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RECYCLING COUNCIL OF BRITISH COLUMBIA

RCBC Background Paper:

Examining The Waste-to-Energy Option

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EXECUTIVE SUMMARY

The objectives of this background paper are to provide unbiased information about Waste-to-Energy (WTE) technology and the proposals that have recently been submitted to Metro Vancouver, and the expected environmental performance of the technology.

The purpose of this document is to aid observers in shaping an informed position on Metro Vancouver's inclusion of WTE as part of the proposed waste management "solution" for the region.

This report focuses on Plasco Energy Group's WTE technology since this company has provided one of the more detailed, serious and innovative proposals to Metro Vancouver. In recognition of the fact that a number of other companies have similarly lobbied the region, it should be noted that this report is neither a statement against or in favour of Plasco Energy Group's proposal.

While some of the research undertaken for this report is specific to the Metro Vancouver area, much of the information is general in nature and many of the conclusions are broad enough to guide the general debate on WTE. The research on avoided emissions and the GHG impacts of WTE facilities and landfills, outlined in Section 2.2, is particularly specific to Metro Vancouver and the province of BC. Care is required when comparing these findings to other jurisdictions where the composition of waste and the GHG intensity of electricity sold on the grid are different than that in Metro Vancouver.

The Recycling Council of B.C. (RCBC) recently reaffirmed its position against using WTE as part of the solid waste management regime in B.C. It is RCBC's position that the use of WTE does nothing to encourage waste reduction and that WTE would, in fact, be quite unnecessary if full extended producer responsibility programs (product stewardship) and full organics diversion were in place.

If one examines the entire life cycle of the products that make up MSW, and does not focus solely on the disposal stage of this process, it is clear that there are other waste management strategies that can achieve higher environmental standards than either landfilling or WTE. A Zero Waste strategy that relies on reducing, reusing and recycling waste will conserve more energy, produce fewer air pollutants and GHG emissions, and will help solve the residual problem still present in any WTE scenario.

1.1 THE POLICY CONTEXT

Many regional districts across British Columbia are currently updating, or planning to update, their Solid Waste Management Plans (SWMP). This opportunity, combined with growing concern about the volume of waste produced in the province and its impact on climate change, is providing a new avenue for Waste to Energy companies to push their technology. Many Waste to Energy companies are lobbying regional districts such as Metro Vancouver to consider their technology as an alternative to landfilling, and are framing this option as the most environmentally and economically responsible method of dealing with the regions' waste. As Metro Vancouver is the first regional district to seriously consider Waste to Energy as an integral part of their SWMP, this report will focus on the WTE debate as it pertains to Metro Vancouver.

This revised SWMP will guide the direction of Metro Vancouver's waste diversion and disposal programs for the coming decade. While the new SWMP is not yet finalized, Metro Vancouver has made it clear that its intent is to utilize the opportunity presented by this planning process to push the option of Waste to Energy as a major component of the region's waste management plan.

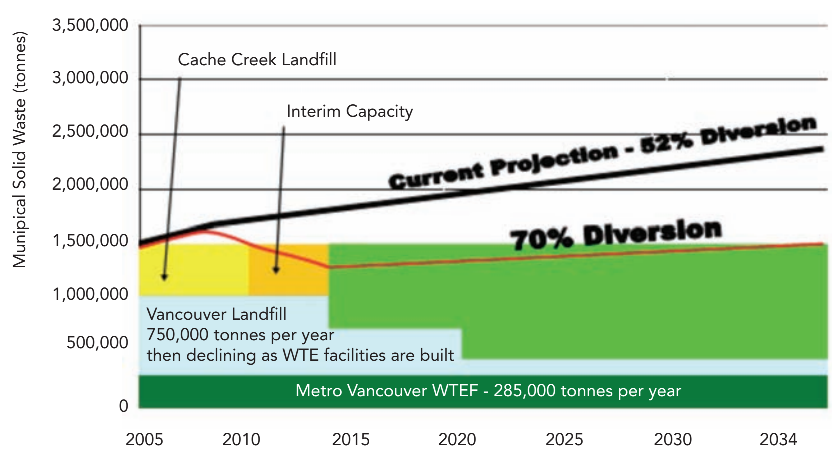
Central to Metro Vancouver's new plan, as outlined in its preliminary *Strategy for Updating the Solid Waste Management Plan (February 2008)*, is an increase in the diversion rate from the current 52 percent to 70 percent. A variety of initiatives have been proposed to achieve this target, from wood waste diversion to the creation of a comprehensive organics collection and composting system. Metro Vancouver staff, however, assert that population pressures will continue to lead to net increases in the total waste generated each year within the region, even if this diversion target is met. As such, Metro Vancouver staff and elected officials have focused their attention on finding a disposal destination for this ever-increasing waste stream.

A large percentage of Metro Vancouver's current waste stream is currently disposed of at the Cache Creek Landfill. In 2006, the Cache Creek Landfill accepted 442,000 tonnes, or 33%, of the region's waste, while the Vancouver Landfill (located in Burns Bog, Delta) accepted 605,000 tonnes, or 46%, and the Burnaby Waste to Energy Facility processed 273,000 tonnes, or 21%.[1] The Cache Creek Landfill is expected to close in 2010, leaving Metro Vancouver without a destination for about a third of its waste stream.

Metro has sent a clear message that it is seriously considering a fundamental shift towards WTE as a major component of its future waste management scenario.

To meet these concurrent challenges, Metro Vancouver has proposed building multiple Waste to Energy (WTE) facilities in the region. Metro Vancouver staff reports focus heavily on the need to expand the traditional 3Rs approach to waste management to include the so-called fourth and fifth Rs; "Recover," which involves recovering energy from waste through thermal treatment and "Residuals Management" which involves handling the materials

Figure 1: Future Waste Management Scenario



Source: Strategy for Updating the Solid Waste Management Plan, Metro Vancouver – February 2008 (Revised March 15, 2008)

[1] RCBC, 2008.

left over at the end of this process. Two of the three goals that Metro Vancouver has proposed to guide the drafting of the SWMP are directly related to its calls for new WTE plants:

- "Goal #2 – Maximize Reuse, Recycling and Material/Energy Recovery"; and
- "Goal #3 – Extract maximum benefit from the disposed waste stream."[2]

As illustrated by Figure 1, Metro Vancouver's intention (though it is still being debated) is not only to replace the current capacity of the Cache Creek Landfill with WTE facilities, but to eventually phase out use of the Vancouver Landfill and continue building WTE capacity. Therefore, it is predicted that by 2035 the region's WTE facilities would process about 1.5 million tonnes of municipal solid waste (MSW). Metro Vancouver elected officials have gone so far as to muse that the region could mine existing landfills to process buried waste and extract the energy. While these proposals have not been officially accepted, Metro Vancouver has sent a clear message that it is seriously considering a fundamental shift towards WTE as a major component of its future waste management scenario.

1.2 PROJECT BACKGROUND

The objective of this report is to provide the Recycling Council of B.C. and other interested parties with impartial information about Waste to Energy technology, the proposals that have been submitted to Metro Vancouver and the expected environmental performance of this technology. The purpose of this document is to aid observers in shaping an informed position on Metro Vancouver's inclusion of WTE as part of the proposed waste management "solution" for the region.

The report focuses on Plasco Energy Group's WTE technology since this company has provided one of the more detailed, serious and innovative proposals to Metro Vancouver. In recognition of the fact that a number of other companies have similarly lobbied the region, it should be noted that this report is neither a statement against, or in favour of, Plasco Energy Group's proposal. While some of the research is specific to the Metro Vancouver area, much of the information is general in nature and many of the conclusions are broad enough to guide the general debate on WTE. The research on avoided emissions and the GHG impacts of WTE facilities and landfills, outlined in Section 2.2, is particularly specific to Metro Vancouver and the province of BC. Care is required when comparing these findings to other jurisdictions where the composition of waste and the GHG intensity of electricity sold on the grid are different than in Metro Vancouver.

1.3 PLASCO ENERGY GROUP

Plasco Energy Group, herein referred to as Plasco, is a privately held company based in Ottawa, Ontario. Plasco considers itself a "waste conversion and energy generation" company, whose "world-leading technology" heralds the end to land-filling, providing a new source for "renewable energy."

With funding from groups such as First Reserve Corp., Plasco has attracted $90 million in investment funding over the last three years. With this funding completed, Plasco has been aggressively promoting its proposed technology to municipalities across North America.

Plasco's patented technology is extremely new and there are no existing Plasco facilities running at the type of processing capacity that is required to service a municipality. Plasco has only operated "research facilities" in Spain and Ottawa, and is currently operating a commercial demonstration project in Ottawa.

1.4 PLASCO'S OTTAWA DEMONSTRATION PROJECT

Plasco's demonstration project in Ottawa, located at the Trail Road Landfill, is operated under a partnership between Plasco and the City of Ottawa. The facility has been in operation since January 2008. Plasco agreed to finance the construction and operation of the plant (with assistance in the form of funding from a federal grant program and the Ontario government) and to remove the facility if the demonstration project is unsuccessful. The City of Ottawa provided the site for the facility and agreed to a tipping fee of $40/tonne.

