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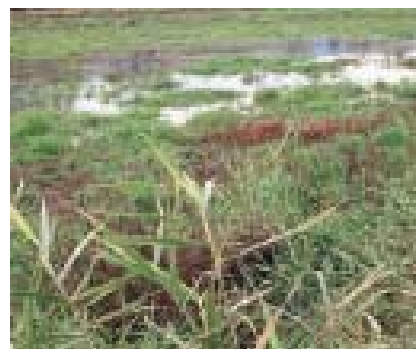
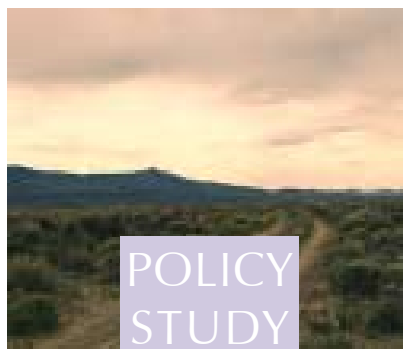
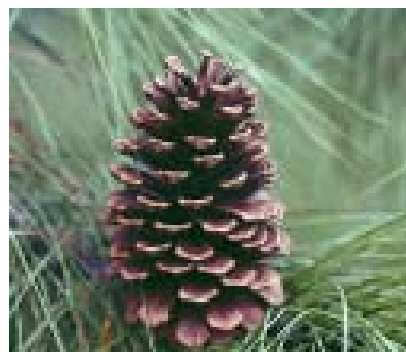
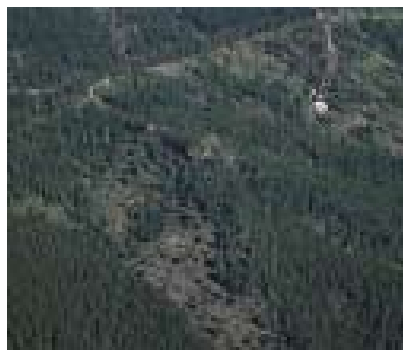
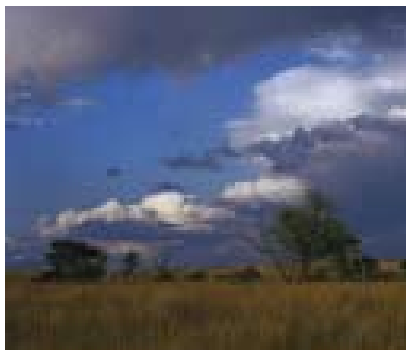
July 2002

VARIABLE-RATE OR "PAY-AS-YOU-THROW" WASTE MANAGEMENT:

ANSWERS TO FREQUENTLY ASKED QUESTIONS

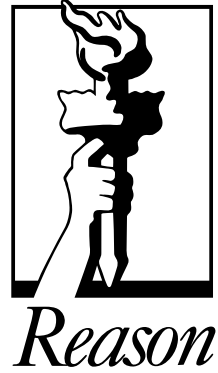
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POLICY
STUDY

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Variable-rate or “Pay-as-you-throw” Waste Management: Answers to Frequently Asked Questions

BY LISA A. SKUMATZ, PH.D.

Executive Summary

As landfills fill up and recycling opportunities increase, more communities across the nation are interested in reducing waste disposal and its costs. City managers are considering a variety of strategies to improve incentives to recycling and composting, as well as increasing the variety of materials that can be recycled or composted.

Currently, in most parts of the country, garbage is removed once or twice a week with revenues coming from one of two places:

- A portion of property taxes; or
- A fixed bill amount that does not vary with respect to the amount of garbage taken away.

Neither method provides an incentive to reduce waste. In fact, with the property tax method of payment, customers never even see a bill and generally have no idea how much it costs to remove their garbage regularly. Areas using this method of payment have sometimes implemented mandatory recycling programs to reduce their amount of garbage.

Variable-rate pricing, or “pay as you throw,” is a new strategy with a growing number of advocates. Under a variable-rate system, customers are provided an economic signal to reduce the waste they throw away because garbage bills increase with the volume or weight of waste they dispose. Variable-rate pricing is being adopted in thousands of communities to create incentives for additional recycling in the residential sector.

Variable-rate programs are very flexible and have been implemented by communities in many forms. The most common types of variable-rate programs are can programs, bag programs, tag and sticker programs, and hybrid programs. Other less common programs include weight-based rates. Each program type is briefly summarized below.

- **Can Programs.** Customers select the appropriate number or size of containers (one can, two cans, etc., or 30–35 gallons, 60–65 gallons, etc.) for their standard weekly disposal amount. Residents who use larger cans or numbers of cans are charged more.
- **Bag Programs.** Customers purchase bags imprinted with special logos ahead of time, and waste must be put in the appropriate bag (i.e. yard waste, recyclables, regular “wet” waste, etc.). The price of the bag incorporates the cost of the collection, transport, and disposal of the waste.
- **Tag and Sticker Programs.** These programs are almost identical to bag programs, except instead of using a special bag, customers affix an appropriate sticker or tag that identifies the type of waste they are disposing.
- **Hybrid Programs.** These programs form a hybrid of the current collection system and a new incentive-based system. Instead of receiving unlimited collection for payment of the monthly fee or tax bill, the customer gets a smaller, limited volume of service for the fee. If the customer needs to dispose of additional waste, there is an additional charge such as a fee per bag or additional container.
- **Weight-based Programs.** This system uses a modified scale on trucks to weigh garbage containers and charge customers based on the actual pounds of garbage set out for disposal. On-board computers record weights by household and customers are billed on this basis.
- **Other Variations.** Some communities or haulers offer variable rates as an option along with their standard unlimited system. Waste drop-off programs, that use punch cards or other customer tracking systems, are also in place in some communities.

Some systems are more appropriate than others, depending on local conditions. Larger communities and urban and suburban communities tend to use can programs. Smaller communities and more rural communities are more likely to use bag, tag, or sticker programs. Bag and drop-off programs are most prevalent in the East, can and bag programs are most common in the Midwest and the South, and can programs are the most popular in the western U.S.

Each type of variable-rate system has strengths and weaknesses. Key advantages and concerns are discussed in the following sections of this study. The factors driving the growth in each program are presented. The study also provides information on appropriate program selection, implementation issues and tips, and rate setting.

This study demonstrates that rate incentives in solid waste have strong and measurable effects on waste disposal behavior and waste disposal. Towns implementing variable-rate programs can expect to see reductions of more than 15 percent in tons disposed, with increases in recycling, yard-waste diversion, and measurable impacts on the highest rung on the waste-management hierarchy: source reduction.

Ultimately, variable rates can help reduce the burden on the disposal system and lead to more efficient resource use, reduced environmental burden, and lower long-run solid waste system management costs. The programs enhance community recycling and waste reduction programs. While these programs may not be appropriate in all communities, many communities can benefit from variable rates. This report offers guidance to communities wishing to examine the feasibility of variable rates for their solid waste systems.

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What is variable-rate waste disposal, and what are its benefits?

Systems of pricing trash for disposal are known by a variety of names: variable rate, pay by the bag, variable-can rate, volume-based, pay as you throw, among others. However, the basic concept underlying all these terms is the same and is very straightforward: customers that put out more waste for collection pay more than those who put out less.

Variable-rate programs provide a number of advantages for communities and residents:

- **Equity.** Variable rates are fair: customers who use more service pay more.
- **Economic Signal.** Under variable rates, *behavior* affects a bill, regardless of what disposal choices a household makes. Without variable rates, avid recyclers pay the same as large disposers. Variable rates provide a recurring economic signal to modify behavior, and allow small disposers to save money compared to those who use more service and impose more costs on the system.
- **Lack of Restrictions.** Variable rates do not restrict customer choices. Customers are not prohibited from putting out additional garbage; but those who want to put out more will pay more.
- **Efficiency.** Variable-rate programs are generally inexpensive to implement and, unlike recycling programs, do not require additional pick-up trucks. They also help prevent overuse of solid-waste services. Rather than fixed all-you-can-throw charges, which encourage over-use of the service, volume-based rates encourage customers to use only the amount of service they need.
- **Waste Reduction.** Unlike recycling programs alone, which only encourage recycling, variable rates reward all behaviors—recycling, composting, and source reduction—that reduce the amount of garbage thrown away. Source reduction is the cheapest waste-management strategy and thus of the highest priority—and it is not directly encouraged by recycling and yard waste programs.
- **Speed of Implementation:** Pay-as-you-throw programs can be very quickly put in place—one community installed a variable-rate program in less than three months (although most take longer).
- **Flexibility.** “Pay-as-you-throw” programs can be implemented in a variety of sizes and types of communities, with the broad range of collection arrangements.
- **Environmental Benefits.** Because they encourage increased recycling and waste reduction, variable-rate programs are broadly beneficial to the environment.

Ultimately, it is anticipated that using variable rates to reduce the burden on the disposal system will lead to more efficient use of services, improved environmental and resource use, and lower long-run solid waste system management costs.

Why apply market principles to waste management?

Research has demonstrated that rate incentives in solid waste have strong and measurable effects on waste disposal behavior. Adapting pricing principles from energy, water, and other utilities, studies show that paying for more (and more specific) garbage service increases recycling and composting and reduces disposal overall.

What are the different types of variable-rate waste-disposal pricing systems?

Variable-rate programs are very flexible, and adaptable to a wide range of community types. They can be categorized into five major types:

- **Variable Can or Subscribed Can.** In this program, customers select the appropriate number or size of containers (one can, two cans, etc., or 30–35 gallons, 60–65 gallons, etc.) for their standard weekly disposal amount. Rates for customers signed up for two- or three-can service are higher than rates for one-can customers. Some communities also have introduced mini-can (13–20 gallons) or micro-can (10 gallons) service levels to provide incentives for aggressive recyclers.
- **Bag Program.** In this program, customers purchase bags imprinted with a particular logo, and any waste they want collected must be put in the appropriately marked bags. Bags holding from 30 to 35 gallons are most common, but some communities also sell smaller bags at a discounted price. Bags can be sold at city hall or community centers; more commonly, communities work with grocery stores or convenience store chains to sell the bags—sometimes with a commission, although sometimes the foot traffic is enough reward to the retailer. The price of the bag incorporates the cost of the collection, transportation, and disposal of the waste in the bag. In some communities, the bag program is used in conjunction with a customer charge or flat-fee program charge, and in those cases, the bag price reflects only a portion of the cost of collection and disposal, with the remainder collected through the monthly charge.
- **Tag or Sticker Programs.** These are almost identical to bag programs, except instead of a special bag, customers affix a special logo sticker or tag to the waste they want collected. The tags need to be visible to collection staff to signal that the waste has been paid for. Like the bag program, tags are usually good for 30-gallon increments of service. Pricing and distribution options are identical to bag programs.
- **Hybrid System.** This system is a hybrid of the current collection system and a new incentive-based system. Instead of receiving unlimited collection for payment of the monthly fee or tax bill, the customer gets only a smaller, limited volume of service for the fee. Typical limits for the base service in communities across the country are one can, two bags, or two cans. Limits usually vary based on maturity of the program, disposal behavior, and availability and comprehensiveness of recycling options. Beyond the approved base service, customers are required to buy bags or stickers, as described above, for any extra garbage. Under this program, the base service level can be tailored to best suit the community or to achieve a variety of objectives. No new billing system is needed, and bags only need to be purchased for service above the base. Current collection and billing are retained with minimal changes, and many customers see no change in their garbage fee. This system provides a monetary disincentive for those who are putting out higher amounts of garbage.
- **Weight-based System.** This system uses truck-based scales to weigh garbage containers and charge customers based on the actual pounds of garbage set out for disposal. On-board computers record weights by household, and customers are billed on this basis. Special “chips,” called radio frequency (RF) tags, are affixed to the containers to identify households, and these are read and recorded electronically on the on-board computer along with the weights for that household. These programs have been pilot-tested in the U.S., and implemented overseas. Certified scale systems are now available.
- **Other Variations.** Some communities or haulers offer variable rates as an option along with their standard unlimited system. Waste drop-off programs, that use punch cards or other customer tracking systems, are also in place in some communities, especially in rural areas.

