**Light Metals 2014**
*Edited by: John Grandfield*
***TMS (The Minerals, Metals & Materials Society), 2014***

# THE VIABILITY OF A "VOLUNTARY REFUND-DEPOSIT SYSTEM" FOR ALUMINUM CAN RECYCLING IN THE U.S.

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Keywords: Voluntary Refund-Deposit System, Aluminum Used Beverage Containers (UBC), Innovation

## Abstract

The concept of a voluntary deposit system is developed and modeled in this paper in comparison to the current state of a voluntary non-deposit ($R_1$) and mandatory refund-deposit ($R_2$) hybrid system in the U.S. The $R_3$ model is found to be optimal in comparison through an increase in the recycling rate, a reduction in operating costs, and the creation of a larger surplus to be used to pay for an IT-based tracking system and research grants to enable future innovations in the collection and processing of recyclables. In the $R_3$ model, consumers are only burdened if they choose to not recycle, or they wish to have the convenience of curbside pick-up.

## Introduction

No scenario presently exists within developed nations where the recycling of used beverage containers (UBC) can be achieved at high collection rates in a cost effective manner achieving market equilibrium between supply and demand. Only in a developing economy like Brazil can conditions be satisfied albeit as a function of a large mass of those under poverty conditions able to make a living via collecting aluminum cans[1]. This *recycling dissonance* often leads policy makers and consumer/citizens having to choose between mandated collection of higher recycling and lower market cost effectiveness or a voluntary model of lower collection rates and greater market cost effectiveness. This study will explore the question of whether these objectives have to be mutually exclusive and if not, how can this state of *recycling dissonance* be eliminated?

In the U.S., the national recycling rate has stagnated under 60% for decades, consisting of ten refund/deposit states (CA, CT, HI, IA, ME, MA, MI, NY, OR, VT) and forty states without such provisions. Within these ten states, higher collection rates exist (90%+ in MI with a 10 cent deposit, 76% in 5 cent deposit states, and 15-25% in no deposit states)[2], and this is consistent with rates found within national programs such as Germany, Sweden, and Japan. However, despite these higher recycling rates, there is no evidence from the extant literature that these programs are economically cost effective relative to the market conditions of supply and demand in the aluminum commodity marketplace. Mandated programs often provide an economic incentive to the consumer limited to *getting one's money back* as a payback for the public good of reducing litter, and reusing a valuable packaging commodity. While all recyclable materials (plastic, glass, paper, and aluminum) are collected and valued equally, the materials have very different secondary market values (e.g., aluminum UBC more valuable than plastic UBC). Finally, there is a limited opportunity for innovators to create disruptive technologies/methods in order to achieve breakthrough results of recycling and reusability.

In this paper, a third model is proposed to *break the chain* of *recycling dissonance* between the two existing models (refund-deposit system and voluntary recycling program) in order to achieve high recycling rates and market cost equilibrium. This model seeks to create a voluntary deposit system providing the consumer an opportunity to opt out of paying a deposit at point of sale through recycling voluntarily on his/her own[3]. By doing so, the consumer receives a more favorable financial incentive (no deposit versus receiving a refund of a deposit) by choosing to voluntarily participate in a recycling program, and, in addition, lower collection processing costs are expected to be achieved.

To conduct this study, the three collection and processing models for UBC will be presented as follows: a voluntary recycling program with no refund-deposit system ($R_1$), a mandated refund-deposit system ($R_2$), and a voluntary refund-deposit system ($R_3$) within the U.S. market. This will be a two part study. The first will analyze the economic viability of $R_1$, $R_2$ and $R_3$ in the U.S. beverage market, and the second phase will survey consumers to understand their preference relative to these frameworks. This paper will be the first phase, the economic viability of this voluntary refund-deposit system ($R_3$) in comparison to the current state hybrid model in the U.S. of deposit and non-deposit states.

