OWMA

ONTARIO WASTE MANAGEMENT ASSOCIATION

Greenhouse Gas Emissions and the Ontario Waste Management Industry

December, 2015

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Executive Summary

The Province of Ontario is preparing to implement a “cap-and-trade” policy for Ontario’s greenhouse gas (GHG) emissions. Ontario’s waste management industry influences Ontario’s greenhouse gas emissions in a number of ways, including direct and obvious sources of emissions like landfill gas emissions and the tailpipe emissions from its fleet of heavy trucks, but it also makes an enormous positive contribution to limiting greenhouse gas emissions. Every year, industry activities reduce current and future greenhouse gas emissions in Ontario by 22 million tonnes CO2eq, 14 Mt CO2eq more than the 8 Mt CO2eq of landfill gas emissions from the legacy waste-in-place in all Ontario landfills. Even so, landfill gas capture, recycling and organic waste diversion rates are still relatively low and will need to increase dramatically for the province to meet its emission reduction targets and make the transition to a sustainable, low carbon and circular economy.

The waste management industry is well positioned to access the substantial regulatory value that will be created by the cap on carbon, through the creation of offset protocols that facilitate growth in landfill gas capture and organics diversion, through partnerships with capped emitters who will value the carbon-free energy generated at waste management facilities, through investment in efficiency and low carbon alternatives in their own operations, and through creative partnerships with government for the direct investment of allowance auction revenue in building the foundation for the circular economy.

The development of a carbon allowance market, including offset protocols for landfill gas capture and organics diversion, will improve the economics of a number of industry options that if implemented would help the province meet its climate change mitigation goals. These include:

- Broader coverage and more efficient technology for landfill gas capture
- Increased rates of organic diversion to composting, digestion and EfW facilities
- Capture and cleaning of gases from landfills, digesters, and EfW facilities for injection in to the natural gas pipeline system

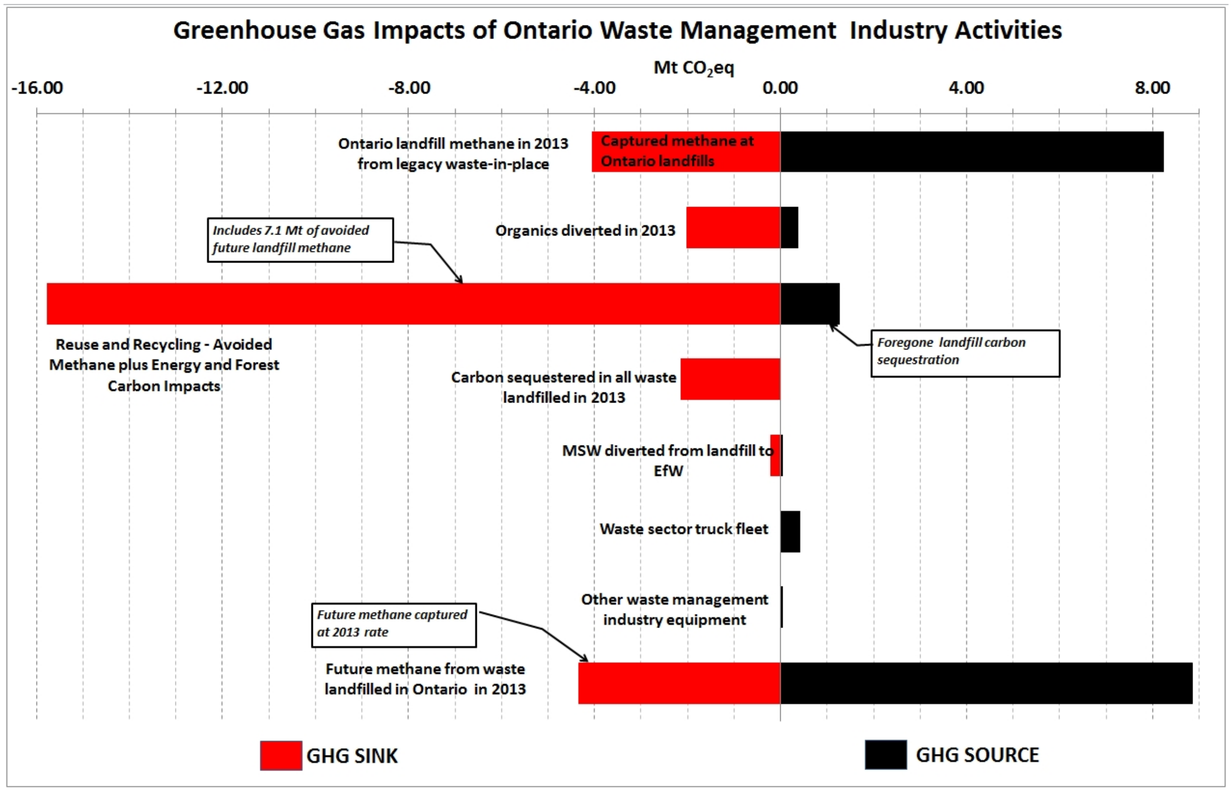

Figure ES- 1

- Increased value for direct use of gases from landfills, digesters and EfW facilities
- Increased rates of materials recycling and reuse throughout the economy.

With regard to reuse and recycling, the industry should press for the early development of offset protocols and/or other mechanisms for increasing the reuse and recycling rates of emissions-intensive materials such as paper products, plastics, glass, aluminum steel, and other metals. This is not only the option with perhaps the largest growth potential for emission reductions from the industry, but also a key to realizing the goals the province has set for a "waste free Ontario".

The industry should now work with the government to analyze the impact of the cap-and-trade program on the economics of these options, under a range of plausible allowance price scenarios, to determine how best to design the related protocols, and to identify where direct investment of regulatory income or other policy options may improve the economics or risk profiles of the emission reduction options the industry has to offer.

There is a strong complementarity between the aspirations of the waste management industry and Ontario's goals for climate change mitigation, a circular economy and sustainable economic development, a complementary which suggests successful collaboration should be achievable. The waste management industry is a major contributor to curbing greenhouse gas emissions; its annual contribution to reducing greenhouse gas emissions at least twenty times larger than the emissions from the trucks and other equipment it uses to achieve this result. Government policy, including cap-and-trade, should be designed to maintain and increase this positive impact.

Greenhouse Gas Emissions and the Ontario Waste Management Industry

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Introduction

The Province of Ontario is preparing to implement a "cap-and-trade" policy for Ontario's greenhouse gas (GHG) emissions. Ontario's waste management industry influences Ontario's greenhouse gas emissions in a number of ways, including direct and obvious sources of emissions like landfill gas emissions and the tailpipe emissions from its fleet of heavy trucks, but it also has an enormous potential to further reduce GHG emissions through recycling and reuse. The purpose of this paper is twofold: first, to summarize the most significant connections between Ontario's waste management industry and the province's greenhouse gas emissions, and second, to identify and explore the challenges and opportunities that the pending GHG cap-and-trade system presents to the industry.

Greenhouse Gas Emissions and Ontario Waste Management Industry – Part of the Solution.

Greenhouse gas emissions in Ontario totalled 170 Mt CO2eq (millions of metric tonnes equivalent of CO_2)[1] in 2013, according to the official inventory maintained by Environment Canada, as illustrated in Figure 1.[2] In this "GHG inventory perspective", emissions from the waste sector are comprised of 8.4 Mt CO2eq of landfill gas methane, or about five percent of the provincial total. The waste sector emissions are comprised almost entirely of the methane emissions from landfills, with much smaller contributions from energy from waste (EfW) facility stack emissions and waste water treatment facilities[3]. However, the GHG inventory perspective does not reveal the full significance of the waste management industry's impact on greenhouse gas emissions, and in particular how much higher emissions would be if not for what have become waste management industry routine practices, including landfill gas recovery, EfW, organics processing (composting and anaerobic digestion), reuse, and recycling. To see these impacts requires supplementing the inventory perspective with a deeper look at the waste that is generated in Ontario and how it is managed.

[1] The unit "Mt CO_2eq" refers to millions of metric tonnes (Mt) of carbon dioxide equivalent (CO_2eq). Carbon dioxide is the principal anthropogenic greenhouse gas, but methane and other greenhouse gases are more powerful agents of global warming on a tonne-for-tonne basis. To facilitate comparison and accounting, quantities of non-CO_2 greenhouse gases are expressed in terms of the equivalent amount of carbon dioxide it would take to cause the same amount of radiative forcing. For example, a tonne of methane emissions is 24 times more effective than a tonne of carbon dioxide at causing global warming, and so is expressed as 24 tonnes CO_2eq.

[2] Emissions inventory data from Environment Canada, "National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2013, Part 3", Ottawa, 2015.

[3] In this paper, waste water treatment facilities are not included as part of the Ontario waste management industry.

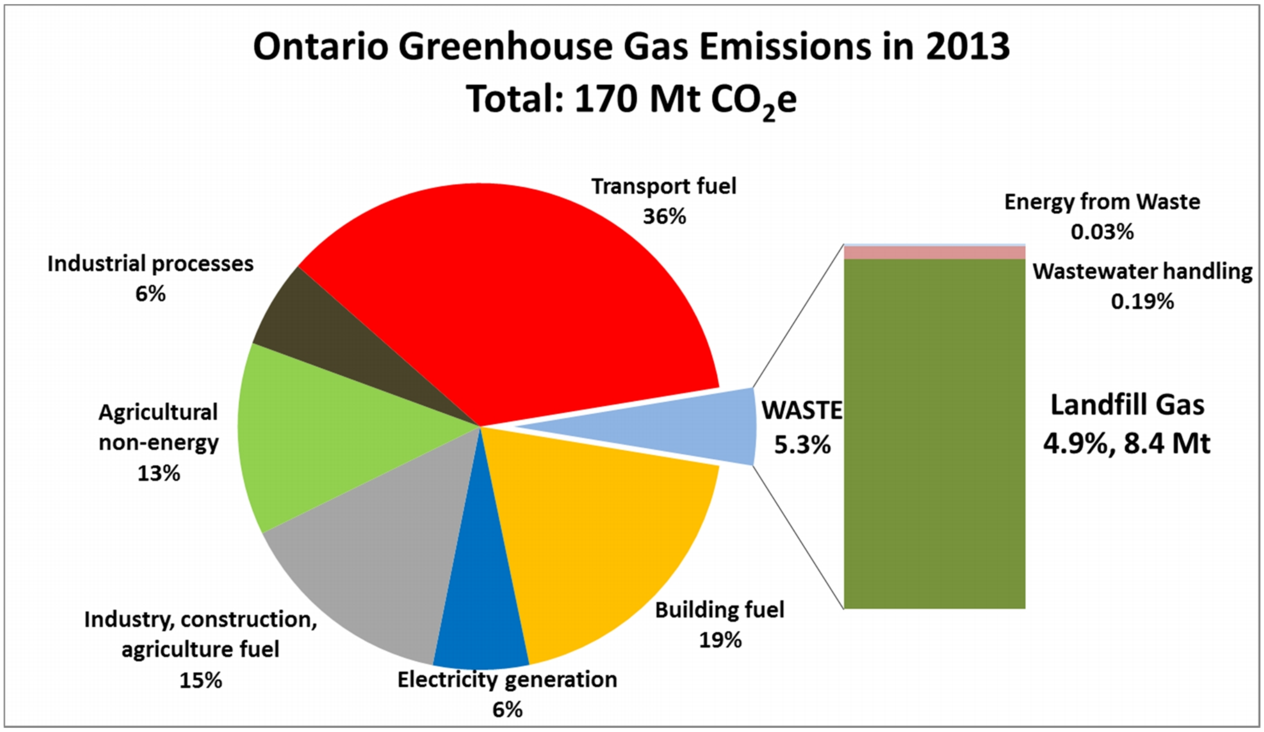

Figure 1. Sources of Greenhouse Gas Emissions in Ontario (2013)