The advantages and disadvantages of each of these systems are summarized in Table 1a and 1b. Using these systems, communities realize savings through reduced landfill usage, efficiencies in routing, staffing, and equipment, and higher recycling. However, there are some negatives: collection changes can lead to additional costs and new administrative burdens (monitoring and enforcement, billing, etc.), rate-setting and revenues are more complex and uncertain, and significant expenditures for public education outreach are necessary for successful implementation of a variable-rate program.

Table 1A: Advantages of Major Variable Rate System Types			
Hybrid System	Variable Can System	Bag/Sticker Systems	Weight-Based
<p>Advantages:</p> <ul style="list-style-type: none"> ▪ Can often use existing containers (which can help limit "scatter") ▪ Can be implemented quickly and inexpensively – easy transition from current collection ▪ No capital investment for trucks, containers ▪ No new billing system needed – continue to bill using current method, but now for more limited service ▪ Can design "base" service amount to community needs – and can modify over time ▪ High customer satisfaction because "out of pocket" can be limited (many will not exceed base units) – and easy transition from current system in customer minds ▪ Can modify system later with little to no wasted expenditure ▪ Stable revenues because "base" paid by all customers ▪ Provides incentive at relatively low revenue risk to the system ▪ Customers only need to buy extra bags/tags for waste beyond their can or base level – less inconvenient than programs for which they have to buy bags for all waste ▪ Multiple haulers can be accommodated using different colored bags/stickers 	<p>Advantages:</p> <ul style="list-style-type: none"> ▪ Multiple can sizes can provide incentives / equity ▪ Using relatively small first container limit can provide good incentives for reduction ▪ Containers are sturdy, tend to reduce scatter ▪ Revenues relatively stable ▪ Possible to use existing containers if sizes are compatible ▪ Experience in larger jurisdictions ▪ Works with automated collection systems ▪ Using standardized containers simplifies enforcement ▪ Billing system can usually accommodate low income, other special services ▪ Can develop rates with very flexible structures for incentives (can develop varying differentials) 	<p>Advantages:</p> <ul style="list-style-type: none"> ▪ Smaller, more flexible increments of service available – easy to make multiple bag or sticker sizes – harder for cans ▪ No billing system needed except invoicing retail sales outlets ▪ Convenient outlets have been willing to sell bags/tags fairly readily in communities (sometimes without commission in exchange for foot traffic) ▪ Easily handle multiple haulers by using colored bags/stickers ▪ Pure bag/tag systems can be enhanced/modified with "base" customer charge (fixed), which can be easily billed, and can reduce revenue volatility ▪ Bags and stickers are cheap; easily distributed (stickers even easily mailed). They are readily available from multiple firms. ▪ Collection can be very fast – collection staff do not need to return to curb after collection ▪ Collection is "clean" – nothing left on curb ▪ Service is "prepaid" when the bag/tag is purchased. Revenues are received ahead of service delivery. 	<p>Advantages:</p> <ul style="list-style-type: none"> ▪ More flexible – better recycling incentive for customers because they save for every bit removed from container ▪ Fair and easily understood – customers used to paying for services by increments (water, electricity, etc.) ▪ Flexible on a weekly basis – customers don't pay for can service they don't actually use ▪ Equipment now available, certified – fully automated and semi-automated

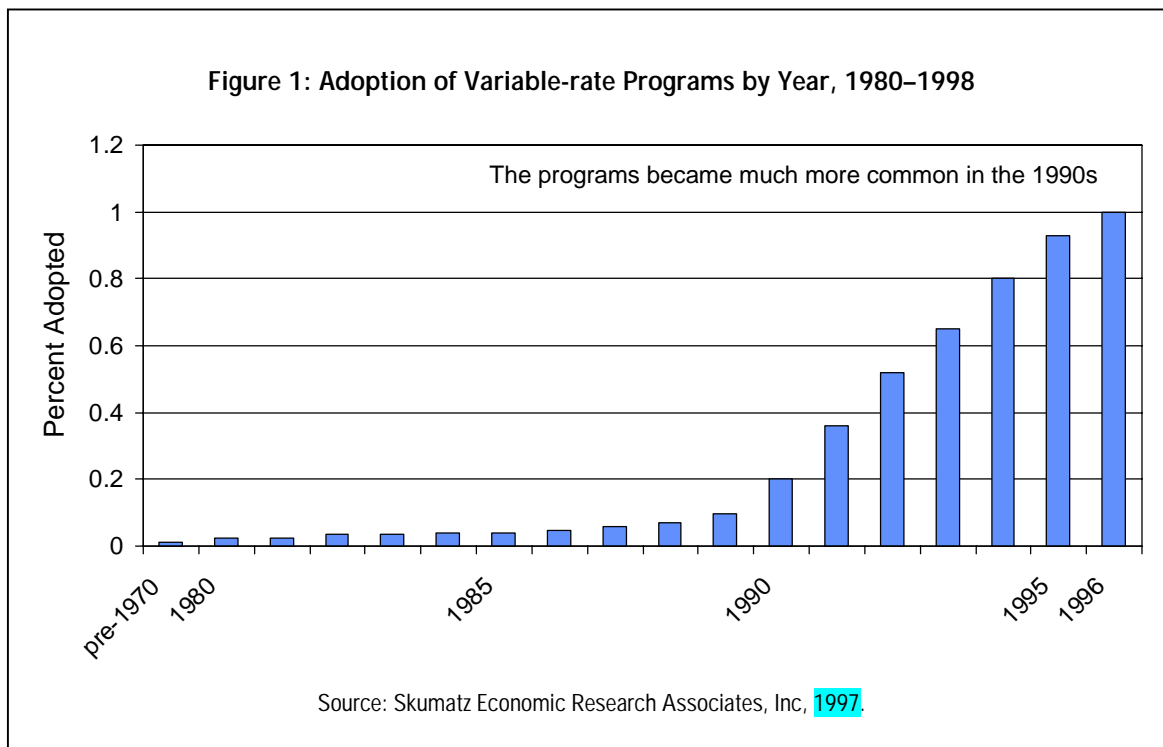
Source: Skumatz Economic Research Associates, Inc. Seattle, WA, © 1998.

Table 1B: Disadvantages of Major Variable Rate System Types			
Hybrid System	Variable Can System	Bag/Sticker Systems	Weight-Based
<p>Disadvantages:</p> <ul style="list-style-type: none"> ▪ Customers don't have incentive to recycle below "base" service level ▪ Need to set up bag/tag system for "extras" beyond base service level; customers need to learn/understand system and where to purchase bags ▪ Customers may not see total cost of garbage system because billed in two portions. 	<p>Disadvantages:</p> <ul style="list-style-type: none"> ▪ Customers must determine their "normal" service level for billing purposes ▪ Customers must call to change service levels ▪ System for handling occasional "extras" beyond subscribed service must be established (bag, sticker) <ul style="list-style-type: none"> ▪ If standardized containers to be provided by community or hauler, purchase, distribution, and storage can be expensive ▪ Initial complications / administration when customers select initial service levels (billing, delivery of containers) <ul style="list-style-type: none"> ▪ Coordination required (and expense) as customers want to change service levels ▪ Slower collection – need to return to curb – and empty containers left on curb afterward ▪ Multiple containers can be expensive to purchase, store, deliver/re-deliver, and estimating proportions customers will want up-front (for ordering) can be complicated ▪ Small containers (especially ones suitable for automated / semi-automated collection) difficult to find ▪ No incentives for recycling below the smallest container 	<p>Disadvantages:</p> <ul style="list-style-type: none"> ▪ Supply and distribution system needed (grocery/convenience stores, etc.) – need to order, distribute, and invoice distributors ▪ Customers must buy bags/stickers for ALL waste (hybrid or can programs have reusable containers for some amount of waste) ▪ Customers need to store/manage bags/tags and have bags on hand when they need them – need convenient distribution system with long hours <ul style="list-style-type: none"> ▪ Does not work as easily with automated collection (unless bags are put in cans, which complicates enforcement)) ▪ Revenue uncertainties relatively high – revenues depend SOLELY on number of bags/stickers sold (unless customer charge used in conjunction) <ul style="list-style-type: none"> ▪ Need to explain to customers how system works and where to get bags/stickers (true for all systems, and for "extras" associated with hybrid and variable can programs also) ▪ Stickers somewhat more complicated to explain to customers (size limits, etc.) ▪ Bags may lead to scatter from animals (ammonia / vinegar in bag can reduce; bags can be put in cans, or stronger bags used) <ul style="list-style-type: none"> ▪ Recycling not encouraged below smallest bag size (although customers may not put out waste each week) ▪ Stickers are somewhat harder to enforce size limits – some hauler judgment required at curb ▪ Structure of rate incentives is limited – a bag is a bag, so second bags can't be more or less expensive than first bags. Also, large bags cannot be priced with additional penalties – customers would just use multiple small bags. 	<p>Disadvantages:</p> <ul style="list-style-type: none"> ▪ Some systems take additional time at the curb – others don't <ul style="list-style-type: none"> ▪ No city-wide systems in operation in U.S. to date – many used overseas ▪ Trucks need to be retrofitted with special scales and need to label containers with RF tags (or less efficiently, bar codes) <ul style="list-style-type: none"> ▪ More complicated billing system needed ▪ Billing procedures need to be established for equipment breakdowns

Source: Skumatz Economic Research Associates, Inc. Seattle, WA, © 1998.

Who is implementing variable-rate waste-disposal pricing?

The most comprehensive inventory and study of variable rate communities is conducted on a biannual basis by the Colorado-based Skumatz Economic Research Associates, Inc. (SERA).¹ As Figure 1 shows, variable-rate programs have caught on in the last decade, and they are in operation in thousands of communities across the U.S. Furthermore, many states recommend variable-rate programs as strategies for increasing recycling and meeting diversion goals; a few even mandate the adoption of variable rates for communities in the state.

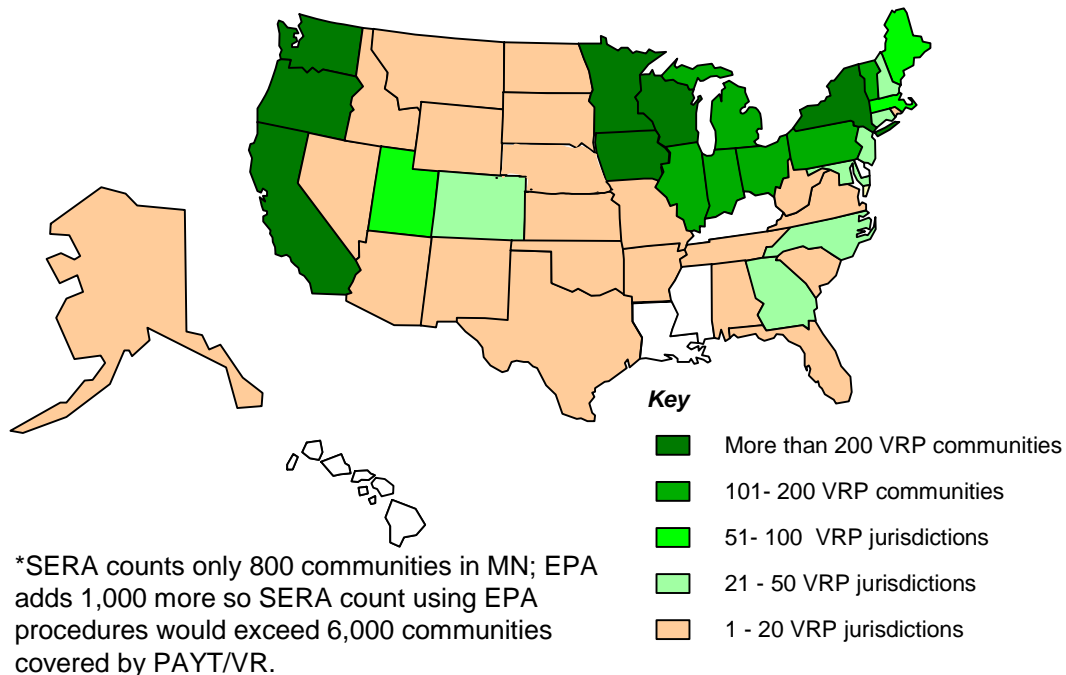


Variable-rate programs have caught on in the last decade, and they are in operation in thousands of communities across the U.S.

