Assessing the Potential for Extended Producer Responsibility in Construction, Renovation and Demolition Waste in Metro Vancouver

ENVR 400

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May 7th, 2013

Executive Summary

Extended Producer Responsibility (EPR) is recognized by the Government of British Columbia, Metro Vancouver, and Metro municipalities like the City of Vancouver as a waste diversion strategy through economic stimulation of the market for recycled materials. As an environmental policy, EPR ensures producers and consumers are physically and financially responsible for post-consumer management of their products in an environmentally safe manner. Successful EPR programs shift the expenses associated with product end-of-life management from governments and taxpayers to producers and consumers, as well as reduces the amount of waste generated from going to landfills and waste-to-energy facilities. Currently, the Province, Metro Vancouver and City of Vancouver are actively supporting and focusing on the establishment of EPR programs for a variety of materials as a waste management solution.

Metro Vancouver's plan is to achieve a large reduction in waste reaching landfills and waste-to-energy facilities through improving the overall diversion/recycling rate from 55% to 70% for 2015, and up to 80% by 2020. Currently, the demolition, land-clearing, and construction waste sector generates the most waste out of all the sectors, contributing an estimated 1.3 million tonnes of waste materials annually. Metro Vancouver has recognized the large potential for waste reduction and diversion in this sector and thus, a specific target of 80% diversion of waste material from the demolition, land clearing, and construction sector within the overall 70% diversion goal for 2015 has been set in place. Under the Canada-wide Action Plan for EPR, published by the Canadian Council of Ministers of Environment in October 2009, the Province has committed to developing EPR programs for construction, renovation and demolition materials by 2017.

This research project aims to help progress EPR programs for building materials by identifying a list of building materials in which an EPR program would have long term viability. It is hoped that results from this project will significantly contribute to the establishment of successful provincial EPR programs for building materials. Municipalities like the City of Vancouver can

utilize it to become a zero-waste city, achieve overall regional waste diversion goals for Metro Vancouver, and guide the province to achieve the interim targets and overall target from the CCME Canada-Wide Action Plan.

To determine the list of building materials for our analysis, a review of *Market Analysis of Used Building Materials* by Kane Consulting *et al.* (2012) was done. From a comprehensive list of building materials currently sent to landfills and the waste-to-energy facility, the list was narrowed down to nine candidate materials for further evaluation of EPR potential*: asphalt shingles, carpet, ceramic tiles, concrete, gypsum drywall, miscellaneous metal products, sheet plastic, miscellaneous glass building products, and wood waste.*

A modified version of the EPR Evaluation Tool developed by the Canadian Council of Ministers of the Environment was used to prioritize a list of candidate materials based on their suitability for EPR. Using this evaluation matrix, candidate materials were assessed over four broad categories: Environmental Impacts, Suitability for Extended Producer Responsibility, Political Interest, and Industry Readiness. Scoring was based on information sourced from literature, Metro Vancouver waste management staff, municipal recycling coordinators and construction and demolition waste professionals.

The raw scores represent the unweighted outcome of the evaluation process. Weighting was adjusted to reflect the varying degrees of importance of each category and subcategory. For the purposes of this study, four sensitivity analyses were conducted based on discussions with City of Vancouver waste management staff with weighted emphasis on one evaluation category at a time.

Table E-1 summarizes the results from the raw score evaluation for the nine candidate materials, and compares these to the results of the four sensitivity analyses. Based on our comprehensive analyses, and taking the raw scores and sensitivity analyses into account, we recommend EPR for asphalt shingles, carpet, sheet plastic, and wood waste in British Columbia.

Furthermore, by emphasizing different criteria, the highest priority material varies. For example, emphasizing the implications of Environmental Impacts and strong political support on the waste diversion strategy of such materials in Metro Vancouver, wood waste should be prioritized. In comparison, in the case of implementing a better waste management in the form of EPR, carpet ranked first. Finally, in terms of industry readiness when it comes to initiating and establishing an EPR program, gypsum drywall came first.

Table E-1. Summary of raw score and sensitivity analyses

Raw Score Results	Equal Weight	Sensitivity 1 – Emphasis on Environmental Impact	Sensitivity 2 – Emphasis on Extended Producer Responsibility	Sensitivity 3 – Emphasis on Political Interest	Sensitivity 4 – Emphasis on Industry Readiness
1. Carpet 2. Wood* 3. Asphalt Shingles 4. Concrete 5. Gypsum Drywall** 6. Sheet Plastic 7. Misc. Glass Building Products 8. Misc. Metal Building Products 9. Ceramic Tiles	1. Wood* 2. Carpet 3. Gypsum Drywall** 4. Asphalt Shingles 5. Concrete 6. Sheet Plastics 7. Ceramic Tiles 8. Misc. Glass Building Products 9. Misc. Metal Building Products	1. Wood* 2. Gypsum Drywall** 3. Carpet 4. Concrete 5. Sheet Plastic 6. Asphalt Shingles 7. Ceramic Tiles 8. Misc. Metal Building Products 9. Misc. Glass Building Products	1. Carpet 2. Wood* 3. Sheet Plastic 4. Asphalt Shingles 5. Gypsum Drywall** 6. Concrete 7. Misc. Glass Building Products 8. Ceramic Tiles 9. Misc. Metal Building Products	1. Wood* 2. Carpet 3. Gypsum Drywall** 4. Asphalt Shingles 5. Sheet Plastic 6. Concrete 7. Ceramic Tiles 8. Misc. Metal Building Products 9. Misc. Glass Building Products	1. Gypsum Drywall** 2. Concrete 3. Asphalt Shingles 4. Wood* 5. Carpet 6. Sheet Plastic 7. Misc. Metal Building Products 8. Ceramic Tiles 9. Misc. Glass Building Products

This research project sourced best available information from literature research (e.g. case studies, annual waste flow reports waste composition studies, etc.) and interviews and

personal communication with industry professionals and local government staff. With this study, we have compiled a list that will enable the Ministry of Environment, Metro Vancouver and City of Vancouver to identify the current status of potential products for EPR, and have included a comprehensive list of recommendations and next steps for waste management within the demolition and construction sector.

Authors

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Andrea Balba is a graduating UBC student majoring in Environmental Sciences and concentrating in Ecology and Conservation. Her interests include plant ecology, urban ecology, waste management and sustainability. . She has completed a number of practical courses which includes environmental research, data and statistical analyses, ecological methodologies, and constructing models in sciences. She is an active member on campus, being involved in UBC's Peer Programs for two years, and also an active academic mentor at a high school in Vancouver.

