SECTION VII. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

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SUMMARY

The most environmentally sound management plan available for dealing with the enormous quantity of solid waste which is generated in the Bay Area is a comprehensive resource recovery plan - one that involves a combination of techniques. Resource recovery is taken to mean reconstituting refuse into usable substances or energies. This type of management is considered to be most environmentally sound because: "it removes waste from the waste stream, thereby reducing disposal requirements, and it converts the waste into a usable resource, thereby decreasing exploitation of natural resources and the pollution of our environment" (Caughron, 1973).

There exist numerous incentives for pursuing resource recovery. Most important among these are: a continuous supply of waste; the availability of techniques to convert the waste into valuable resources; a shortage of inexpensive and clean (relatively non-polluting) energy sources; a shortage of land for depositing waste; a desire to minimize unnecessary depletion of natural resources; and growing public sentiment against the polluting effects that additional productive activities bring about.

One important question that arises is: "Why is it that, in the face of all these incentives, resource recovery is considered by many industries to be uneconomical?" That is to say, why are recovery costs deemed to be greater than recovery benefits? Some of the features in cost-benefit analyses of resource recovery which appear in the literature are, (according to Caughron, 1973):

1. The productivity of labor associated with acquisition and processing of virgin materials (those materials which are made from the original ore or other natural resource) is greater than labor productivity in scrap acquisition and processing;
2. Processors of virgin materials enjoy depletion allowances when extracting virgin materials;
3. Where virgin material processors do not meet air, water and solid waste standards in manufacturing--or where these standards are leniently set--the processors do not pay the full environmental costs created by pollution and waste generation associated with their virgin material uses;
4. Secondary materials, those created by recycling, are not generally credited, in cost-benefit analyses, with conserving natural resources;
5. Secondary materials get no dollar credits for contributing favorably to our foreign trade balance. (Many raw materials come principally from foreign sources [like bauxite] and their use contributes to a foreign trade imbalance);

(continued)

6. Secondary materials get no credit for diminishing the bulk of the waste stream;
7. Secondary materials get no financial credit for contributing to diminished pollution or energy usage in production processes.

When all the costs and benefits of both virgin materials use and secondary materials use are considered, then secondary materials use appears to be more economical than it has in the past.

Role of Technology

All too often reliance is placed on technological fixes, that is, using thriftier technology to produce exactly the same output of goods to solve material resources shortage problems. This is a path which can no longer have heavy reliance placed on it. "While technology is ultimately the only way of renewing 'non-renewable' material resources, it multiplies the legacy of risk to be bequeathed to the next generation. Solutions involving sophisticated technology are not inevitable. As the flow of 'non-renewable' resources increases for the United States as well as for other countries, human dependence on technological fixes becomes greater. At the same time, the power of technology itself becomes greater with uncalculated and perhaps unmanageable side effects" (Page, 1977). As a result, the society finds itself faced with the task of persuading the present generation to take preventive action to avoid imposing unfair burdens upon its future generations.

"In the past, economists have not included preservation of the resource base in their list of macroeconomic goals which need explicit policy measures. They have tended to rely on the invisible hand of the market to match new technology against depletion, much as, before the Depression, they counted on the invisible hand to eliminate unemployment. But now, as material flows are becoming enormously large, lead times short, and the environmental and technological effects pervasive, it is time to make preservation of the resource base an explicit policy issue" (Page, 1977). It is with this in mind that it becomes imperative to pursue resource recovery actively as one means to preserve the resource base and to improve the social welfare of our generation and those in the future.

