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MEASURING SOURCE REDUCTION: PAY AS YOU THROW / VARIABLE RATES AS AN EXAMPLE

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Executive Summary / Abstract

Source reduction (SR) is the highest priority on the solid waste management hierarchy, but the contributions these programs have made toward waste reduction have proved challenging to measure. In this project, Skumatz Economic Research Associates, Inc. (SERA) proposed and developed two major types of methods for developing quantitative measures of the solid waste tonnage diverted by source reduction. One approach was based on using data from one point in time; the other was based on data collected over a series of years. To demonstrate the measurement technique(s), we needed to select a source reduction program as a test. We estimated the source reduction impact from a program with previously unmeasured source reduction impacts – variable rates or "Pay as you Throw" programs (VR/PAYT). These incentive rate programs have been demonstrated to increase recycling and yard waste diversion, but the level of benefits from source reduction were unknown. Variable rates / PAYT were selected as the test program because the estimated source reduction benefits are immediately relevant to the thousands of communities across North America with VR/PAYT programs. We were successful measuring the source reduction benefits from the programs using each of the two methods, and found the techniques developed similar order of magnitude results. We also computed the cost-effectiveness and simple paybacks associated with VR / PAYT programs – estimates that take into account the fuller benefits of the programs, incorporating source reduction alongside other benefits.

The results show that the tonnage reductions attributable to PAYT/VR are very substantial – the source reduction benefits alone were estimated to be 6% of generation, above and beyond the increases in recycling and yard waste diversion encouraged by PAYT/VR. SERA's estimates show that PAYT/VR reduces residential disposal by a total of 16-17% at the landfill from these three impacts (SR, recycling, and yard waste diversion increments).

The techniques we developed and demonstrated can also be used to develop reliable estimates of the source reduction impacts from other types of source reduction programs beyond PAYT/VR at the city, state, or national level.

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I. INTRODUCTION

A. Introduction and Background

The standard solid waste hierarchy places source reduction (SR) or waste prevention as the most preferred method of solid waste management. However, dedicated efforts toward these programs have been hampered by the difficulty associated with measuring impacts of these programs. SR programs have received less attention than recycling and yard waste programs. A key reason is that source reduction is something that "doesn't happen". Measuring something that *didn't happen* can be troublesome, uncertain, and data intensive. And if the impact is difficult to measure it is even harder to try to justify and evaluate project efforts and expenditures, especially in times of tight and competitive budgets.

In setting budgets, many communities may under-budget source reduction programs because when the impacts of a partial program or project are unknown, they are often treated as if the impact is zero. This natural tendency can be problematic in trying to invest in the most effective mix of solid waste programs and efforts, and may lead to higher overall costs than necessary to achieve goals.

However, as communities struggle to find ways to meet aggressive diversion and recycling goals – having already implemented broad-band recycling programs, high-performing yard waste programs, and program inroads into the commercial sector – attention is returning to the potential of source reduction.

- Source reduction – avoiding the costs of collection, processing, and other costs – certainly has the potential to be a tremendously cost-effective method of waste management.

- To date, limited efforts have been made trying to measure savings from two-sided copying, impacts of garage sales and charitable organizations, and other individual efforts.

The researchers were concerned that source reduction would likely continue to receive lower priority in budgets and program efforts if the level of measurement continued to revolve primarily around *ad hoc* or survey-based studies of single business or single-community strategies.

B. Focus on Variable Rates / Pay as you Throw

To address these issues, Skumatz Economic Research Associates, Inc. (SERA) developed this study to focus on exploring whether credible measures of source reduction could be developed. We determined to measure the impacts from a program

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that would be widely applicable. We decided to see if it was possible to develop an estimate for the source reduction impacts of variable rates (VR) or "Pay as you Throw" (PAYT) incentive programs. These programs require those residents that put out more garbage for collection pay higher bills than those that put out less – residents pay for garbage collection "by the bag" or "by the can". Households receive a financial incentive to put out less for garbage collection, encouraging them to reduce their disposal, for instance, by recycling more. Recent work by the author[1] has determined that these programs exist in thousands of communities across the US. The research shows that VR / PAYT programs are in place in all but three states in the U.S., and SERA estimates the programs are available to more than 20% of the U.S. population.[2] If we can measure the source reduction from this program – with applicability to thousands of communities across the nation – we can demonstrate whether source reduction programs can lead to "serious" tons, and whether it looks like it can be a real and cost-effective program.

Under VR/PAYT programs, residents are charged for garbage service based on the number of bags or cans of waste that are collected for disposal. The systems provide an economic incentive to reduce disposal. Methods available to residents include:[3]

- Recycling
- Yard waste diversion and composting, and
- Source reduction.

Previous SERA work[4] has developed estimates of the very significant and strong diversion benefits of variable rates. These studies used statistical analysis to demonstrate that VR/PAYT added another 8-11 percentage points of diversion to existing yard waste and recycling programs – moving communities significantly forward toward 25% and 50% diversion goals. This translates to an increase of 50% or more in recycling, and significant increase in yard waste tonnage in programs, without making other program changes or otherwise enhancing the diversion programs. However, the impacts of VR/PAYT are actually stronger, because, as the study makes clear, source reduction impacts were not accounted for in the estimation work.