As Figure 2 shows, the program count and population coverage for variable-rate programs has increased dramatically in the 1990s—from about 100 to about 6,000 currently—and variable-rate programs are available to more than 20 percent of the national population.²

Figure 2: Variable-rate Communities

SERA's 2000 survey found more than 5,000* variable rates communities and only 4 states without programs. Programs are available to 20% of population.

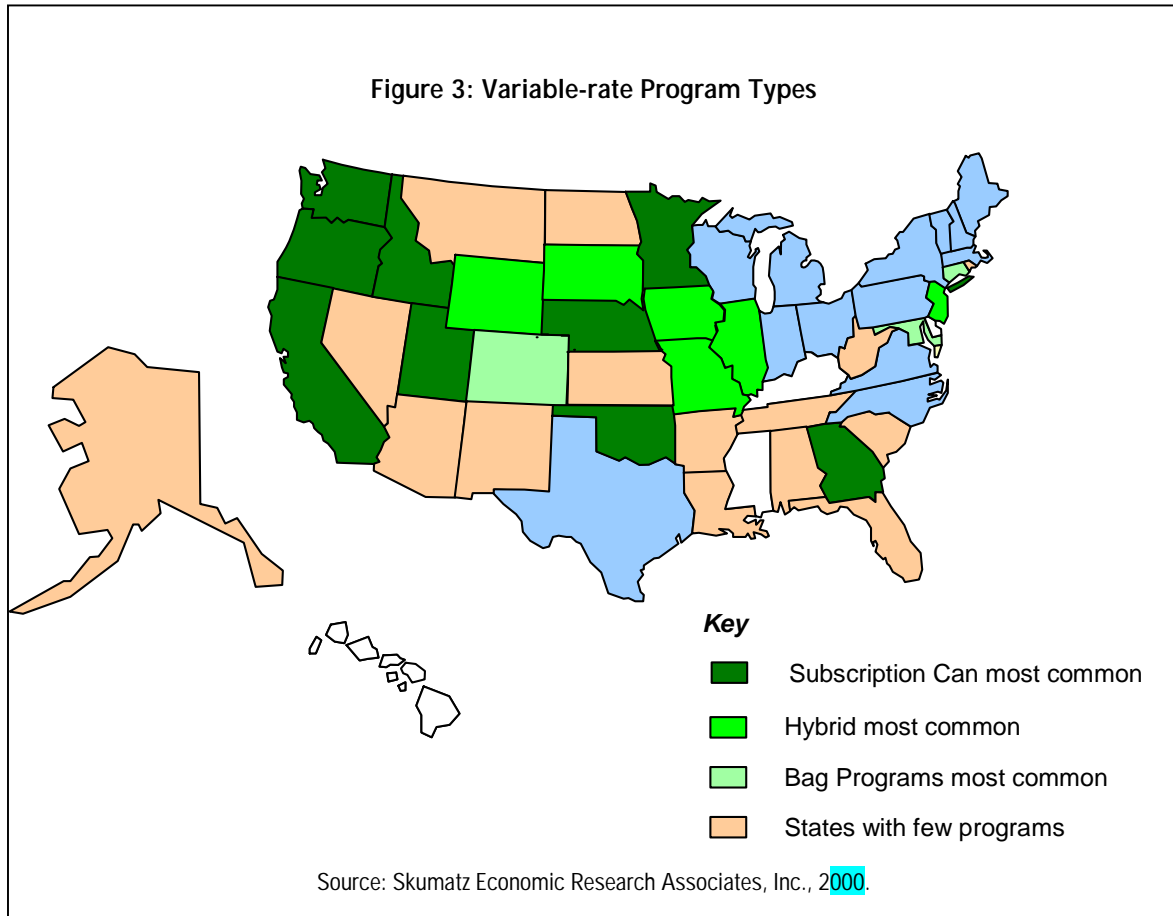


Source: Skumatz Economic Research Associates, Inc., 2000.

Communities with variable-rate programs range in size from about 50 to over a million in population.

Communities with variable-rate programs range in size from about 50 to over a million in population. As Figure 3 shows, variable-rate programs exist in all but four states: Kentucky, Hawaii, Louisiana, and Alabama. One community in Hawaii is currently considering variable rates.³

Nationally, SERA finds that can and bag programs are the most common, followed by hybrid programs. Sticker, optional, and drop-off programs are somewhat less common. No weight-based programs are currently in full-scale operation in the United States. The frequency of types of programs is roughly one-third can, one-fourth bag, and one-sixth each for hybrid and sticker programs.⁴ A few optional and drop-off variations of variable-rate programs are also in place.

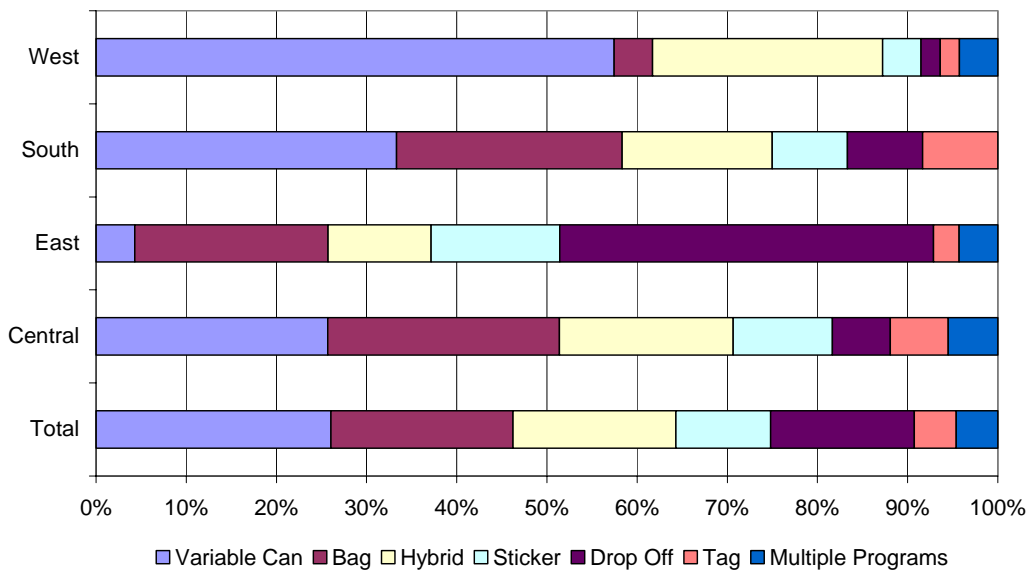


Program Type. Overall, data from the survey indicated that 25 percent of variable-rate communities nationwide use a variable-can program, 20 percent use a bag program, 20 percent use a hybrid program, 15 percent use a drop-off location, 10 percent use a sticker program, 5 percent use a tag program, and 5 percent allow residents to choose from two or more programs (e.g. variable can or sticker). However, when one considers the population covered, variable can represents an even greater percentage.

The distribution of variable-rate programs also varies by region. Drop-off and bag programs are most popular in the eastern United States, variable-can and bag programs are used most often in the Midwest and South, and variable-can programs are by far the most popular variable-rate program in the western United States where towns tend to be larger and have automated collection. The complete breakdown is shown in Figures 4 and 5 below.

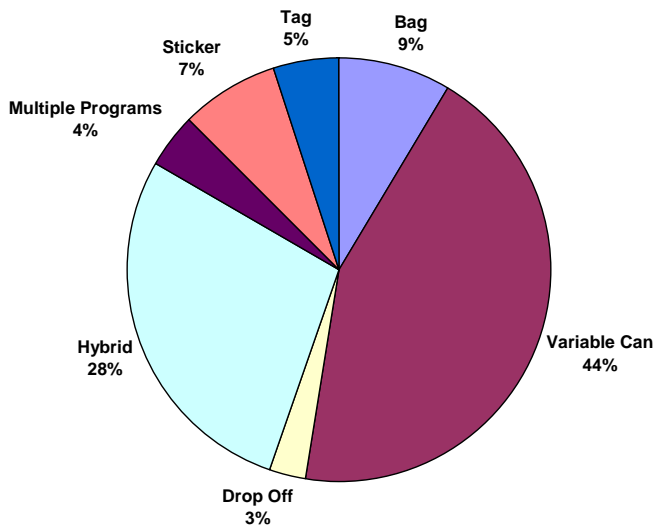
Population. Figure 5 shows that variable-can programs cover the largest percent of the population, followed by hybrid programs. When variable-rate systems are available, variable-can programs serve 45 percent of the population, hybrid programs serve 28 percent, bag programs serve 9 percent, sticker programs serve 7 percent, tag programs serve 5 percent, and multiple programs serve 4 percent.

Figure 4: Variable-rate Program Type by Region



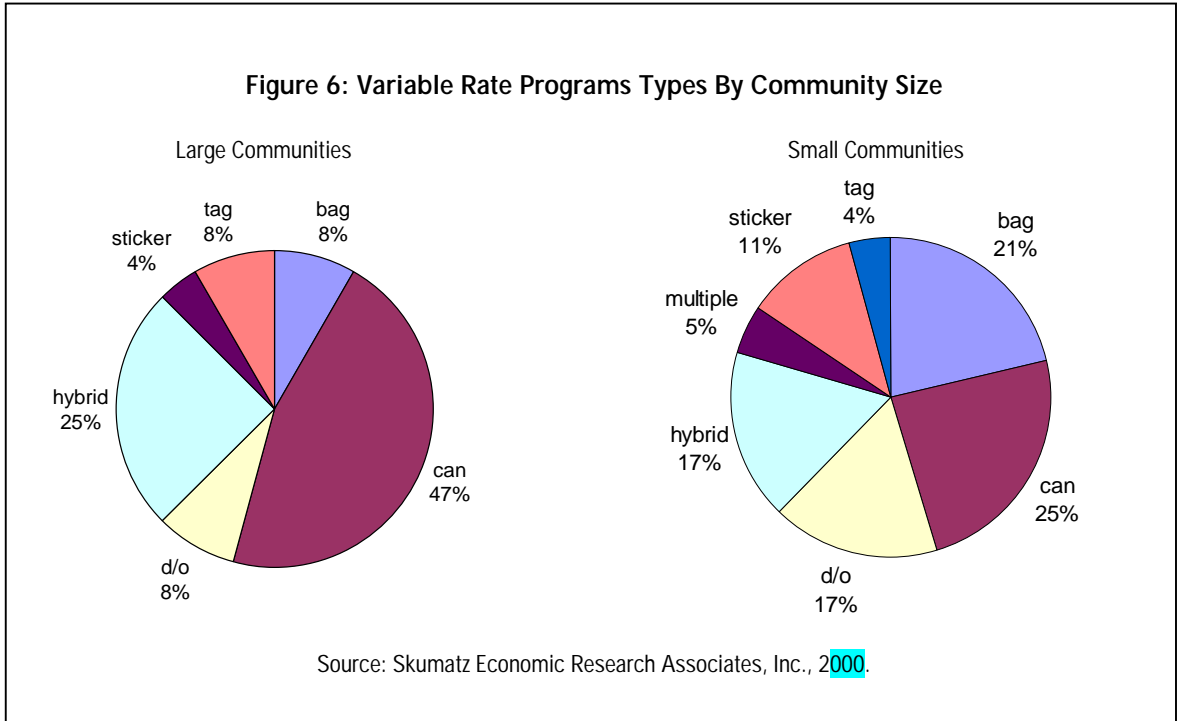
Source: Skumatz Economic Research Associates, Inc., 2000.

