

# WASTE MANAGEMENT

Planning, Evaluation,  
Technologies

DAVID C. WILSON

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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.

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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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# CONTENTS

1. The problem of waste management	1
1.1. Introduction	1
1.2. Types of waste	3
1.3. Technologies for waste management	9
1.3.1. Landfill	9
1.3.2. Volume reduction prior to landfill	13
1.3.3. Resource recovery or reclamation	15
1.3.4. Recovery of materials	15
1.3.5. Energy recovery	16
1.3.6. Processing other wastes	18
1.4. The systems approach	19
Part I. Planning and evaluation in waste management	21
2. Waste management planning	23
2.1. A framework for planning	23
2.2. Terms of reference	25
2.2.1. National legislation and policy directives	25
2.2.2. Local government plans	27
2.2.3. Local government finance	28
2.2.4. The structure of local government	32
2.3. System boundary	33
2.4. Survey information	36
2.4.1. Current waste arisings	36
2.4.2. Forecasting waste arisings	37
2.4.3. The availability of land	39
2.5. Selection of criteria	40
2.6. Technical analysis	42
2.7. Plan selection and implementation	43
2.8. Discussion	43
3. Strategy evaluation	45
3.1. Introduction	45
3.2. Formulation	46
3.2.1. System boundary	46
3.2.2. Survey information	47
3.2.3. Selection of criteria	47
3.2.4. The preliminary analysis of candidate technologies	47
3.2.5. Summary	48
3.3. A classification of models	48
3.3.1. The type of model	48

3.3.2. Choice of technology	52
3.3.3. Time	52
3.3.4. Facility costs	53
3.3.5. Transport costs	55
3.3.6. Capacity of facilities	55
3.3.7. The effects of parameter variability	57
3.3.8. Extensions of the objective function	59
3.4. A case study of a strategy evaluation model	60
3.5. The future development of strategy evaluation models	62
4. A pragmatic approach to planning	63
4.1. Introduction	63
4.2. Methods of project evaluation	64
4.2.1. Principle	64
4.2.2. Alternative techniques	66
4.3. Project evaluation in waste management planning	67
4.4. Developing a single waste-flow model	70
5. The economics of waste processing	71
5.1. Introduction	71
5.2. Historical cost data	72
5.3. Methods of economic evaluation	75
5.3.1. Annual cost versus discounted cash flow	75
5.3.2. The discount rate	77
5.3.3. The time horizon	78
5.3.4. Cost-benefit analysis	79
5.4. Capital cost estimates	80
5.4.1. Influence of design conception—an illustration	80
5.4.2. Differences in operating standards	82
5.4.3. Costs specific to a site	83
5.4.4. Cost estimating procedures	83
5.4.5. Potential pitfalls in capital cost estimation	84
5.4.6. Alternative methods of capital cost estimation	89
5.4.7. Economies of scale in capital costs	89
5.5. Operating cost estimates	91
5.5.1. The operating schedule	91
5.5.2. Estimation procedures	91
5.5.3. Economies of scale	95
5.6. Revenues	97
5.7. Economic data for the case study	100
5.8. Discussion	102
6. The costs of waste transport	105
6.1. Introduction	105
6.2. The cost of waste transport in a collection vehicle	106

6.2.1. Cost as a function of haul distance	106
6.2.2. General form of the cost function	107
6.2.3. Derivation of the cost function	110
6.2.4. An illustrative calculation	113
6.2.5. Discussion	117
6.3. Diseconomies of scale in initial waste delivery costs	118
6.3.1. A simple model of waste transport	118
6.3.2. Extending the model	121
6.3.3. Discussion	121
6.4. The costs of bulk haulage	124
6.5. Discussion	129
7. Uncertainty in an economic study of options	133
7.1. Introduction	133
7.2. A case study	134
7.3. Sensitivity analysis	136
7.4. Risk analysis	138
7.4.1. Method	138
7.4.2. Interpretation	141
7.5. Extending the case study	144
7.6. Discussion	150
8. Energy conservation through resource recovery	154
8.1. Introduction	154
8.2. Process analysis	155
8.3. Energy inputs and outputs	157
8.4. Energy efficiencies	160
8.5. The application of process analysis	164
8.6. Discussion of the results	167
8.7. Sensitivity analysis	170
8.8. The potential of solid waste as an energy source	171
8.9. Assessment	172
9. A systems approach to waste management planning	176
9.1. A framework for planning	176
9.2. Evaluation tools	178
9.3. Postscript	180
Part II. Waste management technology	181
10. The critical evaluation of technologies	183
10.1. Introduction	183
10.2. A consistent basis for comparing technologies	184
10.2.1. A standard plant capacity	184
10.2.2. Estimation of capital costs	185
10.2.3. Estimation of operating costs	187