As Plasco's facility was classified as a demonstration project, it was exempted from most aspects of the Ontario Ministry of Environment's Environmental Assessment process, including public hearings. The facility did necessitate air and waste approval permits, as required by the Environmental Protection Act. Under these permits, the facility is permitted to process up to 75 tonnes/day of regular MSW and up to 10 tonnes/day of "Consistent Carbon Feed (CCF)."[3] The CCF is largely comprised of Types 3,4,5,6 and 7 plastics (which Plasco refers to as "non-recyclable plastics") and shredded tires, which the City of Ottawa agreed to provide since it does not currently have a strong market for these products. The CCF is included to dampen the energy fluctuations of

[2] Metro Vancouver, 2008.
[3] Ministry of Environment (Ontario), 2006.

typical MSW and to boost the BTU content of the MSW, though Plasco is confident that a CCF will not be required in the future, and that typical MSW will suffice to meet its electricity production predictions.

Every month a professional engineer, who is not an employee of Plasco, visits the site to observe and report on its operations and to verify compliance with all relevant provincial permits. Most of these seven reports, which are publicly available on the demonstration project's website, state that "waste handling and waste inventory show minimal quantities processed during this month of operations."[4] In the month of May 2008, for example, the average daily quantity of MSW processed at the facility was 4.5 tonnes, less than one-tenth of the 75 tonnes allowed by the permits and less than what Plasco implies the facility has processed. As a result, very little electricity has been produced and sold to the grid. Plasco's Ottawa website, for example, states that 5.1 MWh have been produced from the 85 tonnes of waste that have been processed. This is an average of .06 MWh/tonne of waste processed, which is a far cry from the 1 MWh/tonne of waste processed that Plasco promises.

Plasco reports that a "series of operational changes has affected [the facility's] ability to ramp up production rates."[5] Constant maintenance and upgrade activities have limited the facility's ability to process a significant quantity of waste. At the same time, some observers have cautioned that the content of the MSW being processed is not clearly defined and is not independently verified to be 'typical MSW'. The waste being processed, and the resulting air emissions data, may therefore not be an accurate representation of an actual commercial-scale facility processing the type of MSW available in Metro Vancouver.

While this facility was designed to demonstrate the benefits of Plasco's technology, it is hard to draw conclusions on the technology's environmental or economic performance since so little MSW has actually been processed in the six months since the facility began operating. At this point it is still unclear whether Plasco's predictions concerning energy production and air emissions are realistic. More time will be needed before Plasco's claims can be proven or disproven by a real operational track record.

1.5 THE PLASMA GASIFICATION TECHNOLOGY

The plasma gasification technology that Plasco operates is different from traditional mass-burn incinerators, as it converts MSW into a synthetic gas (syngas) which is 'cleaned' and then used to run internal combustion engines that produce electricity. Alternatively, traditional incinerators such as the Burnaby WTE facility typically convert MSW into steam, which holds less energy potential than a refined gas such as syngas. Whether or not a plasma gasification plant is considered an "incinerator," however, is simply a matter of semantics, though Plasco does not use the term.

Figure 2, on opposite page, illustrates the different stages of the Plasco conversion process. As explained by Plasco, MSW is first shredded into uniform-sized pieces. Large metal objects, such as white goods and bicycles, are removed to be sold as scrap metal. The shredded waste is fed into the conversion chamber, along with air and steam. Air is then passed over a strong electrical current to produce plasma, an ionized gas that exceeds 8000 C. The MSW is gasified by this heat and reduced to its component molecules (primarily carbon monoxide, hydrogen, tars and un-reacted carbon). Once this gas passes into a secondary chamber, it is refined using plasma heat and process air to produce a cleaner and lighter gas. Plasco claims that this process destroys all long-chain hydrocarbons, which is why it predicts that no dioxins or furans will be created by the process if the facility is operating as expected.

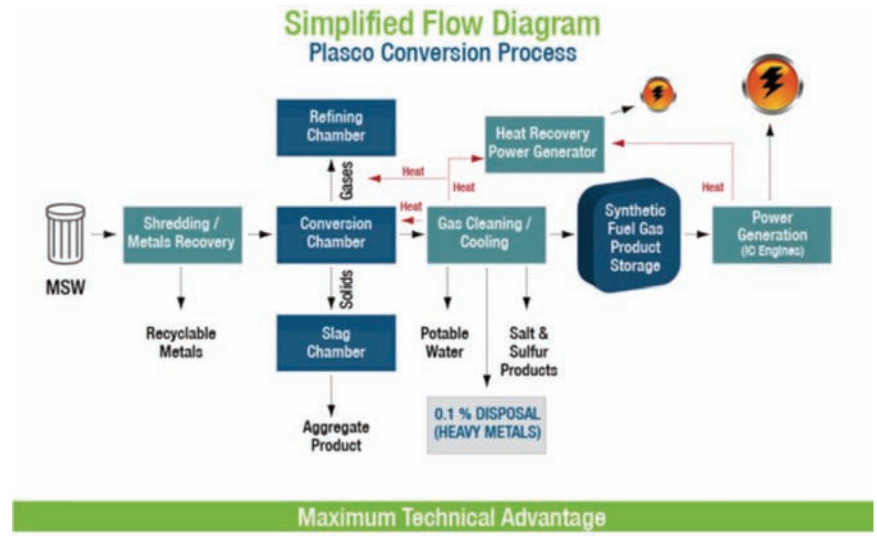
The solid waste left over from the conversion process is sent to a separate chamber where it is melted by another plasma torch. Volatile compounds are removed and the solids are stabilized by plasma heat. The resulting volatile gases are removed, cleaned and combined with the main gas stream. The melted material is cooled in a water bath and formed into solid pellets. This solid residue is further described and discussed in section 2.4.

The gas that is produced in the conversion chamber is 'cleaned' by passing it through a heat- recovery unit before it is cooled and particulates, metals, and acid components are removed. Sulfur and salt are the byproducts of this process, and are further described and discussed in section 2.4. The cooled gas then enters a storage tank that blends the gases together to achieve consistent gas quality. These gases are then fed into an internal combustion engine that powers a generator to produce electricity. This electricity is used to operate the processing plant, with any leftover electricity sold to the grid. Waste heat captured from the engines and from the MSW conversion process can be used to produce more electricity.

[4] Decommissioning Consulting Services Limited, 2008.
[5] Plasco Energy Group - A Partnership for a Zero-Waste Ottawa Website, 2008.

Of main importance is that the Ottawa demonstration project has yet to run at capacity for an extended period of time. Further, the facility has not processed significant quantities of MSW and has produced very little electricity. The process described above is simply the theory behind Plasco's technology which, as of yet, has not been proven at a commercial scale.

Figure 2 Simplified Flow Diagram—Plasco Conversion Process



Source: Plasco Energy Group website at www.plascoenergygroup.com

1.6 PLASCO'S PROPOSAL TO METRO VANCOUVER

Plasco is attempting to portray its technology to Metro Vancouver staff and elected officials as the waste management option with the maximum economic benefit and the minimum environmental impact. As proposed by Plasco, the company would finance the construction and operation of the plant itself. The region is not responsible for this initial capital cost, however it would be responsible for providing a suitable physical site for the plant. Criteria for such a site include approximately 2.4 ha of land in a rural, light-industrial or commercially zoned area that is able to accommodate 400 tonnes of MSW per day. Plasco claims that if the facility does not meet the environmental standards agreed to in the contract, the company would finance the removal of the plant and would return the land to its "original state."

The contract between Plasco and Metro Vancouver would be set for an initial 20 years, and would lock in a tipping fee that would increase by half the rate of inflation every five years. Plasco estimates that the cost of the tipping fee would range from $65 to $89 per tonne. The tipping fee rate depends on the price achieved for the electricity sold to the grid and is dependent on whether the produced electricity is classified as "green electricity" by BC Hydro. In Ontario, where the electricity Plasco will produce is classified as 'green' and nets 11 cents per kWh, the tipping fee was set at $65/tonne. If the electricity is not classified as 'green' and is priced at the normal 9 cents per kWh, the tipping fee will likely be closer to $89/tonne. For comparison, the Vancouver Landfill, Cache Creek Landfill and the Burnaby WTEF all currently charge a $65/tonne tipping fee. The Plasco contract would also include a revenue-sharing agreement, whereby Metro Vancouver would be entitled to 25% of the increased revenue from electricity sales if the price for electricity paid by BC Hydro increases at any point after the contract is signed.

A Plasco facility is designed in modular units that are each capable of processing approximately 100 tonnes of MSW a day. The company is proposing to build one or more facilities with a minimum MSW feed of about 200 tonnes per day, though it is hoping to build facilities with a 400 tonne per day capacity. According to Plasco, the company "fully supports recycling initiatives" and does not mind if the waste stream decreases during the contract period, as long as the municipality gives Plasco one year to prove that their technology cannot match the "environmental performance" of the diversion program. It is unclear, at this point, how this performance would be determined and verified. The methodology used for this process would obviously change the outcome significantly, and Plasco has not yet provided details on how this process would occur.