VR/PAYT shows particular promise as a venue for measuring source reduction because:

- VR has strong SR incentives, and the large estimated impact from previous work on VR/PAYT's effect on diversion programs indicates there may be potentially large SR impact from VR.
- Data can be assembled to measure the SR impacts of VR/PAYT.

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[1] Skumatz, Lisa A., "Update on Variable Rates", Skumatz Economic Research Associates, Inc., Seattle, WA, 1999.
[2] Skumatz, Lisa A., "Update on Variable Rates", Skumatz Economic Research Associates, Inc., Seattle, WA, 1999.
[3] Clearly there are other mechanisms (illegal dumping, etc.) but this has not been found to be a significant problem in variable rates communities and is not include in the discussion. See Skumatz, Van Dusen, and Carton, "Illegal Dumping: Incidence, Drivers, and Strategies", Skumatz Economic Research Associates, Inc. Report Number 9431-1, 1994, and updated in Skumatz articles in *Resource Recycling*.
[4] Skumatz, Lisa A., Ph.D., "Nationwide Diversion Rate Study – Quantitative Effects of Program Choices on Recycling and Green Waste Diversion: Beyond Case Studies", Skumatz Economic Research Associates Report, Seattle, Washington, 1996, and Skumatz, Lisa A., Ph.D., "Achieving 50% in California: Analysis of Recycling, Diversion, and Cost-Effectiveness", prepared for California Chapters of SWANA, Skumatz Economic Research Associates, Inc., Seattle, WA, 1999.

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- Demonstrating the impacts on VR/PAYT will be more difficult than measuring the effects from double-sided copying, but demonstrating the effects will make it clear that measurement of more complex SR programs is not impossible.
- Results of measurements from VR/PAYT will be immediately applicable to thousands of communities – potentially helping to increase the credibility of SR programs across the nation.

C. Source Reduction

We are assuming that source reduction actions by residents include methods to decrease the volume and /or weight of potential wastes, using methods including buying in bulk, buying items with less packaging, re-using items, reducing "junk mail", and a variety of other methods. In this study, we are unable to account for composting separately, so composting will be included in our estimates.

Background research finds that package goods manufactures and distributors have been providing a number of opportunities for consumers to "buy less packaging". Reports from Proctor and Gamble[5] show that even through MSW increased from 1980 to 1993 because of economic and population increases, grocery packaging as a percent of MSW decreased from 15.3% to 12.1% over the period. Grocery discards in pounds per person decreased from a high of 175 pounds per person to a projected 116 pounds per person in 2000, a 26% decrease.

Work by Dr. William Rathje from the Garbage Project in Arizona[6] shows that packaging as a percent of landfilled MSW decreased from about 32.5% in the 1980s to 26.5% in the 1990s. This report also demonstrates that the carrying capacity of most packaging materials has increased dramatically. In the 1970s, 23 ounces of product could be packaged per 1 ounce of plastic packaging. By the 1990s, this ratio had improved to 34 ounces of product per ounce of packaging. Similar improvements were found in aluminum, although the ratios for paper, glass, and steel were relatively steady over the period.

Certainly, consumption in a booming economy has led communities to bemoan the additional generation of unnecessary wastes – from junk mail solicitations to excessive packaging to throw-away electronics to non-recycled cars and innumerable other examples. However, given incentives, the hypothesis is that residents in communities with VR/PAYT will value the economic incentives enough to adopt behaviors that reduce disposal. Communities and industry have conspired to provide opportunities for residents to move their waste out of the garbage can and to reduce the amount of waste generated through at least some aspects of their consumption behaviors. Variable rates and PAYT programs provide added incentives for customers to consider making these efforts.

[5] Keith Zook, Procter and Gamble, personal communication with author.
[6] The Garbage Project, "The Archaeology of Plastic Packaging and Source Reduction", prepared for the ULS report, by The Garbage Project, Tucson, Arizona, July 1997.

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II. MEASUREMENT APPROACHES AND SR RESULTS

A. Measurement Approaches

A primary goal of this project was to develop and test alternative methods of measuring source reduction, and then to use them to estimate the reductions from a specific type of program. The idea was that, given that measuring source reduction is challenging in the first place, using multiple methods might allow us to approach the problem from different angles and "triangulate" estimates to develop a credible estimate of the range of source reduction from the program.

We tested two primary categories of measurement methods:

- Cross section, or comparisons between large number of communities at the same point in time; and

- Time series analysis, in which we develop models that estimate the impacts based on causal factors that underlie waste behavior.

In both cases, we estimate the impacts of the program on generation. Then we develop and subtract estimate of the impacts that VR/PAYT has on recycling and yard waste, leaving the source reduction impact as the remainder. This approach uses the fact that the three primary component of generation are recycling, yard waste diversion, and source reduction. The approaches and results are discussed below.

B. Cross-section method: Comparing across multiple communities at one point in time

SERA has assembled a very large database of program, tonnage, cost, and demographic information from hundreds of communities across the country. This database includes a tremendous diversity of communities including samples of large and small communities, communities from all states, and communities with and without variable rates / Pay as you Throw programs.

