United States Environmental Protection Agency

Advancing Sustainable Materials Management:

2016 Recycling Economic Information (REI) Report

October 2016

Background

> ***This report presents:***
>
> - ✓ ***An understanding of the importance of recycling's role to the nation's economy.***
> - ✓ ***A <u>new</u> methodology that addresses key areas of uncertainty in the 2001 REI study.***
> - ✓ ***A framework that can be updated with new materials and data over time.***

Sustainable Materials Management (SMM) refers to the use and reuse of materials in the most productive and sustainable way across their entire life cycle. On a broader scale, SMM looks at social, environmental and economic factors to get a more holistic view of the entire system. The benefits of maximizing this connection include conserving resources, reducing waste, slowing climate change, and minimizing the environmental impacts of the materials we use. In an era of limitless business ingenuity and limited resources, the sustainable management of natural capital is increasingly a part of the international conversation about how to achieve economic growth without compromising human health and the environment upon which that growth depends. By looking across the life cycle, businesses can maximize the use of goods, while limiting the amount of material sent to landfills. The 2016 Recycling and Economic Information Report aims to increase the understanding of the economic implications of material reuse and recycling. Additionally, the methodology provides a foundation for future work to expand the information and analysis on the economic aspects of sustainable materials management.

The 2001 National Recycling Coalition report, *U.S. Recycling Economic Information Study* laid the foundation for the methodology used to quantify the potential economic benefits of recycling, reuse and remanufacturing.[1] Since this landmark publication, significant changes have occurred regarding the scope and magnitude of recycling activities, their contributions to the national economy and the data and methodologies available to analyze economic activity attributable to recycling.

The 2001 REI study acknowledged several challenges and limitations of the REI methodology, including the inability to isolate recycling activities within multi-faceted manufacturing sectors and the issue of double-counting inherent in the methods used. Since 2001, other researchers refined the methodology to address some of these issues, but challenges remain. The 2016 REI report presents an alternative approach for measuring the economic activity associated with recycling and addresses uncertainties from the 2001 REI study.

The 2016 REI report uses a Waste Input-Output (WIO) model built on the official Input-Output (IO) tables maintained by the United States Bureau of Economic Analysis, which describe the economic transactions between industries and are used to formulate U.S. monetary and fiscal policy. Currently, the U.S. official IO table shows flows of transactions between industries, but does not distinguish between recycling operations and recyclable material flows. Recyclable material flows include products and materials which may be collected, processed and incorporated into another product for final or intermediate use. Recycling operations are the processes involved in the recycling of materials or the use of recycled materials in final or intermediate products. Separating out the recycling activities is complicated because they are either embedded in the broader activities of a manufacturing sector or aggregated within the waste management and remediation services industry. Therefore, to isolate the impact of recycling, EPA identified nine material sectors *a priori*, then developed a methodology to determine the presence of recycled content in final goods and the upstream impacts of the aforementioned recycled content.

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[1] R.W. Beck/NRC. (2001). *U.S. Recycling Economic Information Study.* Washington, DC: National Recycling Coalition (NRC).

The 2016 REI report methodology improves upon the 2001 REI study and is able to model the impact of recycling while limiting the issue of double counting. The 2016 REI report fills a gap in understanding material flows by establishing an analytical framework for estimating the broader environmental and economic impacts associated with recycling. A critical contribution of the refined methodology in the 2016 REI report is the development of a WIO model designed to capture the material inputs (production sectors like mining, energy, materials, parts and products) and outputs (waste and material separation and reprocessing, of products, services and wastes). The WIO model includes the flow of goods and the flow of wastes. The information from the WIO model is cross-walked with separate data tables of taxes, wages and jobs to assess the impact of recycling activities within the U.S. economy.

Additionally, the methodology in this report allows those with the relevant expertise to reproduce results through a transparent model. The methodology allows itself to ongoing improvement, as specific components of material flow estimation are constantly refined. An additional benefit of this improved methodology is the ability for users to explore "what if" scenarios to examine potential impacts of a modified waste flow system. The data are then provided in such a way where each sector can be identified with direct, indirect and induced impacts.