Since the facilities are designed in modular units, the company claims that it will simply disconnect and dismantle one of the units if the waste stream decreases. Plasco does, however, reserve the right to import MSW from other jurisdictions to make up for any MSW shortfalls within the region. Plasco is confident that there will be more than enough MSW to power their proposed facilities, even if Metro Vancouver's diversion rates increase in the future, given the projected increases in population in the region.

2.0 ENVIRONMENTAL PERFORMANCE

Plasco has made extremely ambitious claims about its technology, asserting that its environmental performance far exceeds that of landfills and other WTE facilities. The company refers to its technology, for example, as a "net negative source of climate-changing greenhouse gases" and claim that its facilities have "no harmful emissions." The objective of this section is to critically examine Plasco's environmental performance claims and to compare Plasco's technology, and WTE in general, with other waste management scenarios through the lens of specific environmental criteria. While many comparisons are made between landfills and WTE facilities, which mirrors the way Plasco and Metro Vancouver have attempted to frame the debate, it is important to note that these disposal options do not constitute the only two waste management options available to Metro Vancouver, as will be discussed in Section 2.5.

2.1 AIR CONTAMINANTS AND EMISSIONS

The release of harmful air emissions from WTE facilities is a common concern among critics of incineration. These emissions can be sourced to items in the MSW stream, such as batteries, which when incinerated result in the release of heavy metals into the atmosphere (including mercury, lead and cadmium). If these same items are landfilled, the heavy metals still exist, but many are buried instead of released into the air. Other more serious contaminants such as dioxins and furans are a direct byproduct of the combustion process in a WTE facility. WTE technology has improved steadily over the last few decades in relation to air emissions. New technologies have been applied to older facilities to reduce the release of airborne pollutants, and recently constructed incinerators , including many in Europe, produce significantly lower emission levels than older facilities.

In the context of the Lower Mainland, the majority of the airborne pollution from Metro Vancouver blows east on prevailing winds where it settles in the Fraser Valley. Elected officials in the area, including Abbotsford Councilor Patricia Ross, have initiated a campaign to oppose Metro Vancouver's WTE plans, citing the cumulative effects new WTE plants would have on the region's air quality. Already, children in the Fraser Valley present higher rates of asthma and other breathing difficulties than their cohorts in the western parts of the Lower Mainland.

2.1.1 Concentration Based Emissions

Plasco has attempted to distance itself from the controversy surrounding incinerators and air pollution by branding its technology as intrinsically different, clean, safe and environmentally benign. The company asserts that its technology creates "no adverse impacts to land, air, and water." It also repeatedly makes the claim that it converts waste into energy "without air emissions." This claim, while technically true if the technology works as predicted, is misleading. A Plasco facility creates no air emissions *during the conversion process*, whereby MSW is converted into syngas, since this process is completely contained. However, air emissions occur from the facility when this syngas is burned in the internal combustion engines to create electricity. This distinction, while perhaps important from a mechanical standpoint, makes little difference to citizens and policy makers who are concerned about total net releases of pollution into the local airshed.

Plasco also claims that the emissions from its facilities are minimal, given that the syngas is cleaned before it is burned in the engines, as described in section 1.5. Consequently, the company promises emissions levels far below any other WTE technology currently in operation and far below the province of B.C.'s regulatory limits.

Table 1 outlines the air emissions standards that Plasco argues its technology will meet, as listed by common air pollution parameters. "Plasco's Operational Limit in Ontario" refers to the limits that were placed on Plasco's demonstration facility in Ottawa by the Ontario Ministry of Environment, as outlined in Appendix A of their Certificate of Approval for Air. For each of these parameters, excluding lead, the operational limits are stricter than British Columbia's current provincial regulations. "Plasco's Predicted Performance" refers to the level of emissions that Plasco claims its technology will be able to meet. Finally, the "Ottawa Facility's Actual Performance" column lists the emission levels reported by Plasco on its Zero Waste Ottawa website. Plasco reports a weekly average of emissions for Nitrogen Oxides, Hydrogen Chlorides, Sulphur Dioxide and Organic Matter from its Continuous Emissions Monitoring system at the Ottawa demonstration project site. These numbers are expressed as an average of the

Plasco…promises emissions far below any other WTE technology…and far below the province of B.C.'s regulatory limits.

weekly levels reported from February 12, 2008 to June 23, 2008. Numbers have not yet been released for the other parameters.

It is difficult to draw any definite conclusions from the numbers listed in Table 1. While Plasco has made ambitious predictions about the levels of emissions their facilities will achieve, that are well below current regulatory limits, these predictions have yet to be proven through the actual processing of commercial quantities of MSW. Of the four parameters that Plasco has reported to date, two are approximately twice the level Plasco predicts it will be able to meet and two are roughly half the level Plasco predicts. Because the facility has been operating for less than half a year, and since so little MSW has actually been processed, these numbers are not yet statistically significant. For many of the other parameters, such as mercury and lead, testing results have not yet been reported and it is impossible to know whether or not Plasco's expected air emission levels are realistic.

Since the creation and release of dioxins and furans has remained one of the most controversial aspects of WTE, it is of particular importance to note that Plasco claims its process will not release any of these carcinogenic particles during normal operations. Plasco argues that its conversion process breaks down waste to the atomic level and operates without oxygen present in the "air-starved conditions" of the conversion chamber. Therefore, it is argued that dioxins and furans will not be formed or released. Critics such as Dr. Paul Connett point out, however, that it is impossible to assume that oxygen will not enter the system, as oxygen is often present in typical MSW items such as empty pop bottles. Plasco does note that "during equipment or process malfunctions, dioxins may be formed until the equipment is shut down, or until the process is stabilized. During these short and infrequent transition periods, the facility may produce 0-30 picograms/Nm^3."[6] If a Plasco facility is able to operate at a commercial level without creating and releasing dioxins/furans, WTE technology will have changed dramatically. Until this claim can be verified with emissions reporting from the Ottawa demonstration project and accurate data from an actual commercial facility these predictions will remain contested.

Table 1 – Plasco Air Emissions by Concentration

Parameter	Unit	Plasco's Operational Limit in Ontario	Plasco's Expected Performance	Ottawa Facility's Actual Performance
Nitrogen Oxides	ppmv	110	20	45
Hydrogen Chloride	ppmv	13	2	.9
Sulphur Dioxide	ppmv	14	4	9
Organic Matter	ppmv	75	25	10.6
Mercury	mg/m^3	.02	.0005	
Cadmium	mg/m^3	.014	.001	—
Lead	mg/m^3	.142	.012	—
Dioxins and Furans	ng/m^3	.041	0.00000	—

Source: Plasco Energy Group – Zero Waste Ottawa Website and personal communication

2.1.2 Total Emissions in the Lower Mainland

While it is useful to quantify and compare concentration-based emissions data, those concerned with the air quality impacts of new WTE facilities are generally more interested in the net im-

[6] Plasco Energy Group, 2005.

pact of new facilities on the region's air shed. Since WTE facilities would represent a new and additional source of air pollutants in the Lower Mainland, it is important to quantify the total net emissions that these facilities would contribute.

Figure 3 below outlines the sources of Particulate $Matter_{2.5}$ that Metro Vancouver would be releasing in the year 2020 if the proposed WTE facilities were operating. In this scenario, solid waste operations would be responsible for about 0.26% of total Particulate $Matter_{2.5}$ produced in the region. Figure 4 illustrates that under the same assumptions solid waste operations would be responsible for about 0.5% of NOx releases in 2020. These percentages are extremely small when compared to sources such as heating, transportation and cement production. While the new emissions may seem statistically insignificant, air quality is already a concern in the region, and the issue of adding new sources of emissions remains controversial.