10.2.4. Estimation of revenues	189
10.2.5. Uncertainty in the cost and revenue estimates	190
10.2.6. Discounted cash flow analysis	190
10.2.7. Disclaimer	191
11. Landfill	192
11.1. Introduction	192
11.2. Compaction and choice of landfill site machines	193
11.3. Landfill science	198
11.4. Water pollution	200
11.4.1. Background	200
11.4.2. Recent research	201
11.4.3. Class 1 sites	203
11.4.4. Class 2 sites	205
11.4.5. Class 3 sites	205
11.4.6. Site selection	205
11.4.7. Use of liner materials	206
11.5. Gas generation	207
11.6. Land reclamation	210
11.7. Capital costs of a landfill site	211
11.8. Operating costs of a landfill site	213
11.9. Discussion	214
12. Transfer/treatment prior to landfill	217
12.1. Transfer	217
12.1.1. Types of transfer operation	217
12.1.2. Design considerations	220
12.1.3. Capital costs for road transfer stations	221
12.1.4. Rail transfer	223
12.1.5. Barge transfer	225
12.1.6. Operating, transport, and landfill costs	226
12.1.7. Discussion	227
12.2. Pulverization	228
12.2.1. Background	228
12.2.2. Technology	229
12.2.3. Capital costs	233
12.2.4. Operating, transport, and landfill costs	236
12.2.5. Discussion	238
12.3. Baling	239
12.3.1. Background	239
12.3.2. Technology	239
12.3.3. Cost estimates	241
12.3.4. Discussion	242

13. Incineration	243
13.1. Introduction	243
13.2. Types of incinerator	245
13.3. Products of incineration	248
13.4. Heat utilization	251
13.5. Capital costs	254
13.6. Operating costs	260
13.7. Discussion	261
13.8. Modular incineration	262
13.8.1. Background	262
13.8.2. Quantitative data	263
13.8.3. Discussion	264
14. Physical separation of waste	265
14.1. Introduction	265
14.2. Separation of inorganic and organic fractions	268
14.2.1. Wet pulverization	268
14.2.2. Wet pulping	269
14.2.3. Dry separation	269
14.3. Recovery of organic materials	273
14.3.1. Paper	273
14.3.2. Other organic materials	277
14.4. Recovery of inorganic materials	278
14.4.1. Secondary separation	278
14.4.2. Non-ferrous metals	280
14.4.3. Glass	280
14.4.4. Operating experience	281
14.4.5. Quantitative data	283
14.5. Additional recovery of materials	285
14.5.1. Processes	285
14.5.2. Quantitative data	286
14.5.3. Discussion	287
14.6. Materials recovery from incinerator residue	288
15. Refuse-derived fuels	291
15.1. Introduction	291
15.2. An overview of RDF processes	292
15.2.1. RDF production	292
15.2.2. Upgrading the product	293
15.2.3. RDF utilization	293
15.2.4. RDF options	296
15.3. American RDF	296
15.3.1. Background	296

