable distribution of goods and democratic forms of government necessary for sustainability? As far as sustainability is concerned, what difference does it make whether material goods are given equally to everyone or owned disproportionally by a privileged few? And why might not an authoritarian regime be even more effective in enforcing the principles of sustainability than a democracy? The connection between equity and democracy in our own generation with sustainability for the future is not obvious.

Despite the many issues associated with this classic definition of sustainable development, the goals of respecting the earth for the sake of present and future generations and for economic development, especially for the sake of the poor, have continued to be associated with the concept of sustainable development Perhaps, we should say that there are at least two ideals here, both important, even if not wholly compatible.

THE MORAL CASE FOR SUSTAINABLE DEVELOPMENT

Sustainable development has been embraced by many academic, business, and professional groups. What is its moral foundation? As with many moral issues involving general policies, it is useful to look at the claim from several ethical standpoints.

Before considering these arguments, however, we should make an important distinction. The arguments we consider below are anthropocentric. That is, they are made from the standpoint of the welfare of human beings, whether this be of the poor in developing countries, the more well-off in developed countries, or future generations, whether poor or wealthy. Another type of argument is eco centric, in that it is made from the standpoint of the interests of the natural world, apart from considerations of human welfare. As the quotes around interests indicate, arguments from the eco centric standpoint are generally more controversial and perhaps not appropriate to consider here. Does the natural world have interests, or rights, or is it in some way intrinsically valuable? Without attempting to resolve these controversial issues, we will focus on anthropocentric arguments.

Utilitarian, Respect for Persons, and Virtue Ethics Arguments for Sustainable Development

From the utilitarian standpoint in many of its formulations, future generations of humans (and even animals) should be included with the present generation in the audience over which utility is maximized. If we say that all members of an audience, including future generations, have equal claim to moral consideration, we have an obligation to maximize the quality of life of members of future generations as well as our own, insofar as this is possible. Formulated negatively, we have an obligation not to decrease the quality of life of either present or future generations, in so far as this is possible.

The utilitarian formulation of our moral obligation raises several questions. First, what does this argument imply about the use of nonrenewable resources? If we use any nonrenewable resources at all, we cannot leave as much to future generations as we have ourselves. The utilitarian argument for sustainable development, then, can imply that we should reduce the use of new nonrenewable resources to zero, which may be impossible. Second, how can we know the needs of future generations? To be sure, technological and social developments might so modify the needs of future people that any prediction of future requirements could be wrong. However, we can say with reasonable assurance that humans will always need clean water and air, food, and fuel, and perhaps a few other necessities. Other than this, we can only use our best judgment as to the needs of future humans.

Environmental or Social Collapse?

Some of the classic arguments for environmental concern are indeed utilitarian and anthropocentric. What will happen if the human community fails to adopt some form of sustainable development? Nobody knows what the future holds, but advocates of sustainable development believe that the consequences of not pursuing sustainability might include environmental or social collapse.

The early Malthus believed that the population-food trap was inevitable and would produce horrible suffering, especially for the poor. The later Malthus believed that some factors, such as marrying later and death by disease or war might forestall the inevitable disaster, but only for a time.

A well-known contemporary argument for disaster is provided by Garrett Hardin in his concept of the tragedy of the commons. Consider a village that has a commons area not owned by any individual, which any farmer can use for grazing his cattle. Acting in his own economic self-interest, each farmer puts as many animals on the commons as he can, in order to maximize profit. Eventually, the number of cattle exceeds the carrying capacity of the commons (the optimum number of animals the commons can support) and the animals fail to gain as much weight as before. The farmers respond by putting still more animals on the commons, so that eventually no animals can be supported, and everyone loses.

SUSTAINABLE DEVELOPMENT AND ENGINEERING PRACTICE

Challenges of Implementation

Literal adherence to the goal of avoiding any reduction of nonrenewable resources might severely limit engineering work, since the engineer would only be able to use renewable energy such as wind and solar power to manipulate either renewable material or nonrenewable material already extracted from the earth. Paradoxically, this restraint might have impeded the development of many environment-friendly technologies. For example, manufacturing compact disks (CDs) requires aluminum and gold, which are nonrenewable. Unless the aluminum and gold could have been recovered from material already extracted from the earth, CDs could not have been developed and sold. Yet, CD technology paved the way for more environment friendly technologies that stream music or the spoken word straight to computers, phones, and iPods.24 Whether the less environment-friendly technology could be skipped is doubtful. Engineering practice at the present time, then, will probably depart from what might be called the pure ideal of sustainability. The goal remains, however, to approach this ideal as closely as possible. Here are two examples of increasing approximation to the ideal:

1. **Cradle to Grave**
2. **Cradle to Cradle**

1. Cradle to Grave

According to the classic definition of sustainability in the Brundtland Report, humans should not compromise the ability of future generations to meet their needs. Taken in its most literal sense, this implies that humans must live in such a way that human and other forms of life can live on the planet indefinitely. This implies that, as a minimum, (a) humans must not pollute the earth in such a way that life processes can no longer flourish, and that (b) humans must not consume nonrenewable natural resources in such a way that they are exhausted and not available for future generations. At the present time, neither of these criteria is being satisfied. Contamination of the earth, air, and water continues, and any consumption of nonrenewable resources at all will eventually deplete them, thus threatening future generations. One might argue, however, for using non renewables as frugally as possible until alternatives using only renewable resources can be found, but even in this case, the precautionary principle requires that these issues be thought about now.