Figure 5: Variable-rate Programs by Population Covered

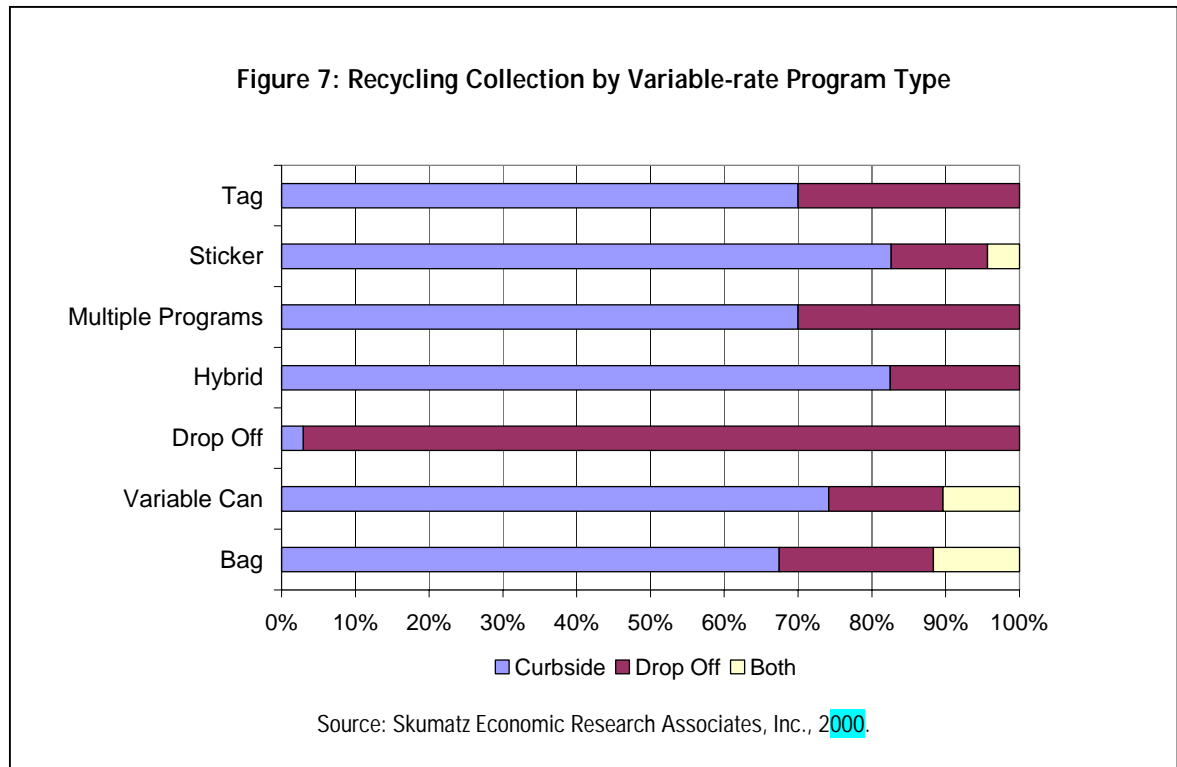


Source: Skumatz Economic Research Associates, Inc., 2000.

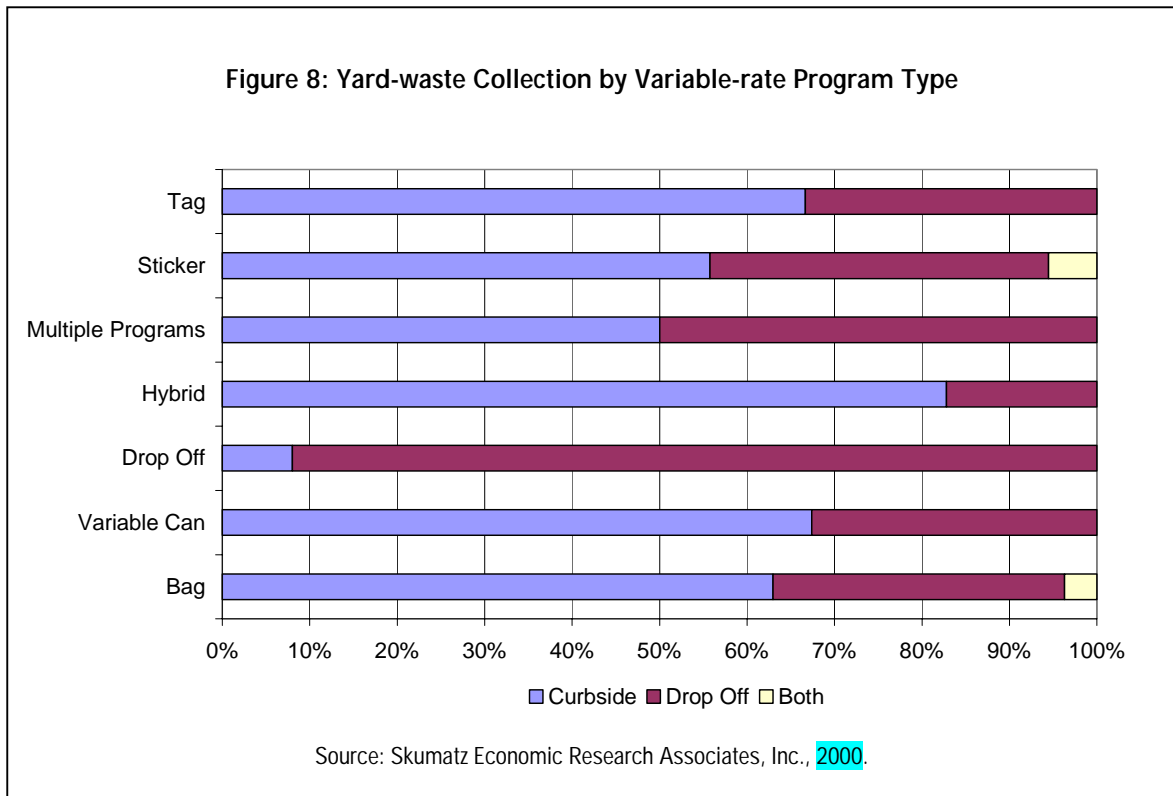
Large vs. Small Communities. As Figure 6 shows, the most common variable-rate programs in large communities are variable-can programs followed by hybrid programs. As the figure shows, in smaller communities, the distribution of variable-rate programs is more even with variable can, bag, hybrid, and drop-off programs sharing equal segments.



Recycling Programs by Variable-rate Type. Nationwide, the prevalence of curbside and drop-off recycling programs varies by variable-rate program type.



Nationwide, the prevalence of curbside and drop-off yard-waste programs varies by variable-rate program type.



Population. A large majority of the communities indicated that they had a curbside recycling program. Nine out of 10 communities (85 percent curbside only, 5 percent both curbside and drop-off) have a curbside recycling program, while the remaining 10 percent have a drop-off program.

80 percent of the population surveyed has a curbside yard-waste program, 10 percent have a drop-off program, 1 percent have both curbside and drop-off yard-waste programs, and the remainder do not have access to yard-waste programs.

How does state legislation affect adoption of variable-rate waste disposal?

Based on surveys with communities, adoption of variable-rate legislation has been driven by a number of factors, including increasing landfill costs, need to reach diversion goals, reports of successful programs, and legislative mandates. The types of legislative and state interventions are listed in Table 2.⁵

In 1999, SERA conducted a survey of state-level recycling contacts to identify the level of assistance their state provides to variable-rate programs. Survey results indicated that 39 states have a state-level policy for variable rates. The results are presented in Table 3. Note that some states offer several levels of assistance. (The lower levels of assistance are in parenthetical lists.)

Table 2: Categories of State-level Legislation and Policies: Regarding Variable-rate Programs	
Levels of Aggressiveness in State Involvement	Example
Voluntary recommendations	A number of states put variable rate pricing in the State Master Plan or Comprehensive Solid Waste Management Plan.
Active promotion of or education about recommended variable-rate strategies	Many states have funded workshops, manuals, newsletter, or case studies about variable rate pricing (examples include Illinois and Wyoming).
Financial incentives for recommended strategies	Some states provide grants specifically for or with preferences for community with or considering variable rate pricing (e.g. Massachusetts).
Requirements to adopt a subset of a menu of strategies	At least one state requires adoption of 3 or 5 strategies from a list of 8 menu items for communities, and the list includes variable rate pricing (Oregon, and 3 vs. 5 depends on population).
Mandatory adoption of strategy if certain goals aren't met	If communities don't reach the 25 percent goal, they must adopt variable rate pricing (examples: Wisconsin, Iowa).
Mandatory widespread requirement of variable-rate programs (without enforcement)	All communities must adopt variable-rate pricing (unclear on enforcement level, but Minnesota requires this).
Mandatory widespread requirement of variable-rate programs (with enforcement)	All entities providing garbage service must implement variable rate pricing (Washington state requires this for all entities for whether the state regulatory commission has oversight, and it is enforced through the rate-review process).

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

Table 3: State Assistance for Variable-rate Programs	
Levels of Aggressiveness	States
Mandatory	Washington, Minnesota (with varying levels of enforcement)
Mandatory adoption of strategy if goals aren't met	Wisconsin, Iowa
Requirements to adopt a subset of menu strategies	Oregon
Financial incentives/grants for recommended strategies	Massachusetts, Maine, North Carolina, Arkansas, Indiana, Texas, Nebraska, Florida, Missouri, Ohio, Pennsylvania (Iowa, Wisconsin)
Active promotion/education about recommended strategies	Illinois, Wyoming, Connecticut, Ohio, New Mexico, New York, New Jersey, Montana, Nevada, Delaware, Alaska, Alabama, Kansas, Utah, Kentucky, South Carolina, Louisiana, North Dakota, Maryland, Rhode Island, California (Iowa, Wisconsin, Washington, Pennsylvania, Ohio, Maine, North Carolina, Arkansas, Indiana, Texas, Nebraska, Massachusetts)
Voluntary recommendations	Michigan (Pennsylvania, North Dakota, Massachusetts, Florida, South Carolina, Wyoming, Montana, New Mexico, California)

Source: Skumatz Economic Research Associates, Inc., 1999/2000.

What are the tonnage impacts of implementing variable rates?

A variety of sources cite dramatic waste reduction from variable-rate programs in conjunction with other reduce-and-recycle programs. States, communities, and trade journal articles have published reductions that range from 20 percent to over 60 percent.⁶

However, communities expecting this level of landfill tonnage reduction from variable-rate programs alone will likely be disappointed, as these estimates combine the effects from variable-rate programs along with new or expanded recycling and yard-waste programs, which were often implemented at the same time.

To provide specific research information, SERA undertook specialized studies to isolate the impacts that could be attributed to variable-rate programs alone—that is, to identify the extra recycling and landfill diversion that would result from variable-rate programs separate from additions or changes in recycling or yard-waste programs.

According to SERA's research, the key impacts communities have found from implementing variable-rate programs include reduction in disposal tonnage and an increase in recycling and yard-waste diversion as well as source reduction.

These studies found that variable-rate programs decrease residential disposal by about 17 percent in weight with 8–11 percent being diverted directly to recycling and yard programs.

SERA conducted several studies using data gathered from over 500 communities across the nation to clarify the impacts that could be attributed to variable-rate programs only.⁷ These studies found that variable-rate programs decrease residential disposal by about 17 percent in weight, with 8–11 percent being diverted directly to recycling and yard programs, and another 6 percent decreased by source-reduction efforts.⁸ The reports also found:

- 5–6 percent percentage points go to recycling (with similar increases for both curbside and drop-off programs);⁹
- 4–5 percent go to yard waste programs, if any;¹⁰
- About 6 percent is removed via source-reduction efforts, including buying in bulk, buying items with less packaging, etc.;¹¹
- The impacts from variable rates were the single most effective change that could be made to a curbside (or drop-off) program. Implementing variable rates had a larger impact on recycling than adding additional materials, changing frequency of collection, or other changes and modifications to programs;¹² and
- These results are confirmed by other work. For instance, a survey in Iowa found that recycling increased by 30 percent to 100 percent, and averaged about 50 percent.¹³ When adjusted to the percent of the total waste stream instead of considering just increases in recycling, these results are very comparable to the SERA findings. Recently completed research by SERA on California communities estimates the impact to be 3–4 percent for recycling and 3–4 percent for yard waste for a total of 6–8 percent for the programs.¹⁴ Surveys conducted by several universities and others also confirm the preliminary source reduction results, i.e. customers report taking the rate system into consideration when they are making decisions at the grocery store.¹⁵

How does variable-rate waste-disposal pricing relate to source reduction?

Source reduction is the highest priority for solid waste management, but the contributions these programs have made toward waste reduction have proved challenging to measure. SERA undertook a project to develop quantitative measures of the solid-waste tonnage diverted by source reduction from variable-rate waste-disposal programs. The project demonstrated that credible economic and statistical techniques could be used to measure source reduction. SERA used two basic techniques to estimate these impacts: comparing data from communities on program performance at one point in time (cross-section approach), and developing “causal” models to forecast tonnage with and without the program (time series approach).

