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An Introduction to EPA's Design for the Environment Program

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ABSTRACT- This article provides an introduction to efforts aimed at designing products, processes, systems, and technologies with environmental objectives as a priority. It describes the efforts of EPA's Design for the Environment Program to inform and reduce obstacles to private sector environmental design initiatives.

I. INTRODUCTION

In today's competitive trade environment, a company's ability to respond to sophisticated customer demands for environmentally preferable products and react to complex environmental rules and regulations can mean the difference between a firm's ultimate success or failure. In the future, substantial opportunities will exist for companies who can design high-quality, environmentally sound products. Such efforts can create jobs and provide a comparative advantage in the international marketplace.

Previous methods of dealing with environmental problems, largely by controlling pollution through "end-of-the-pipe" regulatory approaches, have been expensive and often less effective than hoped. With the advent of pollution prevention philosophy, many firms have begun directing their environmental efforts earlier in the production cycle; from clean-up and control technologies, to better management of manufacturing processes, to reuse, source reduction, and ultimately to the very design of their products.

The design stage is the most critical and effective time to address the environmental impacts of a product. The National Research Council has estimated that approximately 70 percent of the costs of a product's development, manufacture, and use is determined in the initial design of a product, making design a crucial determinant of a product's competitiveness [1]. In addition, the design phase affords the greatest amount of flexibility in choosing everything from raw materials to manufacturing technique. Decisions made at the design stage affect a product's impact on worker and consumer safety, the risks and releases to human health and the environment, and the characteristics of waste streams. [2]. Given the flexibility of the design stage, it is logical that private sector efforts to "Design for the Environment" will be increasingly important to environmental efforts in manufacturing.

II. BACKGROUND

The term "Design for the Environment" (DFE) means many things to many audiences. To the manufacturing sector, DFE is most commonly viewed as an adaptation of the "Design for X" (DFx) concept. In DFx, a desired product characteristic (i.e., safety, durability) is integrated as a goal into the design process. In DFE initiatives, therefore, environmental considerations become an integral part of the design of a product.

A. Industrial Ecology

Many DFE concepts have evolved out of the field of Industrial Ecology (IE). Industrial Ecology, introduced to the general public in 1989 by Robert A. Frosch and Nicholas E. Gallopoulos [3], is a discipline that promotes a cyclical model of manufacturing in which resources are efficiently used and re-used. This contrasts with the traditional linear model of manufacturing, in which material are extracted, used in production, and then discarded. Industrial Ecology, on the other hand, seeks to emulate natural systems so that materials and energy are used and recycled efficiently in ecological cycles.

The basis for Industrial Ecology is actually not new. For years engineers have looked to nature to aid in making man-made systems work better. One example is found in helicopter design; dragonfly hovering mechanisms have been studied meticulously in order to improve the hovering ability of modern helicopters [4].

In the 1970s, designers began calling for a broader look at how organisms interact in natural systems in a way that is, "less concerned with the form of parts or shape of things, but rather with possibilities of examining how nature makes things happen." [6] Distilling business lessons from ecosystems became the goal since many consider nature to be a, "great repository of wisdom about efficiency, adaptation, competition, and sustainability." [7]

B. German Legislation

Interest in Industrial Ecology and DFE initiatives has become more pronounced following the adoption of German legislative measures which require manufacturers and retailers to collect and recycle packaging for a wide range of products. Firms will have to recycle 80 percent beginning in 1995. As a result, many product manufacturers are redesigning their products with disassembly and recyclability as design goals.

Probably the most well-known example of this type of effort is in the automobile industry. In 1988, BMW introduced a limited production edition of a two-seat roadster which can be quickly disassembled. The car's plastic body panels are coded for easy recycling [8]. Although BMW is furthest along in designing for the recyclability of its automobiles, some domestic car manufacturers (such as Ford), as well as other foreign auto manufacturers (i. e., Toyota and Volkswagen) hope to introduce recyclable cars in the near future.

