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RECENT PROJECTS OF THE SLOAN INDUSTRY CENTER FOR A SUSTAINABLE ALUMINUM INDUSTRY PROMOTING ALUMINUM RECYCLING

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The Sloan Industry Center for a Sustainable Aluminum Industry (CSAI) has recently partnered with academia and industry on several projects to promote aluminum can recycling. Some of these projects have focused on counties in Kentucky as a sample test in the hopes that information learned at this level can then be applied to communities across the United States. These projects have included developing a database for understanding the economics of aluminum recycling, implementing a business methodology for improving recycling rates, and increasing the general knowledge regarding recycling behavior. In addition, two new proposals concerning recycling from landfills and studying recycling behavior are currently in the preliminary stages.

The Economics of Aluminum Recycling Bibliography

The CSAI is analyzing the existing dynamics surrounding aluminum can recycling as part of a collaborative study with Gatton College of Business and Economics at the University of Kentucky in Lexington, the Center for Aluminum Technology, and Secat. As part of the multi-pronged research efforts, several projects were undertaken. The first was to conduct an exhaustive effort to understand what is known about the economics of recycling and any special aspects of aluminum recycling. The results of this research segued to the second goal of the study, which was to identify new research areas that would add to the understanding of economic factors/conditions impacting recycling. This new research would add to the existing body of knowledge.

A substantial amount of published research is directly or indirectly related to the economics of aluminum recycling. The published literature was reviewed for the CSAI collaborative study, and a bibliography was developed of research conducted on the economics of the aluminum industry, both in the United States and internationally. It is hoped that this source, believed to be the first bibliography in this area, will become an industry tool. The sources include research on the economics of solid waste disposal and recycling, pricing of garbage, and deposit/bottle bills. This research deals with recycling directly by analyzing curbside recycling, municipal recycling facilities, determinants of recycling, and international experiences with recycling. The complete bibliography contains more than 135 sources and is available on-line at http://www.sustainablealuminum.org/pdf/CSAI%20Bloomquist_Paper01-06.pdf .

Based on a review of the existing research compiled in the bibliography, two critical areas of aluminum recycling were identified that require further exploration: (1) aluminum can disposal relative to the prices of other goods and services from a household view, and (2) the costs and benefits of aluminum can recycling determined from the perspective of society.

To determine relevant real price indexes, data were obtained from the U.S. Bureau of Labor Statistics (BLS). The BLS reports three relevant series. The first is the price index for all recyclable materials. The second is the price index for used aluminum cans; it is a component of the price index for all recyclable materials. The third is the Consumer Price Index, which is used for the price of other goods and services. All data can be retrieved at http://www.bls.gov/data/.

Social costs of recycling include hauling, storing, handling, separating, and consumer time and convenience. If landfill and litter costs are not fully taken into account when residents and municipalities make recycling decisions, then too little recycling will result. If, on the other hand, consumers' time and convenience are highly valued, mandatory recycling might produce negative net social benefits.

The socially optimal recycling rate is the recycling rate that is best for society considered as a whole; particular groups within society may benefit from recycling rates that are higher or lower than the socially optimal rate. If some groups benefit from a higher than socially optimal rate, the gains come at the expense of others and the benefits to the winning groups are less than the losses to the losing groups.

After analyzing more than 135 existing studies related to the economics of aluminum can recycling, it was determined that the real price of used aluminum theoretically should influence recycling rate (Fig 1). A first look at the relationship suggests that it does, and further analysis seems warranted. This research is being coordinated with research on the marketing of aluminum can recycling. Additional research efforts should focus on developing a method that identifies municipalities with low recycling rates, which are likely to have social benefits of aluminum recycling that are greater than the social costs.

Six Sigma Study

With a Sloan Foundation grant, Secat Inc. and the University of Kentucky are conducting a three-year project in Fayette County, Kentucky, to understand and improve recycling rates using Six Sigma methodology. Figure 2 shows the trend of the US recycling rate of Used Beverage Cans (UBCs). This application of Six Sigma is the first methodological attempt at improving the recycling rate. The information gathered during this project is expected to serve as a stepping stone to a national effort to increase recycling rates and thereby increase economic development opportunities.

