Greenhouse Gas Mitigation from Waste Materials Recycling

Extended Abstract #32

Steven B. Young, School of Environment, Enterprise and Development (SEED), University of Waterloo, Waterloo, Ontario, Canada, N2L 3C1

INTRODUCTION

Recycling of materials is one strategy to reduce GHGs. Generally, there is less energy and fewer emissions associated for recycled feedstocks compared to extraction and primary production of replacement feedstock materials. Recycling avoids processes of mining, drilling, mineral processing, smelting and refining, and the opportunities for increasing recycling are tremendous.[1] However, once real-world waste management activities like collection and transportation, and the efficiencies of recycling, are accounted for, there is a question as to how effective recycling is from a GHG perspective. Moreover, there is an interest in monetizing GHG emissions reductions into so-called “carbon credits”, which can be traded to buyers in the environmental market and help to finance greater recycling. To date, carbon credits have not been realised from recycling projects. This paper measures GHG mitigation from four recycling pilot projects, including areas that have not been previously quantified for GHGs, and discusses the barriers and opportunities for developing carbon credit projects that involve waste material recycling.

Previous studies on the GHG emissions associated with materials in the municipal waste stream have examined metals, construction materials and plastics. The US EPA published data in 1998[2] and updated it subsequently.[3] Similar data has been compiled for Canada and other regions, including developing countries like China.[4] These analyses use a life cycle assessment (LCA) approach,[5] and have supported studies on waste management options[6] and decision support tools that assess environmental impacts of waste and waste management.[7]

Carbon credits are tradable instruments that represent real, measurable and verifiable GHG emissions reductions. One form of carbon credits relates to offset projects based on activities in non-regulated sectors that remove GHG’s from or avoid emissions to the atmosphere. GHG offsets protocol methodologies are available for waste management related projects internationally under the Clean Development Mechanism (CDM) and more recently for regulated programs in Canada and the USA. One of the most popular carbon offset project types is methane collection from landfills, which has been widely implemented but does not relate directly to materials recycling. Composting protocols are more relevant as they, like recycling, divert waste from landfills towards beneficial uses; however, carbon credit for composting projects are earned from avoidance of landfill methane emissions,[8] rather than as a result of credits accrued from displacement of alternative materials.

In 2010, the Clean Development Mechanism, created under the Kyoto Protocol, approved an offset methodology for GHG emissions mitigation from recovery and recycling of polyethylene plastics from the waste streams in developing counties.[9] However, this protocol has not yet resulted in projects and credits, possibly because it is both difficult to structure and administrative costs are proportionally high for projects at such a small scale.

This study examined real-world recycling activities of four pilot cases of "enhanced recycling," a five-year (2001-2006), $3.4 million Minerals and Metals Program under the *Government of Canada Action Plan 2000 on Climate Change*. The program examined recovery systems, economic viability, environmental performance focusing on reduced GHG emissions, and social objectives of recycling. The GHG analysis was limited to the examination of the information and activity data provided by the project proponents, and used the emissions factors specified by the project sponsor. Information was not independently validated or verified on-site.

This paper extends the body of knowledge on GHG benefits arising from residential and industrial recycling by reporting on the quantification of GHGs from previously unexamined recycling activities (rural northern communities, non-container metals in curb side collection), and looks specifically at the possibility of carbon credits arising from enhanced materials recycling.

METHODS

The International Organization for Standardization ISO 14064 Part 2 standard for GHG quantification and reporting of GHG projects[10] was applied to develop Measurement and Reporting Plans (MRP), including quantification of GHG emissions reductions, for each Enhanced Recycling pilot demonstration project:

1. *Let's Climb Another Molehill*, managed by the Recycling Council of Ontario (RCO), collected and recycled reduced construction, renovation and demolition wastes at 15 sites in the Greater Toronto Area. A project report detailing activities was published. [1]

2. *Adding Residential Scrap Metal to Municipal Recycling Programs*, undertaken by the Ottawa Valley Waste Recovery Centre, collected residential non-container metal scrap added by households to the existing curbside "blue box" program using a separate vessel.

