2009

Using Material Flow Analysis for Sustainable Materials Management: Part of the Equation for Priority Setting

Frederick W. Allen
U.S. Environmental Protection Agency, allen.derry@epa.gov

Priscilla A. Halloran
U.S. Environmental Protection Agency

Angela H. Leith
U.S. Environmental Protection Agency

M. Clare Lindsay
U.S. Environmental Protection Agency

Using Material Flow Analysis for Sustainable Materials Management

Part of the Equation for Priority Setting

Frederick W. Allen, Priscilla A. Halloran, Angela H. Leith and M. Clare Lindsay

Many possible applications exist for material flow analysis (MFA). One of them is to help with sustainable materials management (SMM), a familiar concept to the readers of this journal—"an approach to serving human needs by using/reusing resources most productively and sustainably throughout their life cycles, generally minimizing the amount of materials involved and all the associated environmental impacts" (EPA 2009).

Governments and industries around the world are stepping up their efforts to manage materials sustainably. But where should governments start? How should they set priorities on what materials to address? A few hundred basic materials are transformed into many thousands of products, making priority setting critical and challenging. A recent analysis indicates that MFA can and should be part of the equation for priority setting, but only part.

MFA can offer many insights and should be an important part of priority setting for sustainable materials management. However, since it only illuminates some of the issues that concern policy makers with regard to materials management, it must be used in conjunction with other types of data.

Background

It is hard to overstate the economic and environmental significance of how people extract, use, reuse, and dispose of the full range of materials that come from and return to the Earth, such as wood, minerals, nonrenewable fuels, chemicals, agricultural plants and animals, soil, and rock. Society uses vast amounts of materials and those amounts are rapidly increasing, raising and/or potentially exacerbating a variety of critical resource and environmental issues.

In 2002, recognizing the seriousness of these issues, the U.S. Environmental Protection Agency (EPA) published a report, *Beyond RCRA: Waste and Materials Management in the Year 2020* (EPA 2002). One of the key findings was that society should shift focus away from managing waste toward managing materials. When we address waste we often miss the chance to make a difference far up the materials chain where many of the impacts of materials are initially generated. Although there will always be some waste, the best way to conserve resources and reduce the impacts of resource use is to address the entire life cycle of materials, looking to improve materials choices and anticipating resource conservation and recovery at every step.

In 2007, the EPA decided it was time to develop a roadmap describing how the EPA and the states might move more quickly toward SMM and formed a workgroup of career staff from around

DOI: 10.1111/j.1530-9290.2009.00168.x

Volume 13, Number 5

the agency and from four state environmental agencies to accomplish this task. The workgroup completed its report, *Sustainable Materials Management: The Road Ahead,* in 2009 (EPA 2009).

The report emphasized that life cycle materials management casts a far broader net than traditional government programs (usually focused on single media, such as air, water, and waste, and on single stages of the life cycle) and represents a change toward more integrated environmental protection. The recommendations detailed measures that the EPA and state agencies can take with current legal authorities, efforts needed to build capacity to manage materials in the future, and ways to accelerate the public dialogue necessary to start a generation-long shift in how we manage materials and create a green, resilient and competitive economy.

One specific recommendation was to "select a few materials and/or products where an integrated life-cycle materials management approach could possibly achieve significant benefits for the environment and reduce resource use," based on an analysis of opportunities and likely collaboration by key stakeholders, and then launch efforts to demonstrate the benefits of life cycle materials management (EPA 2009). It was in the context of these demonstration projects that the issue of priority setting and the use of MFA arose.

The Analysis

From the start the workgroup sought to focus on materials and the ramifications of their flows through the economy. In taking a systems view, it became clear that priority setting had to take into account the full life cycle of materials and products, the amounts of materials involved, the inputs of energy and water resources along the life cycle, the amounts of material waste and the associated environmental impacts all along the materials/product chain. Policy makers are very concerned with all of these aspects.

MFA clearly is useful here, but it can only be part of the equation for priority setting. MFA can illuminate the amounts of materials involved and the amounts of material waste, but it does not include all the information necessary to assess potential impacts on human health and the environment or energy and water consumption. On this point the workgroup generally agreed with the conclusions reached by several other groups (e.g., Van der Voet et al. 2004), but the workgroup then chose to proceed with its analysis somewhat differently from earlier groups.

Seeking to create a suitable analytic framework for priority setting, the workgroup reviewed several recent efforts, including one by the European Commission, the Environmental Impacts of Products (EIPRO) study (Tukker and Jansen 2006). The EIPRO study identified products used by households and government (final consumption) that potentially cause the greatest life cycle environmental impacts, considering various categories of impacts (e.g., global warming potential and several forms of human and ecological toxicity).

The primary data source for EIPRO was the Comprehensive Environmental Data Archive (CEDA), which uses U.S. Bureau of Economic Analysis (BEA) input-output tables as its baseline list of materials, products, and services and offers a high-level view of environmental impacts across the economy. The environmental impact information is obtained by connecting data on monetary flows and peer reviewed data on physical flows and environmental impacts associated with the monetary transactions—for instance, emissions of CO_2 or emissions of toxics to water. The results, based partially on MFA-type information, allow the user to compare environmental impacts of such diverse materials, products, and services as feed grains, pulp mills, textiles, metals, eating establishments, and hospitals (Suh 2005).

