Improving Aluminum Can Recycling Rates: A Six Sigma Study in Kentucky*

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The aluminum can industry is facing a new challenge in declining recycling rates in the United States. The economic benefits of aluminum recycling are widespread and important not only to the U.S. aluminum industry, but to the economy in general. With a Sloan Foundation grant, Secat Inc. and the University of Kentucky, through the Center for a Sustainable Aluminum Industry, are conducting a project in Fayette County, Kentucky, to understand and improve recycling rates using Six Sigma methodology. This application of Six Sigma is the first methodological attempt at improving the recycling rate. To date, the preliminary process map has been identified and an initial estimate of the true recycling rate has been developed. The information gathered during this project and described in this article is expected to serve as a stepping stone to a national effort to increase U.S. recycling rates. The result, it is anticipated, will be increased economic development opportunities.

INTRODUCTION

The aluminum beverage can is part of everyday life for the majority of people living the United States. After successfully facing challenges from the plastics industry and environmental groups, the aluminum can accounted for 100% of the total U.S. beverage can market by 2002.[1,2] Today, the United States is the largest consumer of aluminum cans, which can be found in virtually every home and retail store in the country.

Despite the popularity of aluminum cans, the industry is facing a new challenge from within: the recycling rate of this highly recyclable product is declining. Although the United States is the largest consumer of cans (producing 300 million cans per day—the equivalent of one per citizen per day), it is also the biggest disposer of aluminum cans, as illustrated by Figure 1, which was assembled from industry data.

According to the Aluminum Association, whereas aluminum recycling in sectors such as transportation and construction is about 95%, only 50% of recovered beverage cans were recycled in 2003, compared with 67% in 1992. By comparison, the global recycling rate averages 60%.[3]

The challenges facing the national aluminum industry can be illustrated by reviewing the current situation in Kentucky, one of the top aluminum-producing states in the United States. In 2000, Kentucky was the top-ranked state in primary aluminum with shipments totaling \$2.6 billion.[4] The state has 142 aluminum-related facilities employing 17,639 workers, adding \$741 million value to the state's economy in 2000.[4] Secondary smelting (or recycled aluminum) employs the third largest number of workers of any of the aluminum facilities, and most of the other sectors rely on secondary aluminum as their primary source of metal (Figure 2).

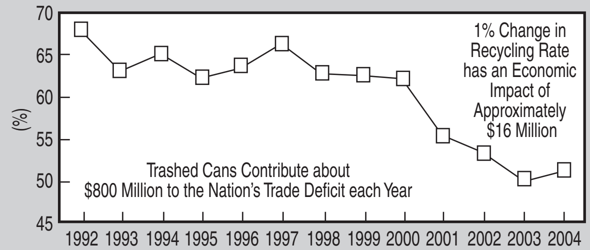

Figure 1. The U.S. aluminum can recycling rate from 1992 to 2004.

Despite its reliance on secondary or recycled aluminum, Kentucky's recycling rates are lower than the national average. In 2002, Kentucky generated 5.46 million tons of municipal solid waste, of which 11% was recycled.[5] Aluminum cans amount to only 2.2% of the total recyclables recovered. This rate is at the lower end of the spectrum in terms of per-capita municipal solid waste when compared to other states.[5]

To address the problem of declining recycling rates, Secat Inc. and the University of Kentucky, through the Center for a Sustainable Aluminum Industry, are studying aluminum beverage can recycling trends in Fayette County, Kentucky. The project implements Six Sigma methodologies to enhance understanding of aluminum recycling and to improve recycling rates. (More information on Six Sigma is available in the sidebar on page 28)

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. See the sidebar on page 30 for further details on the economic advantages of recycling.

FAYETTE COUNTY RECYCLING

Fayette County was selected as a good locality to conduct the benchmark study because of its overall population and the mid-sized city (Lexington) that is located there. The county has a population of 266,768 (2002) with 108,288 (2003) households.[14] There are three recycling centers in the county. One is operated by the Lexington–Fayette Urban County Government (LFUCG) and two are privately owned (Wise Alloys and Baker Iron and Metal Company). The LFUCG gets most of its recyclable municipal solid waste, including aluminum, through the Lexington curbside program, whereas Wise Alloys and Baker Iron and Metal Company operate as a buy-back center where consumers can bring in their recyclables.