Standard evaluation techniques recommend measuring tonnages "before" and "after" the introduction of a program to estimate the program's influences or impacts. An improved technique adds an assessment of the impacts in "control" communities that did not have the program. This extra measurement provides an estimate of what would have happened in the test community if the program hadn't been implemented. That is, this method provides a way to separate out the impacts that might have come from nationwide programs, behavioral changes, weather impacts, or other use of "control groups" to allow the evaluator to separate out the influences of non-programmatic

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changes over time.[7] The estimate of the program's "net" impact is the total "gross" impact less the changes in the control group's tonnage measures.

One by one program impacts, measuring before vs. after their implementation of variable rates for a single community (matched with one or more control communities), could be one way to conduct this study. However, we would have significant problems from several fronts:

- Many towns have poor information on their tonnages before and after program changes, and the towns have a number of other changes going on during the same time period.

- Finding matched "control towns" is always difficult, because communities differ in so many ways, especially with the range of variations in demographics, recycling programs, etc.

- Most one-by-one approaches would suffer because of small sample sizes. The study would be a glorified example of a "case study" approach, and the results would not be as reliable if large number of communities were used.

For these reasons, we decided to use a simpler, but we believe more robust, approach. We separated SERA's database of more than 1,000 communities into sets of communities that "did" vs. "did not" have VR/PAYT. We then computed an estimate of the "generation" per capita, summing the tons from disposal, recycling programs (curbside and drop-off) and yard waste programs (curbside and drop-off).[8]

Using data from hundreds of communities at one point in time achieves several objectives:

- Provides many data points, and large numbers increase the confidence in the results. It avoids the "case study" approach, and makes the results more transferable to a wide variety of communities.

- Using one point in time eliminates the impacts that changes in "other" factors over time may have on generation – for instance, it eliminates the impact from improvements in packaging, etc. All the communities would be measured at approximately the same point in time, with the same opportunities, eliminating the need for additional "control group" estimation techniques.

- The database will include programs that have been in place a long time and a short time (1 to more than 70 years). However, the bulk of the programs were implemented in the 1990s, and the programs should be representative of the communities that might apply these numbers to their programs.

[7] See, for example, Skumatz, Lisa A., "Variable Rates in Solid Waste: Implementation, Experience, Economics, and Legislation", Prepared for the Reason Foundation, Study number 160, Los Angeles, CA, 1993, pages 31-35.

[8] We used the town's best estimate of residential waste. As always, we checked the data for outliers and data problems, eliminating data from a few communities.

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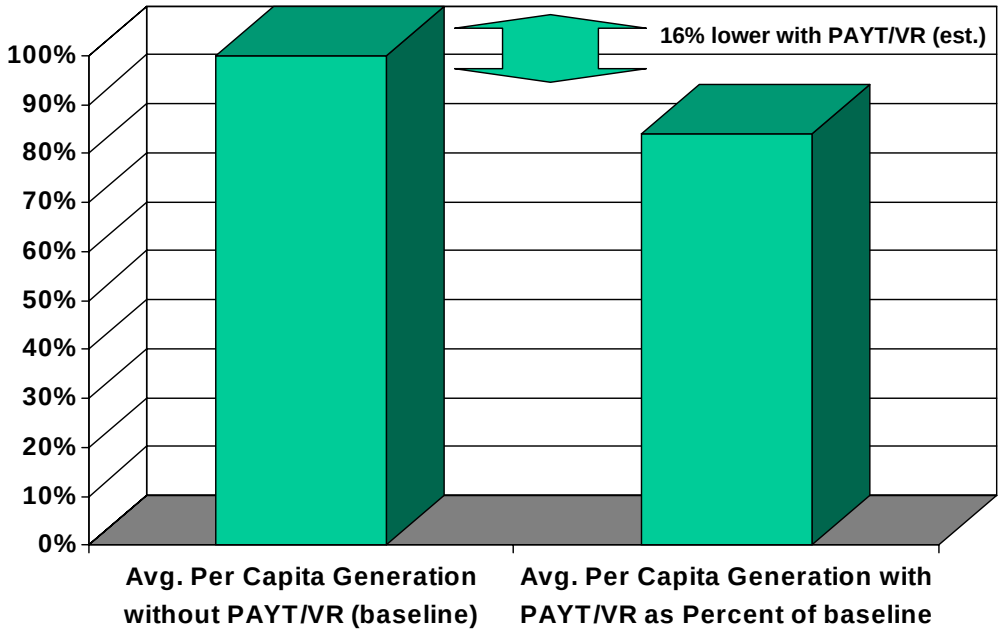
C. SR Results from Cross Section Estimations

Our estimates found that the sample of communities with variable rates had average generation rates that were 16.1% lower than those in non-VR/PAYT communities (see Figure 1).[9] However, we know that this represents a combination of three effects: recycling, yard waste diversion, and source reduction. Estimates of the impacts of VR/PAYT on recycling and yard waste diversion are needed so we can subtract their influence and identify the source reduction impacts of the program.

Figure 1. Estimating SR Using Community Comparisons -- One Point in Time



Source: Skumatz Economic Research Associates, Inc., © 1998, 2000

Very detailed estimates of the impacts of VR/PAYT on recycling and yard waste programs were developed in previous work by the author.[10] This work showed the following effects:

- Increase in recycling program tonnages from VR/PAYT: 5-6 percentage points
- Increase in yard waste program tonnages from VR/PAYT: 4-5 percentage points.

