A Case Study on Internalized vs. Externalized Costs & Benefits for Solid Waste Management Methods: Residential Curbside Recycling in Washington State

Part 1

by
Jeffrey Morris*

April's *UnEconomist* reviewed several important studies on environmental impacts associated with managing solid wastes. A particularly thorough, as well as peer-reviewed, study by the U.S. Environmental Protection Agency (EPA), *A Decision Support Tool for Assessing the Cost and Environmental Burdens of Integrated Municipal Solid Waste management Strategies*, developed a model to estimate releases of 10 atmospheric and 17 waterborne pollutants associated with each solid waste management method.

Research Triangle Institute (RTI) managed that study for EPA. RTI employed the decision support tool (DST) developed in that project to calculate quantitative estimates for releases of these 27 pollutants associated with two specific solid waste management methods in Washington state – residential curbside recycling and residential garbage collection and disposal. Sound Resource Management (SRMG) used these estimates, along with a substantial body of additional data collected specifically for this case study, to conduct an analysis of the internalized costs versus externalized environmental benefits of curbside recycling in Washington state.[1]

Case Study Selection and Purpose

There is a common criticism that "recycling costs more than it is worth," a saying based on the fact that it too often takes more money to collect, process and transport recycled materials to market, than those markets will pay for the recycled materials once they get there. This is especially true for residential curbside recycling programs; because curbside typically dedicates a separate collection vehicle to gather up recyclables from households.

At the same time there is also a widespread belief that recycling has environmental and other societal benefits that go beyond the payoff provided by prices on recycling markets. A quantitative analysis of curbside recycling's costs and benefits, especially one that attempts to attach monetary values to environmental benefits, could shed new light on old criticisms and beliefs. That analysis could also serve as a significant first step toward a more comprehensive study on the sustainability of current solid waste management methods.

SRMG staff and participants in a working group on sustainability and solid waste management issues in Washington state, chose single-family residential curbside recycling and one of its alternatives – residential garbage collection and disposal – as specific waste management methods to compare for an investigation into the costs and benefits of curbside recycling. An important reason for this choice was that there are relatively good information sources in the state on these two methods, such that SRMG could estimate collection quantities and composition, collection system characteristics, and costs for urban and rural areas in both eastern and western

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[1] The interested reader should refer to the January and April 2001 issues of *The Monthly UnEconomist* for definition and discussion of "internalized" and "externalized" costs.

Washington. Based on this information we were able to make reasonable estimates of the impacts on garbage collection and disposal systems if curbside recycling did not exist.

Thus, the case study develops estimates of costs and benefits for curbside recycling that capture a comparison between current levels of curbside recycling versus no curbside recycling at all. This seemed to us to provide a good measure of the costs and benefits of curbside recycling. In addition, because we gathered data on curbside recycling and garbage collection and disposal for each of the four geographic-demographic regions of the state, we were able to compare costs versus benefits of curbside recycling in each of those four very different regions.

The project team also noted that widely accepted measures of sustainability have not as yet been developed in the solid waste arena. In fact, SRMG's review of other studies indicates that emissions quantities for a small number of pollutants are about the only quantitative measures potentially relating to environmental aspects of sustainability that have been rigorously studied for solid waste management methods.

Furthermore, pollutant releases themselves, and their reductions through recycling, are not the same thing as environmental impacts or benefits -- whether those impacts be on public health, climate change, habitat, biodiversity, natural capital, ecosystem health and productivity, the ability of future generations to have at least the same opportunities as current generations, or any other aspect of sustainability that might be affected by pollution. Pollutant releases also are not the only outputs of solid waste management choices that might affect sustainability.

Cognizant of this complexity, and constrained by budget and time limits, the project team chose to limit its analysis of environmental impacts and costs to those caused by the small number of pollutant releases modeled in RTI's DST. That still left the project team to navigate through three significant problems:

- Measuring pollutant releases associated with all the activities involved in curbside recycling versus garbage collection and disposal.
- Evaluating impacts on selected measures of sustainability caused by releases of each pollutant.
- Estimating a dollar cost for the selected impacts.

The project team determined that succeeding at these three tasks would itself be an important first step in developing sustainability measures for solid waste management choices in Washington state.

Case Study Context

To investigate sustainability benefits for curbside recycling, our case study focused on estimating costs of environmental impacts for a limited number of the pollutants (10 atmospheric, including 2 greenhouse gases, and 17 waterborne) released as a result of curbside garbage collection and disposal from single family households, compared with those same pollutant releases resulting from residential curbside recycling. Costs for pollutant releases used in our case study are for the most part based on estimated impacts from pollutants on human health and climate change.