Considerations for Evaluation

In assessing any set of alternatives the first task is to set forth applicable considerations and the criteria for choosing among the alternatives. Such an assessment must look at the positive and negative effects on the economic system, the environmental system, the social system, and the political system. The principal criterion which is employed in the present evaluation is that for each of the following considerations there be a net beneficial effect on all four systems taken as a whole. These considerations are as follows (Clark, et al., 1975 and State Solid Waste Management Board, 1977):

Economic Considerations

1. Effects on the basic economy
2. Effects on existing firms, industries or centers of economic activity
3. Employment income opportunities
4. Substantial public expenditures
5. Change in taxation
6. Excessive burdening of a particular group or sector
7. Growth-inducing effects
8. Adequacy of necessary local resources
9. Short-term energy availability and cost
10. Long-term energy availability and cost
11. Relation to changing technologies
12. Relation to changes in regional and national (and international) economic structures

Environmental Considerations/Impacts

1. Land use impacts
2. Pollution
3. Resource use
4. Ecosystem effects

Social Impact Analysis

1. Consistency with the goals of the community
2. Equitability effects upon various community groups
3. Income, employment, and residential dislocation effects
4. Public physical or mental health effects

Political Implications

1. Political impacts (effects upon who has control over what, etc.)

While this list is seemingly comprehensive, it is by no means exhaustive of all the considerations possible in this type of analysis. By the same token, the discussion of the solid waste management alternatives in this work is limited to those impacts that are considered to be significant.

IMPACTS

Having set forth our criteria for evaluation, we can now look at the solid waste management alternatives discussed in this report and summarize the various impacts each would have if implemented.

Source Separation

Economically speaking, little or no processing is required to produce marketable material. Separating the material gives the products a high market value by meeting more stringent specifications for secondary materials than those which are gathered through mechanical separation processes. Also the processing systems used can be specialized to the material and will have a very high yeild for the volume of material handled. Although further investments in collection equipment will be required wherever participation rises beyond the present collection system carrying capacity, the revenues from the additional materials collected will probably more than offset this investment. One of the major economic problems that a source separation program can be expected to run into is instability of markets for recovered materials.

The market for source separated high quality office paper is a typical example of such price instability (see Section III, Chapter A). The prevailing price for sorted, used white ledger paper has fluctuated from seventeen to one hundred fifty dollars per ton between 1970 and 1977.

As far as the environmental effects are concerned, the primary benefits are increased education of the public to the solid waste problem, reduced consumption of virgin materials, and reduction of energy required for manufacturing as the result of the use of recycled materials. Source separation can also reduce landfill requirements for mixed municipal refuse (MMR) by varying amounts depending on the degree of participation.

The collection and processing of source separated materials may create additional local jobs. However, any gains made in this way must be balanced against those jobs lost due to decreases in the consumption, processing, and handling of virgin materials. To be effective, strong efforts will have to be made to gain public participation. These efforts will have to balance incentives, disincentives, and education so as to allow the administration of the program to distribute the changeover burden fairly throughout the population.

Mechanical Separation

Mechanical separation is a highly capital-intensive process. Quite substantial operating costs are involved. However, even though mechanical separation produces materials that are more contaminated than those produced by source separation, which affects resource market values, source separation alone cannot remove all products of value from the waste stream. Therefore some mechanical separation might be economically viable. Production of refuse-derived fuel (RDF) is the most economically viable use of mechanical separation facilities at present.

The most environmentally positive effect of mechanical separation and production of RDF is the conversion or reclamation of up to 90 percent of the MMR waste stream. Shredding of wastes reduces landfill acreage and cover requirements by up to about 30 percent. As to increased pollution from mechanical separation, relatively simple control of air pollution from dry processes is possible, but the large amounts of polluted water generated in wet processing are difficult to treat or recycle. As in source separation, the recovery of secondary materials from the waste stream via mechanical separation demonstrates significant savings in energy, when compared to the use of products manufactured from virgin materials.

The direct effect of mechanical processing on employment is positive in that jobs are created. However, the proximity of potential users of secondary materials to the sources may also have significant impact on the transport activity normally required of virgin material, and thus have an indirect effect on the employment associated with long distance transport.

Direct Combustion

The direct combustion of RDF is essentially comparable to the use of coal as an energy source, in that the fuel is cheap and plentiful and requires ash-handling capability. As a marketable product RDF will probably have its price determined by the price of coal. Increased prices and/or unavailability of natural gas and oil, which are now used to produce steam, may cause large investments to be made to convert to solid fuels such as coal and/or RDF.