3. *Pilot Project to Demonstrate Cost-Effective Ways of Recycling Scrap Metal from Northern Communities,* with North Central Development, collection from five sites in three northern and remote communities, including transportation means to industrial recycling in the south.

4. *CFER Computer Enhanced Recycling*, Quebec CFER Network, development and optimization of a dismantling and disassembly to obtain the maximum value for the recycled material (ferrous metal, nonferrous metal, glass and plastics).

Each MRP included details on identification, selection, justification and documentation of project elements; information that establishes, justifies and documents procedures to estimate and quantify project GHG emissions, baseline GHG emissions and net GHG emission reductions. GHGs were summed across all activities ("Activity Data" x "Emissions Factor"), measured in carbon-dioxide equivalent units converted using the global warming potentials for each gas. Calculated GHG reduction potential is the difference between the baseline "business-as-usual" scenario that would have occurred in the absence of the project, and the "project" activities that were observed and monitored for each pilot. Activities variously included: collection, sorting, transportation (truck, boat, train), materials recycling (ferrous, aluminium, copper, plastics, etc.), reuse of collected materials (concrete, wood) and/or components (equipment), landfill and/or other disposal of non-recycled materials. Emissions factors were obtained from a report previously completed for the Enhanced Recycling program. [12]

RESULTS

Table 1 summarises GHG quantification results for each project expressed in metric tonnes. The values are presented as both a net reduction value and on an intensity basis in order to facilitate comparison projects.

Table 1. Summary of projects and GHG results.

	Project 1: Construction wastes	**Project 2: Residential scrap metal**	**Project 3: Northern recovery**	**Project 4: Electronics recycling**
Waste collected	222,837 t across 15 sites	19 t for 3,927 households in eight months (6.06 kg/house/year)	2,004 t at five remote sites in northern Canada	294 t obsolete computers and electronics (25,470 pieces)
Materials	Construction, renovation and demolition wastes: concrete, vinyl windows, steel, asphalt	Non-packaging metals from residence: coat hangers, pots, appliances, wire, tools, building materials, etc.	Derelict industrial and construction equipment, docks, vehicles, drums, building materials, etc.	Old computers, equipment, cathode ray tubes: plastics, glass, plastic, ferrous, nonferrous metals, other materials
Baseline activity	Landfill of construction waste	Landfill via residential stream	Dumping in open sites	Landfill and hazardous disposal
Project activity	Reuse: 213,372 t Recycle: 9,457 t	Recycling: 15 t ferrous, 4 t non-ferrous metals	Recycle: 1,964 t ferrous, 40 t non-ferrous. Transport 500-1000 km	Reuse: 72 t Recycling: ferrous 84 t, non-ferrous metals 57 t, plastics/glass 60 t
GHG reduction (t CO2e)	0.21-0.36 t per tonne recovered. Total: 222,000 t reduced	2.0 t per tonne urban scrap metal collection. Total: 38 t	1.2 t per tonne metal collected. Total: 2,000 t	15 t per tonne reused or recycled. Total: 4,600 t

DISCUSSION

Across the four pilot areas studied, the GHG benefit of recycling and reuse was very apparent, even in the Northern case where transportation was extreme. For the residential recycling of non-container metals, where transportation was piggy-backed on existing curb side pick-up, the GHG benefits were significant, at 2.0 t GHG/t material recycled. By avoiding the new production of primary materials like cement, steel and aluminium, a significant credit is apparent for reuse and recycling. This is consistent with other studies showing metal processing to be greater than collection, in the order of 5 to 19 t/t for aluminum and 0.56 to 2.4 t/t for steel.[13] Moreover, projects showed environment and social co-benefits (air, water, resources, mineral security and availability) beyond GHGs.

Carbon credits from recycling

From policy and business perspectives, the possibility of generating carbon credits from recycling projects faces a number of obstacles, including questions of additionality, magnitude, location and ownership of potential carbon credits. In the absence of carbon credits, economic viability varied. If tested, economic additionality was likely for three of the projects: Projects 1 and 3 were not continued after piloting; and Project 4 had negative profitability but continues on a fee-for-service as an environmental and youth employment initiative.[14] Project 2 on residential scrap metal project still operates five years hence and has expanded to other municipalities.