Economic cost estimates for public health impacts from pollutants are available in the scientific literature. Estimated societal costs for greenhouse gas releases are also in the scientific literature. Cost estimates for other impacts of pollutant releases – for example, impacts on biodiversity or habitat or natural capital -- have as yet not been studied as extensively or rigorously. Thus, the specific sustainability indicators developed in this case study are estimated dollar costs for impacts on public health and climate change caused by releases of 27 pollutants, including the greenhouse gases carbon dioxide and methane.

It is important to understand that our analysis accounts for more than pollutant releases from collection vehicles, recyclables processing facilities, garbage transfer stations, hauling of recyclables to market, hauling of garbage to disposal facilities, and disposal facilities themselves. The case study also accounts for releases of pollutants as a result of manufacturing products using virgin raw materials, compared with manufacturing the same products using recycled materials.

Impacts from pollutant releases, as well as other environmental impacts from virgin- versus recycled-content product manufacturing are often referred to as the "upstream" impacts of waste disposal versus recycling. This terminology reflects the lifecycle view of a product from its birth in manufacturing through its disposition after use into the solid waste system. In that lifecycle view, the manufacturing stage is upstream from the use and solid waste stages.

Furthermore, the acquisition of virgin raw materials from natural ecosystems through drilling, mining, logging and other resource extraction activities also contributes to the upstream impacts of virgin-content product manufacturing. The public health and climate change impacts as a result of releases of the 27 pollutants during virgin materials acquisition activities are also included among the externalized environmental costs of garbage collection and disposal reported in this study.

Based on customary terminology, then, this report uses the term "upstream" to refer both to virgin raw materials acquisition and to manufacturing of virgin-content products. The report also uses the term "upstream" to refer to the manufacture of recycled-content products. In that case, acquisition of recycled materials for use in manufacturing occurs through the solid waste system, specifically in this case study through single-family residential curbside recycling. The environmental impacts of materials acquisition for recycled-content manufacturing are, therefore, included among solid waste system impacts reported in this case study, rather than among upstream impacts.

Limitations on Conclusions

Before looking at results from the case study, one must acknowledge the significant limitations that qualify and limit confidence in, and usefulness of, results from the case study. Specifically:

- Impacts on public health and global warming are calculated for only 10 air and 17 water pollutants.[2] By comparison EPA's annual Toxics Release Inventory currently includes information on releases for 644 toxic chemicals and chemical compounds.[3] In addition, the National Research Council has estimated that more than 70,000 chemicals are used in commerce.[4]
- Inputs and outputs of waste management methods have sustainability impacts beyond just their impacts on public health and climate change. Our case study did not address impacts from the 27 pollutants, or for that matter from any other outputs or inputs of waste management activities, on other sustainability indicators -- such as habitat, biodiversity, resource conservation or ecosystem productivity -- from energy and raw material acquisition activities, manufacturing activities or waste handling activities associated with curbside recycling and garbage collection and disposal.
- Even for just public health and climate change impacts of just the 27 pollutants, estimates of externalized costs for each pollutant are quite difficult to compute precisely. As a result, studies using differing methodologies have obtained very divergent estimates. This uncertainty regarding the economic cost of environmental impacts is reflected in this case study by listing both low- and high-end externalized cost estimates.
- Curbside recycling programs and garbage collection and disposal systems that provided information for the case study do not include all curbside programs and garbage management systems in the state. Those that did provide data were often unable to provide all the

[2] Air emissions of mercury plus air and waterborne emissions of dioxins are three important examples of pollutant emissions not included in this case study.
[3] See http://www.epa.gov/tri.
[4] National Research Council, *Environmental Neurotoxicology*, National Academy Press, 1992, p. 2.

the information requested, especially with respect to program costs and truck collection route characteristics. As a result, information on certain parameters, most importantly monetary cost, housing density and truck travel distance/time, may not be representative of all curbside programs in Washington state

It is clear from our case study that there is a large range for the estimated external costs that can be assigned to releases of each pollutant. In order to make this approach more useful for program and policy decisions, additional refinement and work with these external cost estimates needs to be performed. At the same time, it is also clear that it is possible to take reasoned estimates for external costs and benefits and combine those with the usual internalized waste management cost and benefit estimates in order to more comprehensively evaluate solid waste management choices.

The limited findings from this case study are conservative regarding environmental costs and understate the sustainability benefits of existing curbside recycling programs in Washington state. This is because the analysis focuses on environmental costs for only 27 pollutants, while at the same time reporting the lowest estimates of environmental costs for each pollutant that could be found in the literature on external costs.