Profile of Managed Waste in Ontario

The Ontario waste management industry is broadly defined here to include everything that happens to waste generated by Ontario households, businesses and institutions, from its collection and transport through to its final destination, whether it be landfill, EfW (energy from waste), composting, anaerobic digestion, reuse or recycling.

Statistics Canada reports that 11.8 million tonnes of waste were generated in Ontario in 2012,[4] the most recent year for which data are available. The Statistics Canada methodology does not count some significant recycling activity (business to business recycling; reuse/recycling of construction and demolition materials, and we have used OWMA and industry sources of information to add 2.1 million tonnes to the total waste analyzed in this paper, for a total of 13.9 million tonnes.[5] Additional work is currently being done to better capture the full range of waste materials.

Most of us are familiar with the household waste we put out at the curb for collection; we have a rough

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[4] Statistics Canada, CANSIM Tables 153-0043 and 153-0045. This representative year in this paper is based on the Statistics Canada 2012 data, with supplementary data from 2012 and 2013.

[5] The main components of the 2.1 million tonnes of waste in addition to the Statistics Canada total are all in the commercial and institutional sector and include cardboard recycling, (680,000 tonnes), mixed paper recycling (360,000 tonnes), food and other organic waste (310,000 tonnes), glass bottles recycled and reused (375,000 tonnes), recycled motor oil (155,000 tonnes), and tires (131,000 tonnes).

idea of its composition and that some of it ends up in the landfill, some of it is recycled, and some is diverted away from landfill to composting/digestion. All totalled, Ontario households put five million metric tonnes (Mt) of waste at the curbside while waste from industrial, commercial and institutional sources (the so-called "ICI" sector) totals eight million tonnes, and construction, renovation and demolition (CRD) waste generates another one million tonnes, not including additional sources of ICI and CRD materials, which are not included in the Statistics Canada data.

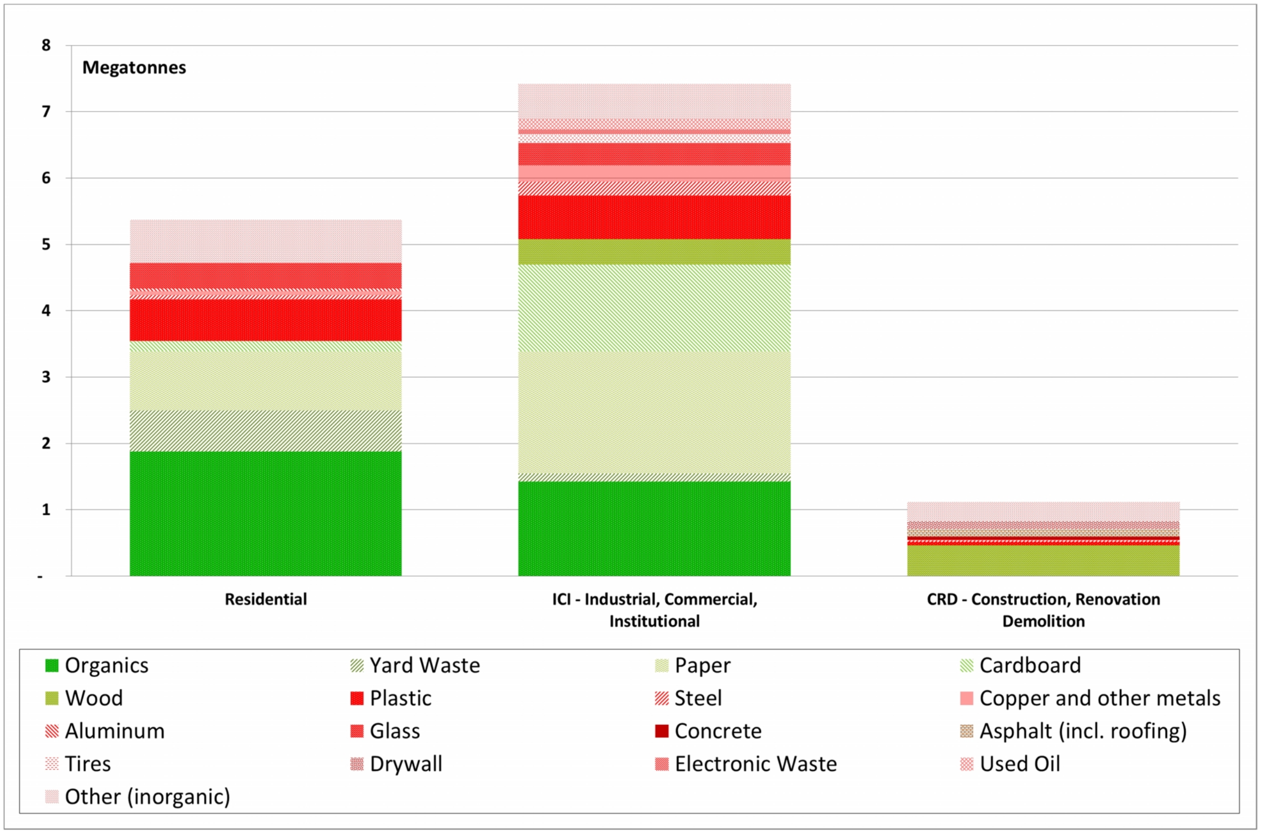

Figure 2. Waste Generation in Ontario[6]

The three different sources of waste in Ontario -- residential, ICI and CRD -- have different compositions, as illustrated in Figure 2. Organic waste (mostly food wastes, paper products, and yard waste) comprise two thirds of the total waste generated in Ontario, and plastics constitute an additional 10% of the total. Household organics (mostly food waste) are the largest component of the residential stream whereas cardboard packaging and paper products are the largest component of the waste from the ICI sector, and wood is the largest component of waste from the construction, renovation and demolition stream captured in the Statistics Canada data.

[6] The figure portrays the estimated waste generation by type for Ontario and is based on a data from Statistics Canada, Waste Diversion Ontario, and industry sources for 2012-2014.

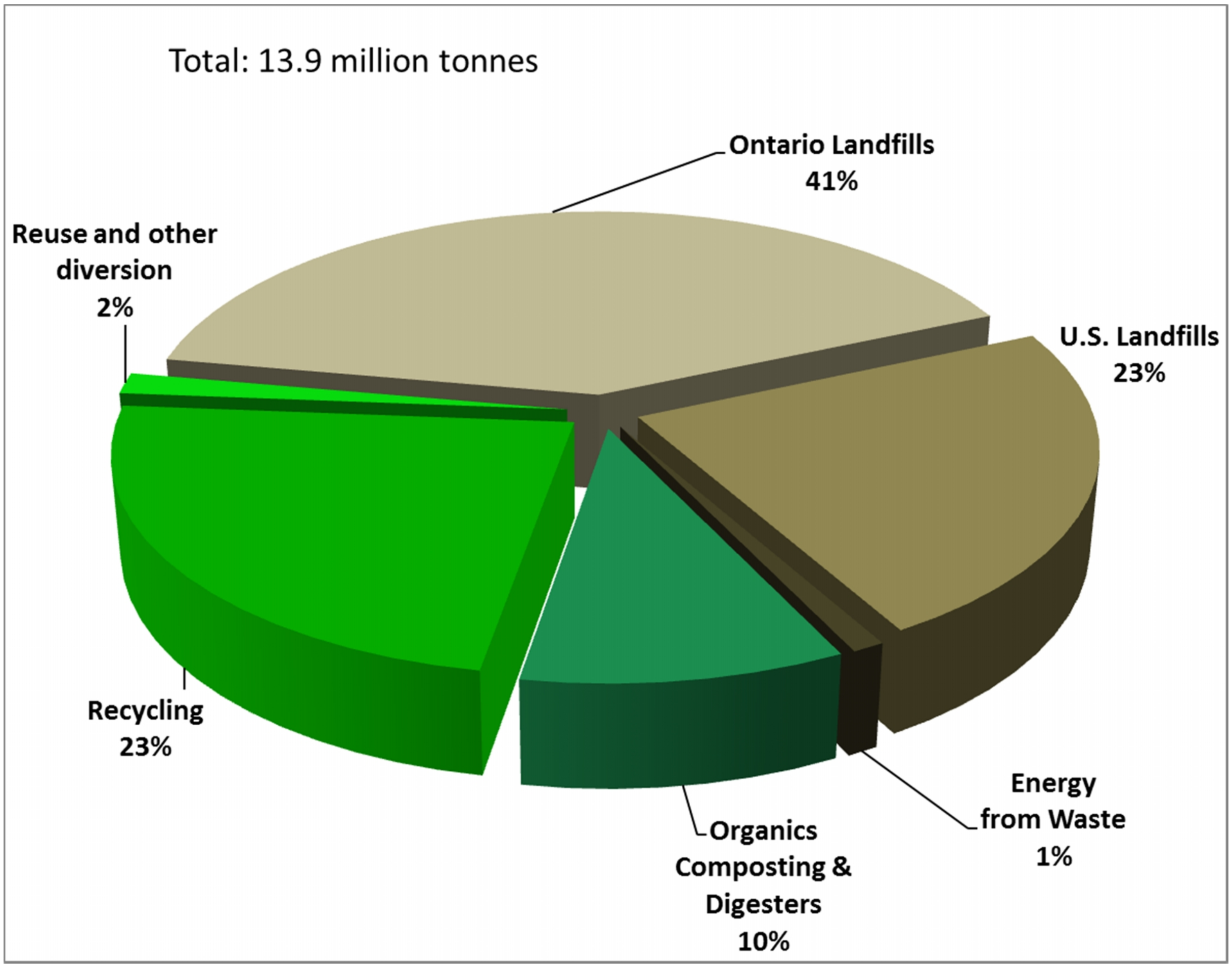

Figure 3. Management of Ontario's Waste in 2013

What happens to this mountain of waste? It is transported by a collection fleet of over 3,650 trucks to one of several final destinations, as shown in Figure 3.