In the curbside program, each household is provided with three bins: Herbie, Rosie, and Lenny. Herbie and Lenny bins are used for nonrecyclable and compostable trash and are sent to the landfill and compost heap directly. Rosie bins are used for all recyclables, which are sorted at the LFUCG Recycling Center. From June 2004 to April 2005, aluminum beverage cans constituted only 1.5% of the total recyclables at the center (Figure 3a), but generated almost 21% of the center's revenues (Figure 3b), 15 times more revenue per unit of weight compared to other recyclables.

Waste composition studies of two recycling demographics are identifying the areas where aluminum cans are most likely to be discarded. These demographics are "home" versus "away from home" recycling and age. Figure 4 shows the recycling demographics of Fayette County broken into the two main recycling categories, with subcategories under each. Efforts in Fayette County will target the recycling rates in both groups. According to Steve Feese, the recycling program manager at LFUCG Recycling Center, 85%–90% of the local households in the county have curbside access. To test the hypothesis that the higher the curbside accessibility, the more recovered aluminum, curbside access will be increased in the county and the aluminum can recovery rate will be tracked to quantify the results of the enhanced accessibility. To address recy-

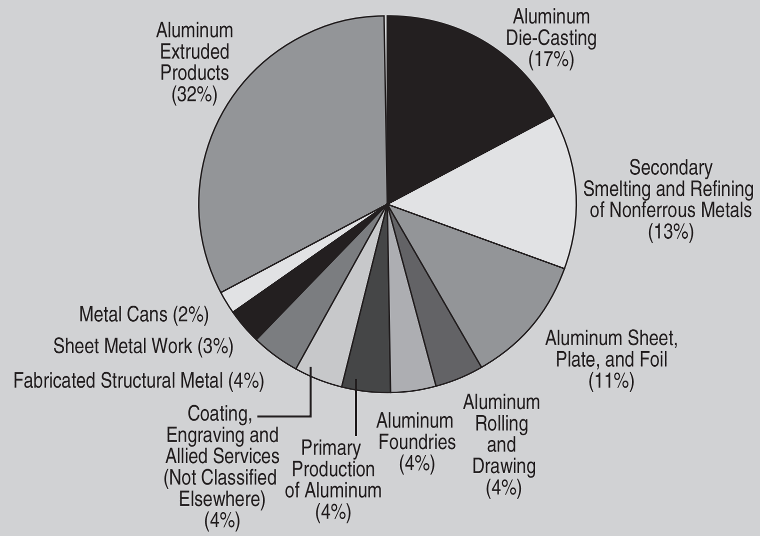

Figure 2. The composition of Kentucky aluminum facilities in terms of number of employees.[4]

