

# THE RECYCLING CHALLENGE TO ENGINEERS: INTERESTING, PROVOCATIVE, AND PRECARIOUS

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## ABSTRACT

The engineer, in designing equipment for the extraction of materials from the post consumer waste stream, is challenged to enlarge his normal approach. Mechanical skills have to be blended with the impact of environmental laws; market constraints upon secondary materials; specifications by consumers of raw materials for melting or processing; cost projections; and possible legislative changes which may disturb the flow and characteristics of the waste.

## EVOLUTION OF SOLID WASTE RECYCLING

As this is being written, it appears that recycling itself is being recycled, and the process is continuing. Several years ago, as solid waste disposal problems became critical, the demand for recycling was spurred on by the belief that there was gold in garbage. That resulted in facilities with massive and expensive equipment to retrieve materials from the waste stream. It soon became apparent that modifications were necessary in concept and goals. The emphasis then shifted to the production of steam and electricity with some recovery of materials themselves in limited systems where the economics warranted it. A second stage is the belief that materials should be source separated to avoid contamination to enhance marketability and re-

duce the expense of retrieval. This latter stage includes the use of curbside or household source separation programs. Within this stage, also current, was the demand to retrieve and process the material as it reached a disposal facility, but before actual disposal processing began. A third stage has been reached in some areas, using mass burn facilities, to avoid all attempts at retrieval of materials. This decision is usually made in the belief that the economics do not warrant the expense measured against the revenue return when power is produced and sold under PURPA (Public Utilities Regulatory Policy Act). Each stage, and/or modifications of them, have advocates and dissenters as experience at the local level and other areas develop. This is a moving target. As a representative of the scrap processing industry, and from my experience in the legislative area of solid waste management, I trust I can add some dimension to the holistic approach so necessary in this topic today.

## WHAT IS RECYCLABLE IN MUNICIPAL SOLID WASTE?

Taken from "Characteristics of Municipal Solid Waste in the U.S. 1960-to-2000-Final Report." Franklin Associates, Ltd., 1986, as reported in Public Works Magazine for May 1989.

## CHART "A"

PERCENTAGE BY WEIGHT				
Paper	37.2	Glass	8.9	Other 19.3
Aluminum	0.7	Plastics	3.7	
Steel	4.1	Food-Yd	26.0	TOTAL 99.9

Note: Totals are combination by this author of various products shown in the original report.

If we examine this chart carefully, we note immediately that the analysis of what may be "recyclable" totals approximately 36.7% of the total. That is obtained by eliminating the food and yard waste as well as the paper, if we can assume that paper at the disposal point is probably contaminated and useful for fuel but not as a material for recycling. (This assumption in regards to paper should be modified depending upon the ability of the facility to actually recover paper prior to the disposal process.) Since we are considering materials on the basis of weight, we face another problem with plastics which should be considered on the basis of volume as well. It follows then, that variations in weight of materials available are insufficient in making decisions when applied to plastics.

Recycling is proposed in the main to conserve land-fill space as these disposal facilities shrink in availability. We also can realize that a change of 1% is not measured against the total of 100%, but against the much smaller percentage of the material being considered for recycling. Change one assumption here and the effect will be felt immediately upon any decision and projections contemplated. Because there is usually a long period of time between the target date for the RFP, as well as the lag in acceptance by the political body seeking the proposal, flexibility in projections is mandatory to protect the engineer.

### RISKS IN PLANNING — THE MOVING TARGET

As engineers, you are familiar with the requirement under EPA that the best available technology is often required in controlling pollution. If grandfathered into

law, you are aware of the potential expense you face down the road. This involves "add-ons". You plan for it. In recycling, however, you face many more possible changes than just technology. I refer to markets; legislated effects upon the composition of the waste stream (banning of plastics for example); federal mandates on packaging and/or design for recycling by manufacturers; banning of yard wastes, deposit laws, and/or flow control of post consumer products; pre-screening and removal of hazardous materials and "recyclables" from disposal waste; and a host of possible changes determined as desirable in the political sense to meet popular demands by the citizens.

That is the challenge to your expertise. You are not alone though, for that challenge is to everyone in the country. Recycling is important, regardless of the size of its impact upon solid waste disposal, but it has many risks. These risks can and should be shared if designers of systems and facilities recognize and identify them in advance. No one said it is easy.

### THE COMPUTERIZED APPROACH

Engineers are most comfortable when dealing with behavioral and physical predictability. They rely upon known characteristics of matter to react as expected when the flow of materials falls within the limits of their known characteristics. However, MSW contains infinite combinations of an infinite variety of materials including organics, metals, plastic, sludge, and so on.

