INCORPORATING POLLUTION INTO U.S. DEPARTMENT OF ENERGY DESIGN PROJECTS: CASE STUDY RESULTS AND PARTICIPANT FEEDBACK

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INTRODUCTION

Pollution prevention seeks to eliminate the release of all pollutants (hazardous and non-hazardous) to all media (land, air, and water). Beyond eliminating pollution at the source, pollution prevention includes energy conservation, water conservation, and protection of natural resources. Therefore, pollution prevention addresses not only wastes exiting a process, but materials entering and being consumed by the process as well. Historically, pollution prevention activities within the U.S. Department of Energy (DOE)\(^6\) have focused on existing process waste streams—the Pollution Prevention Opportunity Assessment (P20A) being the central tool for identifying and implementing pollution prevention opportunities.\(^1\)

However, it is estimated that 70% of a product's total lifecycle cost is fixed by design (i.e., before the product, process, or facility ever gets built).\(^2\) By moving pollution prevention upstream into design, new opportunities emerge for minimizing waste not only during operations, but during construction and dismantlement of a facility as well. This is significant because it is estimated that the environmental consequences from construction of a building are comparable to a decade of operating the building, and demolition creates even more waste than construction.\(^3\)

In recognition of this opportunity, the DOE has funded contractors at the Hanford Site to address incorporation of pollution prevention into the DOE design process. One of the initial and ongoing activities associated with this project has been tracking of trends in design for environment (DfE) and related approaches that might apply toward DOE design projects. Although reference to DfE concepts appeared in engineering texts as early as 1962, the modern DfE movement is in a relatively undeveloped state because very few design methodologies specifically address environmental issues.\(^4\) Most work in this area has been on planning and tool development rather than implementation of pollution prevention practices on actual design projects. Furthermore, most of the work has been developed by private industry, and therefore focuses on consumer product development rather than the types of facilities or processes being designed within the DOE system. Current DOE designs range from typical office buildings, to large-scale research laboratories and process-intensive environmental restoration and waste handling facilities.

Because of the lack of available tools and guidance, the Hanford Site has developed a three-legged stool approach to assist DOE design projects with implementing pollution prevention: 1) Training, 2) Tool Development, and 3) Policy and Procedure Review. The rationale for this approach is that 1) engineers and project managers need to understand basic pollution prevention concepts and techniques before they can integrate them into their own design projects; 2) once they understand pollution prevention, they need tools and methods to guide them; and 3) design policy and procedure needs to be reviewed to remove barriers toward implementing pollution prevention and to provide reference to available tools and information.

During 1993, Hanford contractors addressed the training leg of the project by developing an Orientation to Pollution Prevention for Facility Designers training course.\(^5\) The course provides introductory

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materials and a checklist of specific pollution prevention design opportunities for engineers, project managers, and designers. In 1994, the checklist was developed into a software prototype called the Electronic Design Guideline (EDG). In addition, a guidance document for conducting P2OAs during design was developed. Finally, a review of DOE policy and procedures was conducted to recommend changes to facilitate the eventual integration of the software and Pollution Prevention Design Assessment (P2DA) guidance into the existing DOE design process. The focus during 1995 will be on deploying the software, training, and guidance materials across the DOE complex.

This paper addresses some of the early lessons learned in developing these products for the DOE design community, and specific feedback provided by case study participants and usability testers of the prototype tools and training. The discussion will include the current status of each of these products, user feedback and case study results to date, and future plans as a result of the feedback. It is hoped that the reader can apply this feedback to their own programs to address pollution prevention during design.

TRAINING

Current Course Offering

An Orientation to Pollution Prevention for Facility Design training course was developed for the DOE, Office of Environmental Management, Waste Minimization Division (EM-334). The three-hour course is currently being offered at the Hanford Quality Training and Resource Center, with plans to transfer the training to other sites in 1995. The course, intended for design engineers and project managers, contains two modules. The first module defines pollution prevention using actual success stories to illustrate pollution prevention concepts, benefits, and their relationship to design, and the second module presents a newly developed job aid, the Pollution Prevention Design Guideline.

This course is designed so that participants can answer the following questions. Module 1 of the course addresses the first four questions and Module 2 provides a solution to the fifth question.

1) What is pollution prevention?
2) What are the incentives for pollution prevention?
3) When does pollution prevention need to be considered during the life of a facility?
4) Who is responsible for pollution prevention?
5) How do I go about preventing pollution during the design of a facility?

The main challenges of developing a pollution prevention design course were to present the material in a manner such that participants would understand the incentives and would therefore want to design for pollution prevention, and to subsequently provide tools so that participants could design for pollution prevention. To get the participants involved personally, the course is very interactive and uses a variety


of presentation techniques. Participants are challenged to discuss the course materials in the context of their own design projects, and they practice using the course materials on an actual design project.