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Cecilia Montauban is a fourth year UBC student, double majoring in Environmental Sciences (Ecology and Conservation concentration) and Human Geography. As an international student, her interests include plant ecology, biodiversity conservation, eco-tourism, ecosystem protection and management and environmental education; with a particular focus on the Peruvian Amazon Rainforest. Some of her involvement in the area includes the completion of a summer internship with Vector Peru SAC as an intern Environmental Consultant, as well the completion of numerous fieldwork and research projects in Tambopata, Madre de Dios, and a region of the rainforest.

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Debbie Yeh is a fourth year UBC student, concentrating on Ecology and Conservation within the Environmental Sciences program. With an interest in environmental education, she has spent her past summers in forests and bogs, sharing her enthusiasm and knowledge about plants and animals with children of all ages. In the community, she is part of the executive team at Sprouts: a volunteer-run food co-operative that promotes sustainable living and healthy, local, and organic food to the campus community.

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Introduction

In 2006, municipalities across Canada generated 35 million tonnes of waste, of which only 7.7 million tonnes were diverted as recyclables or organics. If waste production is continued at this rate, it is projected that one billion tonnes of municipal generated waste would be added to the landfills within 25 years (Canadian Council of Ministers of the Environment, 2009). As a regional district composed of 22 municipalities, one electoral area, and one treaty First Nation, Metro Vancouver strives to protect the health of its citizens and the environment by unifying a population of 2.3 million people towards a common goal of becoming a sustainable region. One aspect of achieving this vision is to target reduction and diversion of the 3 million tonnes of municipal solid waste currently being produced annually (Metro Vancouver, 2012).

The guiding principles to improve waste diversion is integrated in Metro Vancouver's waste management plan as the 5R hierarchy: 'Reduce waste at the source' is the top solution, followed by: 'Reuse where possible', 'Recycle more products at the end of their useful life', 'Recover energy or materials from the waste stream', and 'manage Residuals in an environmentally sound manner' (Metro Vancouver, 2010). The plan is to achieve this large reduction through diverting waste from landfills and improving the diversion rate in each regional sector from 55% to 70% for 2015, and up to 80% by 2020 (Metro Vancouver, 2010).

The total amount of solid waste generated in Metro Vancouver originates from three sectors: single-family style (SF) and multi-family residences (MF); industrial, commercial and institutional wastes (ICI); and demolition, land-clearing and construction waste (DLC) (Metro Vancouver, 2011). Contributing the largest volume of waste is the demolition, land-clearing, and construction waste sector, which generates over an estimated 1.3 million tonnes of waste materials annually (Kane Consulting *et al.*, 2012). Metro Vancouver has recognized the large

potential for waste reduction and diversion in this sector and thus, a specific target of 80% diversion of waste material from the demolition, land clearing, and construction sector within the overall 70% diversion goal for 2015 has been set in place (Metro Vancouver, 2010). According to a Metro Vancouver official, when the "5R" hierarchy is applied with regards to construction and demolition waste, it is assumed that the waste is already there and the next ideal option is to look at 'Reuse where possible' and 'Recycle products at the end of their useful life' (N. Tawfik, personal communication, March 13, 2013).

Extended Producer Responsibility

Extended Producer Responsibility (also referred to as industry product stewardship or "take-back" programs) has been recognized by Metro Vancouver as a waste diversion strategy that works to economically stimulate the market for recycled materials. As an environmental policy, it ensures producers and consumers are physically and financially responsible for post-consumer management of their products in an environmentally safe manner (City of Vancouver, 2012). Successful EPR programs shift the expenses associated with product end of life management from taxpayers to producers and consumers, as well as reduces the amount of waste generated from going to disposal (Canadian Council of Ministers of the Environment, 2009).

Given that member municipalities have a large responsibility in ensuring that the Integrated Solid Waste and Resource Management plans are implemented in their respective regions (Metro Vancouver, 2010), EPR provides the potential to enforce waste reduction strategies. Under EPR, producers will be encouraged and supported by municipalities to innovatively redesign their products so that to reduce toxicity to the environment or use fewer resources (Canadian Council of Ministers of the Environment, 2009). Not only is the 5R principles rooted within EPR, but the implementation and long term viability of the program will rely on the municipal government, the producers, and consumers to come together to achieve overall waste reduction (Gartner Lee Limited, 2007).

The Government of British Columbia, Metro Vancouver, and Metro municipalities like the City of Vancouver have recognized EPR as a strategy for better environment health and is currently supporting and focusing on the establishment of EPR programs for a variety of materials as a waste management solution (Metro Vancouver, 2010).

EPR programs in Canada

The Canadian Council of Ministers of the Environment (CCME) makes efforts to reduce the toxicity and environmental risks from products and product waste and to improve the overall life-cycle performance of products, including reducing associated greenhouse gas emissions (Canadian Council of the Ministers of Environment, 2009). In 2009, a Canada-wide Action Plan (CAP) for EPR was developed by the CCME to solidify the commitment of each province and territory and set goals and timelines for products to be considered for EPR implementation (Canadian Council of the Ministers of Environment, 2009). The first phase of the Canada-Wide plan is to implement EPR programs for products such as packaging and printed materials, electronics and electrical products, mercury-containing products (including lamps), household hazardous and special wastes, and automotive products by 2015. Following that, phase two (2) is to add construction and demolition materials, in addition to carpet, furniture, textiles, and appliances, all by 2017 (Canadian Council of the Ministers of Environment, 2009).

Support for EPR programs in British Columbia

EPR programs are regulated by the Ministry of Environment through the Recycling Regulation, under the BC Environmental Management Act (*Recycling Regulation*, B.C. Reg. 449/2004). Notably, the BC Ministry of Environment has aligned its service plan with the CCME's Canada Wide Action Plan for EPR. The target in the plan is to have "comprehensive coverage of the products in all [CCME] subcategories by 2017/18". Completion of this target will be achieved through interim targets of 79% completion for 2014/15, followed by 84%

completion for 2015/2016, as seen in Table1 (Ministry of Environment and the Environmental Assessment Office, 2013).

Performance Measure 6: Completion of the Canada-wide Action Plan for Extended Producer Responsibility

Performance Measure	2012/13 Actual	2013/14 Target	2014/15 Target	2015/16 Target
Percentage of product sub-categories[1] in the Canada-wide Action Plan for Extended Producer Responsibility fully covered by industry-led recycling programs in British Columbia	68%	68%	79%	84%

Data Source: Ministry of Environment

[1] The Canada-wide Action Plan places a number of products into different categories. The Ministry divides these categories into sub-categories. For example, one category is packaging, which the Ministry divides into two subcategories: beverage containers and packaging and printed paper. Some product categories include a large number of products and require multiple industry-led stewardship programs in order to attain complete coverage.