## Literature Review

In 2012, aluminum recycling rates in the U.S. reached their highest level in a decade to 58.1%[4]; however, these rates are significantly lower than those of the EU, with rates between 87-92% during the same period[5]. Of the 58.1% recycling rate in the U.S., it is estimated that there is a 70-75% recycling rate within the deposit states[6], and a rate between 15-25% for the remaining states. The average American purchases 350 aluminum cans a year, which is about ten times higher than the average European[6], and 100 billion cans sold in the U.S.[7], up to 1 million tons of used beverage cans (UBC) can be placed in landfills annually, which is worth approximately $2.5 billion[8]. With a falling price of primary aluminum over the past decade, the average price of recycled scrap is around 1.5 cents per can, providing an economic challenge relative to collection[7].

While there is no debate within industry, policy makers and environmentalists in the U.S. regarding the social and economic benefits of aluminum UBC recycling, this state of *recycling dissonance* leads to different perspectives relative to how to solve the problem ($R_1$ and $R_2$). Those in favor of a refund-deposit system ($R_2$) note that collection rates are substantially higher than in a voluntary program ($R_1$) and its costs are the lowest of any of the mandated options (recycling subsidy, advance disposal fee)[9]. As well, a 10% reduction in total waste can be achieved by a deposit-refund system at $36/ton versus $66/ton for a recycling subsidy and $96/ton for advance disposal fee[10].

There is also some evidence that a refund-deposit system can augment income of the poorer populations through can collection[11], while other studies have found its impact on unemployment to be low given the inability of scrap prices to keep up with inflation[12]. While one study found *city petty-level crime rates* in deposit states to be 11% lower than those in non-deposit states[13], other studies have inferred that a deposit can effectively become a *regressive tax* for those who do not have the infrastructure to recycle or transport the materials to a redemption center, thus they dispose of the containers. Another benefit in a refund-deposit system is the use of unredeemed deposits for municipal programs and projects. In theory, a deposit/refund system uses the former to reduce consumption and raise scrap prices while the refund increases the recycling rate and reducing scrap prices[15] however, this dichotomy can lead to ambiguity[9].

A competitive market devoid of market failures and imperfections would establish an efficient level of recycling, especially given plentiful virgin ore and relatively low extraction costs[16], however market fluctuations exist that impact the creation of an efficient reverse logistics supply chain, and the externality of litter must be addressed. In the $R_2$ model, government sponsored recycling programs enable a stable and constant supply of UBC, but without adjustment to changes in demand, which can reduce the profitability of the operation[14]. In the primary aluminum market, economists agree that resource extraction of aluminum has been subsidized, which also impacts market equilibriums[16].

From an economics standpoint in the U.S., the gross cost (not including material sales or unredeemed deposits) to process UBC (aluminum, plastic and glass) in a non-deposit state is 1.91 cents/can versus 2.69 cents/can in deposit states[17]. The gross cost to process (in cents) is residential drop-off (1.1), CA. Redemption System (1.62), curbside (2.48), reverse vending machine (2.53), and traditional deposit system (4.07)[17]. Since aluminum as a reusable commodity is more valuable than plastic and glass, the commingled approach to recycling effectively subsidizes the collection (and mitigation of landfilling) of plastic and glass as a function of aluminum in both the $R_1$ and $R_2$ models.

Aluminum commodity market volatility in supply/demand is also a factor[7], and the cost effectiveness of a recycling program is largely a function of the revenue generated from the UBC. Secondary aluminum is subject to short-run price volatility, and this hampers recycling incentives and investment in the processing and supply chain system[18]. It is calculated that a 10% increase in price in secondary aluminum could only induce a 2.1% increase in the production use of this material[18]; however, there may be other forces prohibiting greater supply. From the study of the extant literature, there are multiple variables that impact the ability of UBC price to be based upon a balance of supply and demand, leading to questions of the viability of a $R_2$ model to be optimal relative to recycling rates and market equilibrium on its own.

Beyond the variables that impact a $R_2$ model such as aluminum supply/demand volatility, ecological economists note that there are externalities such as disposal operating costs and landfills that are often not factored into the market equilibrium and pro-recycling policies are viewed as required in order to achieve societal environmental objectives. Market conditions may be weak motivators for consumers and corporations, which may require some governmental intervention to address[4]. An efficient reverse logistics model must be developed in order to achieve higher collection rates at an efficient cost; however government intervention may not be the most effective method for its advancement[9].