The course design was a collaborative effort between engineers and training specialists. This pairing was specifically done to ensure not only that the course content was sufficient and accurate, but also that the instructional methodology was appropriate to the objectives of the project.

**Feedback from Course Participants**

One measure of the course's success is the extent to which the participants bring the materials back to their workplace. An attitudinal survey and a knowledge-based questionnaire are administered before and after the course to gauge this. In addition, a traditional course evaluation form is provided after the class to determine the techniques that are most effective and to allow the participants to make additional suggestions for improvement. During 1994, 25 engineers received the orientation training: 63% said that the course would be helpful in their job, 88% said that they would recommend the course to anyone involved in facility design or modification, and 75% said that they liked the course as it currently stands. No one provided specific recommendations for improvement, but several made general comments. The course emphasizes that pollution prevention is related to many of their current design practices, and comes down to basic good engineering practice. One participant commented that this was well-emphasized and perhaps the most important point the course can make. Another participant commented that it was a good course for reminding engineers of all the downstream stakeholders who will use or work with their product in the future.

**Future Plans for the Training Course**

The training course will be updated this year to include some of the tools and information being developed by the other tasks in DOE's project to incorporate pollution prevention into design. For example, the EDG software and P2DA guidance document (both discussed in later sections of this paper) will be added to the existing course materials. In addition, specific design successes from actual use of these tools on a case study basis will be added, as will a bibliography for further reading, and other design for environment materials and information.

Once the course is updated in Spring 1995, other sites throughout the DOE complex will receive training on how to initiate a similar course at their own site. This training will use the Hanford course as the basis, but will include specific suggestions for identifying and targeting the types of design projects specific to each site.

**DIE SOFTWARE AND GUIDANCE DOCUMENTS**

**Current Tools Available**

In 1994, the project developed two tools for DOE design personnel to use to incorporate pollution prevention into their projects: 1) the P2DA guidance document, and 2) the EDG software. The EDG, in conjunction with the P2DA guidance document, are designed to be used on a project-by-project basis. The P2DA process is analogous to the Waste Minimization Assessment method established by the U.S. Environmental Protection Agency for existing process waste streams. The EDG is introduced during the stage of the P2DA when design alternatives are being explored (after the anticipated waste streams have been quantified). As such, the EDG database is not exhaustive, and it is not computational (i.e., it does not compute the lifecycle impacts of implementation). It is merely intended to raise awareness of, and
provide a template for documenting existing technologies and design practices that can improve resource efficiency or decrease waste generation over the entire life of the project (construction, operations, and decommissioning). Because design is an iterative process, the EDG and P2DA guidance are also intended to be used iteratively, being revisited with each successive design stage.

**P2DA Guidance Document.** The purpose of this guidance document is to provide a framework for project managers, engineers, and designers to integrate pollution prevention principles and features into DOE design projects. The framework suggested is referred to as the pollution prevention design assessment. The P2DA is based on DOE's method for conducting P20As on existing waste-generating operations, but is modified to account for the fact that the facility or process does not physically exist yet.

Before the P2DA framework is introduced in the manual, recommendations for establishing the P2DA team and budgeting for the P2DA are provided. The P2DA framework outlines the following five-step process:

1) Identify and quantify waste streams anticipated during construction, operations, and closure/dismantlement of the process or facility being designed.

2) Prioritize streams, set boundaries, and establish goals for the remainder of the P2DA.

3) Identify Pollution Prevention Design Opportunities (P2DOs).

4) Analyze design alternatives.

5) Implement selected P2DOs and document results.

Specific pollution prevention requirements and opportunities for each design stage as delineated in DOE Order 4700.1, *Project Management System* are also discussed and a sample format for drafting a P2DA report is provided in the appendix.

The scope of this manual includes not only the P2DA framework, but also a background discussion of pollution prevention and related topics, the regulatory requirements mandating design for pollution prevention, the benefits and barriers of designing for pollution prevention, and the impact that pollution prevention and related environmental avoidance concepts have had on the engineering profession. Background information is provided to relate pollution prevention and similar avoidance concepts to the underlying principles of engineering design. The purpose of providing this information is to emphasize that pollution prevention should permeate all aspects of engineering practice. As this ideal situation is realized, the need and effort required for a separate P2DA for each design analysis will diminish.

**EDG Software.** The purpose of the EDG software is to provide specific information to project managers and others about pollution prevention opportunities that may apply to their design projects. For use in tracking this information for a particular facility or project, the EDG was designed to allow the user to respond to each opportunity and create a summary report.

The EDG contains a database of 267 opportunities to incorporate pollution prevention features into DOE design projects. Each opportunity provides supporting data that help the decision maker (designers, engineers, and project managers) evaluate the applicability and potential benefits of implementation on
their particular project. The EDG's database was derived from both DOE and non-DOE sources, including pollution prevention literature; industrial design personnel; and federal, state, and DOE sources. A key feature of the tool is the integration of photos, illustrations, and documentation to provide easy access to technical information on specific waste minimization opportunities in design.