Because of the many variables, as well as the position of these variables in a flow model, the computer becomes a valuable tool. It is possible to develop mathematical models for real phenomena that predict "what

if” results. Because the “what if” approach is so important in devising a multi-million dollar system, it should be applied.

The incoming material can not meet narrow specifications. It varies from day to day, hour to hour, season to season, in characteristics as well as quantity.

Therefore, it no longer is appropriate to rely upon that old phrase, “everything being equal, then.” Rest assured that in the field of solid waste, nothing is equal. It is more appropriate to state, we face a “moving target.” This is the challenge when you have the obligation and responsibility to assess the impact of recycling and project the results.

### **CHOICE OF EQUIPMENT AND DESIGN: REGRESSION APPROACH**

First I would like to narrow the subject of recycling to “waste to energy” facilities. I have eliminated those landfills which account for the waste after recyclables are removed, or monofills which accept incinerator ashes that have been screened for recyclables prior to disposal.

Second, I am aware of the impact upon your decisions of environmental laws, regulations, financing, evolving technology, and other aspects of solid waste management which are presented at this conference in other papers. My thrust is to target the impact of nontechnical areas only, as they affect your projections of recyclable materials anticipated volume, value, required facilities, etc.

Because the public has placed a nonrealistic goal upon recycling results, biased by its adverse reaction to incinerators and landfills, the engineer must avoid the same trap. Nonrealistic projections will come home to haunt you, especially if you may be operating the proposed facility as “going private” seems to be the trend today.

Finally, the role of recycling may be just a step in the hierarchy of waste management, but it might be the tail that wags the dog in your planning for any waste processing or disposal system.

The emphasis is upon the necessity for raw material analysis and availability, market research, and the impact of nontechnical considerations, before you choose your equipment or design. A series of choices involve substantial investment in equipment and operational expense. Engineers recognize that there are three important factors that will affect their choice: (a) the nature of the refuse stream in the particular location of the facility; (b) the end product it desires to produce, both the energy derivative as well as the materials to

be removed, if any; and (c) the client’s demand for recycling.

We can practice a kind of “regression analysis” or working backwards when materials recovery is considered. It is determining if there is a market, and what specifications are to be met. Should you process the material to meet these specifications and can you do it? Will market changes in demand or price entail excessive risks?

### **FLEXIBILITY IN PLANNING**

Often the reason for removing anything from the process stream is a protective measure rather than for recovery in order to minimize downstream process problems with troublesome and/or extraneous material. Once this selection is completed, whether for philosophical, political, public relations, or the bias of consultants, the operator may be locked into an inflexible system incapable of adapting to realistic market requirements and changes, or even corrective system technical change.

Therefore, to reduce risk, you can design bypass in your waste flow system. If sorting is feasible in a high market for materials, you sort. But if there is no market, temporarily or permanently, you allow the materials to pass through for disposal. If the cost of conveyors and/or equipment allowing these options is expensive and marginally useful, you may avoid that installation, in which case the system design can permit future retrofit to provide the bypass option and so on. The objective is not to commit the operation to markets that do not materialize or may be temporary, but to adapt to attractive opportunities when they develop.

Your facility may be designed to remove metallics and/or non-metallics either front-end, within the disposal sequence of operations, back-end, from the incinerator ashes, or at separate “recycling centers” or transfer stations. You are aware of shredders, magnetic separators, trommels, air classifiers, gravity separators, electronic aluminum can classifiers or retrievers, glass color sorters, plastic separators coming on stream, and, not least, the “old fashioned” conveyor-belt hand-picking system. Whether we consider mass burn, or production of RDF (Refuse Derived Fuel), we have to make decisions.

The choice of equipment will be affected by the projection of materials to be recovered and recycled. The other effect of any choice is the impact upon the success of recycling because of the decision as to where, when, and how materials are to be recovered, if any.

## **THE TECHNICAL FACTORS**

Let's examine just a few of the "variables" that a system designer must consider. Will the material arrive at the facility comingled, or sorted. If comingled, for example, will metal cans require magnetic separators? Will they require cleaning or shredding or baling? Can the cans be shunted aside for shipment to a scrap processor? What kind of equipment is necessary to meet a consumer's specification, to meet a scrap processor's specifications? What is needed to sort, process for shipment per se or process for meeting a consumer's requirements for plastics? What is the cost of equipment and operations measured against the enhanced value of the remaining fuel if interested in producing steam and/or electricity for sale under PURPA? And, not least of all, after decisions have been made, just how long will these decisions remain viable? That's the "moving target."

## **NONTECHNICAL FACTORS**

Now, we can consider the scenario of the nontechnical areas which led me to choose the title of this presentation.

If an engineer is considering a system that includes recycling goals, or ignores them, he should examine the following list. Each item, of course, does not stand alone but interacts with each other, hence my suggestion for the use of a computer.