Depending on the combustion process used, the landfill requirement of MMR can be reduced from 70 to 90 percent. Also, direct combustion of waste is net energy productive (energy recovered is greater than processing requirements) and therefore could supplant use of increasingly scarce fossil fuels. However, even though plants presently in operation have been shown to meet EPA air emission standards, they are not within the stricter Bay Area Air Pollution Control District standards. While these standards are by no means unattainable, meeting them will add considerably to the cost of the energy derived. Too, the ash residue contains sufficiently high levels of combustibles and soluble minerals so that Class I disposal sites, those being landfills at which complete protection is provided for all time for the quality of ground and surfact waters from all wastes deposited therein, will have to be used for it. This will add to the overall cost of energy production from the waste.

One secondary social impact of direct combustion is a partial alleviation of projected energy shortages. This will help ensure the continued operation of energy-using industries.

Pyrolysis

There is a large demand for the gas produced by pyrolysis and it can easily be substituted for natural gas in industry with minimum modification. Also, the gas produced can be converted into high value hydrogen, methanol, methane, or ammonia (some of these are readily transported, and all are derived almost exclusively from natural gas). Due to its capital intensity and high operating costs, pyrolysis is at present a very expensive energy option. Pyrolysis will become economically competitive as natural gas becomes scarce and its price rises.

Environmentally, the burning of pyrolysis gas is similar to that of natural gas, which is the cleanest burning of all the fossil fuels. Pyrolysis also can reduce the volume of MMR landfill requirements by 80-95 percent (State Solid Waste Management Board, 1977, p. 53). The process is net energy productive and presents the possibility of reducing fossil fuel demand by a small fraction.

If site selection is carefully made, this alternative should present no problems in public acceptance. The production of small but significant amounts of clean energy from wastes while replacing some uses of our rapidly diminishing reserves of natural gas is certainly of social importance, particularly with respect to energy intensive industries. This is probably the most equitable energy recovery alternative because it could result in the conservation of natural gas for residential purposes. The economy of scale associated with this alternative will generally require significantly larger waste generation areas to support it than those currently within the jurisdiction of the private scavenger companies in the

Bay Area. For this reason it will probably encounter more institutional problems than projects that are economically viable at a smaller scale.

Composting

While the composting of homogeneous wastes such as sewage sludge or vegetative wastes is not very capital-intensive, the commercial compost market is very limited and currently being served with compost made from other wastes.

Environmentally, composting represents a closed loop ecological cycle whereby substances grown from the land are ultimately returned to the land for recycling. However, pathogens and heavy metals present in sewage sludges added to complete composting make the value of sludge-type compost questionable.

CONCLUSIONS

Net cost of Operation

Since costs so often become a criterion, if not the major one, in decision-making, the following is a ranking by lowest net cost (Total Annual Cost-Resource Value) for a 1,000 ton-per-day operation of the various solid waste management alternatives:

1. fuel recovery
2. materials recovery
3. pyrolysis
4. composting
5. steam and incinerator residue recovery
6. steam recovery
7. residue recovery
8. electrical energy generation

This point is further illustrated by Table 1 and Figure 1 (Caughron, 1973).

Market Assessment Conclusions

The anticipated shortage of natural gas in the Bay Area poses the single greatest need which resource recovery products can satisfy. This shortage is expected to result in a large demand for energy products derived from solid wastes.