7 Environment Canada, 2008.

2.1.3 Landfills and WTE Compared

In the debate over WTE and air emissions, the fact that landfills are also a significant source of airborne pollutants is often ignored or forgotten. At modern landfill sites methane is often collected, flared, and burned to produce energy and reduce the release of greenhouse gases. Both the Vancouver Landfill and the Cache Creek Landfill have such systems in place and it is assumed that if Metro Vancouver decided to expand its landfill capacity instead of constructing WTE facilities, these landfills would also have gas collection systems. Landfill gas systems often release many of the same pollutants as do WTE facilities, including heavy metals and dioxins. The Vancouver Landfill's gas collection system, for example, released 191 tonnes of carbon monoxide, 37 tonnes of nitrogen oxides and .54 tonnes of Particulate $Matter_{10}$ in 2006.[7]

While both landfills and WTE facilities are significant sources of air pollutants, they are unlikely to produce the same quantity of pollutants per tonne of MSW disposed. When weighing the merits of various waste management options, it is therefore important to compare landfills and WTE facilities according to their air pollutant releases. Metro Vancouver released a report in 2008 entitled *Environmental Life Cycle Assessment of Solid Waste Management: Evaluation of Two Waste Disposal Scenarios for the Metro Vancouver Region* that employed life cycle analysis principles to compare a hypothetical landfill scenario with a WTE scenario. In the report the hypothetical landfill is located in an arid climate 750km from Vancouver, has a total capacity of 50 million tonnes and an annual operating capacity of 750,000 tonnes. It also has a landfill gas collection system with a 65% capture rate. The hypothetical WTE facility has an annual operating capacity of 750,000

Figure 3 – $PM_{2.5}$ Emissions in 2020

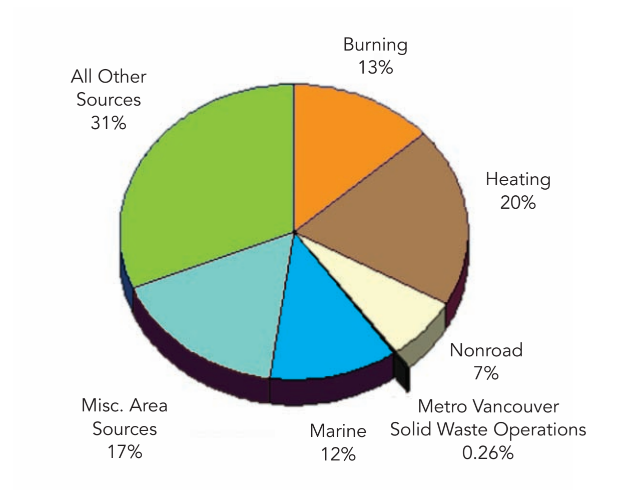
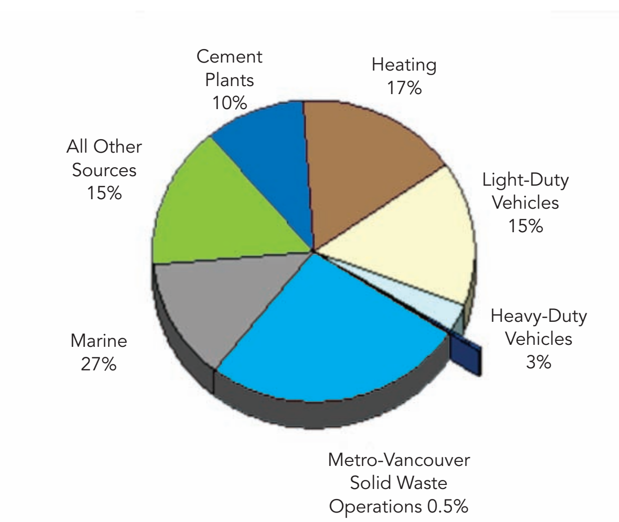


Figure 4 – N0x Emissions in 2020



Source: Fred Nenninger Presentation to RCBC Conference, June 26, 2008 – Metro Vancouver Solid Waste Management Plan Development tonnes, employs mass-burn technology and meets the emission control levels of modern facilities in Europe, which are considerably better than the current Burnaby WTE facility. In this hypothetical example, which was designed to realistically model two of Metro Vancouver's future waste disposal options, it was shown that there is no clear "winner" between landfills and WTE facilities in terms of air pollutants.

Table 2 illustrates some of the results from this report. According to this analysis, a WTE facility produces and releases much higher levels of heavy metals such as mercury, cadmium and lead. Landfills, however, release almost two thirds as many dioxins as a WTE facility. For other important air pollution parameters, such as nitrogen oxides, particulate matter and carbon monoxide, a landfill with a gas collection system actually releases more pollutants. Many of the numbers for the WTE scenario would be considerably lower if Plasco's technology was selected and if it worked according to company claims. However, since these numbers are not yet proven the comparison in Table 2 is considered more valid because it relies on real data in its analysis from actual operating facilities. It is important to note that in this analysis, the landfill emissions would be located outside of the Lower Mainland air shed while the WTE emissions would be located within the Lower Mainland air shed.

Landfills with gas collection systems produce many of the same pollutants as WTE facilities. Whether or not a WTE facility emits more pollutants than a landfill is primarily a function of the parameter that is studied. Researchers weigh different categories of air pollutants differently according to their health and ecosystem impacts, though there is no consensus as to how these pollutants should be contrasted. *Air pollution, therefore, is a waste disposal problem, not a WTE problem.* New WTE facilities would certainly contribute a new source of air pollution to the Lower Mainland, but so would a local landfill that dealt with this same quantity of waste. If Plasco's technology can achieve the emission levels the company predicts, these emissions could be reduced, but not eliminated.

Table 2 – Air Emissions: Landfill Scenario vs WTE Scenario

Parameter	Unit	Landfill Scenario	WTE Scenario
Nitrogen Oxides	g/tonne of MSW	470	190
Sulphur Oxides	g/tonne of MSW	56	84
Carbon Monoxide	g/tonne of MSW	6,100	90
Particulate $Matter_{10}$	g/tonne of MSW	13	3
Mercury	mg/tonne of MSW	0.347	31.9
Cadmium	mg/tonne of MSW	-0.024	4.11
Lead	mg/tonne of MSW	6.46	48.56
Dioxins	g/tonne of MSW	.019	.032

Source: The Sheltair Group, 2008, Environmental Life Cycle Assessment of Solid Waste Management: Evaluation of Two Waste Disposal Scenarios for the Metro Vancouver Region.

2.2 GREENHOUSE GAS EMISSIONS

Waste disposal systems are a significant source of greenhouse gas (GHG) emissions. Metro Vancouver estimates that in 2005, its solid waste program was responsible for 272,000 tonnes of GHGs, or about 93% of the emissions from government operations.[8] Since Metro Vancouver has set a GHG reduction target of 33% by 2020 and 80% by 2050, reducing the level of GHG from the waste management system is critical to the success of the region's climate change strategy.

Both the proponents and the critics of WTE have made extravagant claims about the GHG intensity of WTE facilities. Plasco, for example, argues that its facilities are a net-negative source of GHGs since they offset more emissions than they produce. On the other hand, a recent report by anti-incinerator groups claims that WTE facilities emit more CO_2 per megawatt-hour than a coal-fired plant. Clearly, both of these claims cannot be true. Sorting out the difference between these two claims requires an understanding of two controversial aspects of GHG accounting; biogenic carbon and avoided emissions.

2.2.1 The Biogenic Carbon Debate

Two types of carbon are present in MSW; fossil carbon and biogenic carbon. Fossil carbon is carbon that has its origin in fossils, and is most notably present in MSW in the form of plastics. Biogenic carbon is created by the growth of plants and animals and is present in MSW in the form of wood, paper, plant waste, food waste and rubber. When MSW is sent to a landfill, fossil carbon is buried and not released into the atmosphere. Biogenic carbon is released as landfill gases such as carbon dioxide (CO_2) and methane, which is 21

[8] Nenninger, 2008.
9 Sheltair Group, 2008

times more potent a GHG than CO_2. When the methane is collected and burned, it is converted to CO_2 and released. Nitrous oxide is also released when the landfill gas is combusted, which is 310 times more potent than CO_2. When MSW is processed in a WTE facility, both biogenic carbon and fossil carbon are converted to CO_2 and released into the atmosphere.

The International Panel on Climate Change (IPCC) estimates that biogenic carbon constitutes about 60% of the carbon in MSW.[9] Since biogenic carbon constitutes such a high percentage of the total carbon in MSW, the inclusion or exclusion of biogenic carbon releases in the GHG accounting system of a waste disposal facility will change its total GHG estimate considerably. Whether or not these releases should be included, however, is controversial.

In most GHG emissions inventories, the release of biogenic carbon into the atmosphere in the form of CO_2 is generally not counted as a GHG. Biogenic carbon that is converted to methane, however, is considered a GHG. Biogenic CO_2 is excluded as it is considered part of the natural carbon cycle, since these plants would have released the same quantity of CO_2 if they had broken down in a natural ecosystem instead of in a waste disposal facility. In a forest, for example, a tree consumes CO_2 while it is alive and releases it when it dies. When another tree grows to fill its place, it consumes CO_2 and the quantity of CO_2 in the atmosphere remains unchanged. Forests, however, are not being reforested at the same rate at which they are being converted into products such as wood and paper. As the globe's forests shrink in biomass, this carbon cycle is broken and the consumption of goods like wood and paper becomes a net source of CO_2 emissions.

The IPCC, in its 2006 Guidelines for National Greenhouse Gas Inventories, concludes that biogenic CO_2 releases from incinerators should not be included in the Energy section of a country's GHG accounts. Any decrease in biomass that is causing net releases in carbon should be included in the Agriculture, Forestry and Other Land Use (AFOLU) section of that country's inventory.[10] This basic distinction is why proponents of WTE facilities and many neutral observers assume that biogenic releases of CO_2 from WTE facilities should not be included in their total emission counts.