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

	Community Comparison Method	Time Series Method
Total effect of variable-rate program:	16 percent	17.3 percent
Minus recycling effect for variable rates:	- 5 to 6 percent ¹⁶	- 6.9 percent
Minus yard-waste effect for variable rates:	<u>- 4 to 5 percent¹⁷</u>	<u>- 4.6 percent</u>
Equals estimated source-reduction effect attributable to variable-rate programs	5 to 7 percent from source reduction	5.8 percent from source reduction

Source: Skumatz Economic Research Associates, Inc., 2000¹⁸

The results show that there is a significant amount of source reduction currently resulting from the existing variable-rate programs in operation across the U.S. Even though only 20 percent of the population is covered by these rate-incentive programs, SERA estimates 1.3 million tons are being source-reduced from the existing variable-rate communities.¹⁹ To date, residential disposal has been reduced by 1.7 percent and residential waste-generation by 1.2 percent nationwide from just the source-reduction impacts of these existing programs (see Table 5). Adding in the recycling and yard-waste benefits from variable-rate programs significantly increases the tonnage and cost reductions from implementing variable-rate programs.

These results indicate that each town implementing variable-rate programs can expect to see reductions in tons disposed on the order of 16 percent, with one-third going to increased recycling, one-third to increased yard waste diversion, and about one-third being avoided entirely through source reduction.²⁰ SERA estimate that 5–7 percentage points of additional diversion can be realized from the source-reduction impacts of variable rate programs.

The cost savings from source-reduction are very high—they reflect the tons that communities do not have to pay to collect or dispose. Even using approximations, SERA’s computations of benefit/cost (B/C) ratios show source reduction from variable-rate programs has a B/C ratio on the order of 7.6—and that assumes the entire cost of the variable rate program is “assigned” to the source-reduction program. Ratios of greater than

one 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 eight times as large as the cost. Compared to recycling and yard-waste programs, this is a very high payback. The B/C ratio from all tonnage impacts (recycling, yard waste, and source reduction), incorporating all program costs, is still estimated between 1.2 and 2.2, depending on assumptions (see Tables 3 and 5).²¹

Table 5: Source-reduction Impacts and Cost-effectiveness of Variable-rate Programs			
	Lower Tons Disposed	Percent Reduction	Benefit / Cost Ratio
Total current variable-rate program impacts on U.S. municipal solid waste generation (MSW)—includes recycling, yard waste, and source reduction	3.5 million	1.6 percent, all MSW 3.2 percent residential	7.6
Annual source-reduction impacts of variable-rate programs nationally	1.3 million	1.2 percent MSW, 0.6 percent residential	1.2–2.2 ²²

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

Given that recycling programs alone do not encourage source reduction, the investment in a variable-rate 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.

Which types of variable-rate waste-disposal pricing are more effective at increasing recycling?

Although variable-rate waste-disposal programs in general led to higher recycling than communities without variable rates, SERA was also able to estimate differences in performance between variable-rate program types. Bag programs delivered significantly more recycling than can programs—up to 4 or more percentage points of residential recycling—than can programs. Hybrid programs were also strong performers, delivering about 4 or more percentage points of diversion than can programs. Sticker and tag programs were not common enough to provide reliable separate results for these programs.

Does variable-rate waste disposal automatically increase recycling?

The quantitative work done indicates that the impacts from variable rates are the single most effective change that could be made to a curbside (or drop-off) program. Implementing variable rates had a larger impact on recycling than adding additional materials, changing frequency of collection, or other changes and modifications to programs.²³ SERA’s research indicates that variable-rate programs increase recycling by 5–6 percent²⁴ (with similar increases for both curbside and drop-off programs) and a survey in Iowa found that recycling increased by 30 percent to 100 percent, and averaged about 50 percent.²⁵

Do higher rates or rate bands increase recycling?

Using statistical techniques, SERA estimated rate impacts. Increases of \$1 in rate differentials for 30 gallons of service increased percentages of recycling by almost 0.3 percentage points. Estimated separately, having a rate differential of \$4 or more led to a total increase of about 3 or more percentage. SERA also examined the percentage rate differential for double the service and found the following results. As the ratio of total rates for double the service increases by one tenth (e.g., 1.2 means the 60 gallon rates are 20 percent higher than those for 30 gallons, and increase to 1.3), the percent of residential recycling increases by about 0.2 percentage points. Examined separately, high levels of percentage differences—communities with second cans priced at 80 percent more than 1 can rates—leads to a total of 4.4 percentage points higher residential recycling.

How does variable-rate waste-disposal pricing reduce waste volumes at the curb?

SERA’s research finds that variable rates reduce set out garbage dramatically: from 90 gallons to 30–45 gallons in many communities that also have active recycling and yard waste programs. Some of this is accomplished through actual tonnage reductions (recall the 17 percent reduction discussed earlier), and additional decreases are due solely to deliberate compaction. Research from variable-rate program communities shows that in areas with curbside recycling and yard-waste programs, households set out between 30 and 45 gallons of garbage on a weekly basis; in rural areas this figure can be lower because some bring waste directly to transfer stations and some burn their waste. “Set-out” decreases are important because they reflect the new unit of revenue and are crucial to rate-setting.²⁶

Do variable-rate programs increase illegal dumping?

Illegal dumping is one of the first concerns of communities considering shifting to variable-rate programs. However, illegal dumping already occurs, and one issue that complicates determining whether or not it is a problem is that very few communities have quantitative information on how big a problem illegal dumping is

before they put in new rates—and since illegal dumping is almost always a concern, illegal dumping will be noticed, whether or not it actually increases over pre-variable rate levels.

Several studies have attempted to address the issue of illegal dumping. In a survey of public officials in 10 Illinois communities with variable-rate systems, respondents were asked to rank the dumping problem on a scale of 1–5 with “1” indicating the issue was not a problem. Illegal dumping along roadsides rated a 2.39, and illegal dumping into commercial and government dumpsters rated a 2.90.²⁷ A study of 14 cities²⁸ found 42 percent reporting no problems, 29 percent reporting minor problems, and another 29 percent reporting notable problems. The analysis of contributing factors found that three of four communities with problems were rural, but not all rural communities in the sample had problems. Areas without easy methods for disposing of bulky items also had more difficulties. A Reason Public Policy Institute study of eight Massachusetts communities found no problem in five, and only minimal problems in two.²⁹ One had most significant incidences of roadside dumping, but the community speculated they were actually from a neighboring community with high disposal fees.

A detailed report on illegal dumping and variable rates by SERA examined several kinds of data to identify whether illegal dumping has been found to be a problem.³⁰ Surveys showed low actual incidence of illegal dumping problems. From interviews with over 1,000 communities that implemented variable-rate programs, the report found that less than one-fourth reported actual problems with variable rates, and all said that the problems were short-term and easily dealt with through fines and education.³¹ A small percent insisted that the focus on illegal dumping actually helped them get a handle on the problem and the situation improved. All of the communities felt that fears of illegal dumping should not be a deterrent to variable-rate pricing, because a variety of effective enforcement options were available to address the problem. Follow-up interviews with haulers noted that there was some initial increase in bags alongside commercial dumpsters, but lockable dumpsters usually solve this problem.³² All communities recommended fines and visible enforcement.

The report also found that residential waste was not a large component of illegally dumped material. The surveys did not find a significant increase in illegal dumping associated with variable-rate programs. However, it was difficult to find communities that tracked dumping before *and* after implementing variable-rate programs. The most compelling information uncovered by the SERA study was an examination of the composition of illegally dumped waste: over 75 percent to 85 percent of it was non-residential in origin (i.e., commercial waste).³³ The largest components were construction, demolition, and land-clearing waste (over 25 percent), brush (almost 40 percent), and—the only important component of household origin—bulky items such as mattresses, sofas, and appliances (“white goods”).³⁴ Therefore, communities recommend implementing a convenient “bulky waste” program concurrently to increase the success of the variable-rate program and minimize the incentives for illegally dumping these awkward materials.

Prompt cleanup, bulky waste programs, lockable dumpsters, burn bans, fines, and other strategies will help reduce the incidence of illegal dumping as a result of variable-rate programs. If a community is concerned about illegal dumping, variable-can or hybrid programs—which include some base level of service for all customers, may reduce the incentives for illegal dumping. The SERA report includes a wide variety of suggestions to help reduce illegal dumping concerns.

Is variable-rate waste-disposal pricing difficult to administer?

Anecdotal evidence from SERA surveys indicates that in most cases, after initial efforts to educate customers about variable rates, the programs run themselves. However, as with most programs, there can be certain administrative challenges that need to be addressed, depending on the community and its needs. Listed below are issues that various communities have successfully faced while implementing variable rate programs.

A. Payment Strategies for Large Families and Low-income Customers

SERA conducted a specialized study on the combined impact of variable-rate programs on large and low-income families, and on low-income management strategies.³⁵ First, one must separate the issues faced by large families from those faced by low-income households. Large families may be concerned that variable-rate programs are unfair, since they will have to pay more for the increased amount of garbage they will generate. However, reversing this argument asks whether it has been fair all these years for small disposers to be subsidizing large disposers under fixed-bill, or nearly fixed-bill, systems. Although there is some relationship between family size and amount disposed, all households have opportunities to reduce, and those who limit their waste can gain control over a bill they previously could not lower.³⁶ In most communities, large households do not generally receive discounts on water, groceries, or other services that vary by family size. Therefore, disposal subsidies for large families are not well-justified.

SERA analyzed rates and policies from hundreds of communities with programs that have special rates for low-income customers. The study showed that low-income or elderly discounts are provided in less than 10 percent of communities with variable rates.³⁷ In those communities that do provide discounts, these range from 10 percent to over 60 percent. Eligibility is most commonly certified by mail, and the assistance is provided in can, bag, sticker, tag, and hybrid systems. Low-income issues can be addressed through differential rates for "qualified" households, and through distribution of free or reduced-cost stickers or bags along with other assistance programs.³⁸

B. Revenue Uncertainty

Variable-rate programs, because they depend on customer behavior choices, will inherently lead to more volatile revenue streams than systems with fixed bills. This is a common concern both for haulers and municipalities. Under variable-rate programs, revenues are not based on a stable number, such as number of households, but rather on the number of individual bags or cans of waste sold or disposed. The number of bags disposed can vary month-to-month and week-to-week, based on diversion program availability, seasonal factors, advertisements and promotions, and many other factors, and this can cause significant revenue fluctuations. However, a much greater source of concern is determining—up front, before the program gets under way—the average amount of service that will be used by customers. This is vital for initial rate-setting, and ensuring that the established rates will provide sufficient revenues to fund the waste-management system. Appropriate variable rate-setting is more complicated, but many firms have experience in this area. Uncertainties associated with this process can be significantly reduced if data are available on

current set-outs (volume of garbage and weight of waste set out for collection), remaining recycling potential in the sector, and other information.³⁹ There are differences in the relative revenue volatility associated with different variable-rate programs. Systems with less volatility include variable-can and hybrid programs, or bag/tag programs that include a customer charge.

C. Multi-family Buildings

Although variable-rate systems historically have not been available for large apartment buildings with shared garbage chutes, they are routinely implemented in garden apartments, town houses, and apartment buildings with six or fewer units. Larger multi-family buildings are already receiving a volume-based signal (although at the building and not at the tenant level) through dumpster charges, which are based on cubic yards of service. However, new hardware has become available that provides a workable variable-rate system for large multi-family buildings with combined garbage chutes. Using this hardware, tenants push a button for the type of waste they are disposing (up to six different streams). This system makes recycling and garbage disposal equally convenient, increases recycling by 30 percent–100 percent, and pays back in about three years. To date, more than 200 such systems have been installed (some new and some retrofitted), mostly in Florida and New York, and have led to a significant increase in recycling and decrease in disposal.⁴⁰ In addition, suggestions for various variable-rate incentives that encourage recycling are being tested in communities across the nation.⁴¹ These recent developments show promise for removing barriers to economic incentives for multi-family residents.