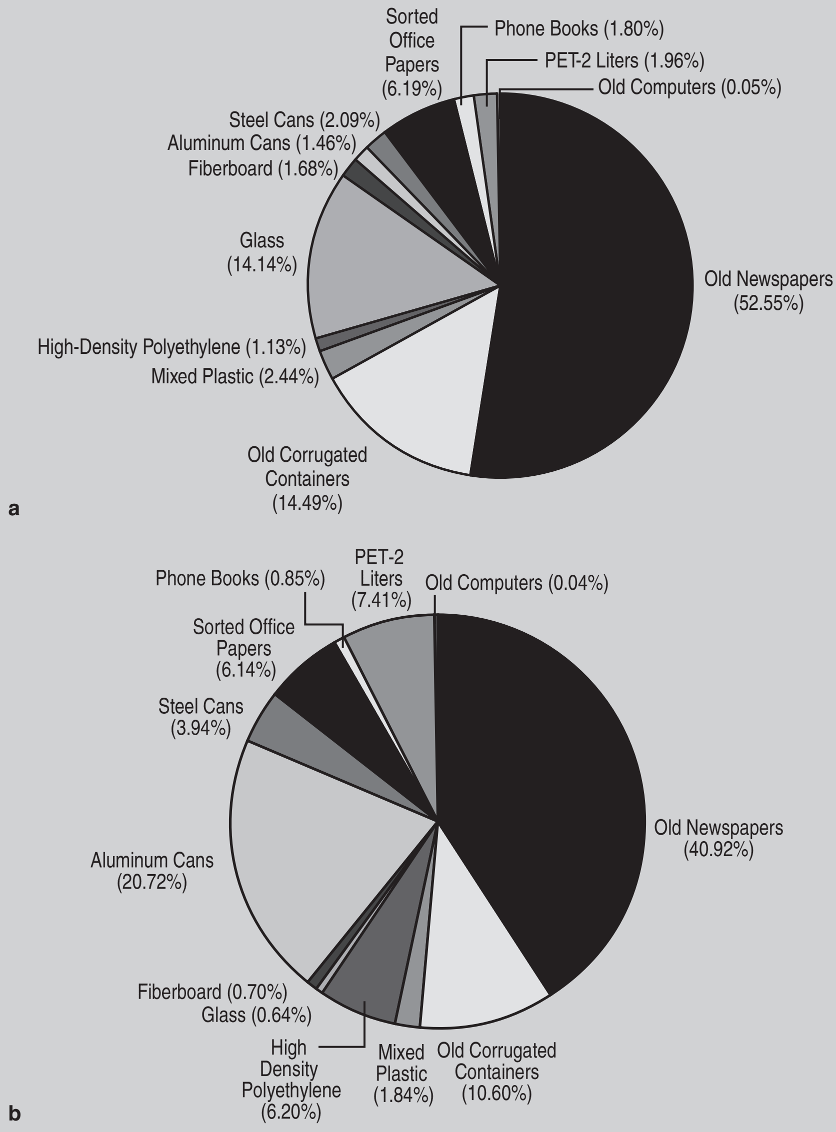

Figure 3. (a) The composition by weight of commodities shipped from the LFUCG Recycling Center (06/01/04 to 04/15/05) and (b) revenue percentages for commodities shipped from the LFUCG Recycling Center (06/01/04 to 04/15/05).

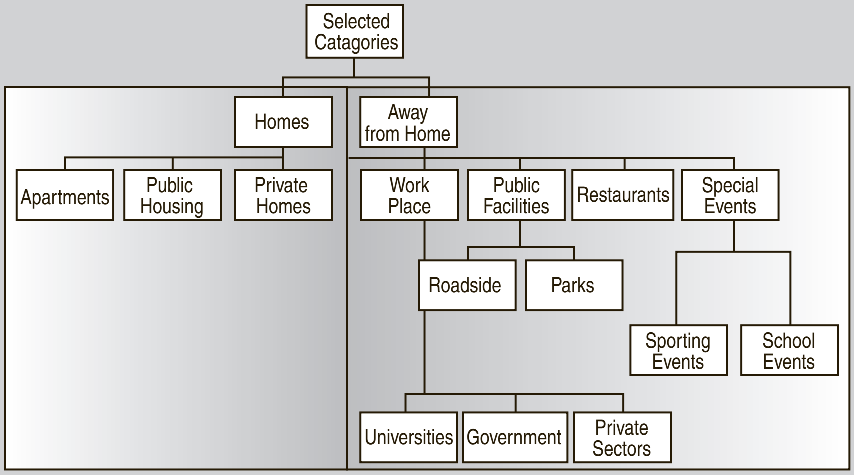

Figure 4. Recycling demographics in Fayette County.

cling away from home, a waste management company will study the recycling behavior of each subcategory of the group to determine where unrecovered cans are most likely to be thrown away. Recycling bins will then be placed in those locations, such as public parks or sport facilities, offices, or shopping centers. As with the curbside access program, the three recycling centers are reporting their monthly aluminum can recovery rates to quantify the success of the efforts.