Table1. Completed and future completion targets of the Canada-wide Action Plan for Extended Producer Responsibility (Adapted from Ministry of Environment and the Environmental Assessment Office, 2013)

Currently, EPR programs are in place for 11 product categories, which include electronics/electrical goods, household hazardous wastes (i.e. paint, pesticides, solvents, pharmaceuticals), beverage containers, and automobile products (tires, lead-acid batteries, used oil, oil filters, antifreeze). A packaging and printed paper EPR program will be introduced in May 2014. The success of these programs have diverted approximately 145,000 tonnes of waste each year from the Greater Vancouver landfills and waste-to-energy facilities-which makes up a significant 17% of recycled materials in the commercial and residential sector (Metro Vancouver, 2011).

The City of Vancouver and the Greenest City Action Plan

As the third largest metropolitan area in Canada and the most populous city in the Metro Vancouver regional district (Statistics Canada, 2006), the City of Vancouver has adopted a Greenest City 2020 Action Plan with a goal of becoming the world's greenest city by 2020. The Greenest City Action Plan has ten green goal areas, one of which is to create zero waste. The Greenest City "Zero Waste" target is to reduce solid waste to landfills and incinerators by 50%

by 2020, based on 2008 levels. In the City of Vancouver, the current diversion rate for construction and demolition materials is at 76%, but still, construction and demolition materials make up at least 34% of the total waste that enters the landfill every year (City of Vancouver, 2012). The potential in reducing waste and increasing diversion in this sector will help bring the city towards becoming a zero-waste city. To do so, the City has made "reduce, reuse, and recycle more construction, renovation and demolition waste", a key strategy for 2020. Combining this strategy with 'Becoming a catalyst for EPR programs', these two strategies will work towards stimulating and establishing sustainable markets for building materials and the resulting waste. Overall, these markets will encompass the "green economy' in which extended producer responsibility programs can help bring forth.

Purpose and Objectives

This research project aims to help progress EPR programs for building materials by identifying a list of building products and materials for which an EPR program would suitable in the near future.

The main objectives of this project are:

- To develop a shortlist of building products that are commonly found in Metro Vancouver waste, as detailed in the 2011 Solid Waste Composition Report for Metro Vancouver and the *Market Analysis of Used Building Materials* (Kane Consulting *et al.*, 2012), which would be suitable candidates for EPR.

- To evaluate the potential of implementing a provincial EPR program for each candidate material using a modified EPR Evaluation Tool designed by the Canadian Council of Ministers of the Environment, based on the Metro Vancouver context. This evaluation matrix ranks candidate materials based on combined scores of evaluation criteria that

fall under four broad categories: Environmental and Health Impacts; Extended Producer Responsibility; Political Interest, and Industry Readiness.

- To conduct a sensitivity analysis in which the candidate materials are scored based on different weighted emphasis on the four major criteria categories (Environmental and Health Impacts; Extended Producer Responsibility; Political Interest; and Industry Readiness).

- To make a set of recommendations for prioritizing certain construction, demolition, and renovation materials for province-wide EPR programs based on the list of ranked candidate materials.

It is hoped that the results from this project will significantly contribute to the establishment of successful provincial EPR programs for building materials, in which municipalities like the City of Vancouver can utilize to achieve their overall regional waste diversion goals for Metro Vancouver, and guide the province to achieve the interim targets and overall target from the CCME Canada-Wide Action Plan.

Methods

Determining the amount of construction, renovation and demolition waste disposed

To determine which building materials to use for our analyses, a review of *Market Analysis of Used Building Materials* by Kane Consulting *et al*. (2012) was done to narrow down the comprehensive list of building materials to ten candidate materials. From this list of candidate materials, evaluation of each material's potential and suitability for provincial EPR

programs was made based on calculating the diversion rates from landfills, scoring based on criteria, and a sensitivity analyses.

The amount of construction, renovation, and demolition waste disposed to landfill and incinerator by each sector: Single Family Residential (SF), Multi-Family Residential (MF), Industrial/Commercial/Institutional (ICI), Drop-Off (DO), and, Demolition/Land clearing/Construction (DLC) was determined (Terminology for each sector is defined in details in Appendix A2).

Table 2 shows the total amount of waste disposed, diverted and generated by sector. Table 3 shows the proportion of building materials in the waste disposed by each sector. The amount of waste disposed to landfill or incinerator for each building material type was calculated by multiplying the percentages for each building material category in Table 3 against the total waste disposed for each sector (SF, MF, ICI, DO and DLC) in Table 2.

Table 2.2011 Metro Vancouver Recycling and Solid Waste Quantities (adapted from Metro Vancouver 2011 Solid Waste Annual Summary Report) (Kosmak 2013, Pitre 2013)

Waste Sector	Disposed (tonnes)	Diverted (tonnes)	Generated (tonnes)	Diversion rate (%)
Residential	**573,070**	**400,324**	**973,394**	**42%**
Single Family	**368,518**	**363,594**	**732,112**	**50%**
Single Family Curbside (reported)	254,530	262,928	517,459	
Single Family Drop Off (estimated)	113,987	100,666	214,653	
Multi-Family	**204,553**	**36,730**	**241,282**	**15%**
Multi Family Curbside (estimated)	197,490	31,137	228,627	
Multi-Family Drop Off (estimated)	7,062	5,593	12,655	
Industrial, Commercial, Institutional (ICI)	**431,373**	**244,648**	**676,021**	**36%**
ICI Curbside (estimated)	425,040	208,959	633,999	

ICI Drop Off	6,333	35,689	42,022	
Demolition, Land clearing, Construction (DLC) (reported)	**366,459**	**1,043,529**	**1,409,987**	**74%**
Extended Producer Responsibility or "Take-Back" programs (reported)	**-**	**128,946**	**128,946**	**-**
Total	**1,370,901**	**1,817,447**	**3,188,348**	**57%**

Table 3. Percentages of building materials by sector from Metro Vancouver's waste composition studies).