- ***Ontario landfills***: About 41% of total generation is disposed in Ontario landfills. At the landfill the waste is spread, compacted and covered. This has been the dominant form of waste disposal in Ontario for decades.
- ***U.S. landfills***: About 23% of total waste generated in Ontario is currently disposed at landfills in the US, mostly to Michigan (2.3 million tonnes in 2013), with the balance going to New York State. The waste exported to New York is relatively small compared to New York State's own waste generation, but waste from Ontario comprises about 16% of all the waste landfilled in Michigan.
- ***Organics management***: About 10% of total generation is managed at organics processing facilities. Household leaf and yard wastes (LYW) are routinely collected and managed separately from other residential waste. Windrow composting is the most common management technique for leaf and yard waste. In addition, food wastes from both the residential and the commercial sector are increasingly being collected and processed at either composting or engineered anaerobic digester facilities.

- ***Recycling:*** About 23% of total generation is recycled. In addition the residential "blue box" program, the ICI sector generates large volumes of paper, cardboard and other wastes that are recycled as feedstock to paper mills, steel mills, aluminum smelters, plastics manufacturers and other industrial operations.
- ***Reuse:*** About 2% of total waste analyzed here is reused, but reuse is underrepresented in the statistics used here. Bottle deposit and return systems for refillable containers (such as beer bottles) are the largest example of reuse of residential waste stream but there a number of materials in ICI and CRD sectors that can be and are reusable to a degree, including building materials such as pallets, brick and wood.
- ***Energy from Waste (EfW)***: About one percent of total waste generation is processed at EfW facilities. EfW has not played a large role historically in the management of Ontario's waste. There is however growing interest in these types of facilities. The Independent Electricity System Operator (IESO) has recently created a Standard Offer Program for EfW facilities. As well, Ontario has recently passed a new regulation (O. Reg. 79/15) to help Ontario's energy-intensive industries reduce their reliance on coal and switch to waste derived fuels as a way to achieve greenhouse gas emissions reductions.

The Greenhouse Gas Impacts of Waste Management Activities in Ontario

Landfill Carbon Emissions and Storage

When organic waste is landfilled – food wastes, paper products, yard trimmings -- conditions are created for anaerobic decomposition, a decay process that produces a mixture of methane and carbon dioxide. The carbon dioxide portion of the gas is considered "biogenic" (see box), but the methane is a powerful greenhouse gas, with a global warming potential (GWP) 25 times that of CO_2. The methane is also flammable, and as such has been a longstanding concern for landfill owners and operators. Many landfill sites have systems for capturing the methane and either flaring it or using it for electricity generation. Burning the methane converts the carbon to biogenic carbon dioxide, thus neutralizing its greenhouse impact.

Some of the organic material placed into landfills does not break down. While not credited in the GHG inventory perspective, landfill carbon storage is a real and

Biogenic CO_2

When organic materials such as paper, food and yard wastes decay (whether in a landfill, through processing at a composting or digestion facility, or elsewhere) or when they are processed at an EFW facility, their carbon content is released as carbon dioxide but it is not counted as an anthropogenic greenhouse gas emission because it is carbon dioxide that would have eventually been released under natural conditions. The carbon in the plants and trees from which these products are made is the result of the photosynthetic capture of carbon from the atmosphere, and in the natural carbon cycle it is returned to the atmosphere when the plant dies and decays (aerobically) on the earth's surface. For this reason, the international conventions do not include biogenic carbon dioxide from waste treatment options as anthropogenic. Carbon dioxide emissions from digesters and composters are not counted, and neither are the carbon dioxide emissions associated with the organic component of EfW emissions.

significant moderating factor in determining the net greenhouse gas impact of landfills and should be considered when evaluating the greenhouse gas impacts of alternative waste management strategies.

Methane (CH_4) emissions. Once buried, organic wastes start decaying and generating methane in a matter of days, and the decay process and its emissions continue for decades. This is why, in any given year, the landfill gas methane emitted by Ontario landfills is almost all the result of waste that was generated and landfilled in years gone by. ***By 2013, the waste already deposited in Ontario's landfills, much of it organic, generated 12.3 million tonnes CO2eq of methane.***

If no more organic waste were added to Ontario's landfills, the methane emissions from the "waste-in-place" would slowly subside, dropping by 50% about every 15 years. By 2030, pre-capture emissions would be less than 6 Mt CO_2eq, and by 2050 emissions would be down to about 2 Mt CO_2eq. However, for the past ten years, landfill gas emissions have been fairly constant; there is enough fresh organic material in the material landfilled every year in Ontario (about six million tonnes per year, some of which is paper and organic waste) to offset the declining emissions from the older waste-in-place.

This dynamic is illustrated in Figure 4, based on the assumption that annual landfilling of waste in Ontario continues at 6 Mt CO_2eq from 2014 forward, about the level it has held now for over ten years. In this scenario, total landfill methane emissions (no deduction for methane capture) are fairly constant at around 12-13 Mt CO2eq, with the emissions due to waste landfilled after 2013 growing gradually until by 2030 they constitute just over half of total emissions.

If total waste landfilled in Ontario increases or decreases in the years ahead, or if the carbon content of the waste that is landfilled increases or decreases, then the methane generated from waste landfilled in the post-2013 period will be more or less than what is portrayed in Figure 4, but over a wide range of plausible assumptions, it remains the case that most of the methane generated at Ontario landfills for the next fifteen years will be from the waste that is already landfilled.

Landfill gas capture

In 2013, 4 million tonnes CO_2eq of methane gas was captured and either flared or burned to generate power or provide industrial process heat. Gross emissions of methane from Ontario landfills in 2013 totalled 12.3 Mt CO_2eq, as illustrated in Figure 4, but landfill gas capture reduced the net emissions to 8.4 Mt CO_2eq.[7]

[7] Environment Canada, "National Inventory Report: Greenhouse Gas Sources and Sinks in Canada 1990-2013, Part 3", Ottawa, 2015. Environment Canada estimates total methane generated from waste-in-place using the Scholl Canyon model, a first order exponential decay model sensitive to inputs specifying the organic component of the waste in the landfill and the rate of decay, determined by the composition of the waste and the moisture content and other characteristics of the landfill. The input coefficients characterizing both the decay time constant and the methagenic potential of the waste are under review and may be revised in 2016 pending the results of that review.

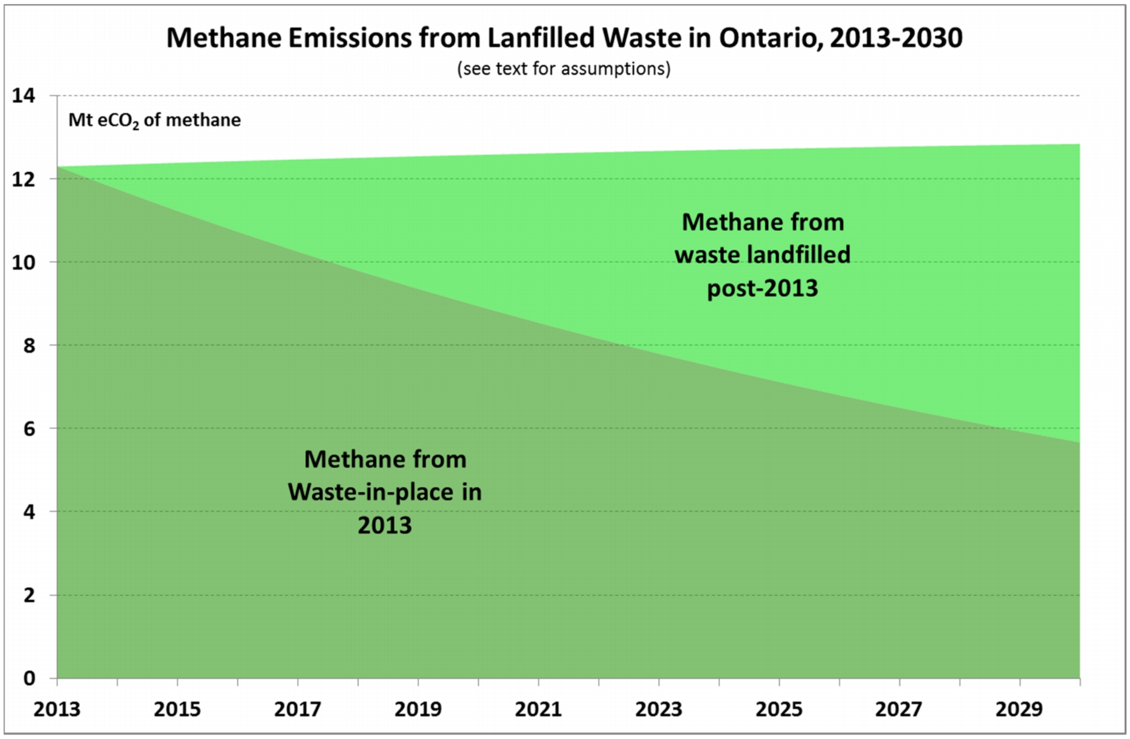

Figure 4. Outlook for Landfill Methane Generation from Ontario Landfills, 2013-2030 (assuming 6 Mt of landfilled waste per year and current organic content)

Landfill carbon storage

As noted above, when organic materials are landfilled, some of the carbon is stored or "sequestered". The amount will vary by material. Both the amount of methane that will eventually be released and the amount of carbon that will be permanently stored vary according to carbon content, material structure and other factors, as shown in Table 1 for some selected materials. For some materials like newspaper and yard waste, more carbon is sequestered than is released in the form of methane, and so the landfill acts as a net sink for these materials. For other materials, like food waste and cardboard, the methane emissions more than offset the storage factor. ***In 2013, organic waste landfilled, including that portion exported to U.S. landfills, resulted in permanent carbon storage of 2.1 million tonnes CO_2eq (of which 1.4 Mt CO_2eq is sequestered in Ontario landfills) .***

Organics diversion and management

Diverting food wastes and yard wastes from landfills in the current year reduces the future stream of methane emissions that these materials would otherwise have generated. When organic material decays in composting or controlled digestion facilities, methane emissions are virtually eliminated[8]. In

[8] Composting has additional greenhouse gas benefits that have not been factored into this analysis. Some of the carbon remains sequestered in the compost, and the soil nutrients recycled in the compost reduce the need for the manufacture and application of fertilizers, thereby displacing additional greenhouse gas emissions.

the context of Figure 4, organics diverted in the post-2013 period reduce emissions in the portion of the graph labelled “methane from waste landfilled post-2013”.