There is a very strong market potential for pyrolysis gas and ferrous metals. The potential for pyrolysis gas includes sizeable markets for its conversion to high revenue yielding ammonia, methanol, and hydrogen. Pyrolysis offers the most environmentally acceptable alternative for achieving the unified objectives of disposal of wastes, recovery of energy, and protection of natural gas reserves. However, as stated earlier, the economy of scale associated with this alternative will generally require significantly larger waste generation areas to

TABLE I

SUMMARY OF RESOURCE RECOVERY PROCESS ECONOMICS*

Process Concept	Investment ($000)	Total Annual Cost ($000)	Resource Value ($000)	Net Annual Cost ($000)	Net Cost Per Input Ton ($)
Incineration Only	9,299	2,303	0	2,303	7.68
Incineration and Residue Recovery	10,676	2,689	535	2,154	7.18
Incineration and Steam Recovery	11,607	3,116	1,000	2,116	7.05
Incineration + Steam and Residue Recovery	12,784	3,508	1,535	1,973	6.57
Incineration and Electrical Energy Recovery	17,717	3,892	1,200	2,692	8.97
Pyrolysis	12,334	3,287	1,661	1,626	5.42
Composting (mechanical)	17,100	2,987	1,103	1,884	6.28
Materials Recovery	11,568	2,759	1,328	1,431	4.77
Fuel Recovery	7,577	1,731	920	811	2.70
Sanitary Landfill (close-in)	2,472	770	0	770	2.57
Sanitary Landfill (remote)	2,817	1,781	0	1,781	5.94

*Based on municipally-owned 1000 TPD plant with 20-year economic life, operating 300 days/year.