The project is also targeting the recycling behavior of the 18–29 year old age group, which historically has the lowest recycling rate of any age group (59%).[15] The University of Kentucky, located in Lexington, has the highest concentration of 18–29 year olds in the county and is participating in the project. Officials have identified key sporting events as an opportunity to promote and increase recycling. Other suggestions have included increasing the number of recycling bins; involving fraternities, sororities, and dormitories in the programs; and providing recycling education to freshmen classes.

The information gathered during this project is being processed using Six Sigma methodology, the first application of this methodology to aluminum recycling.

SIX SIGMA METHODOLOGY

Working with local retailers and aluminum recycling centers in Fayette County, Secat and the University of Kentucky are implementing a multiple-step Six Sigma process. 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.

Scope

In the initial phase of Six Sigma, process issues and improvement goals are determined through three steps: articulate the problem, define the response variable that needs to be improved, and identify customer critical-to-quality issues. This phase outlines the quality issues and identifies the areas of variability in the existing system that must be addressed to improve quality.

In Fayette County, the large number of aluminum cans per week not recycled was identified as the main issue for the project. This lack of recycling leads directly to revenue losses at the local materials recycling facilities (MRFs). It also increases energy consumption at the primary aluminum production facilities, creating negative environmental impacts.

To address the problem of insufficient recycling participation, the percentage of cans recycled each week was identified as the response variable. It was also determined that this variable can be improved by developing a process that enables the customer (the consumer of aluminum cans) to more easily recycle, leading to the set goal of a 20% improvement in recycling rate.

WHAT IS SIX SIGMA?

Six Sigma is a process improvement methodology that uses data and statistical analysis to identify and manage process variations to reduce or eliminate “defects” in a company’s operational performance. Developed by Bill Smith at Motorola Corporation in 1986,[6] Six Sigma can be applied to any work process by adapting the following goals: improve customer satisfaction, increase profitability, and increase productivity.

Six Sigma uses data and statistical analysis to improve processes by focusing on input variables. The methodology identifies sources of variability in the work process that result in “defects,” defined as anything outside of customer specifications. Six Sigma traditionally sets the improvement goal of 3.4 defects per million opportunities. Once these sources have been identified, they are modified to reduce the defects.

Six Sigma has two key methodologies, each consisting of five phases: DMAIC (define, measure, analyze, improve, control) and DMADV (define, measure, analyze, design, verify).[7] The first methodology is used for existing processes, while the second is used to design new processes.

The Six Sigma methodology is conducted by a team of people in five roles.[8] The team is led by the quality leader/manager, who is responsible for representing the customer’s needs. Master Black Belts are responsible for specific areas or functions of a business, such as human resources, and work closely with the Process Owners, who are individuals responsible for a specific process. Black Belts lead the quality projects and work full time with the company until they are complete. They also train the Green Belts, who are company employees trained in Six Sigma.

Six Sigma was originally used in manufacturing corporations, but has branched out in such diverse areas as banking, health care, military, and telecommunications. One of the earliest corporations to use the methodology was General Electric, which reported benefits of more than $300 million during its first year of application.[9] Other major companies that have reportedly used Six Sigma include Ford, Caterpillar, Microsoft, 3M, and Siemens.[10]

Measure

The next phase comprises four steps that map the existing process, validate the measurement systems, and collect data on the response variable to establish baseline measurements for future comparison. Developing a process map of the current recycling process is critical for defining the elements that cause variability in the process.

The aluminum recycling process map developed for Fayette County is shown in Figure 5a. This baseline process map will be used to identify and correct sources of variability further in the Six Sigma methodology.

Validating the measurement systems is vital to implementing and measuring improvement. The systems must be consistent and accurate. For aluminum recycling, the term "weekly" was defined as seven days, Monday through Sunday. The data on incoming aluminum procured from various resellers and the data from MRFs were validated. For aluminum weight measurements, current estimates were used to set the rate of 33 aluminum cans per pound.

To establish a baseline for the response variable (number of cans recycled weekly), data were collected from three key areas:

- Weekly data on incoming aluminum cans and recycling cans (lb/week) were collected for ten randomly selected weeks.
- Recycling rates in Fayette County were estimated via stratified sampling.
- Aluminum cans recycled for the same ten weeks in the first item were also provided by local recycling facilities.