Working with local retailers and aluminum recycling centers in Fayette County, Secat and the University of Kentucky are implementing the 11 steps of Six Sigma. In the project, each aluminum can that is not recycled is considered a defect. The goal is to reduce the defect level by first determining the sources of variability in the recycling process and then decreasing that variability to increase customer satisfaction (i.e., ease of getting the cans to the recycling facility), thereby increasing the recycling rate. To achieve this goal, Six Sigma comprises five phases: scope, measure, analyze, improve, and control.

To date, the preliminary process map has been identified (Figure 3), and an initial estimate of the true recycling rate has been developed (Table 1). In addition, recommendations for improving the process map have been made, such as ensuring delivery and pickup of recycling bins and identification projects to address the ease of recycling for those without access to curbside programs.

The following five items are planned:

1. Determine the true recycling rate using statistical techniques outlined by Six Sigma.

2. Continue to revise and finalize the process map based on new data and input from sources in Fayette County.
3. Document and implement projects of placing recycling bins in all elementary schools to enhance the recycling rate.
4. Ensure sustainability of improvements.
5. Recommend strategies for wider replication.

It is hoped that the results of this study will provide answers on why the aluminum recycling rate is declining and will serve as a first step in developing a national effort to increase the aluminum recycling rate.

Recycling Behavior

A collaborative study between the CSAI, the Center for Aluminum Technology, Secat, and the University of Kentucky at Lexington is developing ways to encourage greater levels of individual aluminum recycling behavior, using Kentucky as a test environment.

Effective recycling programs require people (1) to begin to participate and (2) to continue to participate. Because recycling behavior is voluntary, people participate for reasons that are not readily apparent and not necessarily in their immediate self-interest. Therefore, to be effective, recycling programs must provide people with reasons or motives that spark their participation. These motives must be enduring enough so that people maintain their interest in recycling programs over time.

Based on the findings of previously conducted research programs, recyclers in the U.S. population are reportedly older and wealthier, living in households with fewer members, and more liberal in political orientation. By comparison, Kentuckians are younger and less wealthy, have larger households, and are more conservative politically. Thus, programs to motivate Kentuckians to recycle must overcome their tendencies not to recycle, as compared with national norms.

To increase aluminum recycling in Fayette County, behavior modification programs were proposed. A recent survey by the Kentucky Environmental Council revealed that respondents with more education performed better on 12 recycling knowledge-based questions than those with less education. However, despite their better knowledge of environmental facts, those with more education were not more likely to engage in environmentally responsible behaviors than those with less education, based on their self-reports. The conclusion may be drawn that although they understand the environmental issues, they do not connect those facts with their own actions and behaviors. This weak relationship may be attributed to a difference in the strength of their environmental convictions or the exclusion of other variables that affect the environmental attitude → behavior link.

It was determined that Fayette County needs a 2-pronged approach to increasing the recycling rate. The first approach is to increase the rates of those who already engage in recycling; the second approach is to modify the behavior of those who are environmentally aware, but do not currently engage in recycling. The marginal benefit of reaching the third type of consumer, those who are not concerned about the environment and do not recycle, is minimal. It is possible that these consumers may modify their behavior through the economic actions proposed for the other two segments.

The next phase of this study will address several research issues. First, the research method details must be developed, and successful programs in states with ongoing recycling programs will be studied. Second, the demographic attributes that have the most influence on recycling

behaviors will be established; this will require segmentation of consumers. Third, it must be ascertained which messages or benefits (e.g., economic or environmental) will have the most impact on each demographic set. This will require an analysis of interactions between demographics, intent, and messages. Finally, measures of success (i.e., increases in recycling rates) must be set.

Current Studies

Aluminum Recycling Behavior

A quasi-experimental study of aluminum recycling behavior in Fayette and Warren counties in Kentucky has been proposed to address 5 areas:

- Price elasticity of the supply of aluminum recycled material
- Effectiveness of various communication appeals
- Frequency of communication
- Gains versus reduced losses
- Matching versus mismatching communication appeal effectiveness

The goal of this project is to find the most cost effective method (or methods) for increasing household recycling. Several theoretical orientations can be identified in the applied behavioral analysis literature dealing with recycling; this study will identify which method or combination of methods will have the largest impact on recycling behavior, producing an academically rigorous and interesting study that is useful to the aluminum industry.