The distinction that the IPCC outlines, however, only makes sense on a national level, since the biogenic emissions ignored in the Energy section are compensated for in the AFOLU section. When attempting to quantify and compare the emissions from an actual facility all *net* releases of GHGs should be included, since it does not matter if they are also included in another sector of the economy's GHG inventory. The purpose is not to create a national inventory without duplication, which is what the IPCC guidelines were designed to support, but to quantify and compare the emissions from specific waste management options. Therefore, it is incorrect to ignore the biogenic releases of CO_2 from a waste disposal facility as Plasco has done. It may also be incorrect to include *all* of the biogenic releases of CO_2 in a facilities emissions count, as some opponents of WTE have done in recent reports. One possible compromise is to include only the *net* increase in biogenic releases (equal to the net rate of biomass loss) which are GHGs.

For example, if 10% of the organic waste (wood, paper, plant waste etc.) entering a WTE facility comes from forests that are not replanted, the argument can be made that 10% of the biogenic carbon emissions should be counted. Put another way, if the consumption of certain organic goods such as wood and paper leads to a net biomass decline of 10% in the forests from which these goods were extracted, 10% of the biogenic releases that a WTE facility emits when these goods are processed in MSW should be included in that facility's GHG inventory. While this is a hypothetical example, it provides one possible method of estimating a WTE facility's true biogenic emissions. The difficulty, is to estimate the percentage of organics that come from sources experiencing net biomass loss, and to estimate the rate at which that biomass is declining. Unfortunately, since most waste management literature assumes that all biogenic releases should be ignored, these issues have not been adequately explored. Therefore, while it is important to not ignore the biogenic carbon releases from a waste management facility, little guidance exists to assist us in estimating what the actual net biogenic GHG emissions are from that facility.

What is often forgotten in this debate is that landfills also emit biogenic carbon in the form of CO_2, typically in the conversion of methane to CO_2 when the facility's gas is collected and burned. As such, a fair comparison between the two waste disposal options would either include or exclude biogenic releases in the GHG estimates of each type of facility.

These unresolved questions and conflicts concerning biogenic carbon are one of the major reasons there is such a large discrepancy between the GHG emissions that the opponents and proponents of WTE estimate a given facility will produce.

[10] See IPCC, 2006.

Air pollution is a waste disposal problem, not a WTE problem. New WTE facilities would certainly contribute a new source of air pollution to the Lower Mainland, but a local landfill that dealt with this same quantity of waste would do so as well.

2.2.2 Avoided Emissions

Another equally controversial and potentially misleading component of a WTE facility's GHG emissions count is the issue of avoided emissions. When a WTE facility produces electricity that is sold on the provincial grid, this displaces some other form of power on the grid. Whatever GHG emissions this displaced power usually emits, therefore, can be discounted from the total emissions count of the WTE facility. The controversy lies in determining the GHG intensity of the power that the WTE facility is displacing. This is a question that is highly contested. If, for example, a WTE facility displaces only coal-fired power imported from Alberta (which Plasco assumes would be the case), this would displace about 900 tonnes of $C0_{2e}$ per GWh of energy produced.[11] If instead, the WTE facility was displacing the average GHG intensity of electricity produced in BC, the facility would only displace about 33 tonnes of $C0_{2e}$ per GWh of energy produced.[12] Determining which GHG intensity figure a unit of power produced by a WTE facility is displacing will obviously make a large impact on that facility's total emissions count, but the final decision on what number to use is, at this time, open to debate and interpretation.

Plasco also claims that they will be able to achieve offsets by producing heat that can be sold and used as district heating, thereby achieving additional offsets. These offsets are factored into their advertised GHG figures.

2.2.3 Plasco's GHG Emissions Claim

Plasco has claimed that its facilities would be net GHG negative. For every tonne of MSW processed, the company asserts that 0.6 tonnes of $C0_{2e}$[13] will be released from its facility (through the conversion of fossil carbon to CO_2), 1.5 tonnes of $C0_{2e}$ will be displaced through avoided methane emissions that would have occurred if the waste had been landfilled, and 1.4 tonnes of $C0_{2e}$ will be displaced by avoided emissions from power displacement on the provincial grid. Plasco claims that processing one tonne of MSW would result in a net displacement of 2.3 tonnes of $C0_{2e}$. This claim is based on three basic assumptions, each of which is refuted below.

1) Plasco's estimate of GHG releases does not include biogenic CO_2 releases. Their estimate that each tonne of MSW would produce 0.6 tonnes of $C0_{2e}$ includes only non-biogenic sources of carbon (fossil carbon). As outlined in section 2.1.1, biogenic carbon is a significant source of GHG releases from a WTE facility, and while not all of these releases should be included in an emissions inventory, a portion of them should be. To exclude all biogenic emissions leads to a GHG estimate that is unrealistically low.

2) Plasco's claim that 1.5 tonnes of $C0_{2e}$ will be displaced for each tonne of waste managed through avoided methane emissions that would have occurred if the waste had been landfilled is not applicable in the context of Metro Vancouver. Only landfills without a landfill gas collection system would emit the quantity of methane required to produce this estimate of $C0_{2e}$. Methane is currently collected and burned at both the Vancouver and Cache Creek Landfills and it is assumed that if Metro Vancouver expanded landfill capacity instead of building WTE facilities, these landfills would employ similar, if not improved, landfill gas technology. A modern landfill that employs a landfill gas collection system emits about 400 kg of CO_2 per tonne of waste managed, primarily through escaped methane.[14] This number assumes a methane capture rate of about 65%. While some experts have claimed that higher capture rates are possible, 65% remains a realistic estimate. Needless to say, Plasco's claim that 1.5 tonnes of $C0_{2e}$ will be displaced through avoided methane emissions is rather inflated. At the same time, if Metro Vancouver initiates a serious organics diversion program, as it is currently planning, the amount of methane that the region's MSW is capable of producing in a landfill will decline significantly, further widening

[11] Sheltair Group, 2008.
[12] Ibid.
[13] Equivalent Carbon Dioxide
[14] Sheltair Group, 2008.

the gap between the real avoided methane emissions and Plasco's claim.

3) Plasco's claimed power displacement figure is based on its facility replacing 100% coal-fired power, which Plasco estimates produces about 1,000 tonnes of $C0_{2e}$/GWh. This figure is entirely unrealistic in the context of B.C.'s energy reality. Coal-fired power, which is currently imported from Alberta, makes up a small percentage of the power on B.C.'s grid. B.C. currently imports and exports power, according to ever-changing market conditions and fluctuating water-levels behind the province's major dams. It is unrealistic to assume that the relatively minor quantity of power produced by a WTE facility would have any bearing on whether or not Alberta's coal-fired power is added to B.C.'s grid. At the same time, B.C.'s long-term energy plan is to be entirely energy self-sufficient by 2016.

A more realistic way to quantify the GHG savings from the power displaced by a WTE facility is to consider the GHG intensity of the province's consumption average, which has been estimated at 87 tonnes of $C0_{2e}$/GWh.[15] This figure is the weighted average of the energy that is both produced and imported into B.C. and represents the GHG intensity of the average power on B.C.'s grid. Since Plasco's analysis assumes that the produced power from a Plasco facility will displace power with a GHG intensity of 1,000 tonnes of $C0_{2e}$/GWh, instead of a more realistic figure such as 87 tonnes of $C0_{2e}$/GWh, their GHG predictions are, at best, misleading.

Section 2.2.5 below outlines a more realistic evaluation of the GHG emissions from a modern WTE facility, and compares these emissions with those of a modern landfill.

2.2.4 The Critics' GHG Emissions Claim

While the GHG quantities published by Plasco are grossly underestimated, the GHG estimates of some WTE opponents are potentially overestimated. In a recently released report entitled *Trashing the Climate*, written by representatives from prominent anti-incinerator groups such as Eco-Cycle and the Global Anti-Incinerator Alliance, the authors claim that processing MSW in a WTE facility emits more GHGs per unit of power produced than a coal-fired plant. The authors arrive at this conclusion by including 100% of biogenic carbon emissions in their GHG count.

Section 2.2.1 above outlined the rationale behind including biogenic carbon emissions in the GHG analysis of a WTE facility. While it may be incorrect to exclude all of a facility's biogenic emissions, it may also be incorrect to include *all* of a facility's biogenic emissions. Again, the difficulty is in knowing what percentage of biogenic emissions to include, as so little professional guidance is available on this question. Since biogenic carbon represents about 60% of the total carbon in MSW, including all of this carbon when it is converted into CO_2 will clearly increase the total GHG count by a significant amount.

In summary, analysis that includes all biogenic CO_2 in the calculations of a facility's GHG emissions, such as that contained in the report *Trashing the Climate*, may arrive at an overestimated GHG figure.

2.2.5 Landfills and WTE Compared

While both the strongest proponents and the most vocal opponents of WTE tend to provide GHG estimates that are unrealistic, determining the actual GHG intensity of a WTE facility is fraught with difficulties. Many of the same difficulties exist when attempting to calculate the GHG emissions from a landfill. However, extremely generalized comparisons can be made between the two waste disposal options. While the numbers may not be exact given the large number of assumptions that must be made prior to any calculation, comparisons are still valid.