C. The Montreal Protocol

Major redesign efforts in international manufacturing have also been initiated as a result of the Montreal Protocol of 1987, a treaty which requires industrial nations to discontinue production and use of most CFCs by 2000. Drastic reductions in world CFC production have challenged industries which utilize CFC's to redesign their products and processes, in some cases to yield even better products. For example, new (CFC-free) gas-fired air-conditioners may prove more economical than current models.

D. Designing for One Environmental Consideration

In cases of impetus provided by German legislation and the Montreal Protocol, design efforts have focused on addressing only one particular environmental consideration. While these redesigned products may create less waste or possess a reduced ozone depleting potential, their overall environmental impact has not been evaluated and they may create other significant environmental impacts. For example, a car designed for recyclability may create hazardous waste while in production. In addition, caution must be exercised to avoid transferring an apparent reduction in pollution to a greater impact elsewhere. [8]

E. Broad Interpretations of "Design for the Environment" Efforts

There are numerous examples of what could be deemed "Design for the Environment" work, underway in sectors other than manufacturing. While traditional manufacturing audiences concern themselves with the design of a particular product or process, to others, DFE can mean a whole variety of ambitious projects that capitalize on the broadest interpretation of what "design" and "environment" mean.

One example is the soon-to-open Denver International Airport. This project was designed to employ numerous energy conservation, water conservation, air pollution prevention, waste reduction, and recycling measures in the facility. [9]

Kruger National Park in South Africa has also been featured in numerous publications because of the environmental design and planning that went into developing it. The park was designed for functionality, so that visitors can participate in all desirable activities, yet adverse impact on the land is minimized as much as possible. [10]

Other examples are plentiful. The design of energy conserving houses, integrated pest management systems, and even "environmentally sustainable" communities are also in the spirit of what many would consider "Design for the Environment" efforts. These projects have all achieved some degree of success and are good examples of results that can be achieved by objective driven design planning.

Many of these ambitious design initiatives are forced to make decisions based on incomplete information because of the lack of environmental impact data on many materials, chemicals, and processes and because of a lack of time and money. Later it may become evident that these design choices have created other significant environment impacts. While such projects are important models because they test a number of assertive hypotheses, there is also a crucial role in examining the seemingly obvious "environmental answers." Alternatives are rarely as simple as they seem and the amount of environmental data which should be incorporated into design decisions is substantial.

F. Caution in Defining what is DFE

It is important to be cautious when using the term "Design for the Environment" in its broadest context. One of the reasons we continue to grapple with today's environmental problems is the, "consistent failure on the part of the public, regulators and industry to think of the environment as a complex system, rather than just a few relatively independent media" [11].

If used in a broad and simplistic way, DFE can be used to justify almost any efforts, even those that are not in the best interests of environmental preservation. If no control is used in defining the term, DFE can simply add to false environmental marketing claims.

G. Obstacles to DFE

Growing concern for environmental issues on the part of the public has fueled industry and academic efforts to develop ways to incorporate environmental objectives into decision making. A variety of approaches to evaluating options has emerged, for example, life cycle analysis, pollution prevention audit guidelines, and efforts to design for a specific endpoint such as recyclability or CFC substitution.

While much has been accomplished through these developments, obstacles to implementing pollution prevention schemes and to systematically evaluating alternatives continue to hinder private sector efforts. Studies evaluating alternative products, technologies and processes have been hampered by lack of comparative risk information, lack of a method for comparing unlike risks and lack of a method for integrating risk, performance and cost information into a decision-focused system.

In addition, many barriers to DFE are institutionalized in current business practices. For example, the organization of financial data in a company may make it impossible to adequately characterize the regulatory and environmental costs of producing a product.

III. EPA's DfE PROGRAM

A. The DfE Program's Role

The Design for the Environment (DfE) Program in the Office of Pollution Prevention and Toxics (OPPT) has been created to apply EPA's expertise and leadership to inform and facilitate pollution prevention efforts. It harnesses the expertise for which OPPT is best known: comparative and multi-media risk analysis, methods for evaluating alternatives for risk reduction, knowledge of regulatory requirements, and outreach to industry and the public on pollution prevention topics.