Although run at full-scale, the recycling projects pilots here were indeed small from a GHG offsets perspective: only the construction waste project showed emissions reductions in the 100,000 t range. Fewer than 10% of CDM projects are less than 10,000 t/yr with most between 25,000 and 200,000 t.[15] Of the other projects, only the electronics project has the potential to scale up beyond 10,000 t, if developed to serve large or multiple municipalities.

Ownership of GHG benefits is challenged as baselines (e.g., primary material production) are at large private facilities at sites distant to the (urban) recycling activity. Thus offset programs would need to issue credits for recycling in much the same manner as is currently done for renewable energy projects that offset grid electricity generation.

SUMMARY

Increased reuse and recycling is significantly beneficial from a net GHG perspective. MRPs consistent with ISO 14064-2 are valuable to offset project proponents, recycling program managers, and funding organizations. However, to convert GHG emissions reductions associated with recycling into carbon offsets requires protocols and programs that will overcome the relatively small size of recycling projects, and allow assignment of ownership of emissions reduced remotely to the recycling actor.

Acknowledgements

Thanks to L. Bushi, project proponents, companies, NGO managers, and Natural Resources Canada who provided data and guidance. Supported by GOC contract NRCan-05-01003.

REFERENCES

1. UNEP. *Recycling Rates of Metals – A Status Report of the Working Group of the Global Metals Flows to the International Resource Panel.* 2011.
2. US EPA. *Greenhouse Gas Emissions From Management of Selected Materials in Municipal Solid Waste.* EPA530-R-98-013. Sept. 1998.

3. US EPA. *Solid Waste Management and Greenhouse Gases A Life-Cycle Assessment of Emissions and Sinks*. 3rd Edition. Sept. 2006
4. Zhao W, Voet E van der, Zhang Y, Huppes G. Life cycle assessment of municipal solid waste management with regard to greenhouse gas emissions: case study of Tianjin, China. *The Science of the total environment*. 2009;407(5):1517-26.
5. ISO. *ISO 14044 Environmental management—Life cycle assessment— Requirements and guidelines*. Geneva: International Organisation for Standardisation; 2006.
6. Mohareb A, Warith M, Diaz R. Modelling greenhouse gas emissions for municipal solid waste management strategies in Ottawa, Ontario, Canada. *Resources, Conservation and Recycling*. 2008;52(11):1241-1251.
7. Weitz KA, Thorneloe SA, Nishtala SR, Yarkosky S. The Impact of Municipal Solid Waste Management on Greenhouse Gas Emissions in the United States. *J Air and Waste Manage Assoc*. 2002;52:1000-1011.
8. Climate Action Reserve. Current Organic Waste Composting Project Protocol. http://www.climateactionreserve.org/how/protocols/adopted/organic-waste-composting/current/ (accessed May 2011).
9. UNFCCC Clean Development Mechanism. *AMS-III.AJ.: Recovery and recycling of materials from solid wastes – Ver. 1.0*. http://cdm.unfccc.int/methodologies/ (accessed July 2011).
10. ISO. *ISO 14064 Greenhouse Gases – Part 2: Specifications with guidance at the project level for quantification, monitoring and reporting of GHG emission reductions or removal enhancement*. Geneva: International Organisation for Standardisation. 2005.
11. Recycling Council of Ontario, *Let's Climb Another Molehill*. See http://www.nrcan.gc.ca/mms-smm/busi-indu/rad-rad/pdf/f-molehill-r-eng.pdf (accessed May 2011).
12. ICF Consulting, *Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions. Final Report*, Contract No. K2216-04-0006, October 31, 2005.
13. Damgaard A, Larsen AW, Christensen TH. Recycling of metals: accounting of greenhouse gases and global warming contributions. *Waste management & research: the journal of the International Solid Wastes and Public Cleansing Association, ISWA*. 2009;27(8):773-80.
14. CFER de Bellechasse. http://www.cferbellechasse.ca/ (accessed June 2011).
15. UNEP Riso Centre. CDM/JI Analysis and Database. http://www.cdmpipeline.org/cdm-projects-type.htm (accessed July 2011).

KEY WORDS

Greenhouse gases, GHG, ISO 14064, recycling, waste, offset project, carbon credits