Compounding the conservative focus of the case study is the fact that there has been no attempt to estimate external costs associated with all sustainability impacts from mining, drilling, logging or other types of resource extraction, such as impacts on ecological diversity or habitat preservation. On balance if these additional impacts were modeled, total external costs of garbage collection and disposal would be higher.

As an indication of what a more comprehensive analysis of environmental impacts might look like, consider the Australian study on curbside recycling discussed in the April *UnEconomist*. That Australian study tended to use estimates for external costs that are at the lower end of the range of environmental cost estimates for many pollutants, as shown in Table 3 of the April *UnEconomist*. At the same time, the Australian study included many more pollutants than the 27 modeled in our case study. That study also introduced measures of cost for other sustainability impacts, such as impacts on biodiversity and resource conservation.

As a result, the Australian study's more comprehensive analysis of external benefits reached conclusions that are similar to results in our study for high-end costs from public health and global warming impacts of the 27 pollutants. That is, for both the Australian study and the high-end external cost estimates in our case study, the external environmental benefits of curbside recycling exceed curbside recycling's internalized costs.

On this basis, one can argue that the high-end total external benefit value for curbside recycling in the following discussion is likely to be a better representation of a more comprehensive costs and benefits calculation for curbside recycling. It better reflects the conclusions that would be obtained if additional pollutants were included in the analysis, if impacts in addition to public health and climate change were considered, and if the environmental costs for all pollutants were estimated to fall near the mid-range of environmental costs shown in Table 3 of the April *UnEconomist*.[5]

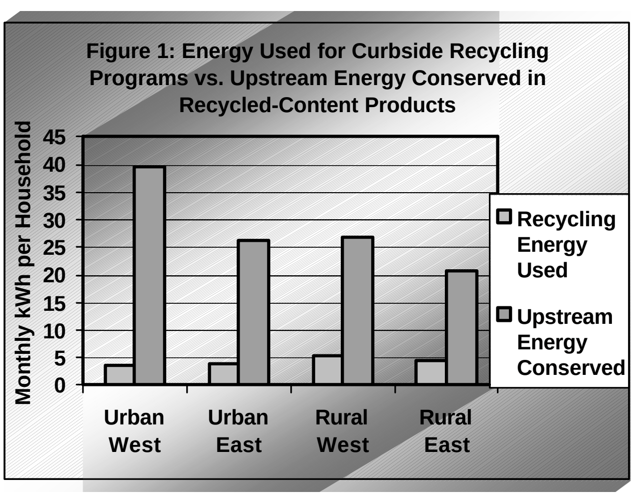
Case Study Results for Energy Use by Curbside Recycling vs. Upstream Energy Conserved by Recycling

Energy use can be a fairly accurate surrogate for the environmental impacts of a solid waste management method because higher energy use is typically associated with greater releases of pollutants and greater ecosystem impacts from acquisition of energy resources. On this basis, it is informative to compare the energy <u>*consumed*</u> by curbside recycling for collection, processing

[5] However, neither internal nor external cost estimates include costs that might be imposed on households as a result of their having to separate materials out of the garbage in order to recycle them.

and hauling of materials to market, against the energy *conserved* by manufacturing products from recycled rather than virgin materials. Recycled-content manufacturing avoids the energy consumption necessary to acquire and refine virgin raw materials for use in manufacturing products.

Figure 1, Energy Used for Curbside Recycling Programs vs. Upstream Energy Conserved in Recycled-Content Products, compares per household energy required to run the curbside recycling collection, processing and hauling system against the energy conserved by using the recovered materials in place of virgin raw materials to manufacture new products. Upstream energy conservation is directly related to the amount of material recycled by each household at which curbside collection is available. The composition of recycled materials is also important. A ton of recycled aluminum cans, for example, has much greater upstream energy conservation benefits than does, say, a ton of recycled glass containers.



As shown in Figure 2, Monthly Pounds Recycled per Curbside Available Household, on average a household in the urban west region recycled 56 pounds per month, compared with between 19 and 29 pounds in the other three regions. Composition also varied among the regions, with the urban east collecting virtually no mixed paper and the rural east collecting virtually no glass. All regions collect aluminum cans, however. Thus, as indicated by the upstream energy conservation bars on Figure 1, it is the quantity recycled that drives the energy conserved by curbside recycling.

At the same time, energy used for the curbside recycling system is relatively insensitive to the amount collected from each household. Rather, it is the length of collection routes and distance between collection stops that tends to drive energy use for curbside recycling. This is indicated on Figure 1 by the slightly higher energy usage per household in rural versus urban areas, despite the lower collection quantities per household in rural versus urban areas on each side of the state.