## **NONTECHNICAL AREAS OF SIGNIFICANT IMPACT UPON RECYCLING MATERIALS FROM THE WASTE STREAM**

### **Markets**

Volatility-absence of long term contracts for scrap materials at fixed prices, although some contracts can be obtained for acceptance of materials priced at changing market price quotations; inability to store materials for future markets; subsidized recycling centers. DEPOSIT LAWS.

### **Legislation (State and Federal)**

Mandated recycling; mandated source separation; mandated pre-disposal recycling at landfills and/or Waste to Energy facilities; subsidized recycling centers.

### **Costs**

Increase in fuel value by removal of noncombustibles. Increase in revenue under PURPA in power production. Increase in revenue from sale of steam.

### **Environmental Constraints**

Removal of materials to improve pollution control equipment efficiency and operating costs. Increase in landfill costs as more stringent EPA rules are made; increase in financial cost under closing requirements for bonds and monitoring. All resulting in rise of value of "avoided costs" determination.

### **Public Relations**

Recycling demand by the public regardless of the economics of recycling versus no recycling.

### **Transfer Stations and Recycling Centers**

Operation of these facilities reduces the flow of recyclables in the waste stream and must be considered in planning.

### **Scrap Processors in the Area**

If they purchase recyclables of post consumer materials, the amount in the waste stream is reduced. However, the equipment and expertise they have available provides a viable option to avoid the purchase of expensive equipment through a contractual arrangement.

### **PURPA (Public Utilities Regulatory Policy Act)**

Any changes in this law could be significant in any projection of revenue in planning for production of electricity.

### **Disposal Facilities**

Transportation costs to more distant landfills or monofills, for either noncombustibles or ashes will certainly increase in time.

## **AN EXAMPLE: IMPACT OF FACTORS ON JUST ONE MATERIAL — ALUMINUM**

To indicate the effect of using the list, let's consider the one popular and valuable item, the aluminum container. We can then note the interplay of external con-

ditions, from the list, upon any decision to extract the containers.

First we shall make some assumptions:

(a) That the RFP (Request for Proposal), or negotiations for a contract, mandates that some recycling shall take place.

(b) That a survey has been conducted in the area to be served, indicating the amount and type of materials contained in the waste stream, including demographic projections for a minimum of ten years.

(c) That the desired facility shall be a Waste to Energy (incinerator) system.

(d) That the state or district does not have a deposit law in effect. That a flow control law is not in effect.

(e) That the region or area or district, collects waste, refuse or garbage, and, if not, controls all private collection systems through contract or law.

(f) That there is no adjacent facility large enough to accept his district's waste, nor is any enlargement or construction of one contemplated in the immediate future.

(g) That the engineer is given the option of presenting a proposal which contains plans for generation of steam, or steam and electricity, depending upon the economics.

(h) That the regional area at the moment conforms precisely to the national chart "A," for the year 1984, which I referred to early on in this report.

## Markets

Scrap markets are volatile for metallics, based upon supply and demand. In the case of aluminum, however, there is an additional effect based upon the competition between steel, plastic and aluminum to furnish the stock to produce the containers. In mid 1989, for example, aluminum ingot prices fell 20¢ per pound almost overnight. The effect of price volatility, as well as the volume variations, is shown in Chart "B" Aluminum.

Because of the possible wide variations in potential revenue the "what if" approach is valuable and necessary in presenting a proposal to a client. Even in this modest 1000 TPD example, your client should be made aware of the wide swing in potential revenue that would result from unexpected price changes in the market. A 20¢ per pound drop equals \$146,000 per year.

An important aspect of recycling aluminum, is the ability to meet the specifications of the consuming industry. The more rigid the specifications if met, the higher price is obtainable, provided sufficient volume exists and sustained volume is possible. A facility, nor-

mally, cannot provide storage space to hold the metal in order to "play the market."

At this point I suggest contact be made with the local scrap processor who can be of valuable assistance to acquaint you with markets, specifications, processing option equipment, and the historical pricing of aluminum in recent years. Furthermore, the engineer should be aware that long term contracts for fixed prices, is abnormal in the scrap market.

## Flow of Materials

Projections made solely upon current studies are seriously flawed. Deposit laws, for example, historically have a great impact upon the volume of aluminum in the MSW stream going for disposal. Again, by reference to Chart "A," the variation of 0.001 has a meaningful financial revenue effect.

## Legislative Impacts

Reference here is not only to deposit laws that might be enacted, but to mandatory "recycling" laws involving source separation by householders, known as curbside collection programs. If the engineer contemplates the purchase of equipment to electronically separate aluminum in the system, this commitment to expensive outlays may be in jeopardy when the flow of aluminum is decreased.