Scope and Definition of Recycling

For the purpose of this analysis, recycling is defined as the recovery of useful materials (such as paper, glass, plastic, metals, construction and demolition material) and organics from the waste stream (e.g., municipal solid waste), along with the transformation of the materials to make new products to reduce the amount of virgin raw materials needed to meet consumer demands. The most significant structural change from the 2001 REI study is the incorporation of material transformation into the definition of recycling, allowing this model to capture the process influence from refurbishing or remanufacturing of goods, providing a more realistic scope of the entire process. The 2016 REI report also considers the economic activity associated with the donation of edible food (e.g., canned goods nearing their expiration date). EPA recognizes that food donation and product reuse or remanufacturing are not "recycling" activities. However, the report uses the term "recycling" when describing the overall scope and results of the analysis.

To estimate the economic activity attributable to recycling, it is necessary to associate recyclable materials and recycling flows with the physical processes involved in transforming recyclable materials into useful products, providing reusable materials to intermediate and final consumers and delivering donated food to those in need. These processes can then be associated with specific product and service industries to estimate the direct, indirect and induced economic activity attributable to recycling, reuse and food donation.

Recycling processes and activities include a range of activities including: (i) material collection; (ii) separation, cleaning and/or other processing (e.g., baling plastic bottles); (iii) transformation of recyclable materials into marketable products; (iv) distribution, storage and service delivery (e.g., distribution of food to and from food banks); and (v) transportation between each stage. For this analysis, recycling activities are defined to include all of these activities. The scope of recycling activities in this report does not include materials that are recovered or reused during the initial production stage, but rather on materials already distributed into the economy. However, to create an efficient analytical framework while avoiding the issue of double-counting, recycling activities were further distinguished as direct or indirect:

- **Direct** recycling activities are those associated with the actual transformation of recyclable materials into marketable products such as the transformation of aluminum scrap into semi-fabricated products (e.g., ingots) in a secondary smelter. For reuse and food donation, the recycling activity is defined as the point for sale (e.g., where reused goods substitute for new goods) or the point of service (e.g., where a food pantry provides donated food to those in need).

- **Indirect** activities associated with recycling, reuse and food donation include the activities involved in the value chain of the direct processes such as the collection, sorting and transportation of aluminum scrap to the smelter or the transportation of donated food from the food bank to the local food pantry.

Table 1 summarizes the materials and types of recycling processes captured in the analysis, which formed the basis of the WIO model developed to estimate the economic impacts of these recycling activities.

Table 1. Materials Included in the Scope of Recycling for the 2016 REI Report

Material Category	Material Subcategories	Material Description	Example Recycling Processes
Ferrous metals	• Iron • Steel	Ferrous metals recovered from appliances, automobiles, steel containers, construction and other sources	Used as a feedstock in steel mills and foundries to manufacture raw steel and castings
Aluminum	No subcategories	Aluminum scrap from used beverage cans, other containers, transportation, construction and other sources	Used as a feedstock in smelting operations to manufacture semi-fabricated products (e.g., ingots, slabs)
Plastics	• PET • HDPE • LDPE	Recyclable plastics recovered for recycling	• Used in new food and nonfood packaging products • Used in new rug fibers • Used in new pipe products • Use in new composite lumber
Rubber	• Rubber crumb • Other recyclable rubber	Ground rubber produced from scrap tires used to produce rubber crumb and used in other scrap forms	• Used in new molded rubber products • Used for playground surfacing and athletic fields
Glass	No subcategories	Glass cullet recovered from glass bottles and jars	• Recovered cullet used in new glass containers • Recovered cullet used in new fiberglass
Paper	• Paper and newsprint • Paperboard	Recyclable paper and paperboard recovered and recycled	Pulp from recovered paper products used in new paper products
Construction and demolition (C&D) material	• Concrete • Asphalt pavement • Asphalt shingles • Gypsum wallboard • Wood	Recyclable materials recovered from construction and demolition waste[2]	• Recovered material used in road construction • Recovered material used in new building products
Electronics	• Computers • Computer displays • Hard copy devices	Recyclable electronics that are recovered for refurbishing, remanufacturing or resale[3]	Refurbishing, remanufacturing and resale as substitute for new equipment

[2] C&D metal waste is included in ferrous and nonferrous metals recycling analysis.