The most important observation about Figure 1 is that energy use for curbside recycling is a fraction of the amount of energy conserved when recycled materials replace virgin raw materials to manufacture new products. A similar result holds for most of the 27 pollutants covered by this case study – i.e., pollution resulting from curbside recycling's collection, processing and hauling activities is a fraction of the upstream pollution avoided by making products from recycled materials. This is further support for the conclusion stated in the previous section – i.e., in our case study the high-end external cost estimates for pollutant releases are more accurate indicators of the overall environmental and sustainability benefits from curbside recycling than are the low-end estimates.

Methodology for the Case Study of Curbside Recycling

The specific concept for this case study was to compare current single-family residential curbside recycling programs in Washington state against the hypothetical alternative of putting currently recycled materials back in the garbage. This methodology provides an even-handed basis for comparing environmental impacts and costs because the same quantities and composition of waste materials are being managed through each method, recycling or disposal.

To some extent this methodology also sidesteps the issue of whether the analysis should use average or marginal costs. Most data gathered for this study reflects averages, both for internalized costs and for the limited externalized costs covered by the case study. However, SRMG did determine that marginal costs should be used as avoided costs in the case of both internalized and externalized garbage collection cost reductions that are to be credited to curbside recycling. This even though it is difficult to precisely estimate what portion of garbage collection costs are saved (i.e., avoided) by managing the materials through curbside recycling rather than curbside garbage collection.

Picking up a smaller quantity of garbage may to some extent reduce route time, trips to the transfer station, fuel use, maintenance costs, and other truck usage parameters. The extent of the savings is likely to be minor or nonexistent if only a few pounds are being removed from the garbage truck. But in our case study we are considering recycling quantities that amount to as much as a quarter or more of household waste in some communities, and keeping this quantity of material out of the garbage truck must have some impact on garbage collection time and costs. So zero savings of internalized garbage costs and externalized environmental impacts is not the correct answer. Nor do costs and impacts vary 100% in relation to the weight of garbage picked up at each household, because there are substantial fixed costs involved in sending a collection truck on a route.

To resolve this dilemma SRMG assumed for purposes of this case study that 25% of environmental impacts from garbage collection vary directly with collection quantities. The DST model provided an estimate of the pollutant emissions that result from picking up just curbside recycling quantities on a garbage collection route. SRMG then used ***25% of these emission levels for each pollutant*** as our estimate of pollutant releases that are avoided by curbside recycling.

Unfortunately, due to time and budgetary constraints SRMG could not collect data on refuse collection and transfer costs for this case study. To accommodate this fact, we had to assume that recycling does not reduce the internalized costs of garbage collection and transfer at all. That is, even though curbside recycling handles as much as a quarter of household waste, we assumed that garbage collection and transfer costs would not change even if there were no curbside recycling programs.

The other important methodological concept for this case study was to categorize data and results for the state into four regions, in order to determine how conclusions might vary according to population density and other demographic and recycling program differences among various areas of the state. The regions were defined according to four geographic areas of the state

1. Urban/suburban areas west of the Cascade Mountains crest (urban west),
2. Urban/suburban areas east of the Cascade crest (urban east),
3. Rural areas west of the Cascade crest (rural west), and
4. Rural areas east of the Cascade crest (rural east).

The distribution of the state's estimated 1,575,000 one-unit housing structures as of April 2000 among the four regions is[6]:

1. 828,000 or 52.6% are in the urban west,
2. 401,000 or 25.5% are in the rural west,
3. 189,000 or 12.0% are in the urban east, and
4. 157,000 or 9.9% are in the rural east.

Finally, the case study is based on information gathered from numerous counties and cities across the state who were able to provide information within the extremely short time frame of the case study (which time frame excluded the possibility of gathering some or all of the information for many communities), from Washington Utilities and Transportation Commission

[6] State of Washington Office of Financial Management Forecasting Division, *2000 Population Trends*, September 2000, Table 7 – Housing Units by Structure Type for Cities, Towns and Counties, April 1, 1990 and April 1, 2000, pp. 28-32.