Source: Midwest Research Institute

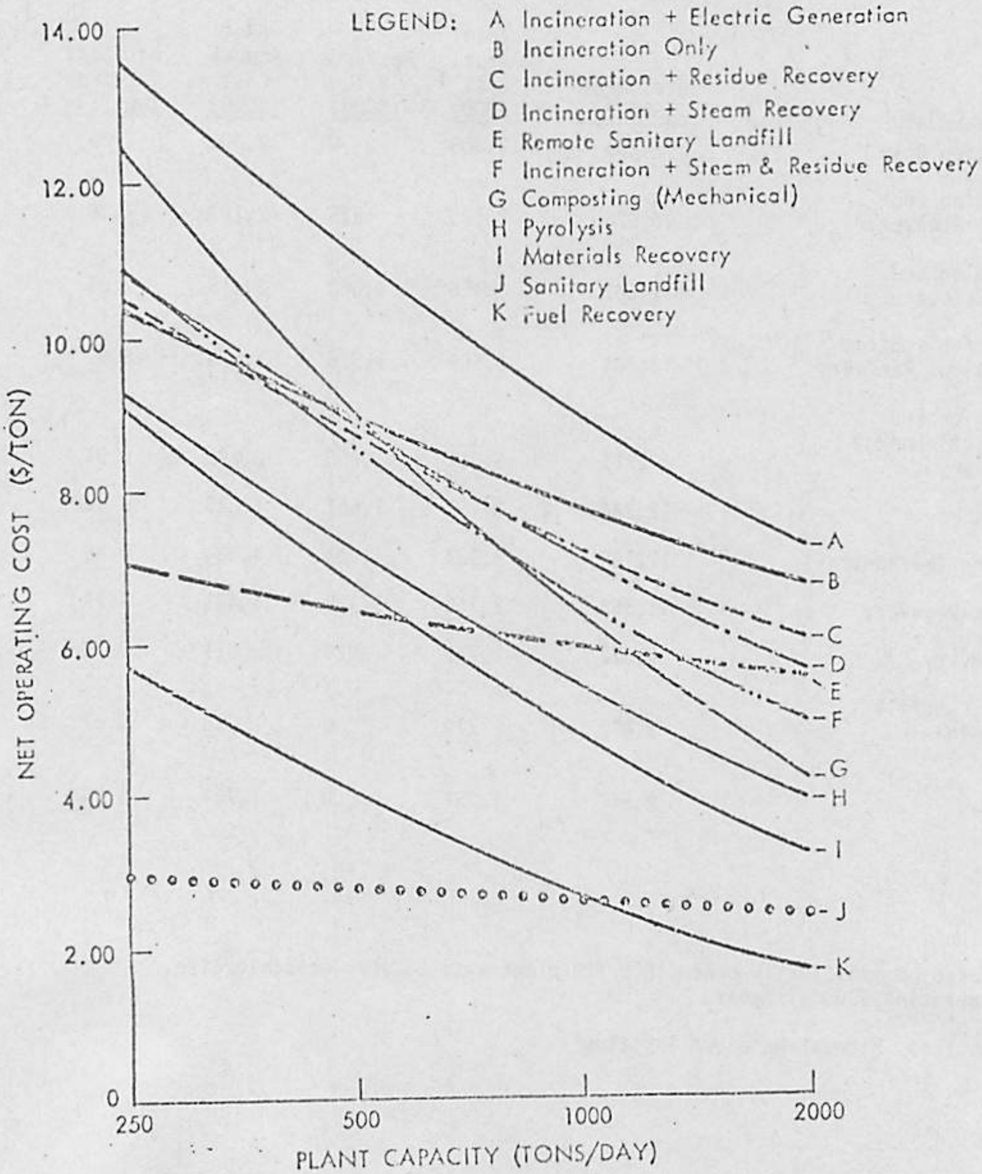

FIGURE I

NET OPERATING COSTS ASSOCIATED WITH MUNICIPALLY-OWNED RESOURCE RECOVERY PROCESSES AT VARIOUS PLANT CAPACITIES (20-YEAR ECONOMIC LIFE, 300 DAYS PER YEAR OPERATION) support it, and will probably encounter more institutional problems than projects that are economically viable at smaller scale.

At present the market potential for shredded fuels, aluminum, glass, newspaper, corrugated cardboard, and plant matter compost is limited. The markets for refuse/sludge-derived compost and for mixed waste paper are very small.

System Specific Conclusions - Source Separation

Small programs can be implemented quickly, but must have good participation to be successful. Source separation is the only technique for reducing wastes to landfill which can be implemented immediately.

Mechanical Separation

While source separation can remove some reclaimable materials from the waste stream, many valuable products still remain to be recovered. Therefore, mechanical "front-end" systems (that is, systems for the initial size reduction, separation, and/or physical modification of solid wastes) consisting of shredding and magnetic ferrous removal are warranted for all central processing alternatives, regardless of the "back-end" system used (back-end refers to the combination of components that changes the chemical composition of the waste and/or converts its components into energy or compost).

Direct Combustion

This the most economical energy conversion alternative, but it exhibits the greatest unknowns concerning pollution characteristics. It is anticipated that the system could be designed to meet local air emission standards, but this has not yet been demonstrated at full scale facilities. This alternative will become more feasible if coal combustion comes to the Bay Area, since those facilities will have the ash-handling capabilities necessary for direct combustion.

Pyrolysis

For system specific conclusions on pyrolysis, see the market assessment conclusions section of this chapter.

Composting

Because of the limited nature of markets for refuse-derived compost with sludge, this option is infeasible except for very small projects.

Landfills

Current solid waste management practices rely almost entirely on landfilling for municipal wastes. Except where combined with local source separation programs, no major reduction of wastes to landfill can be achieved in the next three to five years. It is expected that in the next five years there will be a shortage of landfill capacity in parts of the Bay Area. Therefore costs for landfill disposal will rise dramatically. Even with resource recovery, landfills will still be needed for the residues from the resource recovery process and for those wastes not processible. Resource recovery residues, due to their potential concentration of organics and salts, may present significant leachate problems.

Institutionalization of Function

Since the existing marketplace has not, and possibly cannot, satisfy public objectives in regard to materials use (and more importantly, re-use), the possibility of institutionalizing the function under public or quasi-public agency can be considered. The complexity of issues surrounding resource recovery argues strongly that such a consideration be made. "In order to encourage the private market to conform closely with society's goals, and hence to close politically the gap between private and social positions, an institution needs to be designed to compensate for the existing market failure to reach the re-use ratio that maximizes social benefits. The form of such an institution, however, needs to consider existing market practices and institutions which link waste recovery with industrial re-use.