The most thorough and independent analysis of the GHG intensity of WTE facilities and landfills that is directly relevant to the Lower Mainland is the aforementioned report commissioned by Metro Vancouver entitled *Environmental Life Cycle Assessment: Evaluation of Two Waste Disposal Scenarios for the Metro Vancouver Region*. This report considers the entire life cycle GHG emissions of a landfill and a WTE facility, including emissions from the construction of the facilities, transportation of the MSW to the facilities, the operations of the facilities and the avoided emissions from the power sold onto the provincial grid from both facilities. It should be noted that under the WTE scenario, it is assumed that the waste is hauled an average of 25 km from its source to the WTE facility. This distance increases, along with expected GHG emissions, if waste is imported from other communities, which is possible under Plasco's proposed contract (see Section 1.6).

If one ignores the issue of avoided emissions momentarily, since this issue is so controversial, the calculations show that the GHG intensities of these

[15] Ibid.

While 1.3 kg of heavy metals per tonne of MSW processed may not seem like a large quantity, this represents the production of about 520 kg of heavy metals a day… or about 190 tonnes a year.

two disposal options are remarkably similar. The report estimates that both a landfill and a WTE facility emit just over 400 kg of $C0_{2e}$/tonne of MSW. In a landfill the vast majority of these emissions are from escaping methane and in a WTE facility the majority of these emissions are from the conversion of fossil based carbons in plastics into CO_2. Even though this particular report examines the emissions from a traditional mass-burn WTE facility, these numbers are relatively similar in a Plasco facility. Since the majority of the WTE facility's emissions are derived from the combustion of plastics, this number will only change with the quantity of plastics in the MSW, and is not a reflection of the type of WTE technology. In other words, *if the issue of avoided emissions is ignored, the total life cycle GHG emissions, expressed as $C0_{2e}$/tonne of MSW disposed, is almost identical whether the waste is disposed of in a landfill, processed in a traditional mass-burn incinerator or processed in a Plasco facility.*

Once avoided emissions are included, however, the different technologies begin to diverge in GHG intensity. A landfill with a landfill gas capture system is able to produce energy that, when added to the provincial grid, results in avoided emissions from the displaced provincial power. The Metro Vancouver report assumes that any power displaced from the grid has a GHG intensity of 87 tonnes of $C0_{2e}$/GWh, which represents the provincial consumption average estimated by the report's author. A landfill, therefore, would displace about 55 kg of $C0_{2e}$/tonne of MSW. When this number is subtracted from the GHG intensity total of landfilling, the report concludes that a landfill emits about 370 kg of $C0_{2e}$/tonne of MSW. Since a traditional mass-burn WTE facility is able to produce more power, it is able to displace about 145 kg of $C0_{2e}$/tonne of MSW, resulting in a total GHG intensity estimate of 290 kg of $C0_{2e}$/tonne of MSW.

Plasco claims that its technology will be capable of producing about two times more energy per unit of waste processed than a traditional WTE facility. This claim, however, remains unproven, as section 2.3 will discuss. If a Plasco facility proves capable of generating this quantity of power, and the assumptions that guides the Metro Vancouver report remain valid, a Plasco facility will be considerably less GHG-intensive than either a landfill or a traditional WTE facility. If a Plasco facility is able to produce twice as much power as a traditional incinerator, it will displace twice as many GHGs from the provincial grid. As such, an additional 145 kg of $C0_{2e}$/tonne of MSW can be subtracted from the traditional WTE facility's GHG estimate to calculate a Plasco's facility's GHG intensity, since the quantity of displaced emissions can be doubled. According to these calculations, a Plasco facility would, therefore, produce approximately 145 kg of $C0_{2e}$/tonne of MSW[16]. When compared to the 370 kg of $C0_{2e}$/tonne of MSW from a landfill, and the 290 kg of $C0_{2e}$/tonne of MSW from a traditional WTE facility, the estimated GHG intensity of the proposed Plasco technology appears to be lower.

Extreme caution is advised before drawing hard conclusions from these numbers since they are based on a large number of assumptions. Plasco's Ottawa demonstration project has not yet proven that the technology is capable of producing the quantity of energy required to offset the emissions assumed in the above calculations. The Metro Vancouver report also excluded emissions derived from biogenic carbon in its calculations. Since both a landfill (through methane that is captured and converted to $C0_2$) and a WTE facility produce emissions from biogenic sources it is assumed that comparisons between the two disposal options were still statistically valid. While the general

[16] 290 kg of $C0_{2e}$/tonne of MSW (total GHG intensity estimate of a traditional WTE facility) - 145 kg of $C0_{2e}$/tonne of MSW (quantity of emissions displaced by a traditional WTE facility) = 145 kg of $C0_{2e}$/tonne of MSW (total GHG intensity estimate of a Plasco facility).

[17] The report included biogenic CO_2 emissions in Appendix B and concluded that the WTE scenario produces about twice as many biogenic CO_2 emissions as the landfill scenario. If 100% of biogenic CO_2 emissions are included, the landfill scenario will produce about 617 kg of CO_{2e}/tonne of MSW and the WTE scenario will produce about 875 kg of CO_{2e}/tonne of MSW. If, instead, 10% of biogenic CO_2 emissions are included, as in the hypothetical example illustrated in section 2.2.1 above, the landfill scenario will produce about 395 kg of CO_{2e}/tonne of MSW and the WTE scenario will produce about 349 kg of CO_{2e}/tonne of MSW.

comparison is valid, the actual numbers are not since they do not include any biogenic releases.[17]

In addition, the quantity of methane produced and captured at a landfill and the quantity of plastics in the MSW stream are both difficult to estimate under present conditions and impossible to predict into the future. Metro Vancouver, for example, is planning to introduce a comprehensive organics collection and composting system. This will reduce the quantity of organics in the MSW stream and subsequently reduce the methane emissions from landfills, resulting in a lower GHG intensity. On the other hand, as plastic recycling intensifies with the rising price of oil and new EPR programs, the quantity of fossil carbon in the MSW stream will decrease. This will lower the GHG intensity of a future WTE facility.

Finally, since the avoided emissions from different disposal options is the factor that leads to a diversion of their estimated GHG totals, any changes to the GHG intensity of the province's energy system will considerably change these estimates. The B.C. government recently announced that the province will be energy self-sufficient by 2016 and that the energy system will soon be "carbon-neutral." If these policies are adopted, the avoided emissions from a landfill or a WTE facility will decrease significantly and their GHG totals will increase and converge (since, when avoided emissions do not occur, their emissions intensities are almost identical).

As these examples illustrate, it is extremely difficult to predict and compare the future GHG emissions from different waste disposal options. Expected policy changes and new research on topics such as biogenic carbon releases will change the reality of the GHG emissions from landfills and WTE facilities. While recent research implies that WTE facilities are less GHG intensive than landfills, it is impossible to predict how this will change in the future.

Table 3 – Claimed Residual Products from Plasco's Conversion Process

Residual Product	Quantity per tonne of MSW
"Vitrified Slag (Construction Material)"	150 kg
"Agricultural Sulphur"	5 kg
"Commercial Salt"	5–10 kg
"Heavy Metals and Particulate"	1.3 kg
"Potable Water"	300 L

Source: Plasco Energy Group, personal communication

2.3 ENERGY PRODUCTION

Plasco claims that its technology will be able to produce more than twice as much power per unit of MSW processed as a traditional mass-burn incinerator. For this reason, Plasco portrays itself in its marketing materials as an energy company with an energy solution, not just a waste disposal company with a garbage solution.

According to Plasco's calculations, one tonne of MSW processed at a Plasco facility will produce about 1.2-1.4 MWh/tonne of MSW of net power to be sold to the grid. Existing WTE facilities with mass-burn technologies, such as those found in Europe and the currently operating Burnaby WTE facility typically achieve power outputs of about 0.6 MWh/tonne of MSW. Landfills with landfill gas and capture systems generally produce less power than WTE facilities, with the power load spread over a much longer period of time.

While Plasco has made ambitious predictions about how much energy its facilities will produce, it is unclear at this point whether or not these predictions are realistic. The Ottawa demonstration project has produced only a small quantity of power to date, and has not yet provided reliable data to assess the energy potential of the technology. As previously noted, Plasco has reported that the Ottawa demonstration site has produced 5.1 MWh from 85 tonnes of processed waste. This is an average of .06 MWh/tonne of waste processed, whereas the company is promising 1 MWh/tonne of waste processed.