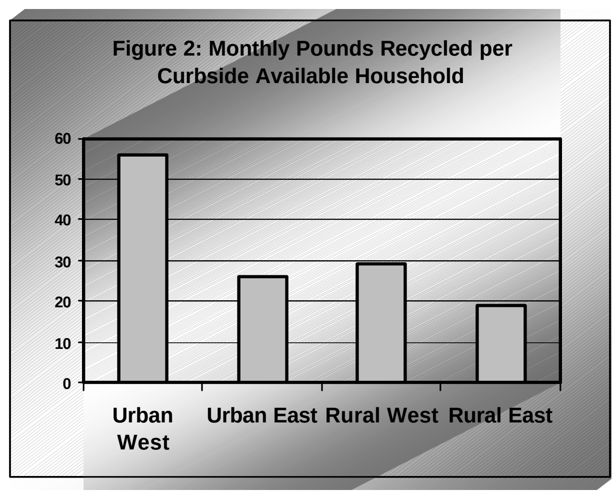
files, from research conducted by Ecology staff and SRMG staff, and from RTI staff.[7] RTI used its Municipal Solid Waste Decision Support Tool (DST) model, developed in cooperation with EPA, to calculate impacts on energy use and on emissions of 10 atmospheric and 17 waterborne pollutants as a result of recycling or disposal of materials currently recycled through Washington's curbside recycling programs. For disposal tonnage processed through Spokane's waste-to-energy (WTE) incinerator, SRMG used EPA's global warming model to add in impacts of reduced carbon sequestration for the comparison with curbside recycling.[8]

Curbside Collection Quantities and Composition in the Four Regions

Figure 2, Monthly Pounds Recycled per Curbside Available Household, shows quantities recycled per household in each region on a monthly basis for single-family households that subscribe for curbside garbage collection and have access to curbside recycling. Some of these households that have their garbage picked up by the garbage collection truck may not participate in their curbside recycling program. But the recycling truck either does pass, or could pass, in front of their house while running its regular curbside recycling collection route.

As shown on Figure 2, quantities recycled per household in the sample of curbside data collected for this study amounted to 56 pounds per month in the urban west, 29 pounds for the rural west, 26 for the urban east, and 19 per month for rural east households. Composition also varied among the regions, with the urban east collecting virtually no mixed paper and the rural east collecting virtually no glass. Otherwise, all regions collected newspapers, cardboard, aluminum cans, tin-plated steel cans, PET bottles and HDPE bottles in their residential curbside programs. The west regions also collected a little scrap metal.

Quantity and composition data for curbside recycling were obtained for collection routes in cities and unincorporated areas serving about 617,000 single-family households in the urban west and 107,000 households in the urban east. Sample coverage in rural areas was much less comprehensive, amounting to 66,500 households in the rural west and just 4,500 households in the rural east. There was insufficient budget to precisely determine whether the low coverage in rural areas was due mostly to lack of curbside recycling availability, to lack of reporting on some programs, or to a combination of both factors.



Other data collected for this study that were important for use of RTI's DST model included distance and time on collection routes between successive stops. Estimated average distances between recycling truck stops varied from 75 to 88 feet for urban areas and 155 to 1,842 feet for rural areas. Estimated average travel times between stops varied from 11 to 30 seconds in urban and 49 to 58 seconds in rural areas.

These data on travel time and distance between successive stops on collection routes are based on only a fraction of the number of households for which quantity and composition data were gathered in the urban and rural west re-

[7] Contact person for the DST at RTI is Keith A. Weitz, Center for Environmental Analysis, Research Triangle Institute, 3040 Cornwallis Road, Research Triangle Park, NC 27709; Ph: 919-541-6973; Email: kaw@rti.org

[8] US EPA, *Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste,* EPA530-R-98-013, September 1998.

gions, encompassing about 60,000 households in the urban west and 13,500 households in the rural west, or 10% and 20%, respectively, of the households in those two regions for which quantity and composition data were available. For the urban and rural east regions, coverage for these collection route parameters amounted to 60% and 75%, respectively, of households for which quantity and composition data were gathered.

Some of the Externalized Costs of Garbage Collection and Landfill Disposal

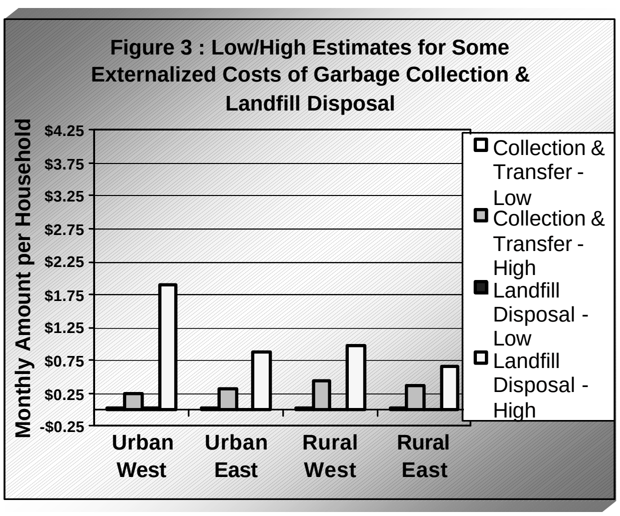


Figure 3, Low/High Estimates for Some Externalized Costs of Garbage Collection & Landfill Disposal, portrays low and high estimates for some of the externalized costs from the environmental impacts of garbage collection and transfer, as well as from landfill disposal, for each geographic/demographic region.[9] Costs in Figure 3 represent monthly amounts per household. These costs are not captured in current market pricing for garbage collection and disposal services in Washington.