As indicated in Table 1, methane generation rates vary by material. ***By applying the net factors (i.e. methane generation less carbon storage) to the food and yard wastes diverted from landfill in Ontario, we estimate a total impact of 1.63 million tonnes CO_2eq.***

Reuse & Recycling

When materials are diverted from landfills for reuse or recycling, greenhouse gas emissions are affected in three important ways. First, as with food and yard wastes, if the material is methagenic, landfill methane emissions are eliminated, offset by a reduction in landfill carbon sequestration (see Table 1). Second, some materials require a relatively large amount of energy to manufacture (e.g. paper, metals, plastics, glass, steel), but can also be made from recycled inputs with much less energy than is required to make them from virgin inputs. For these materials, reducing, reusing or recycling has the effect of reducing the energy use of the industries that manufacture them, and therefore also reducing greenhouse gas emissions. And finally, recycling and reducing of cardboard and paper products reduces the requirement for fresh wood to be harvested, which results in greater forest carbon storage.

Table 1. **Methane Generation and Carbon Storage for Selected Landfilled Materials**[9]
(all figures in tonnes CO_2eq per tonne of waste landfilled, no methane capture assumed)

	Methane	Carbon Storage	Net
Corrugated Containers	2.88	0.79	2.09
Magazines/Flyers	2.85	0.50	2.35
Newspaper	1.16	1.31	-0.15
Office Paper	4.28	0.13	4.15
Phone Books	1.16	1.23	-0.08
Textbooks	4.28	0.13	4.15
Dimensional lumber	0.19	1.20	-1.01
Fibreboard	0.07	1.01	-0.95
Food Waste	1.93	0.08	1.85
Yard Waste	0.76	0.59	0.03
Grass	0.63	0.15	0.47
Leaves	0.72	0.87	-0.15
Branches	0.94	1.17	-0.23
MSW	1.78	0.23	1.55
Drywall	0.00	0.09	-0.09
Wood flooring	0.26	1.20	-0.94

With regard to the energy-related savings, to estimate the impact of recycling it is necessary to estimate the total amount of energy required to manufacture each material from virgin inputs and from recycled inputs, as well as the mix of different fuels and electricity used in the manufacturing process. The total greenhouse emissions “embedded” in the final product is sensitive to both the amount of electricity used in the manufacturing process and the greenhouse gas intensity of that electricity. Greenhouse gas emission factors for aluminum, paper and other materials tend to be significantly lower for Canadian industry than for American industry because of the lower average greenhouse gas intensity of Canadian electricity (we use more hydroelectricity and the US uses more coal) and because electricity-intensive

[9] U.S. Environmental Protection Agency, “Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)”, prepared by ICF International for the US EPA Office of Resource Conservation and Recovery, Washington, March 2015.

industries such as paper and aluminum tend to be concentrated in regions where there is an especially high portion of zero-emission hydroelectricity in the electricity mix.

Table 2
Greenhouse gas impacts of recycling due to energy savings and forest carbon sequestration, for selected materials[10]
(tonnes CO_2eq per tonne of recycled material)

Printed Paper	3.2
Newsprint	3.3
Cardboard	3.3
Mixed Paper and Polycoated	3.3
PET	3.6
HDPE	2.3
Other plastics	1.8
Aluminum	6.5
Steel	1.2
Glass	0.1
Electronics	1.6
Tires	3.3
Ferrous Metals	1.2
Non-ferrous	4.2

With regard to the forest carbon impacts of recycling, when paper waste is recycled it reduces the amount of fresh fibre required by the pulp and paper industry, thus leaving carbon standing in the forest in trees that would otherwise have to be cut down to make pulp and paper. The effect is relatively large in terms of CO_2eq per tonne of paper recycled, although the computation can be complex and depends on the carbon content of the paper, the amount of recycled paper that makes it back to the mill (after losses), the ratio of the carbon input to the mill to the carbon contained in the mill's paper products, the ratio of the carbon cut in the forest to the amount delivered to the mill mouth, and other factors relating to the dynamics of the carbon cycles in the forest ecosystem.[11]

The greenhouse gas benefits of recycling are indirect and often far removed from the community in which the waste recycling takes place, but a unique feature of greenhouse gas pollution is that its impact on global warming does not depend on where the emissions take place. Also, recycling emission impacts can only be approximated from general information about how much energy use and greenhouse gas emissions are associated with different manufacturing processes. **Even with the uncertainties and conservative assumptions associated with these numbers, it is clear that the upstream greenhouse gas benefits of recycling materials such as paper, steel, and plastics represent a very significant emissions sink that is a key to understanding the positive contribution that the waste management industry makes to climate change mitigation.**

The development of factors for estimating the greenhouse gas benefits of recycling selected materials has been the subject of intensive research in recent years.[12] To estimate the greenhouse gas benefits of

[10] Environment Canada, "Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update", prepared by ICF International for Environment Canada, Contract No. K2216-04-0006, October 2005. For the carbonaceous materials, the avoided methane and foregone landfill carbon storage has been counted under the "Organics Diversion" heading, and is not repeated here.

[11] ICF, RIS Enviros and Torrie Smith Associates "Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions", Final Report, Contract No. K223200068, prepared for Environment Canada, Ottawa, March 2001.

[12] U.S. Environmental Protection Agency, "Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM)", prepared by ICF International for the US EPA Office of Resource Conservation and Recovery, Washington, March 2015.

recycling in Ontario, we applied the factors published by Environment Canada, as shown in Table 2,[13] supplemented by information from industry sources and the U.S. EPA. ***The recycling and reuse activities of the Ontario waste management industry reduce global greenhouse gas emissions by 14.5 million tonnes CO_2eq per year, comprised of both avoided future methane emissions and immediate reductions from manufacturing energy and forestry impacts.***

Energy from Waste (EfW) Facilities

A relatively small amount of Ontario's waste – 140,000 tonnes – is processed at thermal EfW facilities, resulting in emissions of carbon dioxide, as well as trace amounts of nitrous oxide (a powerful GHG). When waste is diverted from landfills to EfW facilities, there are several greenhouse gas impacts. The fossil-based carbon in the MSW (plastics, synthetic fabrics, synthetic rubber) result CO_2 emissions (0.39 tonnes CO_2eq per tonne of waste), but the organic-based carbon in the MSW (paper, wood, food wastes) processed by the EfW results in avoided methane emissions and foregone carbon storage at the landfill, so that the net effect is that diversion of MSW from landfills to EfW results in a reduction of greenhouse gas emissions of 1.55 tonnes CO_2eq per tonne of MSW diverted. This is the value we have used in including the contribution of EfW facilities to the overall carbon footprint of Ontario's waste management industry.

In 2013, 140,000 tonnes of waste were processed at EfW facilities, resulting in a net greenhouse gas reduction of 162,000 tonnes CO_2eq, or 0.16 Mt CO_2eq.

Waste Collection and Transportation Vehicles

All 14 million tonnes of waste generated by Ontario households and firms are transported by collection trucks and long haul transportation trailers which are a source of greenhouse gas emissions, albeit relatively small when compared with the other greenhouse impacts of the sector. A typical collection truck will have curb weight of 13 tonnes and a payload capacity of 9.5 tonnes, but gross vehicle weights vary up to 27 tonnes. They are among the most energy intensive vehicles on the road, mainly due to their weight but also because of their low speed, stop-and-go duty cycles, high idling times, and power take-off systems for running the compactors and other auxiliary equipment. While diesel truck fuel economy ratings are typically about 50 L/100 km, actual in-service experience reports fuel consumption of 85 L/100 km and even higher.[14] Fleets are beginning to move to natural gas as a fuel, however, at this time most Ontario waste management trucks use diesel.

The Ontario waste management industry operates a minimum of 3,650 collection vehicles, including both municipally owned and privately owned fleets.[15] Assuming an all-diesel fleet with average annual mileage of 40,000 km per truck and fuel consumption of 85 L/100 km would consume 130 million litres

[13] Environment Canada, "Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update", prepared by ICF International for Environment Canada, Contract No. K2216-04-0006, October 2005.

[14] Hao Cai et. al., "The GREET Model Expansion for Wells-to-Wheels Analysis of Heavy Duty Vehicles", Energy Systems Division, Argonne National Laboratory, Report ANL/ESD-15/9, October 2015.

[15] Data provided by OWMA.

of diesel per year with corresponding greenhouse gas emissions of 350,000 tonnes of CO_2eq per year, or 0.35 Mt CO_2eq. The fuel consumption of the long haul trailer fleet adds another 70,000 tonnes CO_2eq per year, for ***an estimated total from the truck fleet of 0.42 Mt CO_2eq per year***. There is uncertainty in these estimates due to the unknown variability in actual on-road fuel economy, but even with more conservative assumptions than those used here, the aggregate emissions from the transportation fleet of the waste management industry are well under one Mt CO_2eq per year and probably below 0.50 Mt CO_2eq, a small number considering their essential role in facilitating over twenty times that much in emission reductions. This finding is somewhat surprising, but focusses on GHG emissions only, and does not address other vehicle emissions. While the shift to CNG results in a slight reduction in these estimates, the amount would be minor compared to the landfill emissions, or the recycling benefits of the industry.