	Waste Composition by Percentage (%)					
	SF RES	**MF RES**	**ICI**	**DO**	**DLC**	**Combined Average** (total % of waste dispose)
Wood	**2.9%**	**2.4%**	**18.2%**	**42.3%**	**53.3%**	**24.7%**
Clean (compostable) wood (Possibly EPR 2017)	**1.7%**	**1.1%**	**7.4%**	**21.2%**	**26.0%**	**11.7%**
Other (compostable) wood (mixed lumber, rotting wood) - unpainted, untreated	1.7%	1.1%	7.4%	21.2%	26.0%	11.7%
Wooden packaging (Possibly EPR 2013-15)	**0.0%**	**0.0%**	**6.6%**	**0.8%**	**0.1%**	**2.2%**
Wood pallets (unpainted, untreated)	0.0%	0.0%	6.6%	0.8%	0.1%	2.2%
Wood building products (Possibly EPR 2017)	**1.2%**	**1.3%**	**4.1%**	**20.3%**	**27.2%**	**10.8%**
Wood shakes & shingles	0.0%	0.2%	0.0%	0.0%	0.1%	0.1%
Hardwood flooring	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Treated wood (treated lumber, shingles, etc.) - (pressure treated)	0.2%	0.2%	0.2%	2.8%	0.0%	0.4%
Finished wood (panelling, siding, glued particle board, plywood, OSB) - painted, stained or finished	1.0%	0.9%	3.9%	17.5%	8.0%	5.3%
Composite wood (DLC)	0.0%	0.0%	0.0%	0.0%	19.0%	5.1%
Building products (construction & demolition)	**3.0%**	**2.7%**	**6.4%**	**13.7%**	**29.1%**	**11.8%**
Concrete	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**4.1%**	**1.1%**
Preformed blocks	0.0%	0.0%	0.0%	0.0%	2.0%	0.5%
Poured without rebar	0.0%	0.0%	0.0%	0.0%	2.0%	0.5%
Poured with rebar	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Misc. concrete	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Masonry	**0.1%**	**0.0%**	**0.0%**	**1.1%**	**1.0%**	**0.4%**
Brick	0.0%		0.0%	0.0%	1.0%	0.3%
Tile	0.0%		0.0%	0.0%	0.0%	0.0%
Misc. masonry (includes bricks, blocks, concrete)	0.1%		0.0%	1.1%	0.0%	0.1%

Roofing	**0.0%**	**0.0%**	**0.8%**	**1.8%**	**11.3%**	**3.4%**
Tarpaper	0.0%		0.0%	0.0%	0.0%	0.0%
Rigid asphalt building products (e.g. shingles)	0.0%		0.8%	1.8%	7.0%	2.3%
Tar & gravel roofing	0.0%		0.0%	0.0%	4.3%	1.1%
Other roofing	0.0%		0.0%	0.0%	0.0%	0.0%
Outdoor Wall Finishing	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.2%**	**0.1%**
Metal siding	0.0%		0.0%	0.0%	0.0%	0.0%
Plastic siding	0.0%		0.0%	0.0%	0.1%	0.0%
Stucco	0.0%		0.0%	0.0%	0.1%	0.0%
Indoor Wall Finishing	**1.4%**	**0.5%**	**0.6%**	**2.9%**	**0.0%**	**0.8%**
Gypsum drywall (includes some plaster)	1.4%	0.5%	0.6%	2.9%	0.0%	0.8%
Lath & plaster	0.0%		0.0%	0.0%	0.0%	0.0%
Insulation	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**
Styrofoam insulation	0.0%		0.0%	0.0%	0.0%	0.0%
Fiberglass	0.0%		0.0%	0.0%	0.0%	0.0%
Cellulose	0.0%		0.0%	0.0%	0.0%	0.0%
Urethane foam	0.0%		0.0%	0.0%	0.0%	0.0%
Flooring (excluding carpet)	**0.1%**	**0.0%**	**1.0%**	**0.3%**	**0.0%**	**0.4%**
Linoleum	0.1%		1.0%	0.3%	0.0%	0.4%
						0.0%
Plumbing	**0.1%**	**0.0%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**
Ferrous kitchen & bathroom fixtures (sinks, tubs, faucets)	0.1%		0.1%	0.1%	0.0%	0.0%
Plastic pipes	0.0%		0.0%	0.0%	0.0%	0.0%
Metal plumbing	0.0%		0.0%	0.0%	0.1%	0.0%
Misc. Glass Building Products	**0.5%**	**1.0%**	**2.4%**	**3.7%**	**0.0%**	**1.2%**
Misc. glass products: flatware, mirrors, insulation, lightbulbs (assume 100% building products)	0.5%		2.4%	3.7%	0.0%	1.2%
Misc. Plastic Building Products	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**4.0%**	**1.1%**
Sheet plastic	0.0%		0.0%	0.0%	4.0%	1.1%
Rigid plastic products	0.0%		0.0%	0.0%	0.0%	0.0%
Other misc. plastic products	0.0%		0.0%	0.0%	0.0%	0.0%
Misc. Metal Building Products	**0.6%**	**0.9%**	**1.6%**	**3.8%**	**1.0%**	**1.3%**
Sheet metal	0.0%		0.0%	0.0%	0.0%	0.0%
Flashing metal	0.0%		0.0%	0.0%	0.0%	0.0%
Electrical	0.0%		0.0%	0.0%	0.0%	0.0%
Misc. ferrous building products	0.0%		0.0%	0.0%	0.0%	0.0%
Non-ferrous	0.0%		0.0%	0.0%	0.0%	0.0%
Other misc. metal products (renovation/industrial (nails, toolds, doors, panels, etc.)	0.6%	0.9%	1.6%	3.8%	1.0%	1.3%
Misc. Building Products	**0.3%**	**0.3%**	**0.0%**	**0.0%**	**0.0%**	**0.1%**
Other inorganic Building products (linoleum, etc.)	0.3%		0.0%	0.0%	0.0%	0.1%

Misc. c&d materials	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%
Asphalt	0.0%	0.0%	0.0%	0.0%	**7.3%**	**2.0%**
Carpet	**1.0%**	**0.6%**	**4.2%**	**10.6%**	**1.0%**	**2.8%**
Carpet waste (and underlay)	1.0%	0.6%	4.2%	10.6%	1.0%	2.8%
SUB TOTAL CONSTRUCTION & DEMOLITION WASTE	**5.9%**	**5.1%**	**24.6%**	**56.0%**	**82.4%**	**39.1%**

Calculating diversion rates of construction, renovation and demolition waste from landfills and incinerators

The second part of the data analysis consisted of calculating current diversion rates of demolition and construction products, where possible, by comparing the recycling tonnages reported in Metro Vancouver's 2011 Solid Waste Summary Report, as shown in Table 4, to the total tonnes of demolition and construction products disposed in all sectors, as described in the previous section. An additional estimate for asphalt shingles is provided by Gemaco, an asphalt shingle recycling plant located in the Metro Vancouver region.

Equation 1 is used to calculate the diversion rates of wastes generated.

$$Diversion/Recycling\ Rate = \frac{Reused + Recycled + Recovered\ for\ Energy}{Reused + Recycled + Recovered\ for\ Energy + Disposed\ to\ landfills/incinerators}$$

Equation 1. Diversion/Recycling rate, measured in tonnes.