[9] Higher estimates were developed when we used the simple comparison of variable rates towns to non-variable rates towns. We recognized that other factors than variable rates might differ between the communities. Based on our work in the important drivers for tonnage forecasting (Skumatz, "Alternative Approaches for Forecasting Solid Waste Tonnages", SERA, Seattle, WA, 1995), we decided to control for some of these important factors. The reported results came from a model that pulled out the effects of differences in median income and population and rural/urban mix.

[10] Skumatz, Lisa A., Ph.D., "Nationwide Diversion Rate Study – Quantitative Effects of Program Choices on Recycling and Green Waste Diversion: Beyond Case Studies", Skumatz Economic Research Associates Report, Seattle, Washington, 1996

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Therefore, based on these estimates from a previous SERA report, the overall impact of 16 percentage points can be decomposed as follows:

16%	Total effect of VR
5-6%	Minus Recycling effect[10]
4-5%	Minus Yard waste effect[10] yields
5-7%	***Estimated source reduction effects attributable to variable rates/PAYT program per town***

In round figures, these results imply that (see Figure 3):

- Variable rates reduces landfilled/disposed tonnage in communities by 16%
- About 1/3 of that goes to increased recycling[10]
- About 1/3 goes to higher yard waste diversion,[10] and
- About 1/3 goes to source reduction, or is never realized (or paid for) by the solid waste management system.

This has important implications for solid waste management in the nation. Franklin Associates[11] estimates of MSW tonnage for 1998 are shown in Table 1.

Table 1: National MSW Tonnage
(Source: Franklin Associates[11])

Recycled	49,030,000 tons
Yard Waste	13,140,000 tons
Disposed	158,060,000 tons
Generated	220,230,000 tons

Assuming a population of approximately 270 million, assuming 50% of the MSW tons are residential,[12] and using SERA's estimate that 20% of the U.S. population is covered by VR, we can generate the following estimates of the impacts of VR/PAYT on source reduction – and the potential if more communities adopt these programs (see Table 2).

Table 2: Current Estimated Source Reduction from VR/PAYT
(Source: Skumatz Economic Research Associates, Inc.)

1.32 million	***Tons nationwide***
1.2%	***Percent of current residential generation***
0.6%	***Percent of total MSW generation***
1.7%	***Percent of residential disposal (0.85% of MSW disposal)***

These figures, along with a number of other indicators evaluating the performance of VR/PAYT on source reduction are calculated in more detail in Table 3.

[11] Franklin Associates, Marge Franklin, personal communication with the author. This firm conducts the updates of MSW tonnages in the U.S. for the U.S. EPA.

[12] Community estimates are commonly 60% residential to 40% commercial, or 40% residential to 60% commercial; for these extra calculations, we assumed a 50/50 split for residential vs. commercial MSW. This assumption affects the total tonnage computations, but the underlying estimates of PAYT percent impacts from SR on residential MSW remain unaffected.

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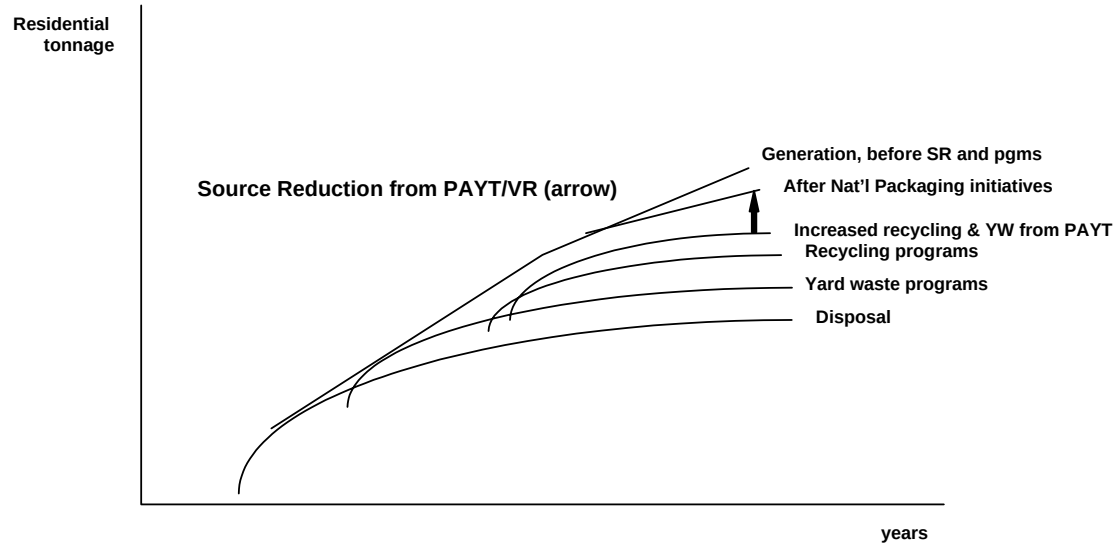
D. Time series method: Estimating behavioral changes and influences

Choices by residents about what types of products to buy, and how to dispose of them are influenced by a wide range of factors. A second method of estimating the size of the impact of variable rates on source reduction uses information on tonnages and influencing factors over a period of time. We can then use statistical techniques to develop a specific quantitative model that tracks the amount of waste disposal behavior explained by each factor.