The amount of energy that can be produced from a unit of MSW is directly related to the quantity of embedded energy within that waste. When MSW is processed in a WTE facility, the vast majority of energy is derived from carbon sourced within specific items in the MSW. However, diversion programs with high capture rates, which should be considered a prerequisite for any waste disposal option, would remove a large percentage of this carbon from the MSW. Plastics are one of the most important sources of energy when MSW is processed at a WTE facility, since plastic is produced from fossil fuels. While viable markets do not exist for every type of plastic in every situation at this time, significantly higher plastic diversion rates are possible and should be facilitated by regional governments such as Metro Vancouver. New EPR programs and the increasing price of fossil

In almost all of these historical cases, the byproducts were proven to be too toxic and had to be landfilled. Agricultural companies and farmers, for example, may not be interested in a source of sulphur as a fertilizer if there is any chance of contamination from items such as heavy metals.

fuels may provide further incentives for plastics diversion in the future. It has even been suggested that landfills may be mined in the future to recover valuable items such as plastics, as the economics of recycling change with the price of oil. While this remains a theoretical option in Canada, destroying these same materials in a WTE facility would limit this opportunity.

Other carbon-based items in MSW that hold high energy potential, such as tires, residual oil, wood waste and paper, are all items that are either covered by existing EPR programs or are being targeted by Metro Vancouver for increased diversion rates. If and when diversion rates of products such as plastics, tires and paper improve the energy potential of the residual MSW will decrease dramatically. In a regional government with high diversion rates, the energy potential of WTE facilities will not be as high as proponents such as Plasco claim. This fact is important when considering the true environmental performance of a WTE facility, since the quantity of energy that a WTE facility can produce is inextricably tied to its GHG intensity (through the GHG emissions it displaces from the provincial grid).

2.4 RESIDUAL PRODUCTS FROM THE CONVERSION PROCESS

Despite some misconceptions, a WTE facility cannot make waste "disappear." Every kilogram of MSW that is fed into a WTE facility must eventually leave that facility, albeit in a different form. The material is converted into different byproducts such as air emissions, GHG emissions, steam, syngas (in the case of gasification), water, and residual waste products. The waste products from a traditional incinerator are typically bottom ash and fly ash, which are sent to landfills, and often contain high levels of toxic materials. For every tonne of MSW processed at a traditional incinerator, such as the Burnaby WTE facility, up to 200 kg of fly ash and bottom ash requires landfilling, which represents about 20% of the mass of the original waste. This waste, which is often toxic, can pose serious problems in landfills. For example, some of the waste materials from the Burnaby WTE facility that were buried in the Coquitlam Landfill were recently found to be leaching from the site and had to be unearthed at significant cost.

In its bid to distance itself from traditional incinerator technology, Plasco has asserted that, in one of its facilities, "99.8% of waste is converted to clean fuel and valuable products." One Plasco advertisement asks the question; "Why not recycle 100% of your waste?" According to the company, one tonne of MSW is converted to 2600 Nm^3 of syngas and residual products, listed in Table 3. The product categories are included in quotations to illustrate the wording that Plasco utilizes in its marketing. Each product category is discussed in more detail below.

2.4.1 Waste Products – Heavy Metals

Of the residual products listed in Table 3, the heavy metals are the only category that Plasco considers a true "waste product." While 1.3 kg of heavy metals per tonne of MSW processed may not seem like a large quantity, this represents the production of about 520 kg of heavy metals a day (assuming a facility with a daily capacity of 400 tonnes of MSW) or about 190 tonnes a year.

The company is quick to point out that these heavy metals are not a byproduct of the Plasco conversion process per se, but result from the disposal of heavy metal containing products such as batteries, electronics and compact fluorescent light-bulbs (CFLs). The quantity of heavy metals found in the MSW will, therefore, change the quantity of heavy metals that are collected in the conversion process. According to Plasco, these heavy metals will be collected together, placed within a secure container and sent to a "controlled disposal site" and not a regular landfill.

More of these heavy metals can be diverted from the MSW stream through effective regional diversion and EPR programs, and by redesigning the way we produce common consumer goods. For example, the upcoming B.C. EPR program on mercury-containing products will help divert heavy metals from B.C.'s MSW in the future. To the extent that these heavy metals are still present in the MSW it may be more environmentally appropriate to collect these materials and dispose of them through a hazardous waste company, as Plasco has proposed. If this same waste is landfilled, the heavy metals will be mixed within the MSW, increasing the likelihood of some of the metals leaching into groundwater

Nevertheless, it is important to recall that when MSW is processed in a WTE facility, including a Plasco facility, some heavy metals are released into the air shed as airborne emissions. As discussed in section 2.1.3, however, a landfill with a gas capture system also produces airborne emissions of these same metals, though generally not as many. If a Plasco facility performs as predicted, heavy metals will primarily be an airborne issue. In a landfill, heavy metals are primarily a water pollution issue. It is not clear which of these scenarios is preferable from a human or ecological health perspective. The priority, therefore, needs to be in removing these metals from the MSW stream in the first place.

2.4.2 "Recoverable" Products

According to Plasco, its conversion process will produce three additional by-products, each of which the company classifies as "recoverable" and considers "recycled materials."

For every tonne of waste processed, Plasco estimates that 150 kg of vitrified slag is created. This slag is a dense solid and is the equivalent byproduct of the bottom ash and fly ash that is created in a mass-burn incinerator. According to Plasco the difference is that its slag is not toxic and will not have to be landfilled. According to Plasco's "initial tests," this slag is "safer than a pop bottle" and completely stable, non-leachable and non-toxic. The company asserts that this slag, when produced in large quantities, will represent a valuable "construction aggregate" that can be used in road building or to displace concrete in construction. Plasco expects this slag to be sold and have an estimated value of about $20 a tonne in California (according to letters of interest submitted to Plasco in a Request for Proposals) and about $9 a tonne in Ontario.

The other two "recoverable" products that the company claims the conversion process creates are salt and sulphur. For every tonne of waste processed, 5 to 10 kilograms of "commercial salt" is created which, according to Plasco, can be sold and used in road maintenance and the chlorine industry. Five kilograms of "agricultural sulphur" is produced that the company expects to be used as an agricultural fertilizer.

Taken together, the slag, salt and sulphur represent about 16 % of the total mass of the initial MSW that was processed. A facility that processes approximately 400 tonnes of MSW per day will produce about 60 tonnes of slag, 20 to 40 tonnes of salt and 20 tonnes of sulphur daily. In a year this facility will produce 21,900 tonnes of slag, 730-1,460 tonnes of salt and 730 tonnes of sulphur. Clearly, if viable markets cannot be found for these materials, or if the materials are proven in time to not be as safe as Plasco predicts, this represents a very large quantity of waste that would still require disposal.

Since so little waste has been processed at the Ottawa demonstration facility to date, and since Plasco has not yet run a commercial scale facility processing MSW, it is impossible to substantiate Plasco's claims concerning the quantity and composition of its processes' residual products. For the sake of this argument, even if one assumes that the process will produce the quantity of residuals that the company claims, the more critical issue will still remain; the exact composition of these materials.

As WTE companies have come and gone over the last few decades, many of them have promised that the byproducts of their facilities will be sold as aggregate. In almost all of these historical cases the byproducts were proven to be too toxic and had to be landfilled. The history of waste management recommends caution in accepting Plasco's claims concerning the economic viability of their residual products. Agricultural companies and farmers, for example, may not be interested in a source of sulphur as a fertilizer if there is any chance of contamination from items such as heavy metals that are found in MSW.

Plasco's technology would have to perform as advertised, 100% of the time, before these materials could actually enter the marketplace as viable products as opposed to waste. If the technology performs as the company claims, Plasco will have broken new ground in the WTE field. If, instead, this waste is deemed too toxic or too potentially toxic these materials will have to be disposed of, as with the residuals from other WTE facilities, eliminating one of the key differences Plasco promotes between theirs and traditional WTE technology.

2.4.3 "Potable Water"

Plasco asserts that its facilities would be a net-producer of clean, potable water.

When landfills and WTE facilities are compared according to environmental criteria, the environmental impacts of every other stage in a product's life cycle, other than disposal, are ignored. It is only by examining every stage in a product's life cycle that the true environmental performance of different waste management strategies can be compared.

Any water required by the conversion process is contained within the MSW, primarily in organics. Even if organics were diverted from the MSW, it is still assumed that the process would not require water. For every tonne of waste processed, Plasco calculates that 300 litres of water will be extracted. This number will decrease with higher diversion rates of organics, but represents almost one third of the initial mass of the MSW. One day of operation, again assuming a 400 tonne/day facility, would net about 120,000 litres of what the Ottawa demonstration's project's Certificate of Approval for Waste classifies as Liquid Industrial Waste. A year of operation would net about 48.3 million litres.

Plasco claims that this water is cleaned completely before it leaves the facility and meets potable standards in any municipality. The company is so confident that it asserts the water could be used for irrigation or industrial purposes, depending on local demand. If a local use cannot be found for the water it is assumed that it will be added to the municipal sewage system. This would still pose a cost to the regional government, since the water would likely have to be processed in the region's water treatment facility, though this cost would not be large.

Again, Plasco's claims concerning its wastewater are unproven. If the water from a commercial facility is proven to be potable, there likely will not be a major concern. If, instead, the water is shown to be contaminated, disposal could prove considerably more difficult and expensive.