D. Customer Acceptance

To address both safety and equity concerns, all systems establish weight limits for the cans and containers. Public education about the new variable-rate program is strongly emphasized by all communities as a key to its success. Most importantly, even though there is generally resistance to and confusion about change prior to implementation, numerous surveys have indicated that these programs are perceived as fair and are very popular after they have been implemented.⁴²

In summary, technical issues are seldom the problem in implementing variable-rate pricing. Variable-rate programs have tremendous flexibility, and usually can be tailored to accommodate most concerns. Political will is usually the largest obstacle to implementing variable-rate programs.

What are the concerns and advantages of pricing by weight instead of volume?

Although the number of variable-rate program communities has been increasing dramatically, and incentives have improved considerably over fixed-fee systems, volume-based rates have several weaknesses. Many of the systems base charges on subscription rather than usage, with variable-can customers paying for a set number of cans on a weekly basis, whether or not the containers are filled. Other variable-rate programs provide no incentives below the smallest can or bag size available. Weight-based systems offer customers stronger incentives, and provide fair, informative billing. They encourage all recycling and reduction efforts,

without requiring a variety of different amounts for different materials and waste streams. Advances are promising for a number of systems, and various forms of the equipment have been pilot-tested in more than two dozen communities across the United States. Full-scale programs are in place in Australia, Denmark, Germany, and other countries.⁴³ SERA dubbed the first test of this system, which it ran in Seattle in 1989, "Garbage by the Pound."

To make weight-based pricing work, several basic components are required:

- **A Weighing Mechanism.** Scales can be retrofitted onto automated and semi-automated trucks.
- **An Identification Method.** Generally cans are labeled with radio frequency (RF) tags; although bar codes and coded route sheets have also been used.
- **Data Storage and Transfer.** On-board data storage is needed, and the data transferred to the billing computer via radio or direct download.
- **A Billing System.** Weight-based billing programs are more complicated than traditional solid-waste billing programs, but they are almost identical to those used to bill for water service.

As of 1996, three companies had weight-based equipment certified as legal for trade and charging for variable rates. These include retrofitted semi-automated tippers with and without stops in the dumping cycle, fully automated tipping arms with hoppers, and commercial dumpster weighing systems. Depending on a variety of assumptions, residential weight-based systems may have paybacks of between six months to over nine years, depending on landfill rates, and system types.⁴⁴

Pilot-test communities in the United States include Seattle; Columbia, South Carolina; Durham, North Carolina; Victoria, British Columbia, Mandham Township, New Jersey; Milwaukee, Wisconsin; Farmington and Minneapolis, Minnesota; and others. Several haulers in Florida and Ohio are working with commercial weighing systems and note that the paybacks can be very rapid. They are finding that restaurant dumpsters are relatively heavy compared to office waste. Most are not charging based strictly on the week-to-week weights, but are using "averages" for the customer to determine more appropriate rates, including more appropriate dumping fee portions. One hauler met with customers to renegotiate rates for the heavier customers. They were able to retain more than 90 percent of their customers, and significantly improved their bottom line, since they had been losing money on the "heavy-load" customers.

Weight-based pricing programs can have fairly significant impact on recycling and diversion. Based on data from the Seattle study, the decrease in average pounds set out from a pilot weight-based experiment was 15 percent (above and beyond the decrease from the volume-based system that had been in place for seven years prior to the weight-based system).⁴⁵ Customers reported their favorite features of the program were that they could pay only for what they disposed of, see clearly what they were paying for, save money on garbage bills, and pay less than those overstuffing their cans. Their concerns included possible cost increases, incorrect weighing of cans, the complexity of the program, and fears that others might cheat by using their containers. Most of these concerns are parallel to those for volume-based systems.

Weight-based pricing systems have been available for some time, and there have been numerous pilot tests, but municipalities have not implemented city-wide programs. Interviews with equipment manufacturers indicate that they have gotten a number of requests for bids for systems by cities across the nation, but none in the United States have yet purchased systems. Interest in weight-based commercial systems seems to have advanced more rapidly, and since they provide bottom-line advantages to haulers, commercial use of these

systems may lead the way. Given the significantly improved incentives, labor savings, flexibility in the systems, the move toward automation, and the programs in place overseas, weight-based systems for residential customers may not be far behind.

What type of system is right for a given community?

Each community must analyze whether variable-rate pricing makes sense for it and, if so, identify which type of program is the best fit. Each of the variable-rate systems has pros and cons that make some programs more suitable for particular communities and their priorities than others. Table 6 below provides a worksheet for evaluating the major advantages and disadvantages of the different system types. Each community can develop “weights” to determine the most important criteria, and examine which system(s) may be most worth pursuing further.

Table 6: Generic System for Selecting Between Variable-rate Program Types Based on Community Priorities⁴⁶						
CRITERIA / CHARACTERISTICS	Total Scores	Pre-assigned Relative Scores (1 = good; 4 = poor)				Community Weights (fill in)
		Can	Bag or Sticker	Hybrid (Can Plus Bag/Tag)	Garbage by the Pound	
Increase recycling/decrease disposal/signals	10	3.5	2	3.5	1	
Equity/fairness	10	3	2	4	1	
Low implementation costs/easy transition	10	3.5	1.5	1	4	
Lower long-run costs for solid-waste system	10	2	4	2.5	1.5	
Minimum disruption to operations/collection	10	3	2	1	4	
Revenue certainty/minimize volatility	10	1	3.5	2	3.5	
Flexible system/adaptable over time	10	3.5	2	1	3.5	
Customer acceptability issues/easy to explain	10	3	2	1	4	
Low incentives for illegal dumping	10	1.5	4	1.5	3	
Ongoing enforcement is low-cost/easy	10	3	4	2	1	
Track record/well-demonstrated success	10	1.5	1.5	1.5	5.5	
Easy to bill or no billing required	10	3.5	1.5	1	4	
Other (fill in)						
Other (fill in)						
Sum of scores by system type (unweighted)	120	32	30	22	36	100 percent
Weighted scores using community-specific weights (fill in)						

Source: Skumatz Economic Research Associates, Inc., 1994.

What are the implementation and administration costs of variable-rate waste-disposal pricing?

Concerns about costs are an issue for every community. It is almost impossible to provide rules of thumb about how expensive it is to implement variable-rate programs. The results hinge on the type of solid-waste management and collection system already in place in the community, and the type of program desired afterward—and every community is different. Surveys asking about the changes in overall cost from implementing variable rates were cited earlier. These studies, conducted by the states of Wisconsin and Iowa, found that for two-thirds of the communities implementing variable rates, costs stayed the same or decreased.⁴⁷ Only one-third had an increase in costs. This demonstrates that 1) these programs do not have to be expensive to implement, and 2) communities can find program types that fit well with their existing or planned solid-waste management system.

The relative costs for implementing and operating the various variable-rate systems are outlined in Table 7 below. Major areas of implementation costs for variable-rate systems include:

- **Phone/Customer Service Costs.** When a change in system occurs, customers call with questions, not only about services, but on-going billing. Some communities handle the extra phone traffic as part of normal work, or are able to absorb it by deferring other administrative work that is not time-sensitive. Some communities have been able to use staff from other municipal calling centers (such as the water department, etc.). More elaborate changes may require additional phone lines and temporary staff for a month or two. Training of staff may also be necessary.
- **Billing.** Different systems require different methods for billing. Variable-can and weight-based systems have more complex billing systems than other program types. However, billing under bag/tag/sticker systems may be simpler than current fixed-bill systems because communities and haulers no longer need to bill individuals but rather bag/tag distributors.
- **Collection Staff Training.** A few of the systems may require modifications to the way in which the waste is collected, and others (weight-based programs, for example) may require additional or new duties.
- **Service Level Selection.** Under variable-can programs, customers need to select a basic service level. This requires sending forms for customers to fill out, entering the information for each household into the billing system, and following up on customers who do not return the form. Other programs do not require these steps.
- **Service Level Enforcement.** Some programs (e.g. variable-can systems with city-provided containers) are almost “self-enforcing;” others may need more aggressive enforcement to assure that customers are not getting more service than they are paying for.
- **Trucks and Equipment.** Weight-based systems require changes to collection vehicles. However, variable-can programs can work with manual, automated, or semi-automated systems. Bag and sticker programs do not work very well with fully automated collection.
- **Containers.** Variable-can programs include the purchase of new, uniform containers. Some communities with variable-can programs allow customers to use their own containers, but specify the size limits that are allowed. Under fully automated collection, it is still somewhat difficult to find stable, small-sized containers for small disposers. Some communities are using special inserts to make larger containers smaller, but these increase costs.

- **Bag or Tag Purchases.** This includes designing, ordering, and storing bags or tags. Note that, on a smaller scale, bags or tags are needed for extra waste for several systems (including variable-can and hybrid programs).
- **Bag or Tag Distribution.** This includes finding and negotiating agreements with grocery stores or convenience stores to sell bags or tags for the program. (These outlets work better than community centers or city hall alone). Some towns have found that commissions for the sale of these items are not needed; in other communities, commissions on the order of 10 percent have been attached.
- **Illegal Dumping Enforcement.** Some of the programs (potentially bag and tag/sticker programs) lead to somewhat greater incentives to dump waste illegally. For these systems, it may be appropriate to institute higher levels of enforcement against illegal dumping than would be needed with other programs.
- **Rate Study.** Rate studies will be needed to compute appropriate rates. Variable-can programs allow more flexibility in incentive structures, and therefore, have more complexities associated with the rate-setting efforts. More information on the distribution of can sizes is needed to support a rate study for variable-can rates than for a bag program, for instance.
- **Recycling and Diversion.** Recycling and diversion programs may need additional capacity to handle the increase in tonnage. This may mean more routes and staff and trucks, it may mean greater operating hours or additional capacity at processing facilities, or it may mean more frequent collection at drop-off sites.
- **Advertising and Outreach.** Public education about the new program will incur costs, including public service announcements, newsletters, bill inserts, or other media.⁴⁸ Not one community SERA surveyed on this issue wishes they had done less outreach. (Suggestions on outreach are provided in a later section.)

Table 7: Relative Implementation Costs For Variable-rate Systems					
	Relative potential cost of the item	Hybrid system	Variable Can	Bag/Sticker	Weight-based
Phone/Customer service	Medium	Moderate to low	High	Moderate	High
Billing system	High	None	High	None	High
Service level selection/admin.	Medium	None	High	None	None
Trucks and equipment	High	None	None	None	High
Containers and distribution	High	None	High	None	High
Bag or tag purchase	Low	Medium	Low	High	None
Bag or tag distribution	Low	Medium	Low	High	
Advertising and outreach	Medium	Low -medium	Medium	Medium	Medium-high
Service level enforcement	Low	Low	Medium	Medium	Low
Illegal dumping enforcement	Low	Low	Low	Medium	Medium
Collection staff training	Low	Very little	Low	Low	Higher
Rate study	Low	Medium	Higher	Medium-low	Medium-high
Recycling and diversion programs	Medium	Medium-low	Medium	Medium	Larger impact
Other implementation comments	—	All need associated and well-known bulky-waste programs. Ordinances will need to be passed for rates, illegal dumping fines, etc.			

Source: Skumatz Economic Research Associates, 1999.

Local communities can assess the changes needed for their system, and identify the systems that are most suited for their needs. Using these same steps—analysis of key priorities (Table 6) and relative implementation burdens (Table 7)—communities may come to very different conclusions on the types of programs that will work best for them. However, there are some patterns. For example, research finds that the percentage of variable-can systems is higher in urban areas, and bag programs are more common in rural areas.⁴⁹ This may relate to the greater prevalence of automated collection (compatible with variable-can programs) in urban areas and concerns for low-cost implementation in rural areas, in combination with a variety of other community-specific factors.

What are the key elements of a variable-rate pricing waste-disposal program?

There are two key elements to a successful variable-rate waste-disposal program: 1) rates that vary and provide an incentive (e.g. rate differential and small cans), and 2) legal alternatives for materials, including recycling, reduction, and composting information and programs. The final rate levels can have a major effect on the success of the variable-rate system as well as the recycling and diversion programs. Each system type presents its own rate-setting opportunities and challenges, but there are several rate-setting issues that are common to all the systems.

