Toward Integrated Design
of Waste Management Technologies

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TOWARD INTEGRATED DESIGN OF
WASTE MANAGEMENT TECHNOLOGIES

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ABSTRACT

Implementation of waste management technologies has been hindered by the intervention of diverse interests. Relying on a perceived history of inadequate and improper management, operations, and technological design, critics have stymied the implementation of scientifically and governmentally approved technologies and facilities, leading to a critical shortage of hazardous, mixed, and radioactive waste management capacity.

The research and development (R&D) required to identify technologies that are simultaneously (1) scientifically valid, (2) economically sound, and (3) publicly acceptable must necessarily address, in an integrated and interdisciplinary manner, these three criteria and how best to achieve the integration of stakeholders early in the technology implementation process (i.e., R&D, demonstration, and commercialization).

The goal of this paper is to initiate an identification of factors likely to render radioactive and hazardous waste management technologies publicly acceptable and to provide guidance on how technological R&D might be revised to enhance the acceptability of alternative waste management technologies. Principal among these factors are the equitable distribution of costs, risks, and benefits of waste management policies and technologies, the equitable distribution of authority for making waste management policy and selecting technologies for implementation, and the equitable distribution of responsibility for resolving waste management problems. Stakeholder participation in assessing the likely distribution of these factors and mitigative mechanisms to enhance their equitable distribution, together with stakeholder participation in policy and technology R&D, as informed by stakeholder assessments, should enhance the identification of acceptable policies and technologies.

I. INTRODUCTION

It has become increasingly clear that waste management technologies will be scrutinized by various stakeholders and that, to a large extent, these stakeholders will negotiate which waste management activities and technologies, if any, will be accepted or approved for implementation.1-4 It is important to determine what information needs to be communicated among the stakeholders, what constitutes credible information for use in negotiation and decision making, and what institutional mechanisms in the technology R&D and commercialization processes are most likely to result in on-the-ground solutions to waste management problems.5-7

If the ultimate goal is to protect public health and the environment, then what is sought is an array of technologies that are simultaneously (1) scientifically valid, (2) economically sound, and (3) publicly acceptable. The R&D required to identify such technologies must necessarily address, in an integrated and interdisciplinary manner, these three criteria and how best to achieve the integration of stakeholders early in the technology implementation process (i.e., R&D, demonstration, and commercialization).

II. TECHNOLOGY DEVELOPMENT AND
STAKEHOLDER CONCERNS

What technical, economic and institutional factors make radioactive and/or hazardous waste management technologies publicly acceptable? Technology development must attend to the full range of technology characteristics (technical, engineering, physical, economic, health, environmental, and socio-institutional) relevant to diverse stakeholders. Efforts in recent years at Oak Ridge National Laboratory (ORNL) illustrate some attempts to accomplish these objectives or, at least, to build bridges

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toward the integrated design of waste management technologies.

Social science research staff at ORNL engaged in environmental and waste management technology R&D have examined environmental and waste management technology acceptance in a variety of settings, as described below. It is interesting to note that many of these efforts focused on and emphasized the importance of equity concerns and stakeholder participation and analysis in technology R&D. Many years before the Environmental Protection Agency (EPA), the Department of Energy (DOE), and other federal agencies began to focus on these issues.

Research for DOE from 1977-1979 on the impacts of the Resource Conservation and Recovery Act (RCRA) on energy supply resulted in a number of topical reports and an integrated policy analysis.8 Among other findings, the integrated policy analysis concluded that (1) siting of new hazardous waste management capacity would be extremely difficult because of the dissociation of risks, costs, and benefits of such capacity; and (2) a “degree of hazard” approach would facilitate policy formulation and implementation.9