With the revenues from the sale of recyclables offsetting only 35% of the total municipal recycling cost[1] (including other materials such as plastic and glass), the question is how to measure the cost of externalities while at the same time questioning whether pro-recycling policies drive rates beyond their economic equilibrium. With regard to the lack of economic viability of these programs, economists have noted that the recycling industry is a young business whose systems and technologies are still developing[16], implying that cost effectiveness will eventually occur.

If a market-based $R_1$ model is not allowed to mature to market equilibrium through the introduction of a $R_2$ model, an unintended consequence could occur in impacting future innovation incentives. Technologies for sorting, handling and re-melting of UBC need to be developed and improved[19] in what is currently a very manually intensive and cost inefficient process. A proliferated use of bar coding to track cans within a disposal/collecting process would enable private and public entities to manage the supply chain and processing costs[9]. Information technology can be utilized to better track collection through the supply chain[3].

Techniques to improve metal recovery to increase the yield from UBC (averaging around 88%) and reducing energy usage as well as new *in situ* chemical analysis of molten metal will minimize processing time for development[19]. From the literature review, there was not found to be a correlation between a mandated $R_2$ model, and market innovations.

Voluntary and involuntary curbside recycling in the United States are growing in popularity, but are restricted to residential locations and the potential for expansion beyond the home appears to be small[6]. A curbside recycling program is convenient to the consumer, but requires a consumer to pay a nominal fee per month, forgoing financial benefit associated with the UBC[6], and is attracting only to those possessing a "moral obligation" to participate in this type of program. Furthermore, curbside recycling is only viable to most "morally obligated" consumers if collected materials can be commingled, which requires a more efficient/technological sorting process[20].

In the U.S., there are differences in geography that impact recycling rates. The deposit states are categorically more constrained in space geographically than the non-deposit states that primarily reside in the south and western regions of the United States, and as well, have less landfill space. Finally, where an individual is consuming a beverage is an important geographical variable as well, with a higher anticipated collection rate for residential and commercial (on-premise) consumption; a mobile "on the go" remote consumption model in the U.S. has been found to be detrimental to collection rates[7]. With the United States being a larger geographical area than many EU nations, with a highly mobile population and large consumption rate per capital, recycling rates would appear to be a greater challenge to address.

## Methodology and Results

To address this problem of *recycling dissonance* in relation to a $R_1$ and $R_2$ model, a voluntary refund-deposit system model ($R_3$) was developed, and is illustrated in Figure 1.

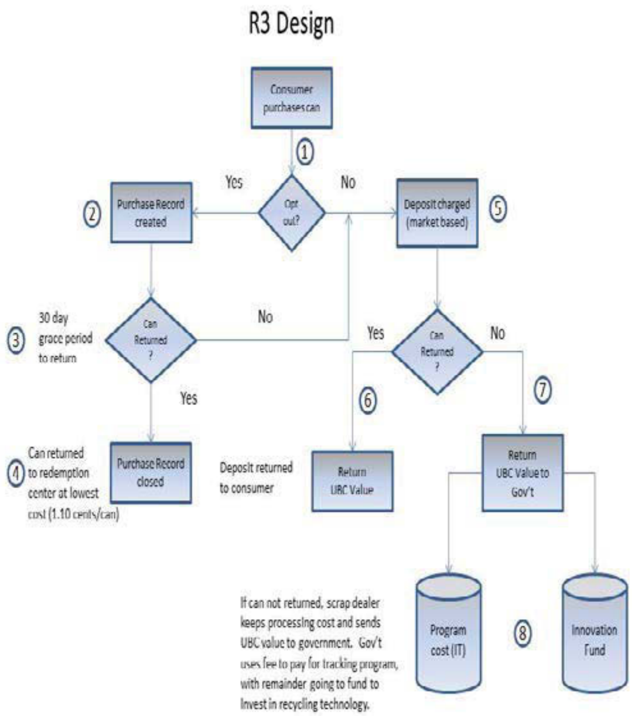


**Figure 1 – Process Flow Design of $R_3$ System**

In this Voluntary Refund-Deposit System, the process flows exist as follows:

1) At point of sale (POS), the consumer will be prompted whether he/she wishes to *opt-out* of a deposit via the individual's *recycling account*. The IT recycling system is administered, and all retailers are required to participate in this program through their POS kiosks.