The baseline in this project is the "true" recycling rate as opposed to historic estimates, which have been as broad as 380 aluminum cans per person annually. Local recycling facilities are providing data on the amount of cans being recycled, whereas local retailers are providing information on the amount of cans sold. In addition, a statistician provided a stratified random sample of the local establishments and the universal product codes of products sold in aluminum cans.

An initial estimate of the weekly recycling rate was determined as 39%, based on data provided by Anheuser Busch Companies and The Kroger Company. However, determination of the true recycling rate is still in progress. Once established, a means for increasing the rate will be implemented.

Analyze

Once the Measure phase has been completed, data must be collected and analyzed to verify relationships and causality of factors. For recycling, the issue becomes explaining why there is a gap between the number of incoming cans to waste facilities and the number of recycled cans. In Fayette County, it was determined the discrepancy is caused by several steps that are missing in the process map. To improve the recycling rate, the process map must be scrutinized and revised to include those steps. This is done in the Improve phase of Six Sigma.

Improve

The initial process map is being modified to include the missing steps responsible for much of the variability in the amount of cans recycled weekly based on input solicited from a large number of people in Fayette County. One area of the process map that has already been revised is the delivery and pick-up of Rosies (Figure 5b). Consumers must

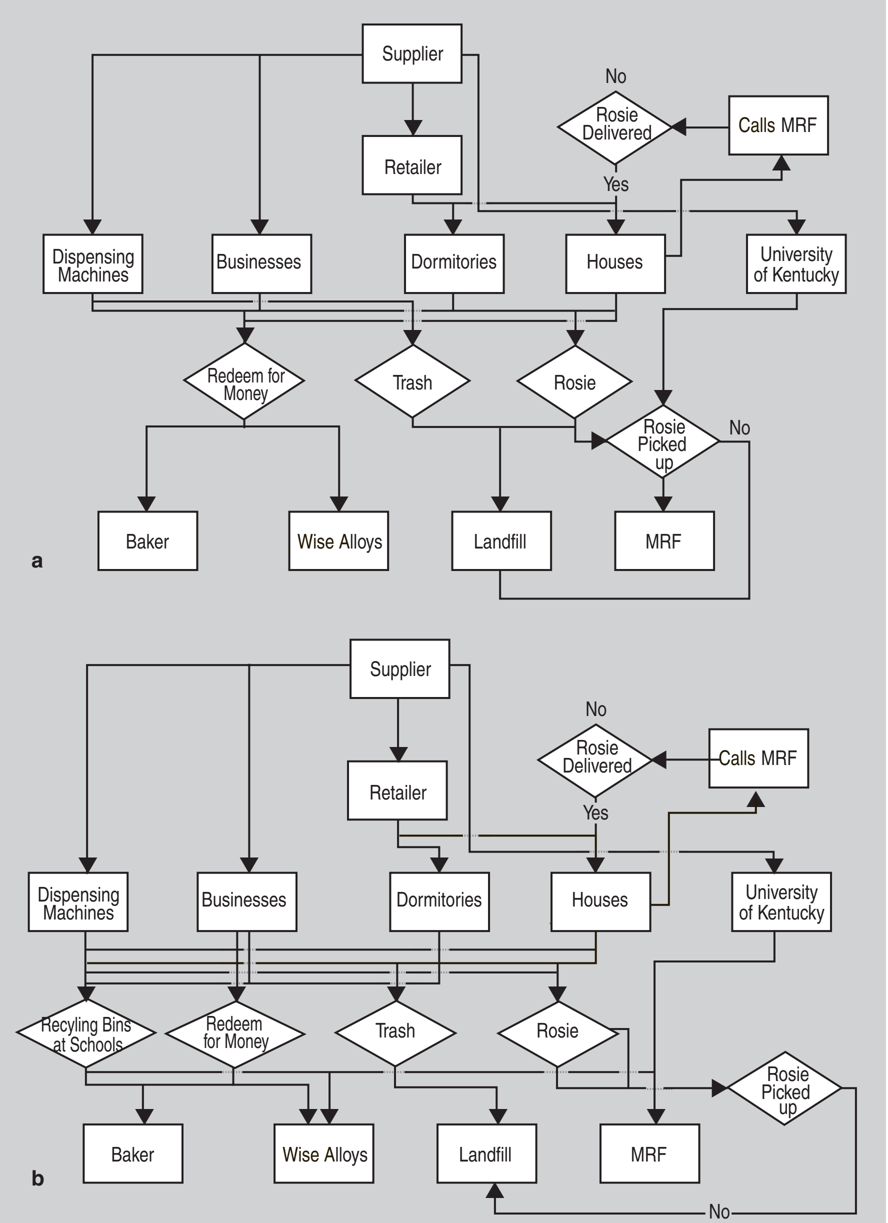

Figure 5. The Six Sigma process map for Fayette County recycling. (a) The initial map and (b) the revised map.

ECONOMIC ADVANTAGES OF RECYCLING

One of the aluminum can's most acclaimed assets is its recyclability. Aluminum has been recycled for almost 100 years, and recycled or secondary aluminum is the leading source of aluminum in the United States.[11] The aluminum can does not experience a loss of quality or energy even when recycled more than once, and recycling the cans uses only 5% of the energy needed to extract the same amount of aluminum from virgin bauxites.

As the world's largest consumer of aluminum products, the United States currently depends on importing aluminum from other countries, such as Canada and Australia, because of a lack of natural resources to produce primary aluminum. Yet a substantial amount of secondary aluminum supply available domestically is wasted because cans are not recycled. The Container Recycling Institute estimated that since recycling began 40 years ago, 1 trillion aluminum cans have been discarded and not recycled. This amounts to $21 billion of wasted potential revenues.[12]