Using some of the same underpinnings as the cross section method, we again assume that waste generation can be decomposed into three major streams – recycling, yard waste diversion, and source reduction. We can develop a model that explains generation, and a factor in the model specifically calls out the influence of the source reduction program of interest (in our case, VR / PAYT). If we then use the model to estimate the current year's generation and also use the model to estimate what generated tonnage would have been without the VR/PAYT program, the result is an estimate of the impact of VR/PAYT on generation.

Figure 2. Measuring Source Reduction from PAYT / VR -- Time Series Method



Source: Skumatz Economic Research Associates, Inc., © 1993, 2000

However, realistically, this estimate of the difference in generation would not only include the source reduction impact, but also would include the impacts of VR/PAYT on recycling and yard waste diversion as well. Therefore, we also need a separate estimate of the impacts of VR / PAYT on these programs. That would provide an estimate of the disposal that "never happened", or the source reduction tonnage of the program (see Figure 2).[13]

[13] A similar approach was discussed and proposed in Skumatz, Lisa A., "Variable Rates in Solid Waste: Implementation, Experience, Economics, and Legislation", Prepared for the Reason Foundation, Study number 160, Los Angeles, CA, 1993, pages 31-35.

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E. SR Results from Time Series Approach

We developed preliminary estimates of the SR impacts using an alternative approach – a time series model (1960-1998). Several models were developed:

- **"Gross impact"**: We fitted models of generation as function of population, households, gross domestic product (in real dollars), price index, recycling prices, and SERA's estimate of the U.S. population with variable rates over time.[14] These results showed that, using 1999 numbers, generation per capita would be 19.7% higher without variable rates. This impact translates to a significant tonnage impact from VR/PAYT.

- **Impacts controlling for packaging**: However, even though we have controlled for some important factors through the modeling approach (demographics, economics, etc.), other important changes may have been omitted from our model. One of the most important nationwide changes were downsizing of packaging, which occurred over the same period. Since no packaging factors were yet factored into this analysis, the model will tend to overestimate the influence of variable rates on generation. Using work published by the Garbology Project,[15] SERA developed a "packaging index", which indicated the number of ounces of packaging needed to package an ounce of consumer products (weighted across the major packaging materials). Re-estimating the model incorporating this factor,[16] we find that generation would have been 17.3% higher if variable rates had not been in place. Note that this may imply that source reduction from packaging has added 2.4 percentage points to source reduction as well.

- **Separating out recycling and yard waste impacts**: As the third step, we then estimated similar models for recycling and yard waste. The separate influences of variable rates on these tonnage figures was 6.9% of generation for recycling, and 4.6% of generation for yard waste influences. The sum of these impacts (11.5%) can be subtracted from the overall variable rates impact of 17.3%. This provides a figure of 5.8% as the estimate of the source reduction impact of variable rates using this time series method.[17]

[14] The model showed significant coefficients for the variables included. For further discussion of the technique and the relative influence of some of the variables included, see, for example, Skumatz, Lisa A., "Forecasting Solid Waste Tonnage: Techniques and Alternatives to Estimate Tonnage, Revenues, Source Reduction, and Program Performance", Skumatz Economic Research Associates, Inc. Research Report 9599-2, 1995/1997, Seattle WA. These evaluation techniques were discussed in Skumatz, Lisa A., Ph.D., "Variable Rates in Solid Waste: Implementation, Experience, Economics, and Legislation", Prepared for the Reason Foundation, Study number 160, Los Angeles, CA, 1993, pages 31-35.

[15] The Garbage Project, "The Archaeology of Plastic Packaging and Source Reduction", prepared for the ULS report, by The Garbage Project, Tucson, Arizona, July 1997.

[16] The estimated coefficients in the revised models were also significant, including the packaging factor.

[17] Similar results can be derived subtracting "fitted" or actual recycling and yard waste impacts.

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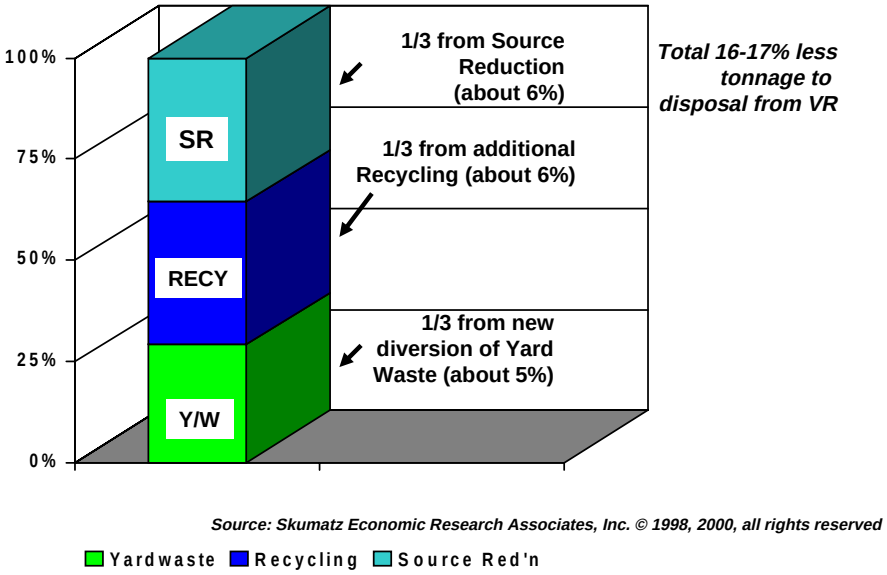
Summary: The estimate of the impact derived using the time series method falls within the range estimated by the cross section method. Approximately 5-7 percentage points seems a reasonable estimate of the SR effects of variable rates using either approach.[18] Given that the figure is a very similar order of magnitude to that estimated using the cross section approach, the computations of tonnages and disposal impacts developed above are similarly valid here.