2.5 THE ZERO WASTE ALTERNATIVE

Sections 2.1 to 2.4 above have analyzed the expected environmental performance of a Plasco facility and, where appropriate, compared this performance to that of a typical landfill and WTE facility. Such analysis, however, only examines the last stage in the life cycle of the products that become MSW. When landfills and WTE facilities are compared according to environmental criteria, the environmental impacts of every other stage in a product's life cycle other than disposal are ignored. It is only by examining every stage in a product's life cycle that the true environmental performance of different waste management strategies can be compared. Plasco and, to some extent, Metro Vancouver have attempted to limit the debate by confining it to a comparison between landfills and WTE facilities. The real debate, however, is between disposal, in any form, and Zero Waste initiatives.

According to the Zero Waste International Alliance, "Zero Waste is a goal that is both pragmatic and visionary, to guide people to emulate sustainable natural cycles, where all discarded materials are resources for others to use. Zero Waste means designing and managing products and processes to reduce the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them." In their present form, Zero Waste strategies include efforts to reduce, reuse and recycle materials and Extended Producer Responsibility Programs. There are endless possibilities for how Zero Waste strategies and programs can be designed and implemented in the future.

Recent studies by environmental scientists and economists have shown that the environmental savings of a Zero Waste approach to waste management vastly outweigh those of either landfilling or processing waste in a WTE facility.[18] While reducing and reusing waste achieves the greatest environmental savings, recycling also nets significant environmental gains. A recent life cycle analysis by Jeffrey Morris, for example, illustrates that recycling common household materials such as paper and plastic imposes significantly lower en-

[18] See, for example, Morris, 2005 and Denison, 1996.
[19] Morris, 2005.

vironmental burdens than disposal of solid waste, even if energy is recovered in a WTE facility or landfill.[19] This conclusion holds true for a wide range of environmental categories, including air pollution, GHG emissions, acidification, human toxicity and ecological toxicity. Most of these environmental savings result from decreased energy usage since recycling materials consumes far less energy in the life cycle of any one product than extracting virgin resources to produce that same product. These findings have been further substantiated by a large and influential report commissioned by Environment Canada entitled *Determination of the Impact of Waste Management Activities on Greenhouse Gas Emissions: 2005 Update*.[20]

It is vastly more energy efficient to recycle materials such as plastics and paper than it is to process them in a WTE facility. Recent studies by Metro Vancouver show that these types of materials still comprise a significant portion of the region's MSW. Increased diversion rates, therefore, should be Metro Vancouver's highest priority. Without these types of materials and the carbon they contain a WTE facility will not be able to achieve the energy output expected, as outlined in section 2.3. A WTE facility requires the carbon in materials such as paper, plastic and tires to produce energy, yet much more energy would be conserved if these materials were recycled than would be produced if they were destroyed in a WTE facility. Therefore, processing materials in a WTE facility represents a lost 'opportunity cost' of energy savings. With these energy savings come GHG and air pollution reductions that outweigh those of either landfilling or processing waste in a WTE facility.

[20] ICF, 2005.

3.0 COMPATIBILITY WITH ZERO WASTE PRINCIPLES

While it is important to examine the environmental performance of new WTE technology according to specific environmental categories, including air pollution, GHG emissions and energy savings, it is equally important to consider whether or not WTE facilities are compatible with the basic principles of Zero Waste. Moving society towards the goal of Zero Waste needs to be the primary objective of any waste management program. As section 2.5 discussed, such an approach will achieve greater environmental savings than a WTE facility. Given this conclusion, the question to ask is if WTE facilities can play a role in the move towards Zero Waste? Or, are the two concepts mutually exclusive?

3.1 WTE AND ZERO WASTE

The new generation of WTE technology, including the technology proposed by Plasco, is being trumpeted as a method to move North American societies towards the goal of Zero Waste. Plasco refers to its demonstration project in Ottawa as a "Partnership for a Zero Waste Ottawa" and the company uses the internet domain names zerowasteottawa.com and zerowastevancouver.com. Louis Circeo of the Georgia Tech Research Institute has written that "plasma arc technology offers a unique opportunity to achieve the 'zero waste' goal by providing the capability to eliminate the need for land disposal…and to recover energy from municipal solid waste and other organic wastes while producing salable products."[21]

In reality, many of the basic characteristics of WTE facilities are inherently contradictory to the principles of Zero Waste. Some of these issues are outlined below.

WTE facilities require a constant stream of MSW, which may reduce regional governments' incentive to increase diversion rates and prevail upon the province to adopt new EPR programs.

The goal of any waste management program should be the elimination of waste. WTE facilities create economic disincentives to eliminating waste.

WTE facilities are often extremely expensive to construct and operate, which can divert money from other waste management programs such as recycling.[22] Plasco's promise of low tipping fees is based on many factors that may not hold true in B.C.

Reductions in MSW flows to a WTE facility reduce the energy outputs of these facilities and the public may be unclear as to the benefits of reducing the waste stream.

WTE facilities destroy valuable resources that can be recycled or composted for greater net environmental savings.

WTE is based on a linear system of resource extraction, production, consumption and disposal and does not facilitate a move towards closed-loop production.

These arguments suggest that it is not the specific WTE technology that is the problem, but the very philosophy that a WTE facility represents. As Dr. Paul Connett has said; "even if we made incineration safe, we would never make it sensible or sustainable. It simply does not make sense spending so much money destroying resources we should be sharing with the future."

All of these arguments may not hold true all of the time in Metro Vancouver. It is not *necessarily* the case, for example, that new WTE facilities within Metro Vancouver will have any bearing on the province's adoption of new and effective EPR programs, since different levels of government are responsible for these two tasks. There is no doubt, however, that the construction of multiple WTE facilities designed to dispose of hundreds of thousands of tons of MSW will have a bearing on future incentives to encourage Zero Waste in Metro Vancouver.

Plasco has publicly stated that it would have no issue with Metro Vancouver reducing the amount of MSW it delivers to its WTE facilities, however Plasco would reserve the right to bring in MSW from outside the region to keep the facilities fed at the operational rate for which they were built. This conflicts with the previously stated position that its facilities are modular in nature and can be added to or reduced in size as required.

At the same time, landfill contracts can provide many of the same disincentives to Zero Waste as Waste to Energy facilities. If a regional district, for example, does not own its landfill they may be locked into a contractual agreement that requires delivering a certain tonnage every year. If, on the other hand, the government owns the landfill, it has a vested interest in recouping their capital costs and ensuring the landfill remains economically viable. Securing a new landfill and signing a contract that requires a massive tonnage a year, be it in Cache Creek, Ashcroft or any other location, would also limit future commitments to Zero Waste planning. This is why the debate needs to be expanded beyond the dated landfill versus WTE facility paradigm.

[21] Circeo, 2007.
[22] Morris, 2006.

CONCLUSION

If Plasco's environmental claims can be proven by a real operational track-record, WTE technology will certainly have improved substantially. However, Plasco's claims concerning air emissions, energy potential and residual materials remain unproven and the Ottawa demonstration project will require more time to substantiate most of the company's predictions.

When analyzed according to environmental performance, there is no clear "winner" between today's two major waste disposal options — landfills with a gas collection system and WTE facilities — even if Plasco's technology performs as predicted. For example, both landfills and WTE facilities release air pollutants. For some parameters, landfills release more emissions. For other categories, such as heavy metals, WTE facilities are generally a larger source. Initial research suggests that modern WTE facilities will release fewer GHG emissions than a landfill, though the range of uncertainty left by unanswered questions surrounding biogenic carbon and avoided emissions remains much larger than this difference. In addition, future changes to the MSW stream from increased diversion of organics and plastics, as well as expected changes to the province's energy system, will further blur the GHG intensity differences between the two disposal options.

If, instead, one examines the entire life cycle of the products that make up MSW, and does not focus solely on the disposal stage of this process, it is clear that there are other waste management strategies that can achieve higher environmental standards than either landfilling or WTE. A Zero Waste strategy that relies on reducing, reusing and recycling waste will conserve more energy, produce fewer air pollutants and GHG emissions, and will help solve the residual problem still present in any WTE scenario.

The existing disposal capacity at the Burnaby WTE facility and the Vancouver Landfill could potentially meet the disposal needs of Metro Vancouver. However, this would require both an ambitious Zero Waste program to expand the current diversion rate and willingness by the City of Vancouver to share its landfill capacity with other municipalities within the region. If the latter were the case, then the two aforementioned facilities would have an annual disposal capacity of one million tonnes of MSW.[23] This capacity would be adequate to meet the needs of the region until at least the date of the Vancouver Landfill closure planned for 2040. With the funds required for Metro Vancouver to build and operate new WTE facilities, a host of groundbreaking Zero Waste initiatives could instead be introduced. These initiatives would ensure that the region's annual disposal rate does not exceed one million tonnes and would have the eventual goal of negating the need to landfill at all. How those initiatives would be developed and deployed requires additional research beyond the scope of this document.

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