The DfE Program focuses on areas it is most familiar with: pollution prevention efforts and environmental risk areas. Thus, the DfE Program promotes the incorporation of environmental considerations, and especially risk reduction, in the design and redesign of products and services. The Program works on a voluntary basis through partnerships with industry and the public formed to apply EPA expertise to specific issues. It builds on the spirit of voluntary EPA programs like Green Lights and the 33/50 Program.

B. Levels of Involvement

The DfE Program has initiated a number of wide-ranging projects which operate through three levels of involvement:

- Infrastructure projects are the broadest in scope and aimed at changing aspects of general business practices in order to remove barriers to behavior change and to provide incentives for undertaking environmental design and pollution prevention efforts.

- Industry projects are joint efforts with trade associations and businesses in specific industry segments to evaluate comparative risks, performance and costs of alternatives and to invoke behavioral change.

- Facility-based program activities will help individual businesses undertake environmental design efforts of their own through the development and application of specific methods, tools, and models.

C. The Need for a Substitute Focus

As regulatory pressure has increased and private sector efforts to go beyond mere compliance have multiplied, there has been a demonstrated demand for information on substitution as a method of achieving pollution prevention. For example, the DfE Program recently received a call from an Air Force Base engineer who was looking for an alternative for toluene in rubber molding. Similar questions are posed on a daily basis at EPA's Pollution Prevention Information Clearinghouse (PPIC).

Case studies available through many sources, including PPIC, provide some helpful process modification information and may direct inquiring companies to leads on alternatives. However, there are significant barriers to behavioral change because information is often missing or fails to be organized in a decision-focused format. The DfE Program is structured to address these problems.

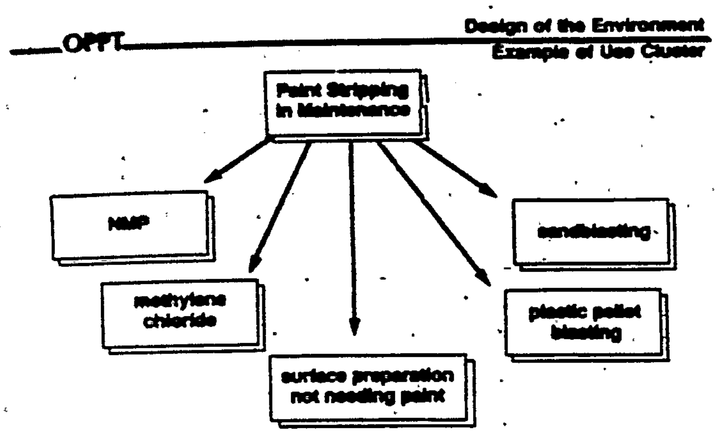
IV. ANALYTICAL TOOLS USED IN EPA's DfE PROGRAM

A. Use Clusters

The DfE Program has developed a methodology for examining substitute chemicals, processes, and technologies. This methodology is currently being applied in the DfE Program's Cooperative Industry Projects. Each project has identified, with the help of industry partners, problem environmental areas for which companies would like to seek substitutes. Existing risk ranking systems can help prioritize problem areas.

Through a process of collecting information on currently existing alternatives and through a search for other promising options, the DfE Program lists all alternatives in a "use cluster tree" for chemicals, processes, and technologies that can substitute for one another in performing a particular function.

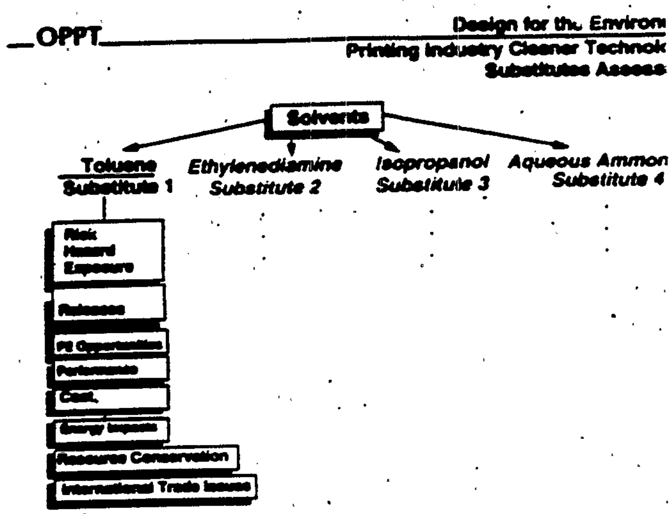
Sometimes, alternatives are not at all similar. For example, the paint stripping function in maintenance applications can be accomplished through the use of chemical solvents such as methylene chloride and NMP, or through alternative practices such as sandblasting and plastic pellet blasting, or can even be avoided all together by using a surface preparation not needing paint.