Figure 3. Impacts Attributable to PAYT / Variable Rates -- What Can Towns Expect?

SERA, Inc. estimates of VR impacts show ***16-17% less tonnage disposed*** --



[18] Alternative estimates: As an alternative approach, we could have used the estimates of recycling and yard waste impacts cited and used in the earlier cross section analysis discussed in the previous section. This approach would have subtracted 9-11 percentage points from the 17.3% overall impact, estimating the SR impact from VR/PAYT as 6.3%-8.3%. Using the time series diversion program numbers with the cross section estimates for diversion programs would lead to an estimate of a 4.6 percentage point impact (16.1-11.5=4.6) for source reduction from variable rates. Note that we developed similar order of magnitude estimates even when modifying the specification of the models somewhat.

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III. COST-EFFECTIVENESS RESULTS

A. Cost-Effectiveness of Source Reduction and Variable Rates/PAYT

It is difficult to determine how much it costs to implement VR/PAYT. Communities differ in both the systems they have now (and their efficiencies) and the costs will differ depending on the type of system they elect to implement. This can vary dramatically. However, two pieces of information are available.

- Two state surveys[19] note that the majority of communities stated that their costs decreased or stayed the same after they implemented VR/PAYT. Wisconsin found costs decreased in 40% of communities, were constant in 27% and increased in 33% of communities. Iowa found that 60% of the communities reported decreased or stable costs. Relatively inexpensive bag, sticker, and hybrid programs are popular in these states, and rates between $7 and $12 per month were fairly common.

- SERA work[20] showed that, in California, where fully-automated can programs are popular, costs for solid waste services increased about 10-20% with the implementation of variable rates. Average monthly garbage and program costs were about $15.40 in the sample.[21]

Piecing together this information allow us to generate order-of-magnitude estimates of the cost-effectiveness of variable rates, as shown in Table 3. Several indicators are computed. The table indicates the number of tons that we estimate are diverted currently on an annual basis from the existing PAYT / VR programs – 1.3 million tons from SR, and over 3.5 million tons when combined with the recycling and yard waste impacts of the program. The columns provide the same computations making assumptions about the percent of the U.S. population covered by PAYT / VR programs. Clearly, if PAYT were universal, additional SR would result. However, mandates also have significant negative aspects, and policymakers need to seriously consider these impacts before proposing mandatory legislation.[22]

Table 3 also includes computations of the Benefit/Cost (B/C) ratio for PAYT programs The results for both SR impacts only, and for the combined impacts (including recycling, yard waste, and SR diversion) are shown. The costs were valued based on the midpoint of the two cost estimates provided above. The B/C results show that SR benefits are almost 8 times as valuable as the cost of implementing the PAYT / VR program. Incorporating the SR benefits improves the B/C ratio from PAYT from 1.4 to over 2.[23]

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[19] By the States of Iowa and Wisconsin. See Frable and Berkshire, "Pay as you Waste: State of Iowa Implementation Guide for Unit-Based Pricing", Iowa DNR, Des Moines, Iowa, 1997; and Gruder, "Wisconsin Volume Based Rate Collection Guide", University of Wisconsin Extension, Madison, WI, 1993.

[20] Skumatz, Lisa A., Ph.D., "Achieving 50% in California: Analysis of Recycling, Diversion, and Cost-Effectiveness", prepared for California Chapters of SWANA, Skumatz Economic Research Associates, Inc., Seattle, WA, 1999

[21] This California estimate is used as a "high" boundary or estimate for the succeeding calculations.

[22] An analysis of state legislative alternatives is provided in Skumatz, "Model Variable Rates Legislation: Elements, Options, and Considerations for State-Level Legislation in Solid Waste", Skumatz Economic Research Associates, Inc., Seattle, Washington, Research Report 9599-1, October 1995.

[23] For those preferring to compare simple payback results, the table contains the information necessary for the computation.

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Table 3: Estimated Source Reduction (SR) Impacts of Variable Rates / PAYT Effects on Tonnage, Costs, and Benefit/Cost Ratios

(Source: Skumatz Economic Research Associates, Inc.)