The pollution prevention design opportunities in the EDG database are sorted first into the 16 divisions of DOE Order 6430.1A, *General Design Criteria,* then further sorted by the hierarchy established in the Pollution Prevention Act of 1990, source reduction, recycling, treatment, and environmentally safe disposal. The divisions of DOE Order 6430.1A are based on the Construction Specifications Institute Masterformat system, and are therefore organized similarly to specifications developed on commercial design projects.

For each opportunity examined, the user indicates on the computer screen whether/how the opportunity will be considered for the current project. Additional remarks are requested so they may be recorded for later documentation. To help the user assess whether or not the opportunities listed are applicable to the current project, additional information is displayed at the right of the screen. More information (examples or references) is found by clicking on one of the buttons in the bottom right corner of the window.

The user interface of the EDG was designed to be quickly learned and easy to use. The user merely clicks the mouse on objects displayed in windows to make selections, to navigate between windows, or to sequence through information displayed on the screen. The functions found in the pull-down menus include file menu operations such as creating a new analysis, loading or saving an analysis, and producing a report; navigating among the 16 divisions; searching for key words in the EDG database; navigating between the EDG windows; and using context-sensitive help.

**User Feedback on Prototype Tools**

During 1994, eight actual DOE design projects used the prototype EDG and draft P2DA document on a case study basis. The eight projects ranged in size from a $1 million reconfiguration of an existing foaming process at a manufacturing facility, to a new major systems acquisition, the Advanced Neutron Source project (ANS). The ANS project entails design of several buildings including a thermal reactor and containment building, and office buildings for researchers and operations staff. In addition to size, the eight projects also represented a variety of design stages ranging from pre-conceptual to definitive design, and were located throughout the country.

Beyond the eight case study projects, the EDG software underwent additional usability testing by pollution prevention subject matter contacts on the Hanford Site, and was the subject of a focus group meeting held in Seattle, Washington, with potential private sector users. The purpose of the focus group was to gage the market potential for transferring the software to non-federal users.

**Case Studies and Usability Testing.** Overall, the case study participants did not use the tools at the level of detail for which they were intended; therefore, valuable feedback was received on the overall concept and usability, but no quantitative data on the P2DA or specific examples of opportunities implemented through the use of the EDG were provided. The tools were not used as intended because the case study exercise did not last long enough, and many of the volunteer participants had other obligations that prevented their full participation.
The predominant feedback from case study participants and usability testers focused on performance/speed of the software, rather than content. Participants indicated that the EDG stimulated thinking and that it was easy to use. Some found that they had anticipated most of the items presented in the database, however, there were many good "idea joggers." Another comment was that input by more than one person is typical of a construction project, so it would be nice if the software were able to support input from multiple users and merge data files.

Overall, participants felt that the prototype software was an innovative product, but that it needed additional development work, including a more descriptive front end on the intended use of the tool, and a mechanism for providing a more channelled path for navigating through the database.

**Focus Group with Potential Private Sector Users.** Development of a version of the EDG for possible private industry application is under consideration. The database has examples that apply to commercial facility design, but much of the context and terminology has a DOE flavor. Results of a focus group (held in November 1994) with architectural and industrial firms suggest that a richer database and terminology relevant to commercial and industrial application will be required, as well as the capability for user's to add their own data to the EDG database.

The focus group participants said that they would use the current version of the software, but mostly for public relations to show their customers what they are doing to be "green" by design. They would want to see more functionality before they would actually use it as a design tool. They also seemed to think—that the concept was a little bit ahead of its time. That is, they are not yet feeling pressure (regulatory or otherwise) to use such a tool in their design process.

Overall, the focus group participants thought the software was intuitive to use. It provides a good template for tracking pollution prevention features implemented (or not implemented and why), but they thought the database behind the template seemed spotty. The participants wanted the software to be able to compute lifecycle costs and to have a more clear treatment of operating and maintenance costs of selected opportunities. However, the EDG software is not intended to be computational. It is intended to raise awareness and provide specific examples of pollution prevention design opportunities. The user must then compute the cost and benefits of implementation specific to their project circumstances.

These comments were not a surprise to the EDG development team because the EDG software is still a prototype, developed for DOE audiences (and not explicitly the private sector). It was intended to raise pollution prevention design awareness rather than provide computational support of DOE decisions. Even so, the exercise of soliciting feedback from the private sector was valuable in determining what needed to be added for improved functionality before deploying the software to the DOE community, as well as what potential future directions the software might take to make it marketable to the private sector.