## Costs and Financing

As mentioned previously, equipment and operating costs for retrieval of aluminum are subject to determination of the effect of legislation, markets, flow control, etc. The computer can be very useful in projecting the "what if" results.

## Environmental Constraints

Here we contemplate the effect of banning, for example, plastics, which could increase the use of aluminum. As far fetched as it seems today, possible federal controls of use of electric power might also have an impact upon the production of aluminum from bauxite. Post consumer aluminum could become more valuable.

## State and Local Policies

Many states have adopted solid waste management legislation. The effect under legislative impact has already been noted. If the state provides subsidies for

**CHART "B" ALUMINUM  
IMPACT OF PRICE AND VOLUME VARIATIONS UPON  
RECOVERY OF ALUMINUM FROM THE MUNICIPAL  
WASTE STREAM**

Assumptions: Model system with 1000 tons per day (TPD) @ 5 day week collection,  
261,000 tons per year (TPY) (1 ton = 2000#)  
Aluminum in Municipal Waste Stream (MSW) .007 by weight. \*\*\*

Aluminum Recovery Prior to Disposal.	Remainder in MSW	To Determine Volume. TPY x 2000# x .007 x Remaining %	Scrap Price Per Lb.		
I. 80% projection in various state plans	20%	730,800#	10¢	30¢	50¢
YEARLY REVENUE			\$73080	\$219240	\$365400
<u>EACH 1¢ IN VALUE</u>		<u>PRICE IMPACT</u>		\$7308 per year.	
		<u>VOLUME IMPACT</u>			
<u>EACH .001 in VOLUME</u>		<u>Yearly Revenue</u> 7	\$10440	\$31320	\$52200
II. 54% U.S. Average- Year-1988	46%	1,680,840#			
YEARLY REVENUE			\$168084	\$504252	\$840420
<u>EACH 1¢ IN VALUE</u>		<u>PRICE IMPACT</u>		\$16808 per year.	
		<u>VOLUME IMPACT</u>			
<u>EACH .001 IN VOLUME</u>		<u>Yearly Revenue</u> 7	\$24012	\$72036	\$120060

\*\*\*Weight of aluminum in MSW, taken from "Characteristics of Municipal Solid Wastes in the U.S. 1960-2000-Final Report" Franklin Associates, Ltd. 1986, as reported in Public Works Magazine for May 1989.

"recycling centers," the attraction of aluminum containers from the waste stream would affect the volume remaining in the MSW moving for disposal, and/or recycling at a Waste to Energy facility.

### Public Relations

Even though analysis indicated the retrieval of aluminum was not economically viable, the demand by the public for recycling could tilt the decision to provide the facilities nevertheless.

### Transfer Stations and Recycling Centers

Obviously, any provisions for retrieval of aluminum at these facilities would and should affect the decisions for doing so in any proposal contemplated. The flexibility required here, however, is the technological advances being made electronically and mechanically to do the job at the lowest cost versus the systems in use at the transfer stations and/or recycling centers. In

this area of concern also, scrap processors, with equipment and expertise already in place, could provide an alternative for the facility to avoid expensive equipment and operational costs.

### The System Proposed

In addition to the comments made here, the type of facility chosen will greatly affect the ability to recycle aluminum (or any other material). Front-end separation and/or retrieval during processing of the MSW is entirely different from back-end retrieval from the ash. The economics of removing the aluminum, front-end, is affected by the desire to improve the fuel properties of the remaining waste. Under PURPA (Public Utilities Regulatory Policy Act) the value of electric power (or steam) will greatly affect the decision to recycle the aluminum.

Although the target here is the aluminum container, obviously the same examination and evaluation of each listed item will apply to any and every other material

being considered for recovery and recycling. Special constraints or conditions apply to certain materials, especially plastics.

Finally, the contemplation of variables, in any material considered for recycling, brings us back to square one. I refer to the need for the use of a computer to design a proposal or a facility. The use of the “what if” approach is not just a game, but a serious application of possible results, affecting the cost of equipment and operation, as well as the goal for a Waste-to-Energy system and/or a modified incinerator mainly for disposal. The professional presenting all of the options available to the agency or client seeking the RFP, would then have the assurance of an authorized decision, if engaged to move ahead. His responsibility is to gather the “facts” and the projections, and recommend a final proposal. With all of the pos-

sible variations and options outlined, the burden of a final decision rests with the engaging client or agency. The engineer provides the smorgesboard, the client chooses the meal.

#### NOTE

Some excerpts have been taken from “MARKETING RECOVERED MATERIALS: A Viewpoint of the Private Scrap Processor,” by Calvin Lieberman, Section 15.2 of *The Solid Waste Handbook*, John Wiley & Sons, Inc., William D. Robinson, Editor. (Courtesy of John Wiley & Sons, Inc.)

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