	Base Scenario: Current Incidence of VR/PAYT	***Scenario 1: Assume 50%*** population covered by VR/PAYT	***Scenario 2: Assume 75%*** population covered by VR/PAYT	***Scenario 3: Assume All*** communities have VR/PAYT
Tonnage and Diversion Percent Computations				
MSW Generation (in tons, Franklin, 1998)	220,230,000	220,230,000	220,230,000	220,230,000
Assume 50% is residential tonnage	110,115,000	110,115,000	110,115,000	110,115,000
Population	270,000,000	270,000,000	270,000,000	270,000,000
Gen/capita/year (in lbs)	816	816	816	816
PAYT/VR Red'n (from est., this report) for each town	6%	6%	6%	6%
PAYT/VR incidence (pct pop. Covered, from SERA)[22]	20%	50%	75%	100%
Tons of SR from VR/PAYT	***1,321,380***	***3,303,450***	***4,955,175***	***6,606,900***
Tons of Recycling from VR/PAYT (SERA est)[23]	1,211,265	3,028,163	4,542,244	6,056,325
Tons of Yardwaste from VR/PAYT (SERA est)[23]	991,035	2,477,588	3,716,381	4,955,175
Total Disposal diversion from VR/PAYT	3,523,680	8,809,200	13,213,800	17,618,400
Pct diversion from SR from PAYT/VR - Residential	***1.2%***	***3.0%***	***4.5%***	***6.0%***
Pct overall diversion from PAYT/VR-Residential	3.2%	8.0%	12.0%	16.0%
Pct diversion from SR from PAYT/VR - Total US MSW	0.6%	1.5%	2.3%	3.0%
Pct overall diversion from PAYT/VR - Total US MSW	1.6%	4.0%	6.0%	8.0%
Costs, Cost-Effectiveness, and Benefit-Cost Computations				
Costs to implement PAYT/VR -- low estimate (zero per majority of towns in WI, IA/surveys)	0	0	0	0
High estimate impl. Cost per capita (CA, from SERA)[23]	$0.56	$0.56	$0.56	$0.56
Use 1/2 low, 1/2 high	$0.28	$0.28	$0.28	$0.28
Costs(times population covered by PAYT/VR programs)	$6,117,500	$15,293,750	$22,940,625	$30,587,500
Assume avoided landfill (LF)costs are $35/ton (excludes transfer/disposal)[24]	$35.00	$35.00	$35.00	$35.00
Avoided LF costs for SR tons	$46,248,300	$115,620,750	$173,431,125	$231,241,500
Avoided LF costs for recycling and YW tons	$77,080,500	$192,701,250	$289,051,875	$385,402,500
Avoided LF costs for all diverted tons from VR/PAYT	$123,328,800	$308,322,000	$462,483,000	$616,644,000
Benefit/cost ratio for SR from VR/PAYT	7.6	7.6	7.6	7.6
Benefit/cost ratio for recycling and YW from VR/PAYT(*)	0.7	0.7	0.7	0.7
Benefit/cost ratio from all avoided tons from VR/PAYT(*)	1.2	1.2	1.2	1.2
Scenarios: B/C ratio if recycling and y/w costs are $2.50/hh, three categories as above (SR, R+Y/W, All avoided tons)	7.6 / 1.4 / 2.2	7.6 / 1.4 / 2.2	7.6 / 1.4 / 2.2	7.6 / 1.4 / 2.2
B/C ratio if landfill costs are $50/ton and program costs are $5/hh/mo; three categories as above (SR, R+Y/W, All avoided tons)	10.8 / 1.0 / 1.7	10.8 / 1.0 / 1.7	10.8 / 1.0 / 1.7	10.8 / 1.0 / 1.7

Note(*): These ratios assume $5 per household for recycling and yard waste programs. Excluding these costs generates benefit cost ratios of 12.6 for recycling/yw programs, and 20.2 for all three effects combined.

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IV. SUMMARY AND CONCLUSIONS

The project demonstrated that credible economic and statistical techniques could be used to measure source reduction. We used two basic techniques to estimate these impacts:

- Comparisons across communities at one point in time (cross section approach).
- Developing "causal" models to forecast tonnage with and without the program (time series approach).

Both approaches developed similar order of magnitude estimate of the impacts of the source reduction impacts of variable rates – a reduction on the order of 5-7 percentage points of generation (see Table 4).

Table 4: Source Reduction Estimates from PAYT / VR from Two Estimation Methods

(Source: Skumatz Economic Research Associates, Inc.)

	Community Comparison Method	***Time Series Method***
Total effect of PAYT /VR	16%	17.3%
Minus recycling effect for PAYT	- 5 to 6 %	- 6.9%
Minus Yard waste effect for PAYT	- 4 to 5 %	- 4.6%
Equals: Estimated SR effect attributable to PAYT/VR	*5 to 7 % from SR*	*5.8% from SR*

The results show that there is a significant amount of source reduction currently emanating from the existing variable rates/pay as you throw (VR/PAYT) programs in operation across the US. Even though only 20% of the population is covered by these rate incentive programs, we estimate 1.3 million tons are being source reduced from the existing VR/PAYT communities.[24] This means that, to date, residential disposal has been reduced by 1.7% and generation by 1.2% nationwide from just the source reduction impacts of these existing programs (see Table 5). Adding in the recycling and yard waste benefits from VR / PAYT programs significantly increases the tonnage (and avoided costs) from implementing VR/PAYT.

Each town implementing variable rates can expect to see reductions in disposal on the order of 16%, with 1/3 going to increased recycling, 1/3 to increased yard waste

[24] Making an assumption that only half of the MSW is residential in origin.