2) If the consumer agrees to *opt-out*, he/she will not be charged a deposit on the purchase, and the number of cans purchased will be recorded to his/her account.

3) Within a thirty day period, if the consumer returns an equal number of cans that have been recorded to his/her account to an authorized redemption center, no charge will be processed. However, if less than the amount recorded is returned to a participating redemption center, the consumer will be charged the appropriate deposit.

4) Once the cans are returned voluntarily to an authorized redemption center, the record is closed on the consumer's account. This voluntary "drop-off" is the lowest cost method of processing returns (1.10/can)[17], and therefore, is incented in this program.

5) For those not *opting out* of the deposit program, or those who *opt-out* but do not return the cans, a market-based deposit will be charged to the consumer at point of sale. The UBC value and processing costs will be adjusted on an annual basis in order to ensure that redemption centers are able to make a profit as an intermediary in the secondary aluminum market (given volatility, as noted above).

6) If the consumer is charged a deposit, and returns the UBC to a participating redemption center, the deposit will be returned to the consumer (via the retailer to the redemption center), without a handling fee cost. The redemption center will earn its processing fee from unredeemed deposits (in order to not disincentive the recycler).

7) If the can is not returned, the redemption center will earn its processing fee, and send the UBC value (and excess processing fees) to the government to cover the funding of the information technology (IT) tracking system.

8) Monies collected by the redemption center beyond its agreed upon processing fees will be sent to the government entity. These excess funds will be used for the cost of the electronic tracking system and to establish an "innovation grant" for recycling technologies.

From the use of data related to the cost of the present state hybrid $R_1/R_2$ model[17] in the U.S., and using 2010 census data (April 1, 2010), Table 1 provides a summary of the economic costs of UBC aluminum recycling (with more details in Appendix 1). In this study, a 1.5 cent value was assumed for aluminum UBC[7] and annual usage of 109.9 billion cans (based upon 350 cans/capita[6], and U.S. census population of 313.9mm):

| Non-Deposit State ($R_1$) | Recycling Rate (Weighted) | Oper. Cost | Surplus (Deficit)/ Can | Surplus (Deficit)/ $ |
|---|---|---|---|---|
| | | | | |
| Curbside | 18.5% | 2.48c | 0.00c | $2.9mm |
| Residential Drop Off | 4.5% | 1.10c | 0.40c | $14.2mm |
| | | | | |
| Total | 23.0% | 1.91c | 0.10c | $17.2mm |

**Table 1 – Non-Deposit State ($R_1$) Economic Model**

In the $R_1$ model, there are 40 states (with 75% of the U.S. population) consuming 79 billion cans, and recycling only 23%. In this model, there is a monthly charge associated with curbside recycling (mandated in Delaware) equal to approximately 6 cents/container[6]. Given the low value of the other recyclables, it is assumed that only 1 cent will be allocated to aluminum UBC (enough to break even), and the remainder to augment disposal/reuse of plastic, glass, and paper. Recyclables are indiscriminately collected to reduce externalities (littering/landfilling), and it is fair to state that the collection of aluminum UBC is used to subsidize the less valuable materials, especially plastic.