Each household will be surveyed before the study begins to determine recycling levels, attitudes toward recycling, and demographic information. Each household will then be surveyed monthly for six months to determine their updated recycling behaviors and attitudes. If feasible, a carrier will monitor the recycling bins from these households and measure the differences before and after the manipulations during the study.

In addition to survey, the responsiveness on recycling behavior will be examined using data from recycling stations. During the past two years the price of aluminum has doubled; data on the amount of material collected by recycling stations in Lexington is also available for this time frame. Additional data will be collected on the prices paid to individuals bringing in recyclable material. All of this data will be used to analyze how responsive recycling behavior is to price changes. This has the advantage of taking into account the non--used beverage can (UBC) sources of aluminum.

The two-county study would be conducted for six months with 48 total conditions (24 in Warren County and 24 in Fayette County). To control for income differences, zip code analysis will be conducted to ensure that there is an equal distribution across income levels resulting in 16 low income conditions, 16 middle income conditions, and 16 high income conditions (an analysis of the impact of income may also be possible). Alternatively, we will collect this information through a survey sent with the initial notification letter. Each condition will require 20 participants for a necessary sample size of 960 households per month. Television advertisements and radio spots promoting recycling will be used in Fayette County, but not in Warren County. Based on the results associated with this extensive study, recommendations for industry strategies to enhance recycling rates in the most cost efficient manner will be developed. In addition, a follow-up study is planned that will incorporates the findings from this research and further assess the most cost-efficient method of increasing recycling rates.

To determine if the marketing campaigns establish a permanent change in attitude about recycling, the same participants will be surveyed 6 months after termination of the program. If the attitude change is not permanent, the first-year study should be conducted with a more extensive and sophisticated advertising campaign. If the attitude change is permanent, repeating the experiment in two additional communities, one more rural and one more urban than the first-year communities, is proposed to enhance the applicability of the results.

Landfill Recycling

The CSAI is also advocating an economical, environmentally friendly process that is less capital intensive and more energy efficient than traditional processes to recover aluminum from the UBCs currently accumulating in landfill. The center has estimated the annual amount of UBCs discarded and accumulating in landfills is approximately 1 million tons, making landfills an attractive alternative source for recovered aluminum. If these cans were recovered from the landfills, it would add an additional capacity of 909,091 tons to the aluminum industry per year, the equivalent of the capacity that could be provided by building three new smelters, each with a 300,000 ton cap. Additionally, capital costs and the release of CO_2 and carbon are substantially lower when recovering aluminum from landfills as opposed to building three new smelters ($180 million plus removal equipment vs. $3.6 billion and 148,499 plus removal vs. 2,969,970, respectively.). Energy consumption would also be significantly lower for the recovered UBCs.

The potential rewards of recovering aluminum from landfills are encouraging, but must be weighed against known and unknown factors to determine if this is a feasible resource for the industry. The resulting process could prove to be economical and environmentally friendly, while reducing capital costs and energy usage.

What Is the Sloan Center?

The Sloan Center for a Sustainable Aluminum Industry (CSAI) is a community of scholars interested in identifying, facilitating, and disseminating innovative, observation-based, business research on keeping the U.S. aluminum industry sustainable. Key themes for the center are recycling programs, workforce development and deployment, and supply chain management.

The CSAI's research agenda gives priority to funding multidisciplinary research teams and focuses on the following research themes, which were identified by members of the aluminum industry as important to their future sustainability in the *Aluminum Industry Vision 2001* and 2004 CEO survey:

- **Recycling programs:** including acquiring a deeper understanding of the factors affecting aluminum product recycling rates and suggestions for programs to increase recycling rates.
- **Workforce development and deployment:** including efforts to analyze industry needs as related to required analytical skills for hourly and professional employees as well as efforts to examine work processes, worker deployment, and management practices as they affect plant performance.
- **Supply chain management:** including a better understanding of the many facets of logistics involving water, rail, and truck transportation, as well as the use of integrated electronic commerce to expedite movement of materials and end products.

The CSAI is composed of a management team and steering committee that oversee all projects. The management of the center is shared by Dr. Paul Jarley of the University of Kentucky; Dr.

Subodh Das of Secat, Inc.; the CSAI Steering Committee; and the CSAI Research Operations Committee.

Dr Jarley provides administrative leadership for faculty research. He chairs the Research Operations Committee, which is responsible for selecting and monitoring projects awarded through the RFP process. He works with faculty to seek grants to grow the center's research enterprise and coordinates continuing education activities.