Drop-in substitutes tend to be rare. Therefore, it is essential to systematically compare the trade-offs associated with different alternatives. EPA's DfE Program has developed a format, to help direct these types of efforts, based on OPPTs Risk Management review for existing chemicals.

B. Substitutes Assessments

Cleaner Technology Substitutes Assessments, or CTSA's for short, are intended to provide a flexible format for systematically comparing the trade-off issues associated with alternatives. Traditional trade-offs such as cost and performance are brought together with environmental trade-offs including comparative risk, releases, energy impact and resource conservation for each alternative. A completed Substitutes Assessment should provide all the information that a designer needs to decide among alternatives.



Too often in the past alternatives have been adopted without an attempt to assess the impacts that the change will bring. Companies also cite numerous anecdotes in which they have switched from a regulated chemical, only to find the alternative is regulated a few years later. By considering the trade-offs associated with alternatives through a systematic format such as the CTSA, such problems may be avoided, anticipated, or at least minimized. Developing answers to these problems will be an ongoing process and will occur as the EPA's DfE Program addresses specific application problems.

The CTSA is a flexible tool. It fits many types of issues and provides an outline of information needs which incorporate pollution prevention, life cycle analysis, and DFE principles, rather than traditional end-of-pipe pollution control strategies into courses in engineering, business, and natural resources.

C. Alternate Synthetic Pathways

The moment that a chemist puts pencil to paper to design how to make a chemical product, he also decides whether or not that process will use or generate hazardous substances that need to be treated, recycled, transported, or disposed. Many of the traditional synthetic pathways that are used to create high volume industrial chemicals utilize toxic feedstocks, catalysts, or create hazardous and toxic byproducts. The EPA is working to encourage University research into alternative methods for producing many important chemicals which minimize or eliminate hazardous substances, first by awarding six grants and now by working with the National Science Foundation to a award additional grants. The results of this research will provide the chemical production industry with important tools to reduce risk and prevent pollution.

D. Insurance Project

Incorporating pollution prevention principles into the day-to-day practices of insurance underwriters, insurance brokers, and corporate risk managers could provide significant opportunities to stimulate voluntary changes in many businesses and industries. In the short run, the EPA has entered into a cooperative effort with the American Institute of Chartered Property and Casualty Underwriters (AICPCU). AICPCU is a non-profit, independent organization offering educational programs and professional certification to people in the property and liability insurance business. The Institute offers a broad array of certification programs for insurance underwriters and brokers, and corporate risk managers. EPA is working with AICPCU to modify the curriculum for the associates in Risk Management (ARM) program to incorporate pollution prevention into their certification program.

VII. CONCLUSION

A. Challenges still ahead

Large challenges still exist to widespread adoption of environmental design initiatives in the private sector. EPA's DfE Program has developed the Substitutes Assessments methodology in an attempt to lay out environmental issues that should be integrated into design decisions and also to provide a model for examining substitutes in a systematic fashion. Although organizing the information in this manner will highlight some desirable choices, due to the complexity of the trade-off issues involving risk, performance, and cost (which will vary from facility to facility), it will generally not prescribe one alternative. This method, however, makes all of the decision factors visible so that decisions can be made with full knowledge of available information and of the uncertainty of some of that information.

Companies have a challenge to identify priority areas of environmental concern and to change the mindset of upper management and design engineers so that a search for alternatives in problem environmental areas becomes a priority.

B. Moving in the right direction

While many challenges still exist, the EPA's DfE Program is working to provide concrete examples for how a company can design its products and services with the environment in mind. Efforts to change the institutional business infrastructure that supports such efforts are also an important direction in which the Program focuses.