Residential drop off is the lowest cost option in both the $R_1$ and $R_2$ models, but is at such a low recycling rate, it is irrelevant as a current state solution.

| Deposit State ($R_2$) | Recycling Rate (Weighted) | Oper. Cost | Surplus (Deficit)/ Can | Surplus (Deficit)/ $ |
|---|---|---|---|---|
| | | | | |
| Traditional Deposit | 61.6% | 3.61c | -1.2c | ($124.2)mm |
| CA. Deposit Program | 54.5% | 1.62c | 1.5c | $106.9mm |
| Curbside | 9.5% | 2.48c | 3.7c | $107.2mm |
| Residential Drop Off | 1.6% | 1.10c | 3.9c | $19.3mm |
| | | | | |
| Total | 71.60% | 2.69c | 1.6c | $358.4mm |

**Table 2 – Deposit State ($R_2$) Economic Model**

In the $R_2$ model, there are 10 states (with 25% of the population) consuming almost 31 billion cans, recycled at a 71.6% rate. Assuming a 5 cent deposit (with only one state at 10 cents), processing costs from the BEAR report[17], and the same assumptions with respect to curbside as above (1 cent allocation from monthly fee per can), and a surplus of $358.4mm is aggregated under the following mixed conditions:

1) In the traditional deposit system, retailers and distributors are mandated to participate to process UBC (as well as redemption centers), and can lose money in the process, or are forced to discount refunds to consumers.

2) The California Deposit system is shown as having a surplus, which is given to the state government for discretionary programs, but at an 88% recycling rate, the program loses money, providing a disincentive for higher recycling rates (or a public funding deficit). It is also not clear whether producer related costs were factored into the BEAR report[17] to determine the program's operating costs.

3) The curbside and residential drop off programs create surpluses as a function of the consumer voluntarily participating in a recycling program, but still being charged a deposit. In the curbside program, consumers are also being charged a monthly fee for collection, and this is viewed as a "convenience" for curbside pick-up by the waste management company or municipality.

From the $R_1$ and $R_2$ models, the following issues were found:

1) In the $R_1$ model, there is a limited opportunity for an improvement in recycling rates through curbside recycling, especially given the mobility of consumption associated with the U.S. public[7].

2) With a goal to reduce externalities, less valuable secondary materials are being subsidized at the expense of aluminum recycling, which is raising the secondary cost of aluminum, and artificially reducing the cost of these other materials (excluding externalities), especially plastic.

3) The $R_2$ model is inefficient because it mandates agents in the process who may be losing money (such as retailers and distributors in the traditional model). This model may require an "invisible ceiling" on recycling rates in order for the program to meet its costs (CA.) or lose money, and can penalize consumers through deposits being charged when voluntarily recycling anyway (also leading to higher processing costs).

4) In the $R_2$ model, the CA. model is most efficient (almost 2 cents lower than a traditional model), but is .5 cent less efficient than voluntary residential drop off in the $R_1$ model.

Based upon the process flow, as shown in Figure 1, Table 3 presents the voluntary refund-deposit system approach. This is assumed to be a national program, but non-deposit and deposit states are presented separately, given different recycling rate assumptions (given culture and history):

| Voluntary Deposit ($R_3$) | Recycling Rate (Weighted) | Oper. Cost | Net Profit (Can) | Net Profit (Tot $) |
|---|---|---|---|---|
| **Non-Deposit State** | | | | |
| Voluntary Opt-Out | 38.7% | 1.10c | .40c | $122.3mm |
| Deposit - Redemption | 7.5% | 1.62c | -1.5c | ($87.2mm) |
| Deposit – Non Redemption | 35.3% | 0.0c | 5.0c | $1.4b |
| Deposit - TOTAL | 42.8% | .08c | 4.9c | $1.3b |
| Curbside | 18.5% | 2.48c | .40c | $389.3mm |
| | | | | |
| Total | 64.7% | 1.01c | 2.3c | $1.8b |
| | | | | |
| **Deposit State** | | | | |
| Voluntary Opt Out | 51.6% | 1.10c | .40c | $63.6mm |
| Deposit – Redemption | 10.0% | 1.62c | -.15c | ($45.3mm) |
| Deposit – Non Redemption | 28.9% | 0.00c | 5.0c | $445.3mm |
| Deposit – TOTAL | 38.9% | 0.42c | 3.3c | $400mm |
| Curbside | 9.5% | 2.48c | 2.7c | $78mm |
| | | | | |
| Total | 71.1% | 1.39c | 1.7c | $541.6mm |
| | | | | |
| Total – US | 66.5% | 0.9c | 2.1c | $2.3b |