Dr Das is the Executive Director of CSAI and acts as the key liaison between industry and the center. He is responsible for organizing forums to encourage faculty-industry interaction, assisting in identifying and communicating emerging industry issues for future research, raising industry funds to support the center, and monitoring the degree to which the center's business knowledge and research results are successfully transferred to industrial practice.

Recyclable Commodities	Weight Shipped (lbs)	Price for April 2005 ($)		Revenues Generated ($)	Composition by Weight of Total Commodities Shipped (%)	Composition of Total Revenue Generated (%)	Ratio of Revenues Generated to Weight Shipped
Old Newspapers (ONP)	15,151,025	82.50	per ton	624,980	50.0%	36.68%	0.73
Old Corrugated Containers (OCC)	4,940,336	77.50	per ton	191,438	16.3%	11.23%	0.69
Mixed Plastic	240,400	0.04	per lb	9,616	0.8%	0.56%	0.71
High Density Polyethylene (HDPE)	461,800	0.29	per lb	133,922	1.5%	7.86%	5.16
Glass	3,238,982	4.80	per ton	7,774	10.7%	0.46%	0.04
Fiberboard	951,160	44.10	per ton	20,973	3.1%	1.23%	0.39
Aluminum Cans	579,252	0.63	per lb	364,929	1.9%	21.42%	11.20
Steel Cans	638,920	200.00	per ton	63,892	2.1%	3.75%	1.78
Sorted Office Papers (SOP)	2,101,710	105.00	per ton	110,340	6.9%	6.48%	0.93
Phone Books	588,600	49.70	per ton	14,627	1.9%	0.86%	0.44
PET-2 liters	659,480	0.20	per lb	131,896	2.2%	7.74%	3.56
Magazines	740,880	80.00	per ton	29,635	2.4%	1.74%	0.71

Table 1: Commodities shipped from LFUCG Recycling Center in the period of 06/01/04 to 05/31/05 for 12 months;
Source: James Carter, Manager LFUCG Recycling Center