15.3.2. Capital costs	298
15.3.3. Other data	300
15.3.4. Discussion	302
15.4. Powder RDF (Eco-Fuel II)	302
15.4.1. Background	302
15.4.2. Quantitative data	304
15.4.3. Discussion	305
15.5. Paper-based RDF	305
15.5.1. Background	305
15.5.2. Quantitative data	307
15.5.3. Discussion	310
15.6. Pulverized waste as a fuel	311
15.6.1. Background	311
15.6.2. Quantitative data	312
15.6.3. Discussion	312
15.7. Cement manufacture	313
15.8. Summary	314
16. Incineration of refuse-derived fuels	316
16.1. Suspension firing of RDF	316
16.1.1. Background	316
16.1.2. Mass burning versus suspension firing	317
16.1.3. Discussion	318
16.2. Incinerator turbine	319
16.2.1. Background	319
16.2.2. Quantitative information	320
16.2.3. Discussion	320
17. Wet pulping	322
17.1. Introduction	322
17.2. Information from the Franklin demonstration plant	324
17.3. Options based on wet pulping	326
17.4. Discussion	329
18. Pyrolysis and other thermal processes	331
18.1. Introduction	331
18.2. Products of thermal processes	333
18.3. Basic process characteristics	336
18.3.1. Method of heat transfer	336
18.3.2. Evolved gas flow	338
18.3.3. Other process variables	339
18.4. Types of reactor	339
18.4.1. Vertical-flow reactors	339
18.4.2. Horizontal-flow reactors	340
18.4.3. Dilute-phase reactors	340



18.5.	Thermal processes developed for municipal waste	341
18.6.	The Occidental process	345
18.6.1.	Background	345
18.6.2.	Quantitative data	346
18.6.3.	Discussion	348
18.7.	The Union Carbide Purox process	348
18.7.1.	Background	348
18.7.2.	Quantitative data	350
18.7.3.	Discussion	352
18.8.	The Andco-Torrax process	353
18.8.1.	Background and operating experience	353
18.8.2.	Quantitative data	357
18.8.3.	Discussion	358
18.9.	The Monsanto Landgard process	359
18.9.1.	Background and operating experience	359
18.9.2.	Quantitative data	361
18.9.3.	Discussion	361
18.10.	Summary	361
19.	Biological processes	364
19.1.	Introduction	364
19.2.	Composting	366
19.2.1.	Principles	366
19.2.2.	Practice	367
19.2.3.	Quantitative information	371
19.2.4.	Discussion	374
19.3.	Hydrolysis	374
19.3.1.	Introduction	374
19.3.2.	Acid hydrolysis	375
19.3.3.	Quantitative data	376
19.3.4.	Discussion	379
19.4.	Anaerobic digestion	379
19.4.1.	Principles and operating experience	379
19.4.2.	Quantitative information	382
19.4.3.	Discussion	384
20.	Hazardous wastes	385
20.1.	Introduction	385
20.2.	Waste reduction	387
20.3.	Recovery	387
20.4.	Incineration	389
20.5.	Chemical treatment	391
20.6.	Biological treatment	392
20.7.	Solidification and encapsulation	392

20.8. Sea disposal	396
20.9. Land disposal	397
20.9.1. Handling problems	397
20.9.2. Future use of the site	398
20.9.3. Water pollution	399
20.10. Discussion	400
21. The state of the art in waste management technology	402
21.1. Comparing technologies	402
21.2. Landfill versus RDF	404
21.2.1. General comparison	404
21.2.2. Local landfill	404
21.2.3. Pulverized waste as a fuel	405
21.2.4. Distant landfill	406
21.2.5. Upgraded RDF	407
21.3. Incineration and other technologies	409
21.3.1. Incineration	410
21.3.2. Other thermal processes	412
21.3.3. Biological processes	412
21.3.4. Additional recovery of glass and non-ferrous metals	413
21.4. Future trends	414
Appendixes	
A. Data and results from the case study of waste management technologies	417
B. Models of waste transport	438
B.1. Waste transport in a collection vehicle	438
B.1.1. The simple model	438
B.1.2. An alternative derivation	441
B.1.3. Extending the cost function	442
B.1.4. Applying the model	443
B.2. Models for waste delivery to a processing plant	443
B.2.1. The basic model	445
B.2.2. Extending the model	447
C. Flowsheets for the DCF computer program	451
D. The gross energy requirements of inputs and outputs to the waste management system	455
D.1. Introduction	455
D.2. Direct energy inputs	455
D.3. Material inputs	455
D.4. Maintenance and operating supplies	456
D.5. Capital investment	457
D.6. Waste water treatment	458