It was assumed that where recycling tonnages were not reported in Metro Vancouver's 2011 Solid Waste annual summary report, zero tonnes were recycled and the diversion rate is 0%.

Table 4. Estimated quantities of building materials recycled in Metro Vancouver in 2011. Data taken from Metro Vancouver Annual Recycling and Solid Waste Management 2011 Summary (Metro Vancouver, 2011). Estimate for asphalt shingles from personal communication with Gemaco (Gemaco, 2013).

Material	Demolition, Land clearing, Construction Waste Recycled (tonnes)

Asphalt (road)	184,543
Asphalt shingles	7,000
Concrete	373,313
Gypsum drywall	78,585
Metal	32,307
Other (bulky items, wood, soil, polycoat, etc.)	74,667
Wood waste	312,041
Total	1,050,528

These findings were used for two main purposes:

- To provide an estimate of diversion rates for each candidate material- a set of data that is not currently reported by Metro Vancouver. These values established a baseline diversion rate for each candidate product.

- To justify the ranking of raw scores in our evaluation tool for the section on disposed tonnages and diversion rates of materials. This gave a more accurate and updated ranking than would be provided by previous literature. These quantitative rates were factored into the evaluation matrix.

EPR Evaluation Tool and Criteria Scoring System

The comprehensive list of building materials or products was narrowed down into a shortlist of nine candidates for EPR, based on recycling and waste composition data tracked by Metro Vancouver and the recommendations of City of Vancouver waste management staff. From our shortlist of nine candidate materials, we used an evaluation criteria and scoring system to determine which materials would be best suited for an EPR program (see Appendix A1 for table of materials).

The tool used is a modified version of an EPR Evaluation Tool published by the Canadian Council of Ministers of the Environment. The evaluation tool combines quantitative and qualitative analysis intended to determine the potential for EPR programs to manage specific products. The evaluation tool itself was adapted from a version provided on the Canadian Council of Ministers website, and consists of a set of criteria and a raw scoring system, organized as a matrix in the form of an Excel spreadsheet (Canadian Council of Ministers of the Environment, 2008 and 2009). The CCME's EPR Evaluation tool is shown in Appendix A3.

Based on the input from City of Vancouver staff, the original CCME EPR Evaluation tool was modified to reflect current waste management practices, recycling markets, and data availability for construction, renovation and demolition waste in Metro Vancouver (M. Kosmak, personal communication, March 14, 2013). Some criteria in the CCME's EPR Evaluation Tool were not included in the modified framework due to significant limitations on the availability of information for some materials. Table 5 shows the ten evaluation criterion and questions that were used, which were drawn from the original CCME EPR Evaluation Framework and adapted.

These criteria/questions were grouped into four categories:

- Environmental impacts
- Suitability for Extended Producer Responsibility
- Public, Producer and Political Interest
- Industry Readiness

The information needed to assess each candidate building product against each evaluation criterion were determined by literature research and conducting interviews with waste management staff from Metro Vancouver and the City of Vancouver, municipal recycling coordinators, and construction and demolition waste professionals. Prior to the interviews, an application for ethics approval was obtained from the UBC Behavioural Research Ethics Board (BREB).

The information from literature research and interviews were then used to score each evaluation criteria on a scale of 1-5, with 1 equating to "low priority for EPR" and 5 being "high priority for EPR". For each criterion, the rationale for each point is shown in Table 5.

The evaluation framework applies a screening tool to the list of products in order to identify potential candidates for EPR programs. However, this report does not identify and analyze program design and implementation options for any specific product.

Table 5. A set of criteria designed to assess the environmental impacts of candidate materials. The matrix below is adapted from the Canadian Council of Ministers of the Environment website (Canadian Council of Ministers of the Environment, 2008).

Category	**Evaluation Criteria/ Questions**	1 Low priority for an EPR program	2 →	3	4	5 High Priority for an EPR program
Environmental Impacts : resulting from manufacturing process, product use, and end of life management	Does this product, or its components or by-products, contain toxins or otherwise hazardous substances to the environment or human health?	*Low potential effects* Limited presence in the marketplace or No evidence of hazardous effects on the environment or human health from product use, disposal or recycling)	*Low potential effects* Not widespread in the marketplace Limited evidence with respect to hazardous effects on the environment or human health from product use, disposal or recycling)	*Moderate potential effects* Product is widespread in the marketplace Unknown potential hazardous effects on the environment or human health from product use, disposal or recycling)	*Significant* *potential effect* Product is widespread in the Marketplace Potentially hazardous effects on the environment or human health, for example the product or its components include a substance on	*Very significant potential effects* Product is widespread in the Marketplace Known hazardous effects on the environment or human health, (ex. product or its components include a substance that

					the Domestic Substance List[1])	is a CEPA toxic or equivalent)
	Is this product a significant component by weight/volume of the municipal stream disposed to landfills and/or incinerators? Refer to Table 7 for combined average (%) and total tonnes	*Not at all significant* <0.5% by volume or weight of municipal waste disposed in landfills and incinerators	*Not significant* (0.5 – 2.0%) by volume or weight of municipal waste disposed in landfills and incinerators	*Average* (2.0 - 3.5%) by volume or weight of municipal waste disposed in landfills and incinerators	*Significant* (3.5% - 5.0%) by volume or weight of municipal waste disposed in landfills and incinerators	*Very significant* (>5.0%) by volume or weight of municipal waste disposed in landfills and incinerators
Suitability for Extended Producer Responsibility	Is this a wasted resource that is not currently recycled, reused or used as alternative energy? Refer to Table 8 for Diverted tonnes and diversion rate (%)	*Limited benefits to an EPR program* Extensive number of recycling/reuse opportunities in place with high participation rates	*Some benefits to an EPR program* Many number of recycling/reuse opportunities in place with moderate participation rates	*Potential benefits to an EPR program* Less than half of municipalities or retailers offer recycling/reuse opportunities with moderate participation rates	*Potential benefits to an EPR program* Only 1-2 municipalities or retailers offer recycling/reuse opportunities with low participation rate	*Significant potential benefits to an EPR program* No recycling/reuse opportunities exist
	Is this a nuisance product in terms of litter, collection, or	*No issues*	*Intermediate*	*Some issues*	*Intermediate*	*Many barriers (in all aspects)*