Other Waste Management Related Equipment

The equipment used at landfills for moving, spreading, compacting and covering the waste are very energy intensive, and their consumption of diesel fuel can vary from 20-40 Litres per hour and higher, depending on their power rating, the job they are doing, the density of the waste they are moving, the skill of the operator, the grades they are traversing and other factors. Even so, diesel consumption by landfill operations equipment is only 1.5-3 Litres per tonne of landfilled waste, which equates to 4.5-9 kg CO2eq per tonne of waste. In that range, ***the total greenhouse gas emissions from landfill operational vehicles in Ontario is in the range of 0.04-0.08 Mt CO2eq.***

The fuel and electricity consumption at other waste sorting and handling facilities (mostly transfer stations and MRFs – material recycling facilities, composters and anaerobic digesters) make an even smaller contribution to the carbon footprint of the waste management industry, particularly given the low carbon intensity of Ontario's power grid. The most power-intensive materials handling and sorting machines can use several kw-hours per tonne of waste processed, but levels closer to 1-2 kW-hours per tonne of waste processed are more typical. ***Translated into greenhouse gas emissions, the contribution of these facilities to the carbon footprint of Ontario's waste management is less than 0.005 Mt CO2eq.***

Fossil Fuel Displacement by Methane from Landfills or Other Waste Management Facilities

When landfill or anaerobic digester methane or direct EfW displaces fossil fuel, either as a direct source of heat or for electricity generation, the reduction of the fossil fuel combustion emissions is another way in which the waste management industry can and does reduce greenhouse gas emissions. It will be a secondary reduction when compared to the reduction from the methane burn itself; a tonne of landfill methane when burned reduces emissions by 25 tonnes CO_2eq. The combustion will release about 50 GJ of energy, enough to displace 2.5 tonnes CO_2eq of natural gas emissions, or 3.5 tonnes of petroleum fuel emissions, or as much as 5 tonnes of coal emissions. If the landfill gas displaces natural gas electricity, then the same tonne of methane could displace 4-5 tonnes of CO_2eq, depending on the efficiency of the landfill gas generator and the efficiency of the generator producing the displaced electricity. We have not estimated the total GHG reductions from fossil fuel displacement in Ontario that results from the application of landfill or digester gas, or from EfW facilities. At this time, it is still a small component of the waste management industry's carbon impact compared with the multi-Megatonne impacts discussed above, but it could play a larger role in the future in helping some industries meet their emission reduction goals.

Summary of Greenhouse Gas Emissions from the Ontario Waste Management Industry

The various impacts of the Ontario waste management industry on greenhouse gas emissions are summarized in Figure 5 and the picture that emerges is quite different than that revealed by the "inventory perspective". Through the operation of engineered landfill sites, landfill gas recovery systems, EfW facilities, organics diversion programs, and recycling initiatives, ***the industry reduces emissions by 9-14 Mt CO_2eq below what they would otherwise be, every year***, and the emissions from all the energy it takes to power the trucks and equipment to make this happen add up to less than one Mt CO_2eq. Notwithstanding this impressive accomplishment, the potential for further reductions is much larger; the landfill gas recovery rate could be much higher, and the potential for the waste stream to be diverted to composting, digesters and materials recycling still has large unrealized potential for growth. **For Ontario to succeed in meeting its sustainability and greenhouse emission targets, the Ontario waste management industry must succeed in doubling diversion rates in the years ahead.** With this conclusion in mind, we turn now to a review of the challenges and opportunities of Ontario's proposed carbon cap-and-trade system to the Ontario waste management industry.

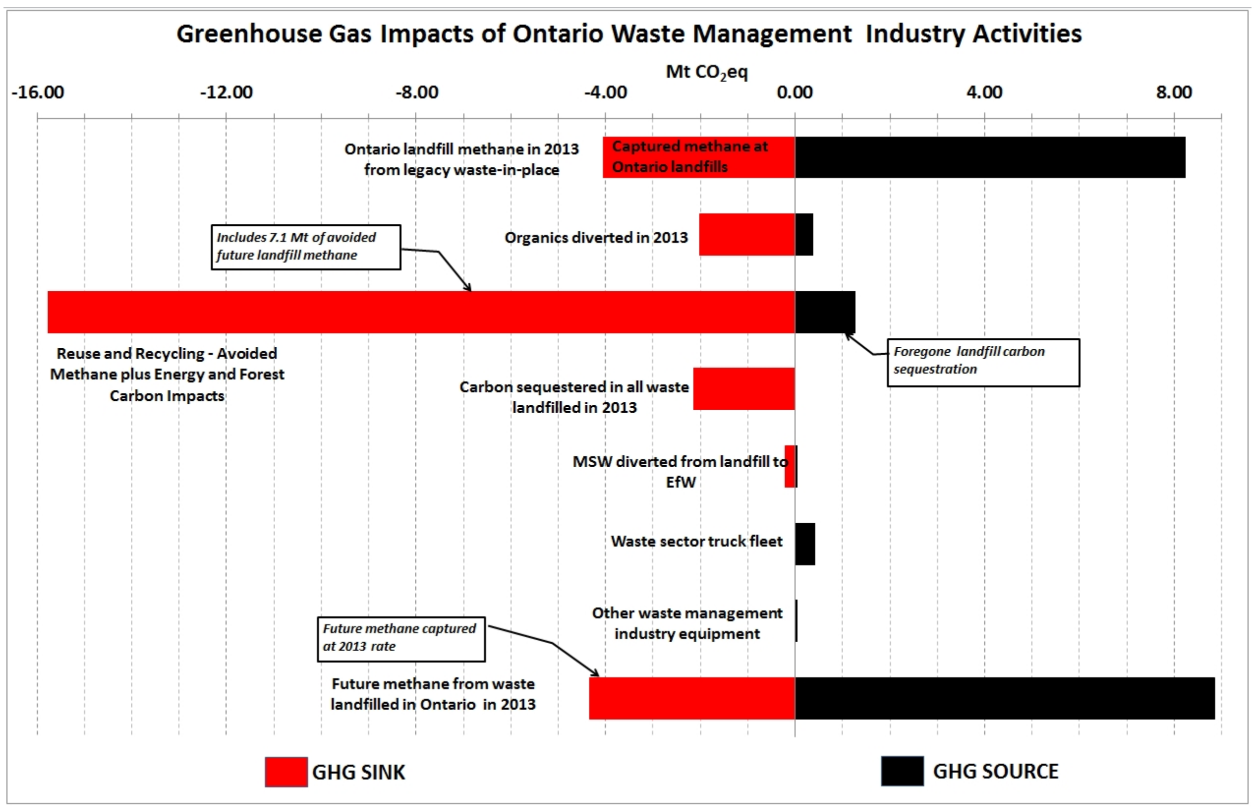

Figure 5. Greenhouse Gas Emissions and the Ontario Waste Management Industry in 2013

Cap-and-Trade: Challenges and Opportunities

The Government of Ontario has set a target of reducing greenhouse gas emissions to 15% below 1990 levels by 2020 and to 37% below 1990 levels by 2030. Ontario's greenhouse gas emissions in 1990 totalled 182 Mt CO_2eq, according to the most recent official inventory,[16] but emissions have declined since then, largely due to the one time impact of the phase-out of coal-fired power plants, and are now in the range of 165-170 Mt CO_2eq. As illustrated in Figure 6, emission reductions in the range of 20 Mt CO_2eq will be required to meet the 2020 target, followed by an additional 30 Mt CO_2eq by 2030. To meet the 2030 target, emissions must decline by an average of 2.6% every year for the next fifteen years, but a slightly higher annual rate of decline will be needed to meet the 2020 target.

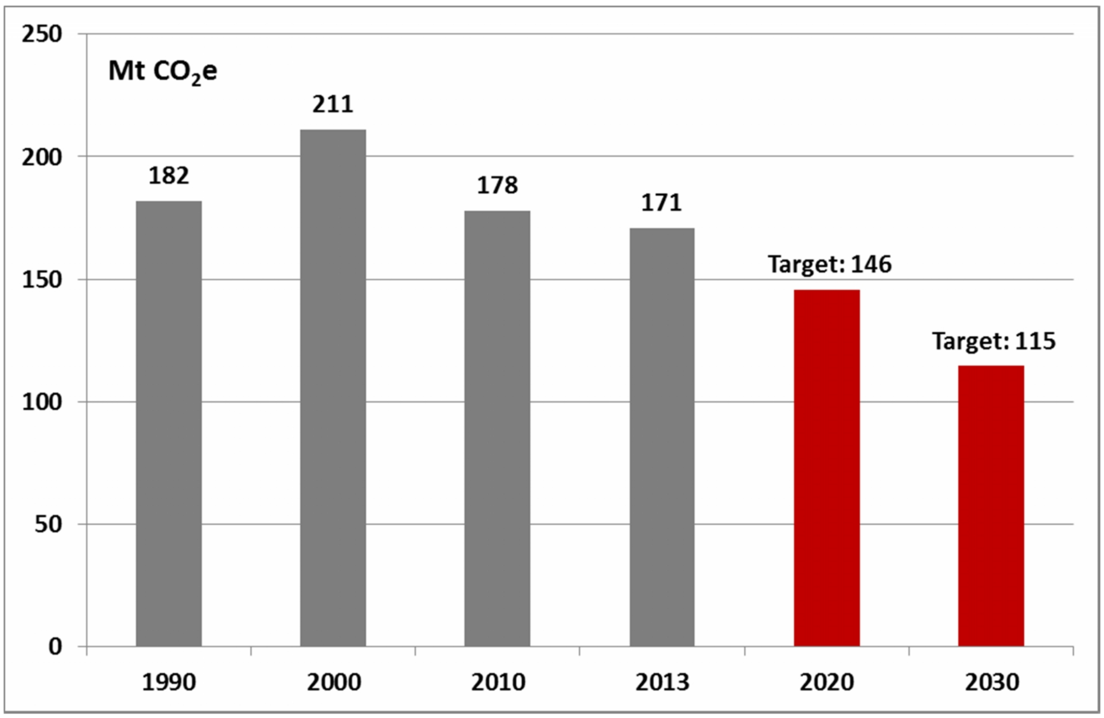

Figure 6. Historical and Targeted Greenhouse Gas Emissions in Ontario

Summary of Proposed Cap-and-Trade Program

A central element of the government's strategy for meeting these targets is the implementation of a carbon "cap-and-trade" program, modeled after and linked to programs already in place in Quebec and California, with the possibility of a pan-Canadian market as other provinces address their climate change mitigation objectives. In a cap-and-trade program, some portion of the greenhouse gas emissions in the economy are "capped" and emitters who fall under the cap must have permits, called "allowances" to

[16] Environment Canada, National Inventory Report, Part 3, Ottawa, 2015.

cover their emissions, with one allowance for each tonne of CO_2eq. The government limits the supply of allowances each year to the amount that corresponds to the targeted emission level, and the allowances are distributed to the capped emitters, usually by way of an annual auction. Emitters under the cap who are able to reduce their emissions to less than the number of allowances they hold may sell their “surplus” allowances to buyers who are also under the cap but are short of the allowances needed to cover their emissions, thus creating a “carbon market”.