The ideal remedy for these problems is clear: Pollutants must be eliminated if they pose any environmental problem, and no additional nonrenewable resources should be extracted from the earth. Instead, those resources already extracted must be reused. This is indeed an ideal, and most descriptions of environmental programs implicitly recognize this by using terms such as minimizing pollution, or becoming more efficient in the use of natural resources, or minimizing waste. From the standpoint of strict sustainability, this is not enough, but we can look at some of the progress made in the direction of what we can call partial sustainability.

Regarding pollution, there are two principal possibilities. Attempts to address environmental problems after the enactment of early environmental laws such as the NEPA were often devoted to controlling contaminants once they were produced. Hazardous substances generated by a manufacturing process were treated as a waste stream that must be contained and treated. A better approach, illustrated by the Pollution Prevention Pays (3P) program discussed later, is to design so that the production of as many pollutants as possible is reduced or even eliminated.

Regarding the use of nonrenewable resources, programs to minimize the use of new nonrenewable resources are often combined with attempts to reduce the material disposed of in dumps (the grave), including toxic substances. This can be done in part by recycling. Old tires can be made into sandals and other products of lower value, and plastic bottles can be turned into park benches. Toxic substances can either be eliminated in the production process itself or removed and perhaps reused before the disposal of the remaining material. Unfortunately, many toxic elements are still put in dumps and may reappear in recycled items. Changing sewage into fertilizers, for example, may not eliminate the heavy metals sewage contains. Furthermore, the down cycling of reused material results in a loss of economic value. Recycled steel may not be appropriate for making new cars, because the recycled steel is mixed with copper and other elements that diminish strength. Finally, many valuable materials are still lost. Dumps are full of copper and other valuable metals. As a result, more nonrenewable materials must be taken from the earth. This approach merely slows unsustainability rather than creating true sustainability.

2. Cradle to Cradle

The procedures discussed above are fundamentally linear, following a product from the extraction of raw materials from the earth to disposal of unused material in dumps or graves. It is probably the approach taken by most uses of LCA.

More visionary approaches attempt to follow natural processes, many of which are circular. This approach, sometimes called cradle to cradle (C2C), is often described as an application of biomimicry. Its advocates say that natural processes, which run on sunlight, are highly efficient, using only the energy they need. Further, nature recycles everything. There is, according to this view, no such thing as waste in nature. Cooperation, mutual dependence, and diversity are everywhere apparent. Although these claims about natural processes can be criticized (e.g., most sunlight is wasted), the approach is highly influential and its adherents claim it should be the basis of true sustainability.

According to architect William McDonough and chemist Michael Braungart, humans dont have a pollution problem, they have a design problem. They design only for the first use of a product, instead of designing for uses after the first product breaks, crumbles, or otherwise becomes useless. Look at a colony of ants. They handle their waste, grow and harvest their food, build their houses out of recyclable material, and make the soil healthier than it would otherwise be. There is no waste. As McDonough and Braungart put it, To eliminate the concept of waste means to design things products, packaging, and systems from the very beginning so that, at the end of a products useful life, the inorganic (or technical) components can be separated from the organic components, the former being upcycled into new products and the latter being returned to the earth for reuse in the natural cycle.

The C2C approach is for the most part still only an ideal, but some manufacturing processes may be approaching the ideal ever more closely. In the manufacture of McDonoughs and Braungarts book, Cradle to Cradle, the paper is a type of plastic and the ink is made of compostable and nontoxic materials. The book can be returned to the earth and decomposed without introducing toxic elements. The authors have also developed an upholstery material that can be thrown on the ground and decomposed when no longer needed.

BUSINESS AND SUSTAINABLE DEVELOPMENT

Three Industry Attitudes Toward the Environment:

The subminimal attitude is associated with minimal compliance with environmental regulations and sometimes with doing even less than what is required. Firms that adopt this attitude often have no full-time personnel assigned to environmental issues, devote minimal financial resources to environmental matters, and sometimes refuse to comply with environmental regulations. If it is cheaper to pay the fines than make the mandated changes, this is what they will do. Managers in this group generally believe that the primary goal of business is to make money and that environmental regulations are merelyan impediment to this goal.

The minimalist or compliance attitude calls for compliance with governmental regulation as a cost of doing business, but their compliance is often without enthusiasm or commitment. Managers often have a great deal of skepticism about the value of environmental regulations. Nevertheless, these companies usually have established policies that regulate environment-related projects.