	other infrastructure difficulties? Is there a difficulty in marketing the collected product?					
	Are similar products being managed under an existing EPR program?	*No related products* being managed currently	*Intermediate*	*Some related products* are currently managed	*Intermediate*	*Many products* are currently being managed
	Is it possible that an EPR program for this product could stimulate product redesign (Design for environment) to reduce material and resource usage, and toxin usage?	*Very unlikely* because of public health, safety, and security reasons	*Unlikely* because difficulty in getting cooperation from producers	*Possibility.* Producers have expressed cooperation and interest	*Likely*. Industry has expressed interest in redesign	*Very Likely.* Redesign products are already available on the market and industry is already engaged in sustainability efforts
Political Interest	Is there political interest in a program?	*None*	*Some anticipated interest* based on current events (for example, knowledge that a large landfill is reaching capacity could	*Low level of current political interest*	*Moderate level of current political interest*	*High level of current political interest*

			be classified as anticipated interest)			
Industry Readiness	Recycling infrastructure: Does a local processing facility exist?	*No processing facility exists*	*No processing facility exists but talks are in the works to establish one*	*No/Few local processing facilities exist, and there are formal plans to implement more*	*Local processing facilities exist, but are currently underused.*	*Many local processing facilities exist and are currently processing a large volume of incoming material*
	Processing Technology: Does the technology exist locally or globally in order to process such materials?	*No technology exists locally or globally to process the material*	*The technology exists globally but not locally due to barriers such as: cost, unavailable resources, lack of interest, etc.*	*The technology exists globally and has the potential to be integrated into local recycling infrastructures*	*Processing technology exists and is already being used at a few local recycling infrastructures*	*Processing technology exists and is already being used at many local recycling infrastructures*
	Producer support: Is there producer interest in a program?	*No support* No discussions have been planned	*Limited evidence for support* No discussions planned with producers but some individuals have expressed interest	*Some evidence for support* Plans for formal discussion have been initiated with producers	*Clear evidence for support* Formal discussions with producers are already in place	*Strong evidence for support* Regular formal discussions are in place

Raw Scores

In the raw score system, each criterion is given equal weight. As there are 10 criteria, the maximum total score for a product is 50. The raw scores represent the unweighted outcome of the evaluation process, without any adjustments for weighting based on value preference. Following the raw scoring, the system was normalized by rating each product out of 100 to allow for comparison of the weightings used in the sensitivity analysis.

The preliminary results of the raw scoring process were discussed with Monica Kosmak, Zero Waste Planning Manager for the City of Vancouver, and revisions were made based on her input.

Equal Weight

Prior to the sensitivity analyses, an equal weighting analysis was done for all candidate products by setting the four criteria group score to 25 (Appendix A4). This prioritized the list based on all four criteria group being equally important to each other and the results provided a baseline to compare the rankings resulting from the subsequent sensitivity analyses.

Sensitivity Analyses

Following the primary evaluation of each product in the four categories mentioned above, a sensitivity analysis was conducted using different value weightings for each of the four evaluation categories to determine if it would affect the ranking for each candidate product.

In order to proceed with EPR program implementation, value can be placed on various aspects to determine which products should be a priority for implementation. For example,

according to City of Vancouver staff, the province of British Columbia has historically placed more priority on EPR for products with high toxicity levels or health hazards, like hazardous waste and electronics; however, more recently, high-volume wastes like packaging and printed paper have been prioritized (M. Kosmak, personal communication, March 14, 2013). For building products, industry readiness and the availability of recycling market sensitivity analysis was designed to assess the effects of specific value preferences on the raw score results.

A wide range of sensitivity analyses is possible. For the purposes of this study, four sensitivity analyses were conducted based on input from City of Vancouver waste management staff (M. Kosmak, personal communication, March 14, 2013). The weighting factors used in these analyses are presented in Table 6, alongside the Raw Score maximum values, normalized to 100 to provide a basis for comparison. The weighting factors and normalization to 100 are adapted from the methodology used by Gartner Lee (2007). For the purposes of this paper, four sensitivity analyses were carried out in which the category of choice was weighted at 50%, and the other three categories split the remaining 50% in the weighting. The sensitivity analysis focused on the value of criteria as follows:

- Sensitivity analysis 1 emphasized the Environmental Impacts criteria that encompass the toxicity and health impacts and the weight/volume of weight produced categories. As shown in Table 6, this criteria was allocated 50 points (out of 100), whereas the other three criteria were given 16.67 points each.

- Sensitivity analysis 2 emphasized the Suitability for Extended Producer Responsibility criteria that encompass the resource, product and design for environment categories. As shown in Table 6, this criteria was allocated 50 points (out of 100), whereas the other three criteria were given 16.67 points each.

- Sensitivity analysis 3 emphasized the Public, Political and Producer Interest criteria that encompass public demand, the political support and industry readiness category. As

shown in Table 6, this criteria was allocated 50 points (out of 100), whereas the other three criteria were given 16.67 points each.

- Sensitivity analysis 4 emphasized the Industry Readiness criteria that encompass the recycling infrastructure, processing technology and producer interest categories. As shown in Table 6, this criteria was allocated 50 points (out of 100), whereas the other three criteria were given 16.67 points each

Table 6. Weightings are manipulated for each major category taken from Table 5. The matrix is based from a sensitivity analysis done from the Gartner Lee report (Gartner Lee Limited, 2007).

		Sensitivity Analysis							
Category	**Sub-category**	**Criteria Value**	**Sensitivity 1: *Emphasis on Environmental Impacts***	**Criteria Value**	**Sensitivity 2: *Emphasis on Suitability for EPR***	**Criteria Value**	**Sensitivity 3: *Emphasis on Public, Producer and Political Interest***	**Criteria Value**	**Sensitivity 4: *Emphasis on Industry Readiness***
Environmental Impact	Environmental Toxicity/Hazard	50.00	25.00	16.67	8.33	16.67	8.33	16.67	8.33
	Human Health and Safety		25.00		8.33		8.33		8.33
Suitability for Extended Producer Responsibility	Alternatives to Disposal	16.67	4.166	50.00	12.50	16.67	4.17	16.67	4.17
	Problem/Nuisance Material		4.166		12.50		4.17		4.17
	Similar Products to EPR		4.166		12.50		4.17		4.17
	Design for Environmental Potential		4.166		12.50		4.17		4.17
Political Interest	Political Interest	16.67	16.67	16.67	16.67	50.00	50.00	16.67	16.67
Industry Readiness	Recycling Infrastructure	16.67	5.55	16.67	5.55	16.67	5.55	50.00	16.67

	Processing Technology		5.55		5.55		5.55		16.67
	Producer Interest		5.55		5.55		5.55		16.67
Total Points		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Results

Waste Disposal Analysis

Table 7. Total construction and demolition waste disposal by sector in 2010 to 2011. Waste composition for DO, ICI and SF-RES were derived from Technology Resource Inc. (2011); MF-RES data were taken from TRI Environmental Consulting Inc. (2012); and DLC data were taken from AET Consultants report (2011). Data for total waste disposed in Metro Vancouver (2010) provided by B. Socher (personal communication, April 29, 2013). Combined average is the sum of the contributing % of all sectors and represents the % of each building material contributing to the overall waste generated in Metro Vancouver in 2010. The combined average and total tonnes are used for scoring each candidate material in the EPR evaluation tool, under the criteria for material waste stream volume and weight.