When this market works as intended, the result is the targeted or capped level of emissions is achieved with the least cost emission reduction measures. Capped emitters will compare what it would cost to lower their own emissions with the going rate for allowances in the carbon market. If the market price for allowances is less than their internal emission reduction costs, then they may opt to buy allowances to cover a portion of their emissions, thereby financing the implementation of some other emitter’s lower cost emission reduction opportunities. Finally, and most importantly to the waste management industry in the case of the proposed Ontario system, capped emitters may purchase emission “offsets” from emitters who are not covered by the cap. If an uncapped emitter can reduce emissions for less than the going rate for allowances, they should find ready buyers for their offsets.

The proposed Ontario cap-and-trade system, which is based on the design of the Western Climate Initiative[17], has been summarized in government briefings.[18] Some of the key design features that are being proposed:

Start-up date: January 1, 2017

First auction: March 1, 2017

The Cap: The cap will start at the level of emissions in 2017, and decline each year in support of meeting the province’s 2020 target, and continue to decline thereafter in support of the 2030 target. Because 2017 emissions will not be known when the program starts, a forecast will be used. A “true up” would be performed in 2021 for the 2017-2020 period.

Sector coverage: Broad coverage of most Ontario GHG emissions, including energy and process emissions from electricity generators, industry, large commercial establishments, institutions, transportation fuels, and natural gas.

Point of regulation. Large emitters (over 25,000 tonnes CO_2eq per year) capped directly; electricity at the fuel distributor level; natural gas at the distribution level (for distributors who meet the 25,000

[17] For a description of the WCI program design, see http://www.wci-inc.org/program-design.php. The 2008 design recommendations can be found here: http://www.westernclimateinitiative.org/the-wci-cap-and-trade-program/design-recommendations, and the 2010 design recommendations here: http://www.westernclimateinitiative.org/the-wci-cap-and-trade-program/program-design.

[18] The summary here is based on MOECC, “Cap and Trade Program Design Options”, November 2015, which can be accessed here: http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2015/012-5666_Options.pdf.

tonne CO_2eq threshold of gas distributed, net of gas sold to industrial and commercial emitters covered by the cap directly); transportation fuels at the distribution level.

Allowance Distribution. In the first compliance period (2017-2020), allowances will be free to large industrial and commercial emitters, but will decline year-by-year in accordance with the cap schedule. Energy-intensive, trade-exposed industries may receive allowances free-of-charge to protect their international competitive position.

Opt-in. Emitters obliged to report under Ontario Regulation 452/09 will have the option of opting into the cap, even if they do not meet the 25,000 tonne CO_2eq threshold.

New facilities that start up after January 1, 2016 and meet the 25,000 tonne CO_2eq threshold will have a two year exemption before being required to comply.

Minimum allowance price. The reserve price will be aligned with Quebec and California reserve price in 2017. The reserve price in the August 2015 auction was $15.84/tonne CO_2eq.

Compliance and Flexibility Mechanisms. After an initial four year compliance period (2017-2020), Ontario will synchronize with the three year compliance periods used by Quebec and California. Banking of allowances for use in the next compliance period will be allowed, but borrowing from future compliance periods will be prohibited.

Offsets. Up to 8% of a capped entity's compliance requirement can be met with emission "offsets" consisting of emission reductions achieved outside the cap (i.e. by entities without a compliance obligation). Offsets must be real, additional, enforceable, verifiable and permanent, all of which will be defined in a set of protocols being developed for use by an Ontario offset registry that will qualify offsets for inclusion in the Ontario market. Offsets issued by California and Quebec will be accepted in the Ontario market and capped emitters in Quebec and California will be permitted to purchase offsets generated in Ontario as part of their compliance obligation. ***Quebec and California have an offset protocol for landfill gas capture and destruction, which is being "evaluated for adaptation on an expedited basis". Also of direct relevance to the waste management industry are protocols that are being developed for "organic waste management" and for "organic waste digestion".***

Complementary Investments. The auctioning of allowances will generate regulatory revenue for the Government of Ontario, the use of which will be linked to GHG emission reductions and a transition to a low carbon economy.

Direct Implications to the Ontario Waste Management Industry

- ✓ Members of the Ontario waste management industry will generally not have compliance obligations under the cap-and-trade program. Landfill emissions are large enough but they are not covered under the cap, and the other types of businesses that make up the Ontario waste management industry do not meet the criteria for falling under the cap – i.e. industrial or commercial establishments emitting at least 25,000 tonnes CO_2eq per year.
- ✓ EfW facilities are a possible exception. As of December 2015, the government was still considering how to treat EfW under the cap-and-trade policy. Most cap-and-trade schemes either provide allowances or exempt EfW facilities from compliance obligations. Processing 65,000 tonnes of MSW annually will generate about 25,000 tonnes of CO_2 from the plastics and other fossil-based components of the MSW, and that is the threshold for inclusion under the cap for large industrial emitters. On the other hand, we have seen that when EfW facilities divert MSW from landfills, the fossil-based emissions are more than offset by the reduced landfill gas emissions at the landfill so from this perspective it would make little sense to put EfW facilities under the cap. The government has indicated its intention to develop offsets protocols for organics diversion programs; a possible resolution of the status of EfW facilities would be to exempt them from the cap but permit offsets from their operations to the extent that their organic diversion (and possibly also metals recycling) impacts exceed the emissions from the fossil-based component of the MSW processed.
- ✓ An additional consideration with regard to EfW facilities under cap-and-trade related to the practice of mixing natural gas with the MSW being processed. Regardless if gas consumption exceeds the 25,000 tonnes CO_2eq, the process could be covered under the cap; if exempt, they would still be exposed to the natural gas price impact of the carbon allowance market.
- ✓ Any members of the waste management industry obliged under Ontario Regulation 452/09 to report their annual greenhouse gas emissions have the option of voluntarily submitting to an emissions cap, even if they do not otherwise meet the threshold emission level. Whether this might be an attractive option depends on the specific circumstances; for example, an entity that can generate surplus allowances at a relatively low cost may wish to be under the cap. A decision to opt in is not reversible.
- ✓ Since many activities in the waste management sector help to reduce greenhouse gas emissions, the sector may be able to monetize these reductions through offset credits. The size of the potential for offsets generated by the waste management industry will depend on what is allowed in the ***offset protocols that are currently under development***. The details of how the criterion of additionality is defined in

these protocols will be particularly important in determining the extent to which emissions that are reduced or avoided by landfill gas recovery, organics diversion and recycling will be eligible as offsets. In the context of offset protocols, “additionality” is included as a criterion for eligibility to ensure that the emission reductions that enter the market are in addition to business-as-usual practice, and do not include activities that are required by regulation. Additionality can be defined with varying degrees of rigour; if it is defined too liberally, it can result in “free riders” in which participants are paid for emission reduction measures that they would have taken anyway, with or without payment for their value as allowance offsets. If it is defined too conservatively, inexpensive emission reduction opportunities will be excluded from the carbon market, the opposite of the intended effect of the market approach to carbon reduction.

Offset prices will be directly related to allowance prices in the cap-and-trade market, but their net worth will be sensitive to how much they cost to quantify, verify and certify. As with criteria like additionality, the details of the offset protocols will largely determine the level of transaction costs that will be required to qualify an offset in the Ontario carbon market.

- ✓ The direct impact of the proposed cap-and-trade program on most members of the Ontario waste management industry will be in the form price increases in diesel fuel and natural gas, and to a lesser extent electricity. Fuel and electricity distributors will fall under the cap, and their compliance costs will be reflected in their prices. Figure 7 illustrates the relationship between allowance prices in dollars per tonne of CO_2eq and diesel and potential natural gas price premiums in cents per litre and cents per cubic metre, respectively, as well as the impact on cents per kilowatt-hour for electricity. These price premiums may be significant, indeed, if they are not then the cap and trade system will not have its intended effect in this sector, which is to stimulate investment in efficiency and alternative fuels. The government will likely start out these premiums at a low price. Nevertheless, the business case for fleet efficiency investments and fuel switching (including to hybrid electric and electric refuse haulers, not only to natural gas) will be bolstered by the cap and trade system, perhaps dramatically so if fuel distributors find their best option for staying under the cap is to auction their allowable fuel to the highest bidders.