In 1979 we developed a suggested action plan for the State of Tennessee on radioactive and hazardous waste management.10 Although the work for Tennessee was only modestly funded and was performed under a relatively tight schedule, the report identified the relevant institutional environment, profiled radioactive and hazardous waste activities in Tennessee and resources available to the state for waste management, discussed dominant institutional issues at that time (many of which still exist), and outlined a strategy that could be used by Tennessee to improve its waste management capabilities. Acceptance of radioactive and hazardous waste management activities by various Tennessee stakeholders was as problematic then (1978-1979) as now, with publicity of inadequate waste management practices at various sites/facilities around the state, thereby limiting the possibility of developing new radioactive and hazardous waste management capacity almost anywhere in the state. Although the report noted at that time that some untried technologies, including hydrofracture and incineration, might be well suited to Tennessee, we also noted that without substantial attention to resolving the dissociation of costs, risks, and benefits associated with alternative waste management technologies, perhaps through the application of an incentive-based mechanism and stakeholder assessments of waste management technology impacts, the siting of any radioactive or hazardous waste management activity or technology was problematic.

In FY1981 we developed a framework for evaluating the utility of incentive systems for radioactive waste repository siting for the Office of Nuclear Waste Isolation.11-14 In addition to identifying the generic and topical questions of such a framework, the work included a functional classification of incentives (i.e., mitigation, compensation, and reward) and enumerated prerequisites to the possible use of incentives in siting. Even though the work was directed at high level nuclear waste repository siting (before Congressional and DOE selection of the Yucca Mountain site), it is viewed as equally applicable to mixed and other radioactive waste facility siting. In fact, subsequent to this work a more generic approach to the use of incentive in environmental mediation for siting a wide range of noxious facilities was developed.15

Following up on another of the conclusions of the Tennessee report (i.e., the potential utility of local, community-based technology assessments), DOE supported an exploratory effort to determine how and with what success a task team representative of diverse stakeholders in a community could assess the social, economic, institutional, health, and environmental impacts of conservation and renewable energy technologies that might be implemented in their community.16 “Experts” developed and provided an assessment protocol for the three communities (Franklin County, Massachusetts; Kent, Ohio; and a three-county region in New York) to use and monitored this experiment in community-based technology assessment, but there was no intervention in the experiments once they were begun. Although there was some variability in how the assessments were performed by the task forces, the impacts identified by the task forces closely paralleled those identified by technical experts, leading one to believe that a comparable approach might also work in assessments of more controversial technologies, including radioactive and hazardous waste management. In fact, this generic approach (i.e., community-based technology assessment) was followed in the case of the Monitored Retrievable Storage (MRS) facility proposed for the Oak Ridge area in the late 1980s.

In FY1982 ORNL provided NEPA assistance to the Nuclear Regulatory Commission (NRC) in its initial assessment of the psychological and community well-being impacts of restarting TMI Unit 1. Although the U.S. Supreme Court ultimately determined that an environmental impact statement on restart impacts was not required, this work facilitated increasing familiarity with notions of risk and perceived risk. In addition, this effort included development and use of an innovative methodology for bounding the policy debate surrounding TMI restart and, potentially, other publicly controversial
Focus group meetings were held with proponents and opponents of restart, and from these discussions it was learned that the basic impacts at controversy were perceived to be the adverse economic impacts of no restart versus adverse public health impacts, including stress, resulting from restart. In addition to asking representatives at these five meetings their assessment of restart and no-restart impacts, suggestions regarding what actions could be undertaken to mitigate the adverse impacts of alternative NRC decisions were solicited from the focus group participants. Restart opponents identified a range of potentially mitigative design and operating modifications; some of these may well be technically, economically, and institutionally feasible (e.g., process to provide undistorted flow of information, full and credible monitoring program, improved alerting system), while others may be more difficult, less feasible, or less valid to implement (e.g., provision of potassium iodide tablets, retrofit for other fuel source, relocation assistance for disenchanted residents).