The amount of revenue a solid-waste agency requires is determined locally and based on operational costs including salaries, equipment, facilities, and disposals. Traditionally, this amount of money is collected through a transfer from a community’s general fund or through billing customers a fixed rate. However, a variable-rate system provides flexibility in setting a rate that both pays the costs and acts as an incentive to reduce the amount of waste disposed of. The range of incentives that a variable rate system will provide is determined by the final rate design.

Rates accomplish two basic functions: recovering revenues, and creating incentives for customers to handle their solid waste as efficiently as possible. Because of these dual functions of solid-waste rates, it is critical the planners review their solid-waste goals and priorities during the rate-setting process. There is no best way to design rates, and choices will need to be made based on an assessment of key priorities.

The process for setting rates requires several technical steps, including population forecasting, waste-generation forecasting, cost allocation, an economic analysis of the impact of the rate on waste generation, and other steps. While some communities may have in-house expertise, others may wish to hire this expertise from outside, either through hiring a consulting service or through a technical exchange.

A. Key Steps and Policy Changes

There are three key questions crucial to setting appropriate rates.

- How much money needs to be raised to cover costs;
- How many paid garbage set outs (cans, bags, tags, etc.) are expected; and
- How should the rates be structured to provide appropriate incentives.

The easiest way to estimate the costs for the new variable-rate system is to look at current costs, and adjust for the types of changes that the variable-rate program will bring. Guidance on some of the most important new costs has been provided elsewhere.

The basic method for determining the number of bags or cans of waste is to examine current set-outs and make two key adjustments. The first is to reduce the total tonnage by the amount expected to be diverted to recycling and yard-waste programs and to source reduction. This adjustment may be something close to the 15 percent estimated in the section on impact, or maybe more if major changes are made to enhance the recycling or yard-waste programs at the same time. The second adjustment is to estimate the amount of compaction that will occur. When a new volume-based system is implemented, customers have an incentive to stomp the waste to put more into smaller (cheaper) containers. It is important to consider whether customers may look for ways to avoid the system. Based on weight limits per bag or can, this waste volume can be translated into a number of bags or cans per household per week. It is prudent to adjust the expected amount of waste downward if customers can easily bring waste to a transfer station directly, etc. (for example, in urban versus rural areas).

Optimal rates for the bag program can be computed with information already available. For example, the revised total monthly revenue requirements on a per-household basis can be divided by the average number of bags estimated to be set out per month to determine the per-bag rate.

The third major rate-setting question has to do with rate design, incentives, and acceptability. Setting appropriate rate levels requires balancing incentives against revenue security. Higher recycling incentives are provided through higher rate levels, bigger rate differentials, and smaller containers or increments in service levels. However, the costs for providing service tend to work counter to stronger incentives. The greatest cost is the fixed cost of getting the truck to residents, regardless of how many cans or bags of waste are collected. To construct greater incentives (higher differentials) requires shifting some portion of the fixed costs to higher can rates. If, however, the community is very successful in using rates to reduce disposal, it may find that it will have fewer garbage set-outs than predicted, and will experience a shortfall in revenues. Fiscally conservative rate designs would have relatively small rate differentials. The problem with low differentials is that they look very similar to flat rates, provide low incentives, and are not worth the extra administrative burden—in other words, flat rates might as well be maintained. The key to rate-setting is to balance incentives with revenue risk.

B. Rate Levels, Steepness, and Program Fees

If a community finds the calculated bag rate unacceptable, it may make adjustments by introducing smaller bags as an option or introducing a customer charge to carry some of the burden of the fixed costs of the system. Other rate policy choices include: the steepness of rates for can programs, and whether to incorporate recycling and program charges into the rates or to list them separately on the bill (“embedded” vs. “line-itemed” program fees).

1. Rate Steepness

Variable-rate waste programs provide economic signals to deter customers from using more service than needed, and reward those customers putting out less garbage. The signals come from two sources: the dollar level of the rates, and the relative rate differentials. The percentage rate differentials represent the relative “extra” fee charged for extra containers of waste. Within limits, higher differentials tend to provide greater

incentives to reduce waste and recycle—the user saves money. Higher differentials mean changing behavior and recycling more saves more money.

Relatively high rate differentials provide incentives for recycling, but they have two other very important effects:

- **Revenue Risks.** The vast majority of the costs of providing solid-waste collection and disposal service are incurred in getting the truck to the door, regardless of how much waste is collected. That is, there are high fixed costs in collecting waste, but once the truck is at the door, it is less than twice as expensive to pickup twice as many cans from a residence. However, the true cost relationship runs counter to the desire to structure significant price incentives for putting out less waste and recycling. Creating significant incentives requires shifting some of the fixed costs of waste collection to the variable portion of the charge. Higher incentives means a higher proportion of the fixed costs have been allocated to “higher can levels”— and the greater the risk that the fixed costs of garbage collection will not be collected in rate revenues. This feature, revenue risk, is one of the pressures for keeping rate differentials lower.
- **Potential Incentives for Illegal Dumping.** Higher rate differentials provide strong incentives for customers to reduce the amount of waste set out for collection—through recycling, source reduction, and, for some, illegal dumping and disposal in others’ containers.

Therefore, a balance is needed between the incentives for greater reduction and the revenue and illegal dumping risks associated with aggressive rate structures.

A survey of rates across the nation finds that variable-can rate differentials vary from just a few percent between straight can levels—10 percent, to more than twice as much for additional cans according to SERA’s research. If the differentials are 100 percent—that is, two cans cost twice as much as one can—that is called “can is a can” pricing. Under this system, prices are uniform for each can of service. High differentials provide incentives to recycle, but also increase revenue risk and incentives for illegal dumping. However, if certain thresholds in incentives—whether dollars or percentages—are not met, the switch to variable rates is probably not worth it because it will likely not modify customer disposal and recycling behavior.⁵⁰

2. Embedded vs. Line-item Program Fees

Some communities charge separately for their recycling programs, using a mandatory line-item charge, and others embed the costs of the recycling program into a combined fee for garbage.⁵¹ This is almost purely a policy choice, with arguments supporting both sides of the question. Separate fees signal to customers that recycling is not free, just cheaper than garbage collection (in many communities). It also diversifies the revenue source. Separate fees also provide a mechanism to keep garbage rates low. However, embedded fees can provide a way to increase the rate differentials and provide stronger incentives. Both strategies have advantages and disadvantages. The major impact of this policy choice is that under embedded fees, lower disposers will pay a higher total bill than they would if the recycling rates were embedded in the garbage fees. Again, either option is acceptable, and can be justified. It may be argued that low disposers are probably larger users of the recycling program and should pay more; others argue that they want higher penalties for large disposers. In that case, embedded fees help achieve that objective.

Quantitative research conducted by SERA in 1996 and updated in 1999 indicated that embedded recycling fees tended to lead to higher levels of recycling than communities with separate program fees (subscription or mandatory line items on bills).⁵² The same research indicated that embedded yard-waste fees also increased yard-waste diversion. However, the policymaker has to make a choice. Even though higher yard-waste program diversion results when no separate fees are charged, this fee structure provides no incentive for composting in the first place—the cheapest method for managing the waste. Some fees—but certainly lower than garbage fees—may make sense for integrated incentives.

How can we get variable-rate waste-disposal pricing implemented in our community?

Getting variable-rate programs approved is often harder than designing and running the actual system. City councils are sensitive to concerns about not fixing things that are not broken. One city council, for example, approved variable-rate pricing as a concept, but left it for the next council to deal with the issue of the actual rates to be charged. The most important issue is to provide information to residents, the press, and stakeholders about the purpose of the change, what the community hopes to achieve through the change, and how to make the program work for residential customers.

There are several key strategies and activities that may be useful in helping communities move in this direction.⁵³

- **Political Support.** One of the most important elements of success is gathering political support for a variable-rate program. This support usually develops from one council member or similar official (someone with a “green” reputation might be a likely candidate) who is particularly interested in the strategy, and who sets the groundwork on the issue. Periodic briefings with council members over a period of time to get them familiar with the issues—the problem that exists, how the new system will help solve it, and good or appropriate case studies of successes in other similar communities—will help. In gathering political support, it is important to work with or through a council member who will be able to bring other council members around to the idea gently. One community had an experience to be avoided. The “champion” (the mayor, in that case), read up on variable rates, felt it was the right thing to do, and even had selected the type of program. Instead of working with council members, the mayor developed all the answers with no input and was perceived as trying to shove the proposal down the throats of the others. Needless to say, this was unsuccessful. Gathering political support is important; keeping it requires making sure that the organizing department provides periodic updates on the program (and especially any problems, so that the council does not hear about them first from the press or without warning from upset citizens). Providing ready, pre-written “talking points” or responses to commonly-asked questions can be an aid to council members/politicians as well. Making sure they are not caught unprepared on questions such as illegal dumping, large families, and other topics will help ensure that a common story is told, and that these issues have been appropriately considered and addressed. Finally, many council members are made even more comfortable with these programs if the programs have been considered and endorsed by a task force made up of representatives from a wide range of interest groups (with the potential to be both pro and con).
- **Hauler Input.** Haulers should be included in the discussion the design of a variable-rate system. These programs are not unfamiliar to haulers—they have read about them, and if they do not run them currently, they are often owned by companies with other subsidiaries who do run them or have

colleagues who are familiar with them. Further, the haulers know the community and its routes best. As long as the community has the basic outline of what it is trying to accomplish, the fine points of exactly how that happens can be subject to design and revisions that would help the system work better for all involved parties. Haulers can often make very useful suggestions that accomplish the same goal and make the program work more smoothly.

- **Customer Education.** It is critical to provide information about the new variable-rate system to households. Outreach to residential customers should include:
 - 1) *The problem to be solved through the new program.* This is a very important question, and often ignored. The questions answered should include why is it an important problem, and how the new system will contribute to the solution.
 - 2) *How the program works: rate levels, where to get bags, types and sizes of containers and limits (volume and weight).* Those in the municipal collection area versus those not collected by the city need to understand that they need to buy different colored bags or tags for extra waste.
 - 3) *Information about opportunities to reduce waste—specific recycling and source reduction opportunities.* What to do with bulky waste should be clearly explained.
 - 4) *Information about and graphic examples of how making different choices about behavior can save customers money under the new program.* Customers also need to understand how some choices lead to higher payments.
 - 5) *Ordinances and fines for illegal dumping, etc.*
 - 6) *Reminders about collection days.*
 - 7) *Phone numbers for where to get more information on the program.*
- **Starter Kit.** An additional suggestion is for communities to develop a “starter kit” to increase acceptance. This might be as simple as including as a door hanger, or even as an insert in the Sunday paper, a free first tag, etc., along with a detailed description of how the system works. This helps make customers familiar with the program, and gives them actual materials with which to begin participating. In addition, it is recommended that the new system be phased in. For the first few weeks, tags should be left indicating that waste was collected, but in the future, tags will need to be acquired by customers. One city left extra waste error-tagged for one day and then returned to collect it all the next day to give citizens the idea of how the system worked.
- **Other Suggestions.** Based on interviews with communities across the nation that have implemented variable-rate programs, these additional suggestions have been helpful.⁵⁴
 - 1) Meet with editorial boards to try to get some favorable up-front coverage and endorsement;
 - 2) Do not neglect customer education—no community reports wishing they had done less outreach;
 - 3) Enlist a “champion” to help get programs accepted and also help when some things (inevitably, no matter how well-planned) go wrong;
 - 4) Make sure collectors understand the program—they are a crucial link in communication;
 - 5) Deal with opponents or bad press coverage immediately;
 - 6) Consider establishing a task force that includes representatives from a wide variety of favorable and unfavorable interest groups;
 - 7) Consider developing a catchy name for the program, as Austin, Texas, did with “Pay As You Throw,” (rather than simply “variable-can rate”).
 - 8) Use logos and other helpful items that relate to the integrated array of programs.
 - 9) Tie with available recycling and other waste-reduction opportunities; and
 - 10) Provide updates on progress in the paper and through other outreach and keep council members up-to-date with “sound bites.”