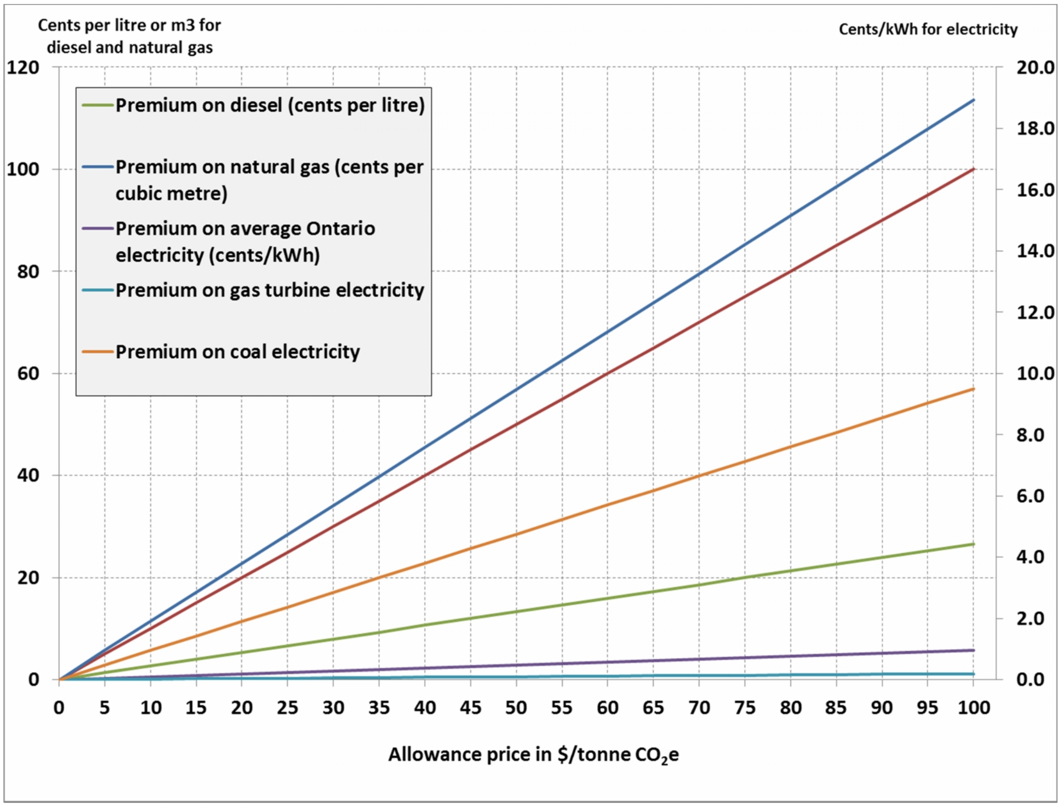

Figure 7. Diesel, natural gas and electricity price premiums vs. allowance price

Potential for Unintended Consequences

There are opportunities as the government sets up its cap-and-trade system to create perverse outcomes where carbon reduction activities may be disadvantaged. This needs to be taken into consideration as the government establishes which facilities will have compliance obligations under the cap-and-trade program. Consideration should be given as to how these obligations might impact emission reductions activities whether from EfW facilities or manufacturing facilities that predominately use secondary raw materials. These same considerations should also be applied to where and how offsets are created. Economic incentives should continue to support those activities that drive the greatest carbon reduction opportunities.

Opportunities

We have identified four types of opportunity that the proposed cap-and-trade system will create for members of the Ontario waste management industry:

- ✓ ***Offset generation.*** The proposed cap-and-trade system has limited scope for offsets due to its broad coverage of fuel and electricity consumption, but the government has clearly signalled that landfill methane and the greenhouse gas benefits of diverting organic material from landfills are on its priority list offset eligibility.

- ✓ ***Partnerships with capped emitters***. There will be enhanced demand for low carbon or carbon free fuel and electricity from capped industrial energy users, electricity and natural gas distributors, and transportation fuel wholesalers. The allowance price will translate into a premium for carbon-free or low carbon energy that can be provided from landfills, digesters, and EfW facilities.
- ✓ ***Internal efficiency and fuel switching measures***. Investment and risk hedging strategies of all energy users will be affected by the allowance prices that emerge from the carbon market. For firms with significant fuel and electricity costs, this will improve the relative cost effectiveness of efficiency and fuel switching options.
- ✓ ***Government partnerships.*** The allowance auctions will generate regulatory revenue, perhaps modest in the first compliance period but ultimately with the potential to grow into the billions of dollars per year. It is the government's stated intention to apply this revenue to "promote productivity and transition to a low carbon economy", and this presents an opportunity for the waste management industry. For example, there may be ways in which the application of this regulatory revenue would be more effective than direct carbon market participation at increasing the diversion and recycling rates that are clearly necessary for Ontario to make the transition to a productive and low carbon economy consistent with the *Draft Strategy For A Waste Free Ontario: Building the Circular Economy.*[19]

We briefly consider how the proposed cap-and-trade system in Ontario could help the waste management industry increase the greenhouse gas emission reductions it is already achieving in five important ways:

- Landfill gas capture and destruction,
- Organic waste diversion (composting, digesters),
- Reuse & Recycling, and
- Energy from waste,
- Landfill carbon sequestration.

Of these, the government has explicitly indicated that the first two – landfill gas capture and organic waste management – are being favourably considered for inclusion as eligible offsets in the Ontario cap-and-trade market.

[19] Released November 27, 2015 with a comment period extending to late February, 2016.

Landfill Gas Capture and Destruction.

A protocol for offsets related to landfill gas capture and destruction is under active consideration for early inclusion in the Ontario cap-and-trade system. Such activity is well suited to the criteria that determine offset eligibility – carbon capture is clearly real, enforceable, verifiable and permanent. That leaves the question of "additionality". Landfill gas capture and destruction is a regulatory requirement for large landfills in Ontario (with more than 1.5 million tonnes of waste-in-place), and the application of the additionality criterion invariably excludes gas capture that is required by law.[20] In some interpretations, this excludes any offsets from a landfill site where gas collection is regulated, while others will consider offset eligibility where measures can be shown to increase capture rates beyond the historical baseline gas capture rate.

A comparison of the landfill gas that is currently captured in Ontario (4 Mt CO_2eq) with what is believed to be the level of uncaptured landfill methane emissions (8.4 Mt CO_2eq) suggests that there is a large potential for "additional" gas capture in Ontario at both regulated and unregulated sites. The value of carbon in the future affect the viability of LFG capture projects at many of these sites – sites at which LFG has been rejected as uneconomic in the past may be attractive targets for carbon offset creation. It is clearly in the in the interests of both the government and the landfill owners/operators to work together to increase the amount of landfill gas being captured and destroyed in Ontario by identifying the "supply curve" of additional gas capture opportunities and determining how Ontario's cap-and-trade system can ensure the cost effective potential receives the necessary enabling investment.

In addition to the emission reductions from landfill gas capture and destruction, greenhouse gas emission reductions are also achieved when the methane combustion is used to displace fossil fuels, either directly or through displacing fossil-fueled electricity generation. Industrial emitters, electricity generators and natural gas distributors covered by the cap will be interested in landfill methane as part of their compliance strategies, and this will put a value on collected landfill gas methane equal to its value as a fossil fuel substitute at the prevailing allowance price. Even where landfill methane flaring is ineligible as an offset under the additionality criterion, it will still have value as a fossil fuel substitute to capped entities looking for ways to meet their compliance requirements. Therefore, landfills, which currently flare methane could create offsets by installing boilers or generator sets to produce electricity/steam or both from the methane.

It is currently not economic to clean up landfill gas and inject it into the natural gas pipeline. Whether carbon offsets will change this outlook depends on both the allowance price and investor confidence in carbon market forecasts over the life of their investments. The government could encourage the

[20] For a review of how several offset protocols for landfill gas capture compare against the proposed criteria for offset eligibility in Ontario, including the additionality criterion, see Det Norske Veritas, "Review of Existing Offset Protocols Against WCI Offset Criteria", prepared for The Western Climate Initiative, February 2010. Accessed at: http://www.westernclimateinitiative.org/document-archives/Offsets-Committee-Documents/WCI-Review-of-Existing-Offset-Protocols/.

establishment of Ontario capacity for renewable natural gas supply by providing price signals to cover any gap between the allowance price and the opportunity cost of such investments, for example through a policy similar to Ontario's feed-in tariff program for renewable electricity.

Organic Waste Diversion

The government has indicated that offset protocols are being considered for both "organic waste management" and "organic waste digestion". In both cases, these are activities that eliminate the future stream of methane emissions that would occur if the waste was landfilled. As illustrated in Figure 4, the methane emissions from future landfilling of organic wastes will gradually come to dominate pre-capture landfill gas emissions in Ontario. While increasing the landfill gas capture rate will partially address this growing source of emissions, it will never be as efficient as avoiding the generation of the methane in the landfill in the first place through diversion to composting, anaerobic digestion or EfW facilities.

Of the 3.7 Mt of food and yard waste generated in Ontario, 1.4 Mt is being diverted to anaerobic digesters (200 kt), on-farm digesters (175 kt), open windrow composting (520 kt) and contained composting (485 kt).[21] There is a potential to more than double the 1.63 Mt CO_2eq benefit that comes from these activities.

The application of the value created by Ontario's emission cap to the unrealized potential for diverting organic waste from landfills to emission-free alternatives is another area where the government's and the industry's goals are mutually reinforcing. Protocols for organic waste management and anaerobic digesters are in place in other carbon markets[22] and are under development for inclusion in the Western Climate Initiative to which the Ontario system will be linked. The government's recently released "Draft Strategy for a Waste Free Ontario: Building the Circular Economy" includes proposals to utilize potential legislative mechanisms like disposal bans and generator requirements to drive greater organics diversion in Ontario. As with landfill gas, investments in the utilization of methane from anaerobic digesters so the gas can be injected into the natural gas pipeline system would benefit from price signals and guarantees similar to those provided in the feed-in tariff program for renewable electricity, price signals that could be covered by regulatory value created by the carbon cap. This would be especially helpful in areas where connectivity to the pipeline system is available but access to deliver electricity to the electric grid is not.

[21] These data do not include an estimated 200 kt of organic waste that is processed in backyard composters.

[22] See the protocols reviewed in Det Norske Veritas, "Review of Existing Offset Protocols Against WCI Offset Criteria", prepared for The Western Climate Initiative, February 2010. Accessed at: http://www.westernclimateinitiative.org/document-archives/Offsets-Committee-Documents/WCI-Review-of-Existing-Offset-Protocols/. Also, see the Alberta SGER protocols for composting and anaerobic digesters at http://aep.alberta.ca/climate-change/guidelines-legislation/specified-gas-emitters-regulation/offset-credit-system-protocols.aspx.

Reuse & Recycling

The greenhouse gas reductions from recycling are second only to organics diversion in the waste management industry's contribution to reducing greenhouse gas emissions. Our preliminary analysis indicates that recycling programs in Ontario currently result in over 14 million tonnes CO_2eq per year of greenhouse gas emission reductions from manufacturing energy savings, reduced landfill gas emissions and forest carbon sequestration.

The enormous opportunity associated with recycling and reuse have been well-articulated through the European Commission's recently released Circular Economy Package which includes revised legislative proposals on waste management to stimulate Europe's transition to a low carbon economy with a focus on strengthening reuse and secondary raw material markets. They estimate the potential of this transition to reduce the European Union's emissions by 450 million tonnes CO2eq per year. The Ontario government's proposed Waste Free Ontario Act and Draft Strategy for a Waste Free Ontario: Building The Circular Economy" provide a similar emphasis.