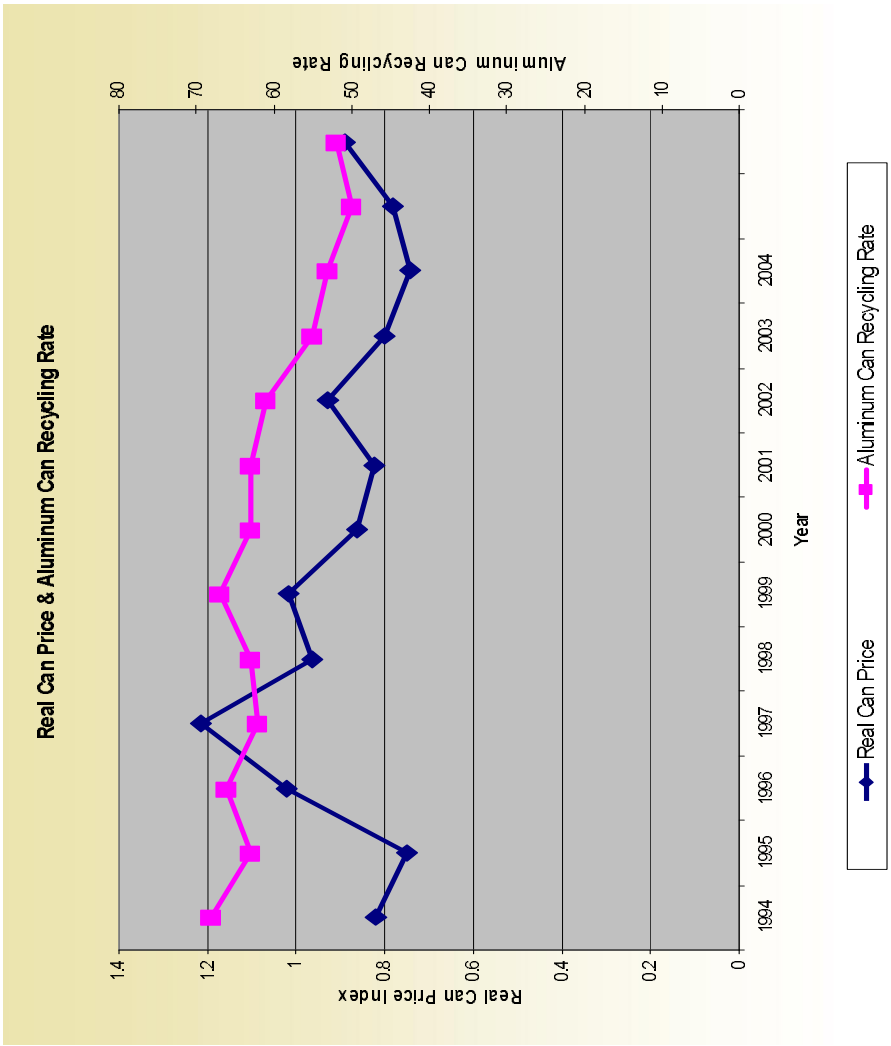

Figure 1: Economics of Aluminum Recycling

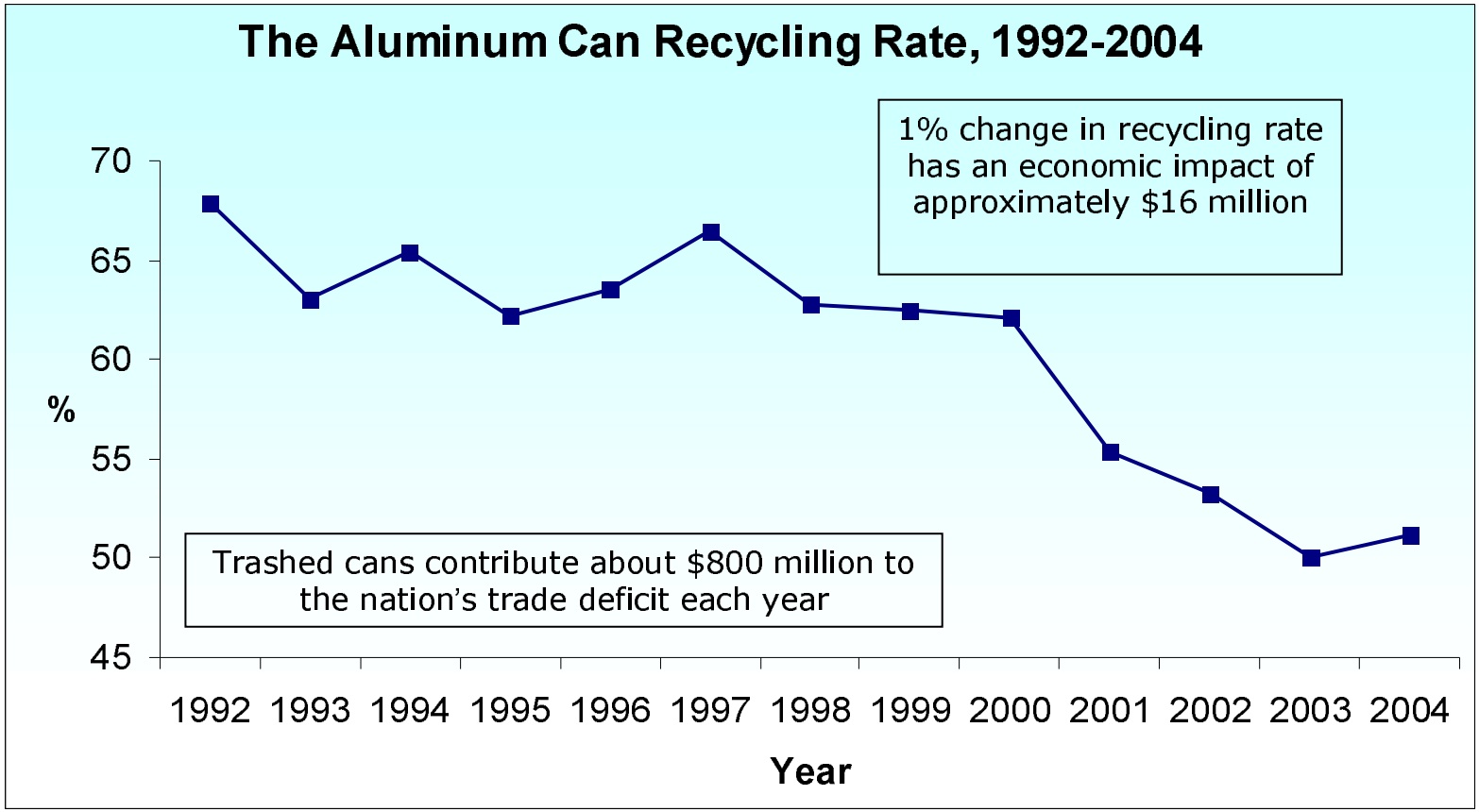

Fig 2: National Aluminum Beverage Can Recycling Rate Trends.