	SF %	MF%	ICI %	DO %	DLC %	TOTAL WASTE %	SF (tonnes)	MF (tonnes)	ICI (tonnes)	DO (tonnes)	DLC (tonnes)	TOTAL WASTE (tonnes)
Wood	**2.9%**	**2.4%**	**18.2%**	**42.3%**	**53.3%**	**24.7%**	**7,381**	**4,740**	**77,400**	**53,870**	**195,323**	**338,713**
Clean (compostable) wood	**1.7%**	**1.1%**	**7.4%**	**21.2%**	**26.0%**	**11.7%**	**4,378**	**2,172**	**31,623**	**27,030**	**95,279**	**160,483**
Other (compostable) wood (mixed lumber, rotting wood) - unpainted, untreated	1.7%	1.1%	7.4%	21.2%	26.0%	11.7%	4,378	2,172	31,623	27,030	95,279	160,483
Wooden packaging	**0.0%**	**0.0%**	**6.6%**	**0.8%**	**0.1%**	**2.2%**	**-**	**-**	**28,180**	**968**	**366**	**29,515**
Wood pallets (unpainted, untreated)	0.0%	0.0%	6.6%	0.8%	0.1%	2.2%	-	-	28,180	968	366	29,515
Wood building products	**1.2%**	**1.3%**	**4.1%**	**20.3%**	**27.2%**	**10.8%**	**3,003**	**2,567**	**17,597**	**25,871**	**99,677**	**148,716**
Wood shakes & shingles	0.0%	0.2%	0.0%	0.0%	0.1%	0.1%	-	395	-	-	366	761
Hardwood flooring	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	-	-	-	-	366	366
Treated wood (treated lumber, shingles, etc.) -	0.2%	0.2%	0.2%	2.8%	0.0%	0.4%	458	395	1,020	3,528	-	5,402

	SF %	MF%	ICI %	DO %	DLC %	TOTAL WASTE %	SF (tonnes)	MF (tonnes)	ICI (tonnes)	DO (tonnes)	DLC (tonnes)	TOTAL WASTE (tonnes)
(pressure treated)												
Finished wood (panelling, siding, glued particle board, plywood, OSB) - painted, stained or finished	1.0%	0.9%	3.9%	17.5%	8.0%	5.3%	2,545	1,777	16,577	22,343	29,317	72,559
Composite wood (DLC)	0.0%	0.0%	0.0%	0.0%	19.0%	5.1%	-	-	-	-	69,627	69,627
Building products (construction & demolition)	**3.0%**	**2.7%**	**6.4%**	**13.7%**	**29.1%**	**11.8%**	**7,712**	**3,357**	**27,288**	**17,426**	**106,456**	**162,239**
Concrete	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**4.1%**	**1.1%**	**-**	**-**	**-**	**-**	**15,025**	**15,025**
Preformed blocks	0.0%	0.0%	0.0%	0.0%	2.0%	0.5%	-	-	-	-	7,329	7,329
Poured without rebar	0.0%	0.0%	0.0%	0.0%	2.0%	0.5%	-	-	-	-	7,329	7,329
Poured with rebar	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	-	-	-	-	366	366
Misc. concrete	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Masonry	**0.1%**	**0.0%**	**0.0%**	**1.1%**	**1.0%**	**0.4%**	**255**	**-**	**-**	**1,388**	**3,665**	**5,308**
Brick	0.0%		0.0%	0.0%	1.0%	0.3%	-	-	-	-	3,665	3,665
Tile	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Misc. masonry (includes bricks, blocks, concrete)	0.1%		0.0%	1.1%	0.0%	0.1%	255	-	-	1,388	-	1,643
Roofing	**0.0%**	**0.0%**	**0.8%**	**1.8%**	**11.3%**	**3.4%**	**-**	**-**	**3,400**	**2,229**	**41,373**	**47,003**
Tarpaper	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Rigid asphalt building products (e.g. shingles)	0.0%		0.8%	1.8%	7.0%	2.3%	-	-	3,400	2,229	25,652	31,282
Tar & gravel roofing	0.0%		0.0%	0.0%	4.3%	1.1%	-	-	-	-	15,721	15,721
Other roofing	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-

	SF %	MF%	ICI %	DO %	DLC %	TOTAL WASTE %	SF (tonnes)	MF (tonnes)	ICI (tonnes)	DO (tonnes)	DLC (tonnes)	TOTAL WASTE (tonnes)
Outdoor Wall Finishing	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.2%**	**0.1%**	**-**	**-**	**-**	**-**	**770**	**770**
Metal siding	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	37	37
Plastic siding	0.0%		0.0%	0.0%	0.1%	0.0%	-	-	-	-	366	366
Stucco	0.0%		0.0%	0.0%	0.1%	0.0%	-	-	-	-	366	366
Indoor Wall Finishing	**1.4%**	**0.5%**	**0.6%**	**2.9%**	**0.0%**	**0.8%**	**3,563**	**987**	**2,550**	**3,707**	**73**	**10,881**
Gypsum drywall (includes some plaster)	1.4%	0.5%	0.6%	2.9%	0.0%	0.8%	3,563	987	2,550	3,707	37	10,845
Lath & plaster	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	37	37
Insulation	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**-**	**-**	**-**	**-**	**37**	**37**
Styrofoam insulation	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Fiberglass	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Cellulose	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	37	37
Urethane foam	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Flooring (excluding carpet)	**0.1%**	**0.0%**	**1.0%**	**0.3%**	**0.0%**	**0.4%**	**255**	**-**	**4,250**	**382**	**37**	**4,924**
Linoleum	0.1%		1.0%	0.3%	0.0%	0.4%	255	-	4,250	382	37	4,924
Plumbing	**0.1%**	**0.0%**	**0.1%**	**0.1%**	**0.1%**	**0.1%**	**127**	**-**	**213**	**153**	**330**	**822**
Ferrous kitchen & bathroom fixtures (sinks, tubs, faucets)	0.1%		0.1%	0.1%	0.0%	0.0%	127	-	213	153	-	493
Plastic pipes	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Metal plumbing	0.0%		0.0%	0.0%	0.1%	0.0%	-	-	-	-	330	330
Misc. Glass Building Products	**0.5%**	**1.0%**	**2.4%**	**3.7%**	**0.0%**	**1.2%**	**1,273**	**-**	**10,201**	**4,688**	**37**	**16,198**