**Future Plans for Finalizing and Deploying the Tools**

In 1995, the P2DA guidance document will be distributed throughout the DOE complex, and the EDG prototype software will be finalized for widespread distribution to the same network of DOE design projects as the P2DA. Finalizing the software will include quality assurance and testing, updating the user's manual, and optimization for increased speed. The specific features that will be added to the software include

- an introduction module to make the EDG more integrated with the P2DA process and orientation training.
a function to filter only applicable opportunities for the user to view based on project definition data

an option for printing the database of opportunities or seeing the list of opportunities on-screen

a function to support the user's ability to add/delete one's own opportunities

POLICY AND PROCEDURES

The complex system of environmental laws that has evolved over the last 20 years has influenced the attributes of new products, but generally the effect has been indirect. That is, the laws themselves do not contain explicit design requirements, but the regulatory climate created by the laws has motivated design changes for other reasons such as cost and public perception. At the same time, environmental laws have been implicated in interfering with innovative design for pollution prevention because they are too prescriptive.

Some of the benefits of incorporating pollution prevention into design are to

- lower lifecycle costs
- outpace emerging and forecasted environmental regulations
- conserve energy
- simplify environmental management
- incorporate pollution prevention features while the design is still flexible
- provide an incentive for developing innovative clean technologies.

Some of the barriers to designing for pollution prevention include

- lack of information and experience on how to do it
- increased design cost (for a lower total project cost)
- different contractors through design, construction, operations, and decommissioning of the project
- lack of definitive design data to develop a quantitative analysis.

These barriers need to be addressed at the policy and procedure level to facilitate the incorporation of pollution prevention into design. If this third step of DOE's three-legged stool approach to pollution prevention during design is not addressed, the tools and training may not be used once they are deployed.

Current Situation

At the DOE, federal laws and executive orders get translated into DOE Orders at the headquarters level, which in turn are developed into site-specific procedures and policies. As part of the project to design pollution prevention into new products, processes, and facilities, the Hanford team reviewed this network of regulations, policy, and site-specific procedures to recommend to DOE Headquarters how to increase the use of DfE tools once they were made available on a widespread basis throughout the DOE complex (see footnote (b) on page 3).

This review examined the flow of design and project requirements within the DOE at a local level, including the flow of design information between the DOE site Operations Office, the operating contractor, architectural engineering contractor, and design and construction subcontractors. It
emphasized the need to improve communications among these players to realize pollution prevention savings during design. Management support at all levels is necessary to implement pollution prevention opportunities and to approve design or funding changes. One finding in the review was that pollution prevention was typically assigned to the environmental compliance department within the contractor's organization. Any policy or procedure change mandating pollution prevention during design, however, needs the involvement and ownership of the design organizations as well. Environmental compliance departments often do not have the authority or knowledge to revise working-level, design procedures.

Several recommendations for specific wording changes to procedures were provided for companies to incorporate pollution prevention into the design process. These recommendations were written for the company's environmental compliance manual, project management manual, Engineering Handbook, Standard Engineering Practices document, and Project Checklists. In addition, the potential for addressing pollution prevention during the NEPA\(^{(a)}\) planning process, quality assurance process, and specifications writing process was also addressed.

**Future Plans**

During 1995, the project will solicit stakeholder input on how to deploy the tools developed during 1994 and how they should be used in the field. A product plan will be developed to address both the short-term methods for disseminating this information throughout the DOE complex as well as a longer-term plan for where to go from here.

**CONCLUSION**

The DOE is now beginning its third year of addressing how to incorporate pollution prevention into its design projects. The first two years focused on raising awareness and developing tools to help design projects save money and be more efficient through pollution prevention. The third year will focus on how to effectively deploy these tools throughout the DOE complex.

During the development of the training course and software, course participants and alpha testers were asked to provide input on the continued development of these products. Much of the feedback received turned out to be generalized to the broader issue of pollution prevention during design. It is hoped that the feedback provided in this paper can be of use to others as they embark on their own company-specific plans for incorporating pollution prevention principles into design.

The main feedback from users is that pollution prevention during design is a logical extension of good engineering practice and other techniques already being employed in the current design process. Software tools can provide an excellent template for tracking techniques implemented on a particular project and for quickly filtering through a large database of example techniques based on project size, design stage, and major systems being designed. We have found, however, that no matter how well-informed engineers are, or how good their design tools are, there are still barriers toward pollution prevention during design that need to be addressed. These are mostly policy or procedural barriers that

\(\text{(a)}\) The National Environmental Policy Act (NEPA) requires that federal agencies provide a detailed statement on the environmental impact and possible alternatives to proposed actions that affect the quality of the human environment.
can be overcome through simple wording changes, followed by education. By attacking the issue on these three fronts (training, tools, and policy/procedures), a balanced program to incorporate pollution prevention into the design process will follow.

REFERENCES