**Table 3 – Voluntary Deposit State ($R_3$) Economic Model**

As is shown in Table 3, national recycling rates increase from 40.6% in the aggregate $R_1$/$R_2$ model to 66.5% in the $R_3$ model, operating costs fall significantly and a surplus of $2.3 billion is achieved, and is allocated as follows:

1) <u>Voluntary Opt-Out ($185mm)</u> – almost two thirds of recycled UBC aluminum is anticipated through the

voluntary opt out program, which offers the lowest processing costs of 1.1 cent/can. This will be a market-based program, and redemption centers will be incented through an opportunity to profit in the recycling industry (versus mandated retailers and distributors who lose money in today's traditional program).

2) Deposit Program ($1.7b) - a significant surplus is created in the $R_3$ model, largely from the expectation that, at least in the short-term, a large percentage of UBC will be discarded in the non-deposit states related to individual consumer behavior patterns. These funds will be used to pay for the IT based tracking system to be implemented nationwide and to fund innovation grants related to improving recycling rates/efficiencies. Eventually, as behaviors change, this surplus will decrease.

3) Curbside ($467mm) – at least at the onset, those in non-deposit states who wish to participate in curbside recycling will also forgo their deposits, unless the curbside company/municipality can create an *opt-out* program. Eventually, the cost associated with the convenience of curbside recycling will be adjusted based upon market conditions of supply and demand.

Table 4 shows a comparison of the three models from this study.

| | $R_1$ (Voluntary) | $R_2$ (Mandated) | $R_3$ (Hybrid) |
|---|---|---|---|
| Recycling Rate | 23.0% | 71.6% | 66.5% |
| Oper. Cost/Can | 1.91c | 2.69c | 0.9c |
| Surplus/(Deficit)/Can | 0.10c | 1.60c | 2.10c |
| Consumer | Not responsible | Responsible and burdened | Responsible, not burdened |
| Distributor/Retailer | Not involved | Mandated | Choice |
| Redemption Ctr | Not Profitable | Not Profitable | Profitable, market-based |
| Curbside Program | Break-even, subsidize externalities | Break-even, greater subsidies for externalities | Market-based profitability, no subsidies |
| Government | Market-based, externalities not addressed | Externalities addressed, not market based | Market based and externalities addressed |

**Table 4 – Comparison of $R_1$, $R_2$, and $R_3$ Models**

## Conclusions and Future Research

In this study, a voluntary refund-deposit system is developed ($R_3$) and compared to a hybrid model in the U.S. of the $R_1$/$R_2$ systems.

As is shown in Table 4, significant improvements in recycling rates, operating costs and surplus is achieved in this process. Although the $R_3$ model has a lower initial recycling rate than $R_2$ (but higher than the combined $R_1$/$R_2$ model), this is anticipated to be temporary once the non-deposit states modify their behaviors. The problem of *recycling dissonance* is addressed through using an IT based system to only burden those consumers who do not choose to recycle, or wish to have the convenience of curbside recycling. Unredeemed funds should be used to ensure the profitability of those who wish to manage the redemption process, and fund public costs (IT tracking system and innovation grants).

Further research should be conducted to further study this approach. One, a study needs to be conducted (the second part of this research) to survey consumer perceptions and willingness to participate in a $R_3$ program versus the person's current state $R_1$/$R_2$ involvement. Second, the economic models should be updated based upon 2014 cost assumptions. Finally, the specifics of a $R_3$ model should be developed, especially in relation to the IT tracking system (including the bookkeeping of refund/deposits), how to address the issue of inefficient materials commingled with aluminum (such as plastic) being subsidized by in order to manage externalities, the economic model of curbside recycling and the disposition of unredeemed deposits within the government entity.


## Acknowledgements

I would like to express thanks to Ray Peterson, board member of The Metals Society (TMS), for his support of this project.


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