Beginning in FY1983, a team comprising social, physical, natural, and engineering sciences at ORNL initiated assistance to the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) (now the Program Manager for Chemical Demilitarization) in the implementation of its long range demilitarization program to dispose of the unitary chemical weapons stockpile. In FY1983 our work included characterization of institutional issues (e.g., appropriate division of political authority and responsibility; equitable distribution of costs, risks, and benefits) that could adversely affect the demilitarization program and possible strategies (e.g., enhanced interaction with stakeholders and stakeholder participation in technology design through iterative reviews) for enhancing public acceptance of high-temperature incineration. In subsequent years, this team supported the U.S. Army's assessment of the health and environmental impacts of storing, transporting, and disposing of the unitary stockpile. This latter effort involved: (1) the preparation of a draft programmatic environmental impact statement (DPEIS) for the Chemical Stockpile Disposal Program and associated scoping activities; (2) support for the preparation of numerous technical support studies (including a comprehensive probabilistic risk analysis, characterization and evaluation of past disposal technologies used by the U.S. Army, proposed monitoring regimes, and an emergency response concept plan) after issuance of the DPEIS; (3) working with five community groups funded by the U.S. Army to prepare their own health and environmental assessments; and (4) preparation of the final programmatic environmental impact statement (FPEIS). Ongoing work (FY1989-94) includes preparation of site-specific environmental impact statements for the Army's eight storage and proposed disposal installations, support for the U.S. Army's implementation of an intergovernmental consultation and coordination process (designed by ORNL staff), and the preparation of technical studies to support the U.S. Army's implementation of a state-of-the-art emergency planning and preparedness program (Chemical Stockpile Emergency Preparedness Program). All of these ongoing efforts involve substantial interaction with local interested publics.

Another example of using social sciences to understand societal choices regarding technology adoption was exhibited in a recent examination of waste-to-energy as a municipal solid waste management strategy. Wasteto-energy is touted by its supporters as a positive means of handling municipal solid waste (reducing reliance on landfills) while simultaneously deriving the benefit of electricity generation. Nevertheless, in recent years waste-to-energy initiatives have frequently been canceled or abandoned. This investigation was driven by a desire to understand the reasons why waste-to-energy facilities so often have not been built. The approach was to examine comprehensively waste-to-energy acceptance using a three-tiered approach. First, on a national scale, demographic and socioeconomic factors that could affect waste-to-energy technology acceptance or rejection were investigated, and it was determined that these factors did not conclusively lead to acceptance or rejection. Second, a detailed investigation of the financial aspects of waste-to-energy was undertaken, particularly in light of the Tax Reform Act of 1986, and it was determined that financial issues do not distinguish those communities that accepted waste-to-energy from those that rejected it. Finally, four case studies were conducted of communities where waste-to-energy decisions were made recently; the technology was formally accepted and rejected in two communities each. Although inappropriate for making broad generalizations, these case studies revealed: (1) acceptance/rejection is a continuous rather than a dichotomous variable — there were degrees of acceptance and rejection; (2) the size of the proposed facilities relative to the waste stream was a significant factor in decision making, particularly in relation to the suite of waste management strategies used by communities and in terms of the perceived urgency for additional landfill capacity; and (3) the community decision-making process is a necessary but not sufficient condition to acceptance (if viewed as problematic by stakeholders, the process may influence the decision and result in rejection of the technology).

Most recently, social science staff at ORNL are currently involved in supporting the development of "new" waste management technologies (e.g., molten salt oxidation and
catalytic extraction process) in Oak Ridge. Although these programs are still in their infancy, support will include socioeconomic impact assessment, cost analysis, the development of emergency action procedures, and designing stakeholder participation programs for these technology development efforts. In each case, the plan is to provide the results from these efforts, in an iterative fashion, to the design engineers as the technologies are being developed, thereby enhancing the prospects that the designs will meet social, economic, and institutional requirements much earlier in the technology R&D and commercialization process than otherwise would be the case.