About the Author

Dr. Lisa A. Skumatz, an economist, is principal of the Colorado-based research and consulting firm Skumatz Economic Research Associates, Inc. (SERA). She is especially known for her work in variable-rate waste disposal, and her quantitative work measuring the impact of recycling, yard waste, and source-reduction programs. Much of Dr. Skumatz's recent work has focused on developing strategies and programs to revitalize recycling at the state level. SERA (www.serainc.com) specializes in the economics of solid-waste management, especially program evaluation and cost-effectiveness, rate studies, incentives, integrated planning, and modeling/forecasting. SERA has worked with community, state, and federal solid-waste agency clients across the nation, and has published numerous documents and reports on solid-waste economics. Dr. Skumatz received her undergraduate degree from the University of Wisconsin at Madison and her Ph.D. from Johns Hopkins University.

Acknowledgements

The author wishes to acknowledge significant contributions to this report by John Green of Skumatz Economic Research Associates, Inc.

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Garbage by the Pound: On the Streets, Lisa A. Skumatz, Hans Van Dusen, and Jennie Carton, Policy Study No. 184, January 1995.

Variable Rates for Municipal Solid Waste: Implementation Experience, Economics, and Legislation, Lisa A. Skumatz, Policy Study No. 160, June 1993.

Mandates or Incentives? Comparing Packaging Regulations with User Fees for Trash Collection, Lynn Scarlett, Policy Study No. 158, May 1993.

Endnotes

- ¹ Sera Inc, now located in Colorado, was previously headquartered in Seattle, Washington.
- ² Lisa A. Skumatz, and Cabell Breckinridge, *Variable Rates in Solid Waste: Handbook for Local Solid-waste Officials*, Prepared for EPA Region 10 (Seattle: Skumatz Economic Research Associates, Inc., 1990); Lisa A. Skumatz, “The State of Variable Rates: Economic Signals Move into the Mainstream,” *Resource Recycling* (updated August 1997); Lisa A. Skumatz, “Continued Growth for Variable Rates,” *Biocycle* (November 1995); Lisa A. Skumatz, and John Green, *Growth in Variable Rates: Progress and Results* (Seattle: Skumatz Economic Research Associates, Inc., 1999).
- ³ Skumatz and Green, *Growth in Variable Rates: Progress and Results*.
- ⁴ Lisa A. Skumatz, *U.S. Waste Management Survey* (Seattle: Skumatz Economic Research Associates, Inc., 1998).
- ⁵ Lisa A. Skumatz, *Model Variable Rates Legislation: Elements, Options, and Considerations in State-level Legislation in Solid Waste*, Research Report 9599-1 (Seattle: Skumatz Economic Research Associates, Inc., 1998). This report also includes recommendations on effective state-level legislation and initiatives.
- ⁶ See for example, Minnesota Office of Waste Management, Solid Waste Program Development Unit, *A Guide to Volume-based Fees for Garbage Collection* (St. Paul, MN: n.d.); Linda Good, *Borough of Perkasio, Pennsylvania, Annual Report on the Borough of Perkasio: Per-bag Disposal Fee, Waste Reduction, and Recycling Program for the Year 1988* (Perkasie, PA: Borough of Perkasio, 1989); Daniel Blume, *Under What Conditions Should Cities Adopt Volume-based Pricing for Residential Solid-waste Collection?*, Master’s Memo Study, Duke University, prepared for the Office of Management and Budget, Office of Information and Regulatory Affairs (Washington, D.C.: May 1992); U.S. Environmental Protection Agency, *Pay As You Throw Manual* (Washington, D.C., 1994); Lisa A. Skumatz, “Forecasting Solid-waste Tonnage: Techniques and Alternatives to Estimate Tonnage, Revenues, Source-reduction, and Program Performance,” Research Report 9599-1 (Seattle: Skumatz Economic Research Associates, Inc. 1995); Lisa A. Skumatz, *Variable Rates for Municipal Solid Waste: Implementation, Experience, Economics, and Legislation*, Policy Study No. 160 (Los Angeles: Reason Public Policy Institute, June 1993). The U.S. EPA attributes a 25 to 45 percent reduction in landfill tonnage from these programs.
- ⁷ Lisa A. Skumatz, *Nationwide Diversion Rate Study—Quantitative Effects of Program Choices on Recycling and Green Waste Diversion: Beyond Case Studies* (Seattle: Skumatz Economic Research Associates, Inc., 1996); and Lisa A. Skumatz, *Achieving 50 percent in California: Analysis of Recycling, Diversion, and Cost-effectiveness*, prepared for the California Chapters of Solid Waste Association of North America (SWANA) and Skumatz Economic Research Associates, Inc., (Seattle: Skumatz Economic Research Associates, Inc., 1999).
- ⁸ Lisa A. Skumatz, *Measuring Source Reduction: Variable Rates as an Example*, (Seattle: Skumatz Economic Research Associates, Inc., 1998, revised and updated May 2000); Skumatz, *Nationwide Diversion Rate Study*.
- ⁹ Ibid.
- ¹⁰ Ibid.
- ¹¹ Skumatz, *Measuring Source Reduction*.
- ¹² Skumatz, *Nationwide Diversion Rate Study*.
- ¹³ Garth W. Frable and Michael Berkshire, East Central Iowa Council of Governments and Iowa Department of Natural Resources, *Pay-As-You-Waste: State of Iowa Implementation Guide for Unit-Based Pricing* (Cedar Rapids, IA: January 1995).
- ¹⁴ Skumatz, *Achieving 50 percent in California*.
- ¹⁵ Sarah Stone and Ellen Harrison, “Residents Favor User Fees,” *Biocycle* (August 1991); and Terri Emmer, Jim Neidhart, and Christine Bennett, “An Analysis of the Effects of Volume-based Waste-disposal Fees on Consumer Behavior,” unpublished paper (Durham, New Hampshire: University of New Hampshire, 1992).
- ¹⁶ Lisa A. Skumatz, *National Diversion Rate Study*.
- ¹⁷ Ibid.
- ¹⁸ Lisa A. Skumatz, *Measuring Source Reduction*.
- ¹⁹ This makes an assumption that only half of the municipal solid waste is residential in origin.
- ²⁰ These are round figures for illustration purposes. The accurate figures were shown elsewhere in the report: 5–6 percent to recycling, 4–5 percent to yard-waste diversion, and the remaining 5–7 percent is source reduction. Source: Lisa A. Skumatz, “Nationwide Diversion Rate Study.”

- ²¹ Skumatz, *Measuring Source Reduction*. These benefit/cost ratio figures may serve as approximate inverses of the payback calculations. Two assumptions are needed: that most of the costs of the variable-rate program are first-year implementation costs, and that the economic incentive sticks—i.e. that each year users keep their generation down in response to the rates. 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 percent of their recycling goals.
- ²² Ibid. The benefit/cost 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, the ratio is 1.2; if program costs are \$2.50, the ratio is 2.2; if program costs are \$5 and landfill costs are \$50, the ratio is 1.7. The percent of municipal solid waste assumed to be residential also affects these computations.
- ²³ Lisa A. Skumatz, *Nationwide Diversion Rate Study*.
- ²⁴ Ibid.
- ²⁵ Frable and Berkshire, *Pay-As-You-Waste*.
- ²⁶ Note that decreases in set-outs don't directly reflect the changes in costs for the system. This is a complicating factor in rate-setting.
- ²⁷ Survey findings were reported in Jeanne Becker and Marilyn Browning, "Volume-based Garbage-collection Fees: An Analysis of 10 Illinois Programs," *Resource Recycling* (March 1991).
- ²⁸ Daniel Blume, *Under What Conditions Should Cities Adopt Volume-based Pricing for Residential Solid-waste Collection?*
- ²⁹ Lynn Scarlett, *Mandates or Incentives? Comparing Packaging Regulations with User Fees for Trash Collection*, Policy Study No. 158 (Los Angeles: Reason Public Policy Institute, May 1993).
- ³⁰ Lisa A. Skumatz et al., *Illegal Dumping: Incidence, Drivers, and Strategies, Research Paper 9431-1* (Seattle: Skumatz Economic Research Associates, Inc., November 1994); and Skumatz, *Variable Rates for Municipal Solid Waste*.
- ³¹ Skumatz et al., *Illegal Dumping: Incidence, Drivers, and Strategies*.
- ³² This strategy was reported as practical even in cold or icy climates.
- ³³ Skumatz et al., *Illegal Dumping: Incidence, Drivers, and Strategies*; and Skumatz, *Variable Rates for Municipal Solid Waste*.
- ³⁴ Skumatz et al., "Illegal Dumping: Incidence, Drivers, and Strategies;" and Skumatz, "Variable Rates for Municipal Solid Waste."
- ³⁵ Lisa A. Skumatz et al., "How Can Low-income Programs Work? Addressing Special Populations Under Variable-rate Systems" *Research Report* (Seattle: Skumatz Economic Research Associates, Inc., 1994).
- ³⁶ However, this is a less than linear relationship. See Lisa A. Skumatz, *Forecasting Solid Waste Tonnage: Techniques and Alternatives to Estimate Tonnage, Revenues, Source Reduction, and Program Performance*.
- ³⁷ Ibid.
- ³⁸ Ibid.
- ³⁹ Weight is recorded because compaction can affect set-outs and, therefore, computed rates as well.
- ⁴⁰ Lisa A. Skumatz and John Green, "Reaching for Recycling in Multi-family Housing," *Resource Recycling* (October 1999); and Lisa A. Skumatz and John Green, *Movin' On Up—Strategies for Increasing Multi-family Recycling*, (Seattle: Skumatz Economic Research Associates, Inc., 1999).
- ⁴¹ Ibid.
- ⁴² Examples include Sarah Stone and Ellen Harrison, "Residents Favor User Fees," *Biocycle* (August 1991). In this Cornell University survey of Tompkins County, New York, residents found 78 percent reported the systems as fair or somewhat fair. Participants in Seattle's "Garbage by the Pound" survey found the weight-based rate to be fair and appreciated knowing what they were paying for. These results are found in Lisa A. Skumatz, "Garbage by the Pound: The Potential of Weight-based Rates," *Resource Recycling*, (July, 1991); and Skumatz, Van Dusen, and Carton, *Garbage by the Pound: On the Streets*, Policy Study No. 184 (Los Angeles: Reason Foundation, January 1995).
- ⁴³ Sources for the section on weight-based rates include: Skumatz, Van Dusen, and Carton, *Garbage by the Pound: On the Streets*; Skumatz and Van Dusen, "Weight-based Faces and Uplifting Future," *World Wastes* (November 1995); and Skumatz, Van Dusen, and Carton, "Garbage by the Pound: Ready to Roll with Weight-based Rates," *Biocycle* (November 1994); and Lisa A. Skumatz, "Garbage by the Pound: The Potential of Weight-based Rates."
- ⁴⁴ Skumatz, Van Dusen, and Carton, *Garbage by the Pound: On the Streets*.

- ⁴⁵ Hans Van Dusen and Lisa A. Skumatz, *Seattle Solid-waste Utility Garbage By the Pound Pilot Project Summary*, (Seattle: Seattle Solid Waste Utility, April 1991).
- ⁴⁶ Adapted from Lisa A. Skumatz, *Considering Variable Rates: Are They a Good Fit for the Municipality of Anchorage*, (Seattle: Skumatz Economic Research Associates, Inc., 1999).
- ⁴⁷ Frable and Berkshire, *Pay-As-You-Waste* and Sherrie Gruder, *Wisconsin Volume-based Rate-collection Guide: Economic Incentives for Source Reduction and Recycling* (Madison: University of Wisconsin Extension, Solid and Hazardous Waste Education Center, November 1993, updated June 2000).
- ⁴⁸ Some communities report expenditures on the order of \$2–3 per household.
- ⁴⁹ Lisa A. Skumatz and John Green, *Growth in Variable Rates: Progress and Results* (Seattle: Skumatz Economic Research Associates, Inc., 1999).
- ⁵⁰ Preliminary work by SERA indicates these incentives may be on the order of \$5 per can per month or \$1 per bag per week; additional quantitative work is ongoing on this issue.
- ⁵¹ A very few charge separately for recycling, through a lower bag charge for recycling bags and a higher bag charge for garbage bags.
- ⁵² Skumatz, *Achieving 50 percent in California*.
- ⁵³ Skumatz, *Variable Rates for Municipal Solid Waste*.
- ⁵⁴ Ibid.



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