[3] For the purposes of this analysis, electronics recycling includes the recovery, refurbishing/remanufacturing, and resale of electronics devices. It does not include the processing of used electronics into commodity-grade scrap, such as ferrous metals, nonferrous metals, glass, and plastic. To avoid double-counting, commodity-grade scrap is included in estimates of recycling of the respective commodity.

Material Category	Material Subcategories	Material Description	Example Recycling Processes
	• Keyboards and mice • Televisions • Mobile devices		
Food and Organics	**<u>Donated Food</u>** • Gleaned produce • Rescued food • Salvaged food	Produce, prepared food, and salvaged food recovered from farms, wholesalers, retailers and food service facilities that otherwise would have been wasted	Delivery to people in need through community food service programs
	<u>Recyclable Organics</u> • Animal by-products • Crop residue • Dairy by-products • Deceased animal stock • Grease/Fats, Oil, Grease • Plate waste • Produce, oilseed, and grain residues • Spoiled food • Trim and other cooking waste • Yard trimmings	Recyclable by-products from food processing, spoiled food that is no longer edible, grease and other cooking waste and organic material (food waste and yard trimmings) diverted from the solid waste stream	Recovered material used in producing minimally processed animal feed, rendering and animal by-product processing, biofuels manufacturing, anaerobic digestion, compost manufacturing and landscape material application

The Waste Input-Output (WIO) Model Methodology

The WIO model developed under the 2016 REI report quantifies employment, wages and tax payment impacts attributable to recycling. Using the IO tables as the starting point, the WIO model adds information about recyclable and recycled material flows in the U.S., information about employment and local, state and federal tax revenue. Combining this information with detailed statistics regarding economic transactions enables the estimation of the economic activity attributable to recycling. The WIO model also can be used to assess or disaggregate certain sectors from the larger scope to identify economic information from individual sectors (i.e. material or industry).

The WIO model is based primarily on an approach that captures the direct and indirect production of recycling. This approach also accounts for upstream supply chain economic activity attributable to recycling processes. For example, in steel recycling this approach adds the number of employees who work in material recovery facilities that separate and provide steel scrap, employees who work for suppliers of other inputs to steel recycling (e.g., electric utilities) and employees of suppliers throughout the upstream supply chain.

Two primary types of data were collected to create the WIO model: 1) recycling process data (including data used to characterize recyclable material flows, recycling process inputs and outputs and recycled material flows) and 2) economic data to enable analysis of the impact of recycling on jobs, wages and tax revenue. These data are summarized below[4]:

- **Recyclable material production data** were collected from a wide variety of industry sources and publicly available reports. These reports were used to collect information on production volumes, recycling statistics, and the recyclable material proportions. For the recycling process

[4] Data sources can be found in the full methodology report.

inputs, mass-based and monetary-based data were gathered from life cycle inventory datasets such as ecoinvent 3 and CEDA 4 in addition to other sources.

- **Recycling material proportions** were estimated based on publicly available information describing virgin and recyclable material flows associated with each recycling process. The distribution of recyclables was modeled by identifying the major consuming sectors of recyclable materials and/or major intermediate and end-uses of recyclables and the economic sectors in which the associated recycling processes occurs.
- **Employment and wage data inputs**, reflecting total economic activity in a given sector as opposed to recycling-related subset, were collected from publicly available information sources, including the Census Bureau Statistics of U.S. Businesses (SUSB), the U.S. Agricultural Census and the U.S. Census of Governments.
- **Corporate tax data** were collected from the Internal Revenue Service (IRS) Statistics of Income (SOI) program.

These data sources were selected to ensure that the methodology leveraged existing public data and could be reproduced and updated in the future as new data become available. These data were integrated into the WIO framework by associating economic sector classifications in the original data source with the sectors used in the IO tables. Economic data were attributed to specific recycling processes using the material flow information to calculate the share of production in recycling industries that can be attributed to recyclables. For more information on the full methodology and the data collection process for the 2016 REI report please see the separate 2016 REI methodology document.