C. Opportunities for DfE

Many American industries are driven by ever-changing technology. Survival in these competitive industries is now mandating that firms design flexible products which satisfy varying applications and consumers. In addition, production methods are becoming more flexible to accommodate new technologies, products, and manufacturing techniques. High technology areas such as electronics, computers, and automobile manufacturing are particularly well suited for DFE efforts.

Other sectors, such as dry cleaning and printing, require change much less frequently. In these cases, DFE efforts are actually attempts to <u>re</u>design products and processes. Yet, even in slower changing sectors, many companies are facing growing pressures to dramatically change their products and services.

Substantial opportunities exist for companies who can design high-quality, environmentally sound products. Those companies which are able to integrate environmental objectives in the earliest design stages of their products will profit from savings through regulatory compliance, marketing advantages, and increased competitiveness. EPA and the DfE Program are working with industry partners to realize these opportunities.

can be supplied in greater or lesser depth (or even left out) depending on the specific example under consideration. The document lays out the trade-offs and highlights missing information. The missing pieces can be used to design data collection efforts or simply to inform companies about the degree of uncertainty surrounding the choices.

D. Relative Risk Ranking

Many companies find that quality information about the relative risks of chemical alternatives is difficult to access and understand. OPPT along with many companies, defense contractors, federal agencies, and other offices within EPA have developed computerized risk ranking systems. The DfE Program is working to bring all major players together in workshops aimed at standardizing the approaches.

Publicly accessible computerized relative risk ranking can provide a powerful tool for DFE efforts. It can help prioritize problem environmental areas where a search for alternatives may be necessary. In addition, it can provide preliminary comparative risk information about different alternative chemicals that might serve as substitutes.

V. COOPERATIVE INDUSTRY PROJECTS IN EPA's DfE PROGRAM

Many difficult issues such as how to compare unlike risks, how to calculate the risks of mixtures, how to weigh risks in different media, and how to compare chemical and process change options still exist.

The DfE Program is presently working with three industry segments who are already reevaluating their current production and working practices.

These projects are working to apply the methodology described above to specific use cluster areas and, through practical application, will address many of the questions that must be worked out in applying this methodology. Current cooperative industry projects include:

- Computers and Electronics
- Printing, and
- Dry Cleaning

The DfE Program also hopes to establish working relationships with other industry segments.

VI. THE DfE PROGRAM'S INFRASTRUCTURE PROJECTS

Another major goal of EPA's DfE Program is to break down institutionalized barriers to DFE efforts. A number of projects have been initiated for this purpose:

A. Capital Budgeting and Environmental Accounting Project

Every business collects information for its own internal decisionmaking, eg., cost and pricing decision, (managerial accounting) and to provide to external audiences such as bank stockholders, creditors, bankers, and government (financial accounting). Every business also must decide how to invest its available capital in new equipment and products.

At present, many cost accounting systems and capital budgeting processes do not provide enough information to business managers to make optimal decisions in increasingly competitive global markets. In the environmental arena, for example, part or all environmental costs for treatment, disposal, and administration are often allocated to overhead cost polls which in turn mask the true environmental costs of a particular product or process. Potential future liabilities may not be accounted for at all.

As long as this and other cost information is hidden from managers, costing and pricing decisions will underestimate the costs of some products and overestimate the costs of others. Managers face a similar lack of information when they evaluate investment alternatives in new equipment and products. Without adequate information to include in the financial analysis of capital investments, and given problems in the methods of analysis, managers will not see the advantages of investments that prevent pollution and minimize environmental impacts. EPA's DfE Program seeks to promote the design and development of better accounting and capital budgeting practices within firms' managerial accounting systems.

B. Curriculum Development

EPA recognizes that many of today's companies have trouble implementing pollution prevention and DFE efforts because their employees have not been educated or trained with these objectives as a priority. To begin to fill this academic vacuum, the EPA has established the National Pollution Prevention Center at the University of Michigan. The Center is developing curricula in multiple disciplines (ie. business, accounting, marketing) which

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