SRMG calculated externalized costs for estimated emissions of the 10 air and 17 waterborne pollutants based on estimated costs to public health and the environment for each pollutant. Figure 3 portrays costs using both low- and high-end cost estimates for the public health and global warming impacts of each of the 27 pollutants. The per pound external cost estimates for each pollutant are reported and referenced in Table 3 of April's *UnEconomist*. SRMG converted costs per pound for each pollutant to household costs per month.

As shown on Figure 3, using high-end cost estimates for public health and global warming impacts, environmental costs per household for garbage collection, transfer and hauling vary somewhat among the four regions -- ranging up from $0.24 per month in the urban west to a high of $0.43 for the rural west. At low-end external cost estimates, environmental costs for garbage collection and transfer only amount to a few cents per household in all four regions.

Variation in environmental cost estimates among the regions is explained by differences in amount of material collected, as well as by differences in distance and travel time between stops on the garbage collection route. Emissions appear to be more sensitive to distance and travel time between stops than to amount collected at each stop on the garbage collection routes.

For example, under the assumption used in this case study that garbage collection is picking up only what is currently being recycled through curbside programs, the urban west garbage collection route picks up nearly twice as much per household compared with the rural west, and nearly three times as much as the rural east garbage collection route. Yet urban west externalized collection costs are lower than either rural west or rural east costs, as indicated most clearly in Figure 3 by high-end cost estimates for pollutant releases.

Figure 3 also portrays some of the estimated environmental costs of landfill disposal. RTI's DST model assumed that landfill disposal is all via Subtitle D lined landfills using gas collection systems without energy recovery. This may not be an accurate assumption for every landfill used for garbage disposal by cities and counties in

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[9] The words "some of" or "some" are often used to modify phrases and words such as "externalized costs" in this report. This is an attempt to indicate that this case study is evaluating only the costs of public health and global warming impacts from releases of only 27 pollutants.

Washington state. Furthermore, in the urban east 90% of refuse is sent to Spokane's WTE incineration facility. The comparison of recycling with WTE disposal is presented in Part 2 of this report in June's *UnEconomist*. Figure 3 portrays results for the 10% of urban east refuse that is landfilled. All waste from city and unincorporated county garbage collection routes included in our data sample for the other three regions goes to landfill.

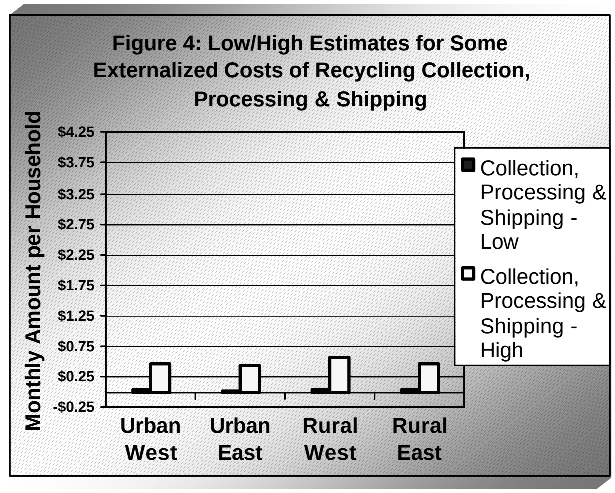
Environmental impacts of landfill disposal calculated using RTI's DST model depend directly on amounts landfilled from each household. As indicated in Figure 3, estimated high-end externalized costs of landfilling vary between a low of $0.67 per month for each household in the rural east, where the monthly disposal quantity is 19 pounds for each household, up to $1.90 in the urban west where monthly disposal is 56 pounds per household. Low-end estimated monthly costs of the environmental impacts from landfilling amount to only one or two cents for each household in each region.

Environmental impacts of landfill disposal in RTI's DST model also depend on the amount of paper and cardboard that is landfilled. A higher proportion of paper raises the per pound environmental cost of landfilling slightly.

In the urban west, urban east, and rural west, paper and cardboard account for 69% to 75% of curbside recyclables. In the rural east, by contrast, paper and cardboard account for 90% of curbside recyclables because most of the sample for that region is based on curbside programs that do not collect glass. Glass accounts for 19% to 23% of curbside recyclables in the other regions.