Key Findings from the 2016 REI Report

It is estimated that in 2007, recycling activities contributed 757,000 jobs (0.52% of all jobs in the U.S. economy), $36.6 billion in wages (0.62% of total wages paid), and $6.7 billion in tax revenues (0.90% of total revenues). Table 2 summarizes the economic estimates from the most recent methodology.

Table 2. 2016 REI Report Estimates of Contributions of Recycling to U.S. Economic Activity/Quantity and Value Contribution

Metric	Total	Percentage of US Economy (2007)
Jobs	757,325	0.52%
Wages	$36,636,597,000	0.62%
Tax Revenue	$6,795,244,000	0.9%

When normalized on a per 1,000-short-ton basis, the estimates indicate that 1,000 tons of recycled material attributes 1.57 jobs, $76,030 in wages and $14,101 in tax revenues. Construction and demolition provided the largest contribution to all three categories considered (job, wage and tax revenue), followed by ferrous metals, and non-ferrous metals (aluminum). The results from the analysis under the direct and indirect production of recycling approach are summarized in Figure 1.

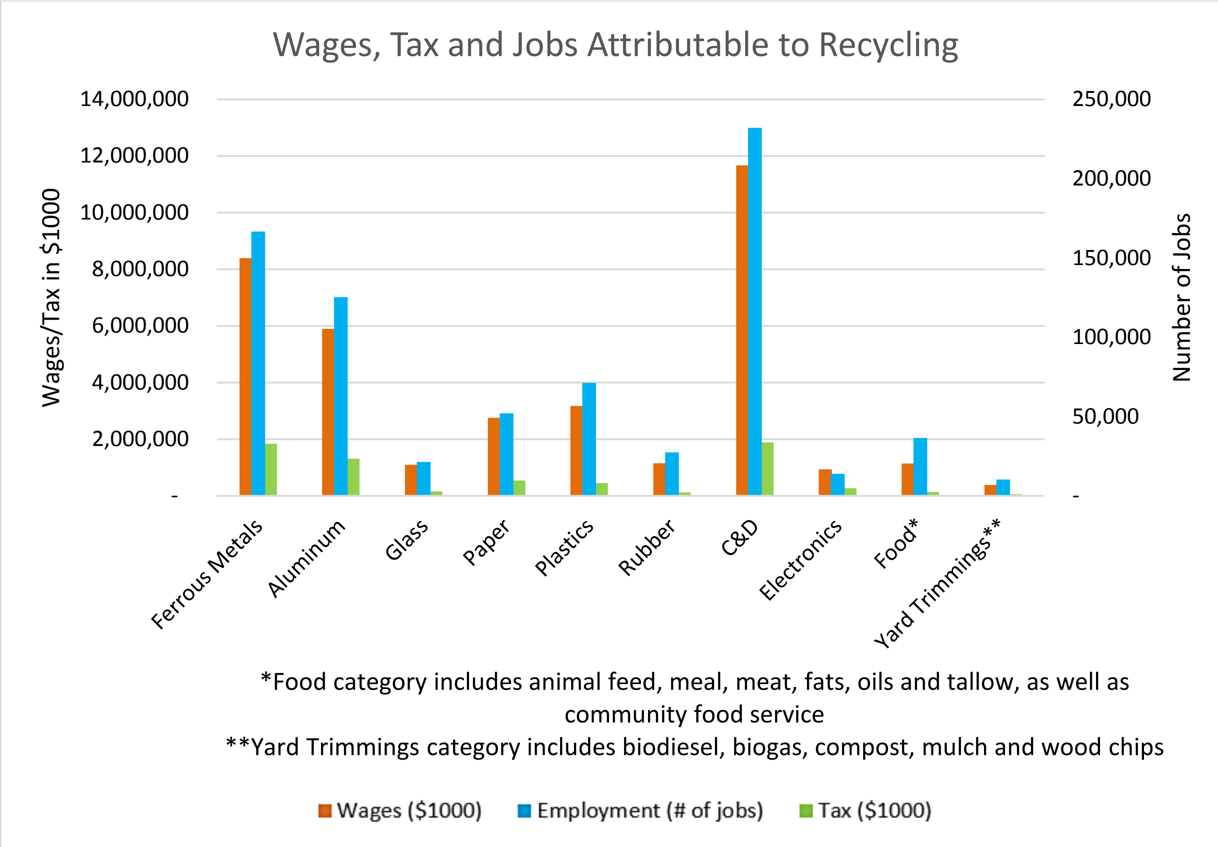

Figure 1. Wages, Tax and Jobs Attributable to Recycling

Comparison of the 2001 REI Study and the 2016 REI Report

While conceptually similar to the original 2001 national REI study, the 2016 REI report's estimates of the contributions of recycling to the U.S. economy are significantly lower than the comparable estimates by the 2001 REI study, which assessed recycling economic impact to include nearly 2.5 million jobs, $88.9 billion in wages and $6.7 billion in tax revenue. While the estimates from the 2001 REI study, based upon 1997 data, are higher than the current report, the methodology modifications significantly improve the accuracy of the estimates of economic impacts. One of the main improvements made in the 2016 REI report is the reduction of double-counting between different sectors and processes of the various recycling industries. This refinement alone is responsible for a more accurate estimate of recycling's impact on the U.S. economy. While this report can be viewed as the next edition in estimating the economic impacts of recycling, there are several fundamental differences between the 2001 REI study and the 2016 REI report, which make direct comparisons difficult and sometimes unequivocal. The most significant differences include:

- **Definition of recycling processes**—the 2001 REI study included recyclable material collection, processing and related activities (e.g., wholesaling) in the definition of recycling processes and estimates of recycling direct economic contributions. The 2016 REI report does not classify these activities as recycling processes. Rather, recyclable material collection, processing and related activities are defined as upstream supply chain processes. Using the relationships defined in the WIO model, they are included in the estimates of indirect economic activity attributable to recycling. Additionally, information regarding transformation of material for refurbishing or remanufacturing is newly captured in the current report.