Recycling is not on the list of proposed offset protocols currently under consideration by the Government of Ontario and including recycling in carbon offset protocols has only recently begun to receive serious attention from carbon market regulators, most notably in Alberta (see box) and for small scale projects for plastics and e-waste recycling under the international Clean Development Mechanism.[23]

The solutions to verification, ownership and additionality issues that have been developed for other types of offset protocols can be applied to materials substitution (recycling) protocols. The development of recycling offset protocols is also resulting in methods for substituting conservative default assumptions for complex and expensive analyses, an approach of interest to other sectors where transaction costs associated with quantification and verification are a significant barrier to market development. Boundary issues (deciding where the boundary for the GHG calculations are) present a challenge as the greenhouse gas reductions from recycling activity (e.g. making cardboard packaging in New York State from recycled paper collected in Ontario) often occur outside the carbon market jurisdiction, raising the question as to whether and how the Ontario carbon market might encourage the greater processing in Ontario of recycled materials generated by Ontario industries. In the longer term, the increasing interconnectedness of carbon markets, exemplified by the Western Climate Initiative, will act to resolve some transboundary issues.

Finally, it is important to note that nearly half the greenhouse gas benefits of recycling in Ontario come from the avoided landfill gas emissions that result from recycling paper and cardboard packaging. This

[23] The Recycling Council of Alberta is sponsoring the development of and application for approval of a recycling protocol for the Alberta SGER carbon market (contact Christina Seidel at info@recycle.ab.ca). Also, the Clean Development Mechanism of the Framework Convention on Climate Change has protocols for small scale projects related to plastics recycling – "AMS-III.AJ.: Recovery and recycling of materials from solid wastes --- Version 4.0" , accessible at https://cdm.unfccc.int/methodologies/DB/1SQIW5QZHAYFDJX4BDCVC5P9RTBNL1 -- and for recycling of e-waste – " AMS-III.BA.: Recovery and recycling of materials from E-waste --- Version 1.0" accessible at https://cdm.unfccc.int/methodologies/DB/3KXR3AG8ZP2L2Q5TDXXTT17U9GFE70.

avoided methane is no different from the methane that is avoided from diverting food and yard wastes to composters and digesters. The scope of the organics management offset protocol that is under development should include cardboard and paper product recycling along with food and yard wastes.

Energy from Waste

As with organics diversion and paper product recycling, EfW facilities result in reduced landfill methane emissions (partly offset by reduced landfill carbon sequestration and the emissions from the fossil-based component of the processed waste), and as such they should be included in offset protocols that cover the diversion of carbonaceous waste from landfills. Second, the energy generated by EfW facilities will be of interest to utilities and industries who are capped and are seeking low carbon substitutes for fossil fuel as part of their compliance strategies. In addition, to the extent EfW facilities are a source of recycled metals and other materials that can be used in manufacturing, offset protocols for recycling should be designed to include these materials in their scope.

Landfill Carbon Sequestration

An estimated two million tonnes CO_2eq are permanently sequestered in Ontario landfills every year. It is mostly biogenic (see "Biogenic CO_2" box on page 5) and is therefore not counted in the prevailing GHG inventory frameworks. While carbon markets do not generally give direct credit to landfills for carbon sequestered, it is not a small factor (see Figure 5) and to avoid unintended consequences it will be important to consider it in estimating the net GHG benefits of recycling paper products and of diverting organics from landfills to options such as composting, anaerobic digestion and EfW. For example, in developing the estimate in Figure 5, we subtracted the foregone landfill carbon storage from the avoided methane to get the net benefit per tonne of waste diverted.[24]

[24] When the organics are diverted from landfills to composting, not all of the landfill carbon storage is lost, as some carbon is retained in composted soil. However, we have not included a credit for soil carbon storage in our estimates of the greenhouse gas benefits of diverting organic wastes to compost.

Alberta Protocol Summary

The Recycling Council of Alberta has developed a GHG Protocol for Recycling under the Specified Gas Emitters Regulation in that province. This protocol has been in development for a number of years, and has just undergone the final project technical review. There are a number of learnings from this protocol development regarding the claiming of offsets for recycling activities that could potentially be applied in other jurisdictions, including Ontario.

<u>Methodology</u>

The protocol methodology allows for quantification of indirect GHG emission reductions resulting from the substitution of recycled feedstock for virgin feedstock. This is quantified by using defined emission factors (called Lifecycle Emission Savings Factors, or LESFs) that represent the difference in lifecycle GHG emissions from manufacturing an end-product using one tonne of 100% virgin feedstock compared to one tonne of 100% recycled feedstock. The Emissions Reduction – and thus Offset Credits – are thus calculated on the basis of the incremental displacement of virgin feedstocks in the project year compared to the established baseline. This is done by multiplying the relevant LESF by the mass proportion of recycled feedstock utilized in the project and baseline years.

The methodology uses a baseline, which is calculated by determining the percentage of recycled feedstock that was used over a three-year average baseline period. The baseline condition is the GHG emissions from extracting, processing, and manufacturing products from natural resources. The project condition used within the offset calculation is the process of using recyclable materials as a feedstock to produce end-products. These recyclable feedstocks are used as a substitute for virgin feedstocks. GHG emission reductions occur from displacing the need to extract and process virgin resources.

<u>Ownership</u>

One of the key issues around claiming offsets for recycling is ownership. The entity responsible for making recycling happen (municipalities, businesses and waste management companies) is the driver for the activity, so may feel some ownership over the results. Similarly, recyclers who process materials and prepare them for recycling are important players in the recycling chain. However, offset systems must ensure that the offset is credited at the point where the GHG reduction occurs, or in the case of indirect offsets, ensures the offset has occurred. In the case of recycling, this is the point at which recycled materials replace virgin materials in the manufacture of a new product.

Therefore, in the Alberta system, the point of crediting for the protocol will be at the end-product manufacturer, whom is choosing to use (or increase their use of) recycled feedstock for their manufacturing process. Credits will be generated when there is a full or partial displacement of virgin feedstocks by recycled feedstocks in the project condition.

In the Alberta protocol, the project developer must manufacture within Alberta an eligible end-product utilizing eligible recycled feedstocks that would otherwise have been manufactured utilizing virgin feedstocks. Furthermore, the project developer must demonstrate, through feedstock invoices that raw materials originate within Alberta.

Although highly defensible from a verification and leakage avoidance point of view, the assignment of offsets at the manufacturing stage incorporates primarily indirect offsets, as the actual GHG reductions are a result of upstream activities related to primary resource extraction. Therefore, this protocol approach requires some justification and coaching of system developers. Adoption of similar approaches within other jurisdictions will also validate this approach.

Additionality

One of the key burdens of proof is to show that the use of recycled feedstock is additional, and not required or business as usual. Additionality means GHG emissions reductions must be incremental to regulatory requirements and business as usual/sector common practices. In defining additionality, Alberta Environment has set an adoption level of 40% as being business as usual for an industry. This excludes certain manufacturing sectors, potentially steel mills and boxboard plants for example, where high incorporation of recycled feedstock is already the industry norm. However, even though these facilities would not be eligible for credits, it is important to recognize their ongoing global contribution to GHG reductions.

One of the potential downsides to this requirement is the inability of long-term recyclers to participate if incorporation of recycled content is standard practice within their operations. However, it is reasonable to assume that these companies have sufficient other incentives to operate in the absence of GHG offsets.

Quantification and Verification

As offsets are calculated by multiplying the relevant LESF by the mass proportion of recycled feedstock utilized in the project and baseline years, required quantification involves proof of total weight of recycled and virgin material feedstocks in project and baseline years. This is likely to be documentation through invoices, weigh bills and scale tickets that demonstrate the amount of materials utilized as feedstock in the manufacturing process. This level of verification is not seen as a barrier within the system, as records of material inputs is standard practice.

Conclusion

The Ontario waste management industry already plays a major role in limiting greenhouse gas emissions in Ontario. In 2013, industry activities reduced current and future greenhouse gas emissions by 22 million tonnes CO_2eq, 14 Mt CO_2eq more than the 8 Mt CO_2eq of landfill gas emissions from the legacy waste-in-place in all Ontario landfills. Even so, landfill gas capture, recycling and organic waste diversion rates are still relatively low and will need to increase dramatically for the province to meet its emission reduction targets and make the transition to a sustainable, low carbon and circular economy.

The waste management industry is well positioned to access the substantial regulatory value that will be created by the cap on carbon, through the creation of offset protocols that facilitate growth in landfill gas capture and organics diversion, through partnerships with capped emitters who will value the carbon-free energy generated at waste management facilities, through investment in efficiency and low carbon alternatives in their own operations, and through creative partnerships with government for the direct investment of allowance auction revenue in building the foundation for the circular economy.

There is a strong complementarity between the aspirations of the waste management industry and Ontario's goals for climate change mitigation, a circular economy and sustainable economic development, a complementary which suggests successful collaboration should be achievable. The waste management industry is a major contributor to curbing greenhouse gas emissions; its annual contribution to reducing greenhouse gas emissions at least twenty times larger than the emissions from the trucks and other equipment it uses to achieve this result. Government policy, including cap-and-trade, should be designed to maintain and increase this positive impact.

With regard to the industry's own use of fuel and electricity, particularly for the truck fleet, but also for electricity, the carbon allowance market will cause increased costs. Industry members should assess their options for hedging against these price increases by evaluating their efficiency and fuel switching options against a range of plausible allowance price scenarios. At the same time, given the role the industry plays in delivering greenhouse gas emissions far in excess of its own emissions, policy impacts that make the industry's work more expensive should be identified and avoided.

The development of a carbon allowance market, including offset protocols for landfill gas capture and organics diversion, will improve the economics of a number of industry options that if implemented would help the province meet its climate change mitigation goals. These include:

- Broader coverage and more efficient technology for landfill gas capture
- Increased rates of organic diversion to composting, digestion and EfW facilities
- Capture and cleaning of gases from landfills, digesters, and EfW facilities for injection in to the natural gas pipeline system
- Increased value for direct use of gases from landfills, digesters and EfW facilities (i.e. without connecting to the natural gas pipeline system)

The industry should now work with the government to analyze the impact of the cap-and-trade program on the economics of these options, under a range of plausible allowance price scenarios, to determine how best to design the related protocols, and to identify where direct investment of regulatory income or other policy options may improve the economics or risk profiles of the emission reduction options the industry has to offer.

With regard to reuse and recycling, the industry should press for the early development of offset protocols and/or other mechanisms for increasing the reuse and recycling rates of emissions-intensive materials such as paper products, plastics, glass, aluminum steel, and other metals. This is not only the option with perhaps the largest growth potential for emission reductions from the industry, but also a key to realizing the goals the province has set for a "waste free Ontario".