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diversion, and about 1/3 being avoided entirely through source reduction.[25] ***We estimate that 5-7 percentage points of additional diversion can be realized in a town from the source reduction impacts of variable rates/pay as you throw programs – above and beyond the increased recycling and yard waste diversion from the programs.***

The research shows that 5-7 percentage points of additional diversion can be attributed to communities that have implemented VR/PAYT programs. This is an estimate of the diversion strictly from the source reduction (SR) impacts of the programs. This means that, to date, disposal has been reduced by 1.7% and generation is 1.2% lower nationwide from just the source reduction impacts of existing VR/PAYT programs	***Example**: Town A starts with 100,000 tons of waste disposed* *Town A will expect to see about 5,000-7,000 tons less disposal (increased diversion) from source reduction alone if they implement VR/PAYT. (100,000 TPY times 0.05 to 0.07)* *Adding the estimated increases in recycling and yard waste diversion, Town A's total disposed tonnage would fall by 16,000 tons. (100,000 times 0.16)* *Town A's disposal before: 100,000 tons* *Reduction from SR from PAYT: 5-7,000 tons* *Town's total disposal after all PAYT impacts: 84,000 tons*

The cost savings from the source reduction influence are very high. Even using approximations, computations of benefit cost (B/C) ratios show source reduction from VR/PAYT has a B/C ratio on the order of 7.6 – and that assumes the entire cost of the VR/PAYT program is "assigned" to the source reduction program. Ratios of greater than 1 are usually considered good investments (they "pay back" in a year or less), and this figure implies the value of the benefits from the program are almost 8 times as large as the cost. Compared to recycling and yard waste programs, this is a very high payback. The benefit cost ratio from all tonnage impacts (recycling, yard waste, and SR), incorporating all program costs, is still estimated between 1.2 and 2.2, depending on assumptions (see Table 5 and Table 3).[26]

[25] These are "round" figures for illustration purposes. The accurate figures were shown elsewhere in the report – 5-6% to recycling, 4-5% to yard waste diversion, and the remaining 5-7% is source reduction. Source is: Skumatz, Lisa A., Ph.D., "Nationwide Diversion Rate Study – Quantitative Effects of Program Choices on Recycling and Green Waste Diversion: Beyond Case Studies", Skumatz Economic Research Associates, Inc. Report, Seattle, Washington, 1996.

[26] These benefit/cost ratio figures may serve as approximate inverses of the payback calculations. Two assumptions are needed: that most of the costs of putting in the variable rates program is first-year implementation cost, and that the economic incentive "sticks" – that each year users keep their generation down in response to the rates. There is strong evidence for both conclusions. In this case, the payback period for the SR from VR/PAYT would be $12.2 million cost to implement VR/$92.5 million avoided costs for SR or .13 years (or 45 days). Payback periods for the recycling and yard waste programs, and for the combination of all three programs are also estimated at less than one year. These programs also move communities a long way toward 50% recycling goals.

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Table 5: SR Impacts and Cost-Effectiveness of PAYT / VR

(source: Skumatz Economic Research Associates, Inc.)

	Lower Tons Disposed	*Percent Reduction*	*Benefit / Cost Ratio*
Total current PAYT program impacts on U.S. MSW generation (includes recycling, Y/W and SR)	3.5 million	1.6%, all MSW 3.2% residential	7.6
SR Impacts of PAYT nationally (annual, SR only)	1.3 million	1.2% MSW, 0.6% res.	1.2-2.2 [27]

Given that recycling programs alone do not encourage source reduction, the investment in a variable rates or PAYT program has significant advantages including:

- High levels of source reduction,
- Environmental benefits, strong program paybacks, and
- Additional recycling and yard waste diversion impacts that provide significant progress toward meeting diversion goals.

VR/PAYT programs have a myriad of benefits, including equity, education, and increasing recycling and yard waste diversion. However, because the magnitude was not known, the source reduction benefits were have usually been ignored. In this project, we find that these source reduction benefits are high on a per-community basis and have already led to significant source reduction diversion at the national level. Source reduction programs are valuable, are measurable, and lead to significant savings and a more cost-effective overall mix of solid waste management programs. All things considered, policymakers and community decision-makers can now know that source reduction's payback means investing in source reduction can be a very good investment.

About SERA and the Author:

Dr. Lisa Skumatz is an economist and Principal of the Seattle-based research and consulting firm Skumatz Economic Research Associates, Inc. (SERA). SERA works with clients across the U.S. and Canada and specializes in helping communities and states with PAYT/VR rates as well as planning, evaluating, improving, and benchmarking recycling and other waste management programs. SERA has published extensively in the areas of program cost-effectiveness, and quantifying impacts and performance results for incentive, recycling, yard waste hazardous waste, and other programs. SERA's work also includes comprehensive analysis of strategies and policies to increase diversion and reach goals. SERA is currently tailoring the results of this PAYT source reduction estimation work for cities and states, and is working with communities and states to apply the methods to estimate impacts for other types of SR programs. For another project we are quantifying the impacts of outreach/education on recycling diversion. For additional information or to order copies of the report contact SERA. Phone: 206/624-8508, FAX: 206/624-2950, email: skumatz @ serainc.com, web sites: serainc.com, and payt.org.

[27] The B/C ratios differ with changes in cost assumptions. If recycling and yard waste program costs are assumed to be $5/household per month and landfill costs are $35/ton, ratio is 1.2; if program costs are $2.50, B/C ratio is 2.2; if program costs are $5 and landfill costs are $50, ratio is 1.7. The percent of MSW assumed to be residential also affects these computations.

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