- **Scoping approach**—in the 2001 REI study, industry sectors directly or indirectly engaged in recycling were identified *a priori* based on the methodology established in earlier REI studies and recommended by the Northeast Recycling Council (NERC, 1998). The 2016 REI report identifies the scope of recycling activity using a materials flow approach. Recyclable materials are selected *a priori* and industries directly engaged in recycling are identified based on government and industry information documenting the flows and destination of these materials. Industries indirectly engaged in recycling are identified using the WIO model.
- **Proportioning economic factors**—the two studies used a different approach for apportioning jobs and wages associated with processes that use a mix of recyclable and virgin material feedstocks. The 2001 REI study counted all jobs (and associated wages) engaged in processing recyclables regardless of the mix of recyclable and virgin materials in the process. The 2016 REI report apportions jobs and wages according to the mix of recyclables and the virgin materials for which recycles are used as a substitute.
- **Input-output methodology**—the 2001 REI study used a proprietary set of multiplier models created for local and regional economies using the national economic input-output tables, estimates of non-market transactions and local and regional economic data. The WIO model used in the 2016 REI report uses national IO tables with peer-reviewed primary factor input multipliers. These differences affect the magnitude of double-counting in the indirect estimates.
- **Base year and recycling trends**—the 2001 REI study used a base year of 1997 and the 2016 REI report uses a base year of 2007 to estimate economic activity attributable to recycling. Differences in absolute and relative contributions of recycling to national economic activity between 1997 and 2007 would be affected by changes in conditions such as: economic output and employment in different sectors, recyclables recovery, recyclable and recycled material markets and recycling technology.

Conclusion

The 2016 REI report illustrates that recycling provides positive economic impacts in the United States, as well as environmental and social benefits. The report also provides a more precise analysis with a new transparent, replicable methodology that benchmarks recycling activities in 2007. It affords new opportunities to measure those impacts in nine major sectors while opening the doors to assess the broader aspects of the life cycle of recycling and reuse in the U.S. economy.

Looking Forward

While the economic impacts documented in this report are pronounced, the effects of recycling reach beyond employment. This report is just the beginning of EPA's work to document the economic impacts of Sustainable Materials Management. Recycling is just one, albeit vital, component of SMM and additional work is needed to document the economic impacts of other parts of the material life cycle. Along with the social and environmental benefits of recycling, the economic impacts show a positive role of recycling within the U.S. Thus, adopting SMM practices can help improve our social surroundings, provide employment and vital wages, while conserving environmental resources.