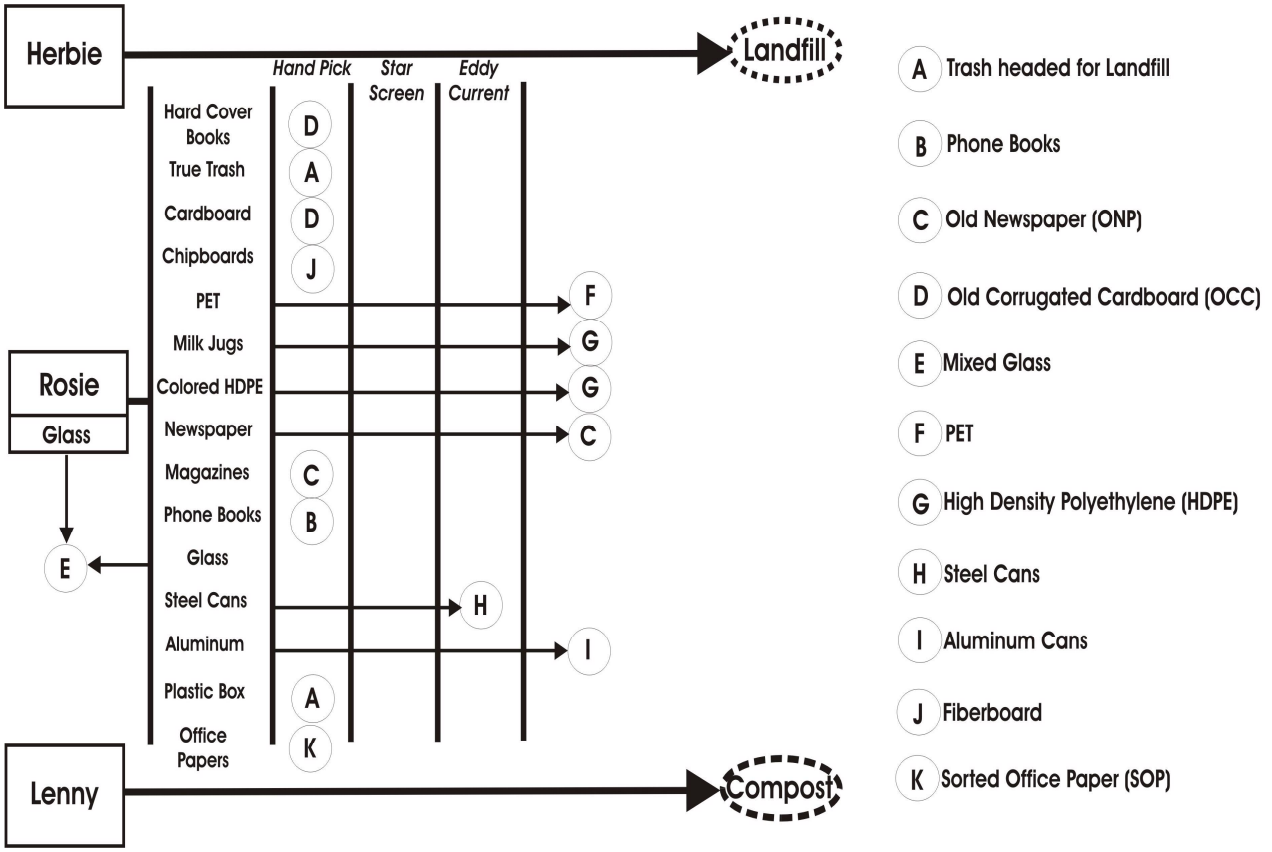

Figure 3: Separation Process at Fayette County Recycling Facility
Source: James Carter, Manager LFUCG Recycling Center