Incentives for Government Involvement

Incentives for government to share a part in developing these institutions appear to be:

1. Advantages of resource recovery to decrease waste costs and to minimize needless exploitation of the limited resources provided by our environment are shared by the society as a whole.
2. Waste disposal is public business. Actions affecting waste disposal will logically include public agencies, since responsibility for waste disposal is a public sector phenomenon in the Bay Area.
3. Government is already involved in resource development, because state and federal legislatures are responsible for conferring numerous artificially-created advantages upon virgin materials processors" (Caughron, 1973).

The foregoing leads to the question of public vs. private ownership. One important aspect of this question is cost. Since most waste reclamation systems have high initial costs, municipally-owned plants offer substantial cost advantages over privately-owned plants. "Tax-free municipal bonds can be sold at about a 5 percent annual rate, while high-grade industrial bonds would cost approximately 8 percent when held to maturity (It should be noted, however, that the tax-free status of municipal bonds tends to offset the savings when total government revenue is considered). Municipalities also have an advantage over private owners with respect to property taxes and income taxes (here again, apparent savings differ from actual savings when total public revenue is considered).

In addition to incurring out-of-pocket costs for taxes related to property values, the private owner-operated resource recovery process suffers several other economic disadvantages when compared with a municipally owned and operated process.

The private firm, too, must satisfy its owners by providing an adequate return on its invested capital. To obtain a 10 percent net after tax return requires that a firm in a typical 50 percent tax bracket earn a pre-tax return of 20 percent. If the facility in question is financed by both internal (equity) and external (debt) capital, the average interest cost will lie somewhat between the rates applying to these different sources of funds. For example, if the project were financed 30 percent with equity capital and 70 percent with debt capital, having 20.0 percent and 8.0 percent interest rates, respectively, the firm's composite cost of capital would be 11.6 percent. In this case, interest charges applied to various investment categories would be 11.6 percent for a private owner, instead of only 5.0 percent plus a small loss of bond holder income tax revenue for a municipal owner.

The effects of additional fixed costs on net operating costs are summarized in Table II (Caughron, 1973). We can see that a municipality should be able to process its wastes for some 20 to 40 percent less than if it were to contract the operations to a private firm, assuming operations of comparable efficiency. However, it should be noted that a municipality or other political jurisdiction may be unable to or may not choose to burden its taxpaying citizens with the debt loads required for resource recovery and may instead opt for private ownership in spite of higher annual operating costs.

It may be possible to combine the best of both sectors with public ownership and private operation. Since operation of most resource recovery facilities requires highly technical knowledge, private operation may be the best option, since improper management and operation could result in excessive downtime and added costs to the operator. Also, since the materials salvage business is highly dependent on personal ties of long standing, private operators of resource recovery facilities might be more readily accepted by buyers than government personnel. In such a situation, benefit sharing might be possible between the public and private sectors.

A consideration of all factors points to the need for a planning effort combining public ownership and private operation of resource recovery facilities.

RECOMMENDATIONS

In future planning for solid waste management in the San Francisco Bay Area there is a need for a comprehensive mix of solutions tailored to specific needs. This means integration of 1) waste reduction measures such as beverage container legislation and other packaging controls; 2) source separation of various wastes to minimize contamination levels and allow for ease of separation; 3) processing and conversion of wastes in projects sized to market needs and optimum economics; and 4) environmentally sound landfilling of non-reclaimable materials.