The enduring theme that has emerged over the last few years is that technologies intended to improve environmental quality and community and national well-being have often failed in their implementation. This failure may have little to do with the actual quality of technology choices but may have everything to do with a failure to consider adequately a number of key elements — the dissociation of costs, risks, and benefits of alternative solutions to waste management and other environmental protection problems, the distribution of political (i.e., decision making) authority, responsibility, and liability, and the role of technical and non-technical experts and laypersons in identifying and characterizing problems and objectives, their corollary assumptions, and alternative approaches to the resolution of problems.

III. DESIGNING TECHNOLOGIES FOR ACCEPTANCE

It seems clear that efforts to date to “engineer” public acceptance of waste management and other environmental protection technologies have often failed not for the lack of good intentions but, rather, for a failure to attend to the totality of dimensions of technology that are important to people and to incorporate the public and stakeholders in the technology design effort in a timely manner.

What this suggests is a fundamental re-design of the technology research, development, demonstration, and commercialization (R, D & C) process to incorporate public and stakeholder concerns much earlier in the process. In contrast to the traditional R, D & C process, where public and stakeholder concerns are addressed relatively late (e.g., through public hearings and permitting), after basic technology design decisions have been made, an integrated technology design process would incorporate such concerns at the beginning, when problems are being defined, planning assumptions are being developed, alternative structural (i.e., technological) and non-structural approaches are being considered, a single technological approach is being selected (if appropriate), and basic design parameters of a selected technology are being developed (see Fig. 1).

This concept implies the development of teams of people to solve problems, many of whom have never worked together before, but some of whom may have previously been at odds simply because of the extant temporal flow of decision making and technology design. The existing R, D & C process is fragmented and sequential, and, therefore, costly and inefficient. Adverse reaction by the public and/or stakeholders to the technology choice and/or specific parameters of the technology chosen occurs toward the end of the chain, requiring mid-stream revisions or outright changes in approach. An integrated technology design process, on the other hand, would identify public and stakeholder concerns (and choices) early in the process and could be used by decision makers and technology designers before decisions are made and costs are sunk.

It should be recognized that even an integrated technology design process will not eliminate all mid-stream revisions to technology choice, design, and deployment. Problems and our definitions of problems change, as do fundamental societal perspectives about which problems should be solved, when they should be solved, and how much those solutions should cost; in fact, concerns for inter-generational equity might demand that our solutions be sufficiently flexible to permit future generations to improve on prior decisions and commitments (i.e., technological choices). Rather than being a roadblock to problem solving, this dynamism could be recognized within problem domains such as radioactive and hazardous waste management and incorporated in our decision making and R, D, D & C processes.

At a minimum, the assessment of socioeconomic, institutional, and health and environmental risk issues and technology R, D & C should occur simultaneously to identify potential public and technology concerns and to improve the chances for the technology’s overall acceptance. This assessment could be used as input to the technology design team as it develops the basic parameters of the selected design. A somewhat more ambitious approach would include social, environmental, and health scientists (and potential stakeholders) on the technology design team itself. Both of these approaches would enhance the possibility of incorporating socioeconomic/stakeholder parameters (and, in some cases, threshold values for those parameters) in the technology design and implementation process, thereby decreasing the total resources required to field sound environmental protection and waste management technologies.
IV. CONCLUSIONS

Integrating social, cultural, political, and economic (as well as health and environmental risk) variables with basic physical scientific and engineering variables in defining problems, surveying and evaluating structural and non-structural approaches to solving those problems, and selecting the approach and specific design parameters of the selected approach has the potential to offer relief from existing waste management dilemmas. As noted above, the integration of all relevant disciplines and stakeholders in the design of a technology (if a structural approach is selected as the appropriate approach to problem resolution) offers several advantages over the traditional R, D, D, and C process — most importantly, it defines, early on, the requirements that each party brings to the problem and its solution rather than delaying consideration of these requirements until well after basic decisions and design commitments have been made. This approach has the corollary advantage of emphasizing the notion that only a societal team — one comprising all stakeholders — can solve societal problems.

REFERENCES


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