The economic advantages of increasing aluminum can recycling rates are substantial. It has been estimated that a 1% change in the national can recycling rate would result in savings of about $16 million per year and produce 40 million pounds of aluminum per year.[13] In addition, this 1% change will save 1 trillion BTU of energy per year.[13]

The costs of virgin aluminum and secondary aluminum for can stock have a price difference of about $0.40/lb. Based on the current production rate (100 billion) and the recycling rate (50%), replacing the lost aluminum with imported primary aluminum adds more than $800 million to the U.S. trade deficit. Replacing those cans in 2003 with virgin materials consumed an equivalent 10 million barrels of crude oil.

These national trends are also reflected in the data for Kentucky. If the aluminum recycling rate in Kentucky was increased by 1%, the additional $5 million per year in economic construction could enable the construction of a recycling plant employing potentially 80–120 people at an average salary of about $50,000 per year.[13]

call and request a recycling bin; however, sometimes the Rosie is not delivered or is not picked up when full. In addition, people without access to the curbside program must take their cans to a local MRF or to the Good Foods Co-op, which requires motivation.

This decision by consumers to recycle is another large source of variability. The project team is currently working with academic organizations to understand the motivation behind recycling and will use this information to implement, in coordination with government officials, programs designed to encourage and increase this recycling behavior.

After the process map is finalized, the data described in the Measure phase will be gathered again to determine any increases in the recycling rate. The mean and standard deviation will be computed again from a random ten-week selection to determine the extent of any improvement.

Control

Once improvement is achieved, it is important to ensure that progress is sustained. In the Control phase, the initial pilot runs transition to production and are continuously measured for variances, which are corrected before they result in defects. For this purpose, aluminum recycling rates in Fayette County will be monitored weekly on a control chart. Any points out of the control chart would be investigated and fixed to eliminate the variability.

CONCLUSIONS

As a result of this project, the following steps are planned to increase recycling efforts in Fayette County, Kentucky:

- Determine the true recycling rate using statistical techniques outlined by Six Sigma
- Continue to revise and finalize the process map based on new data and input from sources in Fayette County
- Document and implement projects of placing recycling bins in all elementary schools to enhance the recycling rate
- Ensure sustainability of improvements
- Recommend strategies for wider replication

It is hoped that the results of this study, the first methodology study in aluminum recycling, 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.

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