Some of the Externalized Costs of Recycling Collection, Processing and Hauling

Figure 4, Low/High Estimates for Some Externalized Costs of Recycling Collection, Processing and Shipping, portrays low and high estimates for some of the externalized costs from the environmental impacts of recycling collection, processing and hauling operations. Costs in Figure 4 represent monthly amounts per household. These costs are not captured in current market pricing for curbside recycling services in Washington.



Recycling has externalized environmental costs that occur from pollutants released by collection vehicles, material processing facilities, and vehicles used to haul processed materials to manufacturers of recycled-content products. Based on high-end cost estimates for public health and global warming impacts of the 10 air and 17 water pollutants, externalized costs of curbside recycling operations vary slightly among the regions from a per household low of $0.43 per month in the urban east to a high of $0.56 in the rural west. At low-end environmental costs, externalized costs for the public health and global warming impacts of recycling collection, processing and shipping operations only amount to four or five cents monthly per household.

As with garbage collection trucks, environmental costs of recycling trucks depend more on distance and travel time between stops than on amount collected at each stop. On the other hand, impacts from processing facilities and from transporting materials to market vary more directly with recycling quantities per household.

Due to budget and time constraints SRMG was unable to collect regionally specific data on average distances to actual markets for processed recyclables. Default values for shipping distances in RTI's DST model were used for all regions – 200 miles by truck for paper and cardboard, 90 truck miles for aluminum and tin cans, and 90 truck miles for glass and plastic bottles.

Thus, the regional variations shown in Figure 4 are due mostly to the variations in estimated travel time and distance between recycling collection route stops. Actual variations among the regions in shipping distances to recycling markets are not reflected in the estimates shown in Figure 4. Actual distances to markets can be significant for the economics of a specific recycling business, but average regional differences in distances to markets are less significant overall for the comparison among the four regions than on-route efficiencies and quantities set out per household.

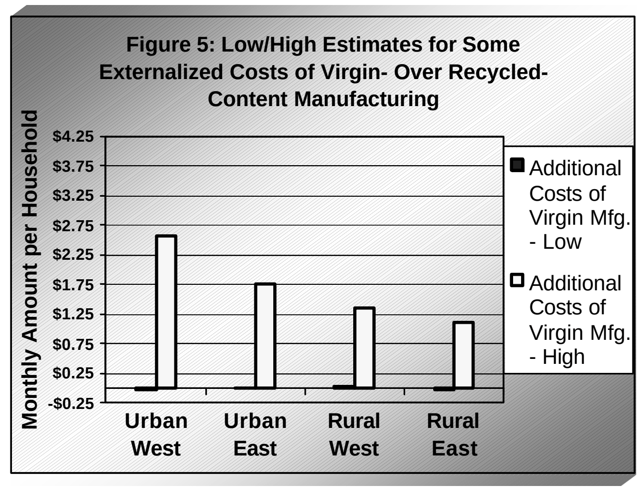
Some of the Externalized Costs of Virgin- versus Recycled-Content Manufacturing

Figure 5, Low/High Estimates for Some Externalized Costs of Virgin- over Recycled-Content Manufacturing, portrays low and high estimates for some of the externalized costs from the environmental impacts of manufacturing products with virgin raw materials instead of manufacturing those products with recycled materials. That is, Figure 5 shows externalized costs for the extra environmental impacts of making products with virgin materials.

Costs in Figure 5 represent monthly amounts per household. These costs are not captured in current market pricing for manufactured products.

Based on high-end cost estimates for public health and global warming impacts of the 10 air and 17 water pollutants, the externalized environmental costs of using virgin rather than recycled materials to make products vary among the regions from a high of $2.57 per month in the urban west to a low of $1.11 per household in the rural east. At low-end environmental costs, virgin- and recycled-content manufacturing are essentially equivalent.

The variation among the four regions in externalized upstream costs shown in Figure 5 at high-end environmental costs is mostly due to variation in pounds recycled per household. In addition, some of the variation is due to the absence of mixed paper in urban east recyclables, the lower amount of cardboard in rural west recyclables, and the absence of glass in rural east recyclables. The importance of different materials in the additional upstream costs of virgin-over recycled-content manufacturing will become clearer when estimated environmental impacts for each type of recycled material are discussed in Part 2 of this report in the *UnEconomist* for June.