After looking at several options, the workgroup decided to use the latest version of CEDA (3.0) and adopted the BEA's list of 480 commodities (materials, products, and services) as its classification scheme. The new version of CEDA included 13 environmental impacts as well as energy use. It also enabled the workgroup to examine the 480 commodities from three different perspectives: "direct impact/resource use/waste," "intermediate consumption," and "final consumption." All the perspectives examine every stage of the life cycle, but they yield different results. The first perspective measures direct impacts throughout the life cycle and does not include embedded impacts. It is more likely to highlight raw materials and intermediate products at early stages in the life cycle where their uses are widely dispersed throughout the economy. The second perspective measures accumulated (direct plus embedded) impacts throughout the life cycle and provides insights into impacts that accumulate in a product, whether it is intended for intermediate or final consumption. The third perspective measures embedded impacts associated with final products only, tending to show which final products account for the greatest overall life cycle impacts.

The workgroup then merged data on material use and waste from the World Resources Institute's MFA database[1] and information on water use from the U.S. Geological Survey[2] with the CEDA data. Because these information sources used different classification schemes and levels of detail, extensive cross-walking was required. This produced 17 different categories of impacts or criteria that could be used for priority setting (13 environmental impacts, plus material use, material waste, energy use, and water use). Because each category was expressed in different units, relative statistical rankings were produced for each category and then an applied vector analysis approach was used to produce a relative ranking of the 480 commodities in each of the three perspectives.

Looking at the relative rankings of the 480 commodities and weighting each of the 17 criteria equally (as a way of getting started rather than a value judgment), 38 of the commodities ranked in the top 20 from at least one of the three perspectives. Slightly under half of the 38 ranked in the top 20 on only one or two of the three perspectives. All of the 17 criteria were important to the outcomes, with different criteria being important for different commodities. Material use and material waste, the two criteria directly supported by MFA, contributed significantly to the high rankings in each perspective for a diverse range of high-tonnage commodities. In most cases, other criteria also were significant contributors to the high rankings for these commodities. High rankings for low-tonnage commodities were indirectly supported by MFA-type information, because environmental impact criteria were based in part on data about physical flows.

The 38 highest ranking commodities can be grouped into seven broad categories: construction and development, food products and services, forestry, metals, nonrenewable organics, textiles, and a small group of miscellaneous products and services.

Because the analysis was quite innovative and complex, the workgroup submitted it for independent peer review. The reviewers agreed with the overall approach and concluded that the results were a reasonable starting point for identifying materials, products, and services as priorities for SMM demonstration projects.

Implications and Opportunities

Several important implications and opportunities can be gleaned from this analysis for the application of MFA.

1. MFA can offer many insights and should be an important part of priority setting for sustainable materials management. However, because it only illuminates some of the issues that concern policy makers with regard to materials management, it must be used in conjunction with other types of data. The analysis described here enables decision makers to choose approaches that provide a range of environmental benefits even when there is special interest in a particular goal, such as reducing global warming potential.
2. In light of the difficulties that the workgroup encountered in merging MFA data with data from other sources, application of MFA would be much easier if the architects of the various databases anticipated this process. Moreover, to enhance the application of MFA, it ought to be possible to incorporate or link into MFA additional environmental, energy, and water information.
3. To be of real use in a changing economy, MFA and other databases used in this project all need better and more current data. Too much of the data are as old as a decade.
4. The approach used in this project opens up many opportunities for further analysis of material flows and their effects, doing new runs on the existing model and

creating new models to improve our analytical abilities further.

5. This analysis also can be used as a starting point to identify needs for better (and more transparent) MFA and life cycle data and to identify products that should be priorities for multiattribute environmental performance standards and labels.

Notes

1. http:// archive.wri.org/pubs/pubs_dataset.cfm?PubID=3881
2. http://water.usgs.gov/watuse/

References

Suh, S. 2005. Developing sectoral environmental database for input-output analysis: Comprehensive environmental data archive of the U.S. *Economic Systems Research* 17(4): 449–469.

Tukker, A. and B. Jansen. 2006. Environmental impacts of products: A detailed review of studies. *Journal of Industrial Ecology* 10(3): 159–182.

EPA (U.S. Environmental Protection Agency). 2002. *Beyond RCRA: Waste and materials management in the year 2020*. Washington, DC. www.epa.gov/osw/inforesources/pubs/vision.pdf. Accessed August 20, 2009.

EPA. 2009. *Sustainable materials management: The road ahead* (report and appendix – technical support document). Washington, DC: EPA. www.epa.gov/epawaste/inforesources/pubs/vision.htm. Accessed September 2009.

Van der Voet, E., L. van Oers and I. Nikolic. 2004. Dematerialization: Not just a matter of weight. *Journal of Industrial Ecology* 8(4): 121–137.

About the Authors

Frederick W. Allen, Priscilla A. Halloran, Angela H. Leith, and **M. Clare Lindsay** are all on the staff of the U.S. Environmental Protection Agency (EPA). They were part of the workgroup described in this column. Allen also is a member of the Editorial Board of the *Journal of Industrial Ecology*. The views expressed here are their own and not necessarily those of the EPA or the U.S. Government.

Address correspondence to:
Frederick W. (Derry) Allen
Counselor, National Center for Environmental Innovation
Office of Policy, Economics and Innovation (1807T)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460
allen.derry@epa.gov
www.epa.gov