

**WASTE
MANAGEMENT**
Planning, Evaluation,
Technologies

DAVID C. WILSON

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DAVID C. WILSON
Harwell Laboratory

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PREFACE

For many years, disposal of the wastes produced by an industrialized society was characterized by the maxim, 'Out of sight, out of mind'. Gradually this attitude has begun to change, and much progress has been made over the past decade. It is increasingly recognized that the goal of a cleaner environment can only be achieved by integrated control of all types of pollution and of all wastes, whether they be discharged to air, to water, or to land. In addition, with growing shortages of energy and materials, waste is now seen as a potential resource, and the challenge of economically exploiting that potential is beginning to be taken up in earnest.

This book then is directed at the subject of waste management. For our purposes, 'waste' is defined loosely as any unwanted residual material which cannot be discharged, directly or after suitable treatment, to the atmosphere or to a receiving water. We are thus concerned with all solid and semi-solid wastes, and with some liquid wastes. In order to focus the discussion, attention is directed primarily at municipal solid wastes, but the principles and technologies can equally be applied to other types of waste.

The technologies available for the disposal, treatment, separation, or reclamation of municipal wastes have burgeoned in recent years. When this fact is added to increasing pressures on resources—of land, materials, energy, environmental quality, and finance—and to the local political difficulties in establishing *any* facility to handle wastes, it is clear that waste management is becoming an increasingly thorny problem for the public, the planners, and the decision makers alike. The purpose of this book is two-fold:

- (a) To present a systems approach to the problem of planning for waste management, and to consider in detail the comparative evaluation of alternative technologies on the two important criteria of economics and the conservation of resources;
- (b) To provide a comprehensive, up-to-date, and critical review of the state of the art in waste management technology. The use of the methods developed for quantitative evaluation enable some 30 representative options to be compared on a consistent basis, thus allowing an assessment of the most promising technologies for the future.

The book begins with a general introduction to the problem of waste management. International data are presented on types and quantities of waste generated, on the composition of household waste, and on the current use of technologies for municipal waste disposal. In addition an overview of available technologies is given.

Part I. Planning and evaluation in waste management

Chapter 2 introduces a simplified and formal conceptual structure of the planning process for waste management. Many difficulties are avoided if the system is properly defined, and much of the chapter is devoted to topics such as legislation, local government finance, and surveying current and forecasting future waste arisings. Emphasis is laid on the separation of the political planning process from the supporting technical analysis. This analysis is often aided by the use of mathematical models to provide an abstraction which one can understand and specify clearly. However, in order to compromise between reality and tractability, these models must focus on some aspects of a problem at the expense of others.

Previous work in planning for waste management has been largely restricted to the application of sophisticated operational research models to strategy evaluation, focusing on the combination of facilities to produce a least-cost plan. These models, reviewed in Chapter 3, are limited by an inability to consider data uncertainty or multiple objectives. The approach developed here (Chapter 4) focuses rather on the prior problem of selecting the best technologies to use. By including in each option all the operations performed on the waste arising from one source, a 'single waste flow model' is defined that will be sufficient for many planning purposes.

In principle, each option is evaluated against each criterion, the results being displayed in tabular form. Attempts are often made to reduce this table to a single performance index for each option against all the criteria, with interpretation reduced to choosing the option with the best index. However, this depends on complete quantification, which for essentially qualitative criteria introduces subjective elements into the analysis. Attention here is rather on the development of quantitative measures of performance on a few criteria, leaving the assessment of intangibles and overall balancing of criteria to the decision maker. The criteria chosen for detailed consideration are those of economics and resource conservation, where the prospects for objective evaluation are best.

Cost estimates for alternative waste management options are often difficult to compare owing to significant differences in assumptions about a process, in the estimating procedure used, or in the operations included. Conventions are proposed in Chapter 5 to alleviate these problems. In addition to processing and the disposal of any residual waste, each option must also include all significant transport steps. Simple models are developed in Chapter 6 to calculate the cost of transporting waste, in collection or bulk haulage vehicles, as a function of the distance travelled. All the component parts of the overall cost estimate are subject to considerable uncertainty. To determine the most critical parameters on which the estimate depends, and to allow proper consideration to be paid to their

uncertainty, a discounted cash flow model incorporating sensitivity and risk analysis is developed in Chapter 7.

Economics does not always adequately reflect the scarcity of physical resources. The contribution which resource recovery from waste makes to the conservation of energy and materials may be measured conveniently by its implications for primary energy use. Process energy analysis is applied in Chapter 8 to evaluate the primary energy inputs to each option, and the savings implied by the use of the recovered fuel and material products. The results are expressed as two measures of net energy efficiency, differing in whether or not savings from materials recovery are included.

The techniques for economic and energy evaluation are demonstrated in Chapters 7 and 8 by a case study of some 30 options, using the best information available. The uncertainty in the estimates is substantial, and the analysis must therefore be carried out explicitly for any specific application. Nevertheless, certain general conclusions on the status of options may be drawn; the results from the case study provide the quantitative basis for the critical review of technologies in Part II.

Previous studies of waste management planning have often resulted in a 'black box' to produce the optimal plan. The framework developed here aims rather to expose the core of the problem. A number of simple, quantitative tools are developed for use in screening options for waste disposal, treatment, or resource recovery. The final assessment of intangibles and balancing of criteria is left with the planners and the politicians.

Part II. Waste management technology

The second half of the book is devoted to a comprehensive and critical review of the state of the art in waste management technology, as seen in early 1980. Progress in this field has been rapid over the last ten years, and it is currently difficult to find a balanced judgement on the relative merits of the processes, or even to see clearly the relationships between them. It is hoped that this treatise will help to remedy this situation.

The many technologies are rationalized under nine headings, which are dealt with in Chapters 11-19, respectively:

- Landfill;
- Transfer or treatment prior to landfill;
- Incineration;
- Separation processes;
- Production of a solid refuse-derived fuel (RDF.);
- Direct incineration of RDF;
- Wet pulping;
- Pyrolysis and other thermal processes;
- Biological processes.

In addition, Chapter 20 looks briefly at technologies appropriate to the management of potentially hazardous wastes.

Each chapter follows a similar pattern. Particular emphasis is given to the overall objectives of the technology, to the similarities and differences between the various derivative processes, and to the relationships with other technologies. Flowsheets are presented in a standard format to allow easy comparison. The state of development and operating experiences are emphasized. Where there have been significant recent advances in our understanding of the scientific basis of a technology, then these are reviewed in depth: an example is the simple landfilling of wastes.

A unique feature of this book is the emphasis given to collating quantitative information on the technologies. This enables the use of the evaluation techniques developed in Part I to compare some 30 options, selected as typical of the state of the art, on a consistent basis. Some readers may prefer to skip from the qualitative introductory sections at the beginning of each section or chapter directly to the discussion at the end.

The final chapter of the book brings together the general conclusions of Part II, and the results of the evaluations on the criteria of economics and resource conservation, to provide an overall picture of the current state of the art in waste management technology and to speculate on future trends.

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