The progressive attitude: calls for responsiveness to environmental concerns, usually reflecting the personal commitment of the CEO. The companies have well-staffed environmental divisions, use state-of-the-art equipment, and generally have good relationships with governmental regulators. Managers probably believe that it is in the firms long-term interest to go beyond legal requirements, because doing so generates good will in the community and avoid slaw suits. More than this, however, they may be genuinely committed to environmental protection and even sustainability, and have setup units devoted to these policies.

Stages in the Development of an Environment-Friendly Firm:

1. Viewing compliance as a challenge to innovate and complying with the most stringent rules, so as to be ahead of other firms when the more stringent rules are enforced and believing that this approach can give them a market advantage.
2. Designing the firms own products and services to be more sustainable.
3. Requiring suppliers to make their operations more sustainable by methods such as developing more fuel-efficient vehicles and machines.
4. Turning waste and pollutants into valuable products that can be sold for profit.
5. Questioning the implicit assumptions behind products and services and thereby thinking outside the box. (Can we develop water less detergents?)

The CERES Principles

The CERES Principles exemplify the progressive attitude toward the environment.

The following is our summary of the ten principles:

1. Protection of the biosphere. Reduce and make progress toward the elimination of any environmentally damaging substance, safeguard habitats, and protect open spaces and wilderness, while preserving biodiversity.
2. Sustainable use of natural resources. Make sustainable use of renewable natural sources, such as water, soils, and forests, and make careful use of nonrenewable resources.
3. Reduction and disposal of wastes. Reduce and, if possible, eliminate waste, and handle and dispose of waste through safe and responsible methods.
4. Energy conservation. Conserve energy and improve the energy efficiency of all operations and attempt to use environmentally safe and sustainable energy sources.
5. Risk reduction. Strive to minimize environmental damage and health and safety risks to employees and surrounding communities and be prepared for emergencies.

6. Safe products and services. Reduce and, if possible, eliminate the use, manufac ture, and sale of products and services that cause environmental damage or health or safety hazards, and inform customers of the environmental impacts of products or services.

7. Environmental restoration. Promptly and responsibly correct conditions the company has caused that endanger health, safety, or the environment, redress injuries, and restore the environment when it has been damaged.

8. Informing the public. Inform in a timely manner everyone who may be affected by the actions of the company that affect health, safety, or the environment and refrain from taking reprisals against employees who report dangerous incidents to management or appropriate authorities.

9. Management commitment. Implement these principles in a process that ensures that the board of directors and chief executive officer are fully informed about environmental issues and fully responsible for environmental policy, and make demonstrated environmental commitment a factor in selecting members of the board of directors.

10. Audits and reports. Conduct an annual self-evaluation of progress in implementing these principles and complete and make public an annual CERES report.

The 3P Program

Minnesota Mining and Manufacturing (3M) illustrates some of the ideas discussed above. 3M is a firm with 90,000 employees and a list of over 60,000 products to its credit. In 1975, in the early days of the environmental movement, it launched the 3P program. Its goals were to

(1) reduce or eliminate pollution,
(2) benefit the environment through reduced energy use or more efficient use of manufacturing materials and resources, and
(3) save money for the company. This latter goal could be accomplished by being able to avoid or defer buying pollution control equipment, reducing operating and materials expenses, or increasing sales.

Preventing pollution was to be accomplished by eliminating it at its source (in products and manufacturing processes) rather than removing it after it is created. 3M believes that this approach is more environmentally effective and cheaper than eliminating polluting chemicals after they are created. It further believes that this goal can be accomplished by techniques such as reformulating products, modifying processes, redesigning equipment, recycling, and waste recovery. In its first year in its U.S. operations alone, the 3P program produced reductions of 112,000 tons in air pollutants, 15,300 tons in water pollutants, 397,000 tons in sludge/solid waste, and 1 billion gallons in wastewater.

Here are three examples of the way the 3P program works. In a 3M facility in Alabama, both cooling water and waste water were disposed of together and both were considered waste. By recycling the cooling water, the capacity of a planned wastewater treatment facility could be scaled down from 2,100 to 1,000 gallons/ minute. The new recycling facility costs $480,000, but 3M saved $800,000 on the construction cost of the wastewater treatment plant because of the reduction in wastewater from 2,100 to 1,000 gallons/minute. In another project, new equip ment was installed in a resin spray booth to minimize overspray. On a $45,000 investment, the company saved $125,000 on the cost of the resin used the first year alone. In a 3M plant in St. Ouenl Aumone, France, employees installed a new decking system in the trucks that transport finished products from the facility. The decking system allowed one truck to carry two levels of load without stacking the pallets on each other and damaging the products. Daily truckloads from the facility were reduced by 40 percent, saving about 12,500 gallons of fuel and $110,000/year.3

3M has framed a new set of goals to be realized in the decade from 2015 to 2025. Among the goals are developing more sustainable materials and products, reducing manufacturing waste by an additional 10 percent, attain zero landfill status at more than 30 percent of its manufacturing sites, indexed to sales, reduce global water use by an additional 10 percent, indexed to sales, and increase renew able energy to 25 percent of total electricity use. From 1975 to 2015, the 3P pro gram eliminated the production of 2 million tons of waste and saved $1.9 billion.

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Thank you