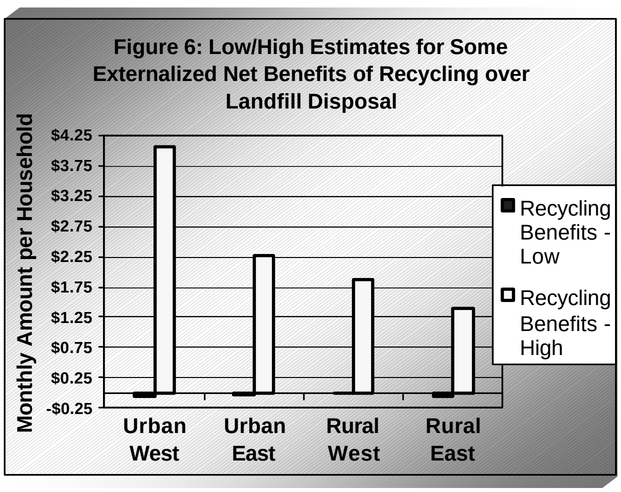
Summary of Results for Some of the Externalized Costs of Recycling versus Landfill Disposal

Figure 6, Low/High Estimates for Some Externalized Net Benefits of Recycling over Landfill Disposal, summarizes externalized cost estimates shown in Figures 3, 4 and 5 to show some of the net environmental benefits of curbside recycling over landfill disposal. Using the high-end environmental costs, curbside recycling has net externalized environmental benefits versus landfilling:

- Recycling avoids the additional externalized costs of virgin-content manufacturing (shown in Figure 5) because it substitutes recycled materials in place of virgin materials in manufacturing products;
- Recycling avoids all of the externalized costs of landfill disposal and a 25% portion of the externalized costs of garbage collection (both shown in Figure 3); and,

- Recycling incurs only the externalized costs of recycling collection, processing and shipping (shown in Figure 4).

At high-end externalized environmental costs, curbside recycling's net savings in public health and climate change impacts are worth an estimated high of $4.06 per month for each curbside available household in the urban west, down to a low of $1.40 in the rural east. Quantity recycled per household is the primary driver of curbside recycling's environmental benefits, with other variables playing a supporting or qualifying role as previously discussed.



Using the low-end environmental costs per pound of pollutant emissions, recycling actually costs a few pennies in externalized costs. This is due to curbside recycling collection and shipping operations having greater environmental costs than the 25% of environmental costs for curbside garbage collection and hauling activities that are avoided by curbside recycling in the case of low-end external costs. In the low-end case, landfill disposal has negligible environmental cost and virgin-content manufacturing is virtually equivalent to recycled-content manufacturing. Thus, in the low-end case there is little upstream or disposal avoidance benefit from recycling to offset the impacts of recycling trucks and processing operations.[10]

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Part 2 of this report compares external benefits from recycling against the internalized costs incurred to run curbside recycling operations. Part 2 also includes an external cost analysis of disposal through waste-to-energy (WTE) incineration that parallels the landfill disposal analysis covered here in Part 1. Part 2 appears in *The Monthly UnEconomist* for June 2001.

About The Monthly UnEconomist

This monthly online newsletter available at www.ZeroWaste.com (or www.SoundResource.com) intends to provide insight and analysis on the everyday economics of recycling and the unpriced or underpriced environmental benefits of reducing waste disposal and replacing virgin-content products with products manufactured from recycled materials. In addition to *The Monthly UnEconomist*, Sound Resource Management's website ZeroWaste.com also offers recycling markets price history graphs, reports on a variety of topics including the economic and environmental benefits of recycling, and GarboMetrics - elegant, yet not mysterious, tools and spreadsheet models for solid waste and recycling.

These materials are all available for no charge at www.ZeroWaste.com. User feedback is encouraged via info@ZeroWaste.com, and substantive comments will be published in our newsletter whenever they add to our understanding of recycling.

As an example of newsletter content, some issues of the *UnEconomist* analyze northwestern and northeastern U.S recycling market prices for nine recycled materials (mixed paper, ONP, OCC, glass containers, tin cans, UBC, PET bottles, HDPE natural bottles, and HDPE colored

[10] The reader is cautioned to review the Limitations on Conclusions and Case Study Results for Energy Used by Curbside Recycling vs. Upstream Energy Conserved by Recycling sections of this paper before making conclusions based on the low-end environmental costs for pollution releases.

bottles). These prices are tracked by online graphs updated quarterly.

In addition, some issues of the *UnEconomist* are devoted to GarboMetrics, economic models for managing and analyzing solid waste and recycling. These newsletter issues explain the structure and use of GarboMetric models provided at ZeroWaste.com for such purposes as designing garbage customer rate structures and correctly comparing garbage rates in different communities. GarboMetric models and corresponding issues of *The Monthly UnEconomist* can be downloaded at no charge from www.ZeroWaste.com.