Following are the policy recommendations which the authors of this report would like to make to local and state officials and anyone else concerned with the problems of solid waste management:

Waste Generation (Source Reduction) - Strong educational efforts need to be made to alert the public, institutions, and industry to practices that result in unnecessary wastes. Legislative efforts, such as the beverage container legislation in Oregon, need to be pursued to bring about waste reduction where

TABLE II

EFFECT OF FACILITY OWNERSHIP ON NET OPERATING COSTS*

Process Concept	Net Annual Operating Cost under Municipal Ownership	Additional Fixed Costs Incurred by Private Owner**	Net Annual Operating Cost under Private Ownership	Net Operating Cost ($/ton)		Increased Cost for Private Owner ($/ton)
				Municipal Owner	Private Owner	
Incineration Only	$2,303,000	$ 590,000	$2,893,000	7.68	9.64	1.96
Incineration and Residue Recovery	2,154,000	676,000	2,830,000	7.18	9.43	2.25
Incineration and Steam Recovery	2,116,000	735,000	2,851,000	7.05	9.50	2.45
Incineration + Steam and Residue Recovery	1,973,000	809,000	2,782,000	6.57	9.27	2.70
Incineration and Energy Recovery	2,692,000	1,125,000	3,817,000	8.97	12.72	3.75
Pyrolysis	1,626,000	781,000	2,407,000	5.42	8.02	2.60
Composting (Mechanical)	1,884,000	1,088,000	2,972,000	6.28	9.91	3.63
Materials Recovery	1,431,000	733,000	2,164,000	4.77	7.21	2.44
Fuel Recovery	811,000	480,000	1,291,000	2.70	4.30	1.60
Sanitary Landfill (Close-in)	770,000	141,000	911,000	2.57	3.04	0.47
Sanitary Landfill (Remote)	1,781,000	160,000	1,941,000	5.94	6.47	0.53

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*Based on 1,000-TPD plant, operated 300 days per year.

**Based on 5 percent interest for municipality and 11.8 percent interest for private owner (70 percent debt at 8 percent and 30 percent equity at 20 percent). See Table I.

voluntary efforts do not succeed.

Materials Separation - Source separation programs can be implemented quite rapidly and have a potential for removing large amounts of valuable materials from the waste stream. One suggestion of this report is a substantial fee increase for the use of more than one garbage can for mixed waste pick-up, so as to deter non-participation in these programs. Pick-up for glass and metals could be bi-weekly and newspapers could be picked up by the regular packer trucks, which now pick up the mixed wastes, by adding special racks (this type of newspaper pick-up is presently done on a small scale by the Oakland Scavenger Company and several other collection companies in the Bay Area).

Since it is doubtful that we will ever approach 100% participation in source separation programs and since waste reduction can be of only limited value, some mixed waste recovery will be necessary. New transfer stations, which will act as the front-end processing step for total resource recovery systems, will need to be developed. These should be situated so as to promote efficient regional collection and marketing of recovered materials.

Energy Conservation through Energy Recovery - There presently exist numerous technologies for recovery of energy from the waste stream. Due to uncertainties in the economic and technological performance of these systems, as well as the long lead times associated with these projects due to their capital intensity, this solid waste management alternative does not present an immediate solution to the solid waste problem. Research needs to be continued into these energy recovery options so that useful economic and technical data can be generated. Assuming that the composition of the waste stream is not going to change very much in the next 15 to 20 years makes energy recovery appear to be a viable alternative when the rising prices and diminishing stocks of fossil fuels are taken into account.

Resource Recovery Markets - One recommendation which several of the authors of this report came up with was a need for the formation of a cooperative market for all recycling centers. By joining together in a cooperative effort, Bay Area recycling centers could enlarge operations, obtain economy of scale, and ensure a steady supply of materials to potential buyers.

One problem which has been encountered is the preferential status which virgin materials have enjoyed over secondary materials. It is recommended that economic incentives, such as those presently given to virgin materials, also be given for the use of secondary materials to make them cost competitive with virgin materials. This would be the minimum recommendation, since it is the belief of the authors of this report that the substantial environmental advantages derived from using recovered materials warrant a preferential status for their use over the use of virgin materials. Preferential status for recovered materials would create a productive system based more on flows of materials rather than one based on the continued exploitation of rapidly diminishing stocks of natural resources. This would also minimize the environmental degradation brought about by that exploitation.

Landfills - Since there will always be some non-reclaimable materials in the waste stream, part of the planning effort will have to be for the siting and maintenance of environmentally sound landfill sites.

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