	SF %	MF%	ICI %	DO %	DLC %	TOTAL WASTE %	SF (tonnes)	MF (tonnes)	ICI (tonnes)	DO (tonnes)	DLC (tonnes)	TOTAL WASTE (tonnes)
Misc. glass products: flatware, mirrors, insulation, lightbulbs (assume 100% building products)	0.5%		2.4%	3.7%	0.0%	1.2%	1,273	-	10,201	4,688	37	16,198
Misc. Plastic Building Products	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**4.0%**	**1.1%**	**-**	**-**	**-**	**-**	**14,658**	**14,658**
Sheet plastic	0.0%		0.0%	0.0%	4.0%	1.1%	-	-	-	-	14,658	14,658
Rigid plastic products	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Other misc. plastic products	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Misc. Metal Building Products	**0.6%**	**0.9%**	**1.6%**	**3.8%**	**1.0%**	**1.3%**	**1,476**	**1,777**	**6,673**	**4,879**	**3,665**	**18,470**
Sheet metal	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Flashing metal	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Electrical	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Misc. ferrous building products	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Non-ferrous	0.0%		0.0%	0.0%	0.0%	0.0%	-	-	-	-	-	-
Other misc. metal products (renovation/industrial (nails, toolds, doors, panels, etc.)	0.6%	0.9%	1.6%	3.8%	1.0%	1.3%	1,476	1,777	6,673	4,879	3,665	18,470
Misc. Building Products	**0.3%**	**0.3%**	**0.0%**	**0.0%**	**0.0%**	**0.1%**	**764**	**592**	**-**	**-**	**37**	**1,393**
Other inorganic Building products (linoleum, etc.)	0.3%		0.0%	0.0%	0.0%	0.1%	764	-	-	-	-	764
Misc. c&d materials	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	-	592	-	-	37	629
Asphalt	0.0%	0.0%	0.0%	0.0%	**7.3%**	**2.0%**	-	-	-	-	**26,752**	**26,752**
Carpet	**1.0%**	**0.6%**	**4.2%**	**10.6%**	**1.0%**	**2.8%**	**2,545**	**1,185**	**17,852**	**13,502**	**3,665**	**38,749**
Carpet waste (and underlay)	1.0%	0.6%	4.2%	10.6%	1.0%	2.8%	2,545	1,185	17,852	13,502	3,665	38,749

	SF %	MF%	ICI %	DO %	DLC %	TOTAL WASTE %	SF (tonnes)	MF (tonnes)	ICI (tonnes)	DO (tonnes)	DLC (tonnes)	TOTAL WASTE (tonnes)
SUB-TOTAL CONSTRUCTION & DEMOLITION WASTE	**5.9%**	**5.1%**	**24.6%**	**56.0%**	**82.4%**	**39.1%**	**17,639**	**9,282**	**122,539**	**84,798**	**301,778**	**536,037**
TOTAL WASTE DISPOSED IN METRO VANCOUVER							**254,530**	**197,490**	**425,040**	**127,382**	**366,459**	**1,370,901**

Note: Numbers may not add evenly due to rounding.

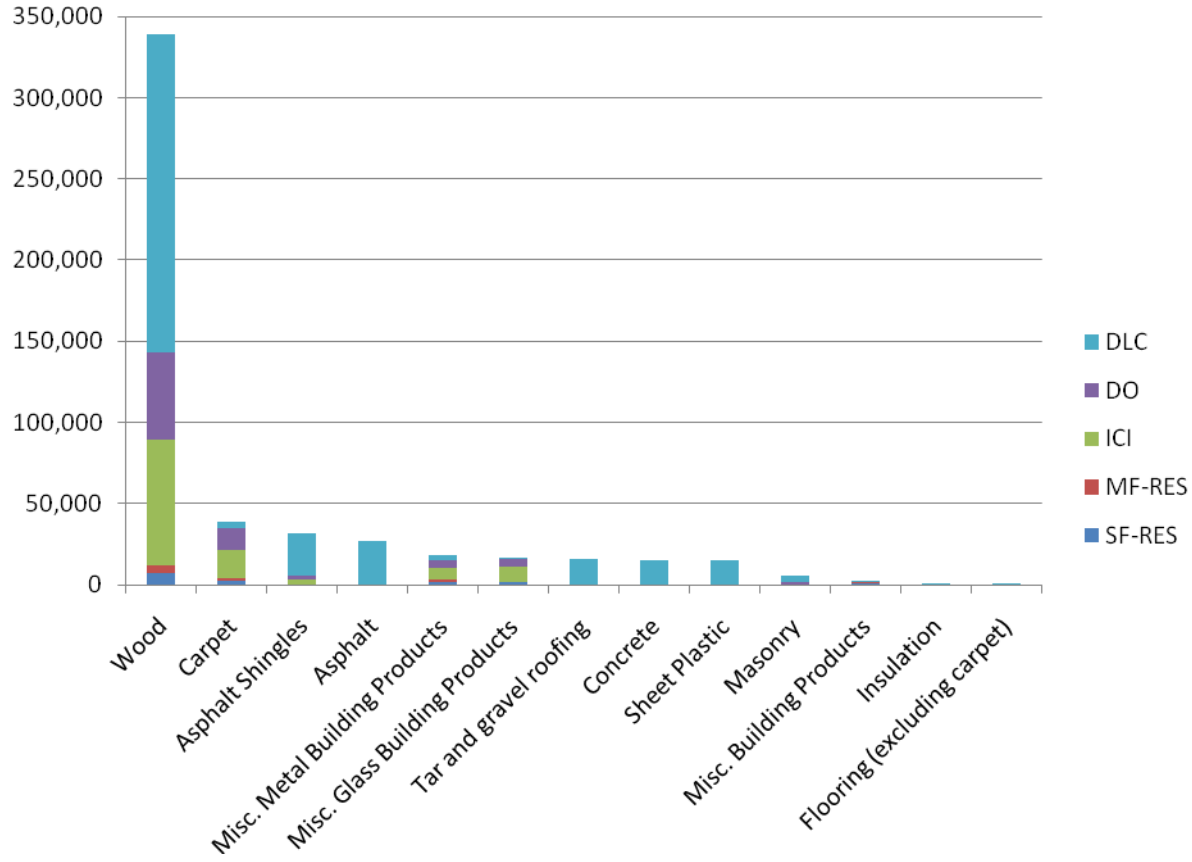
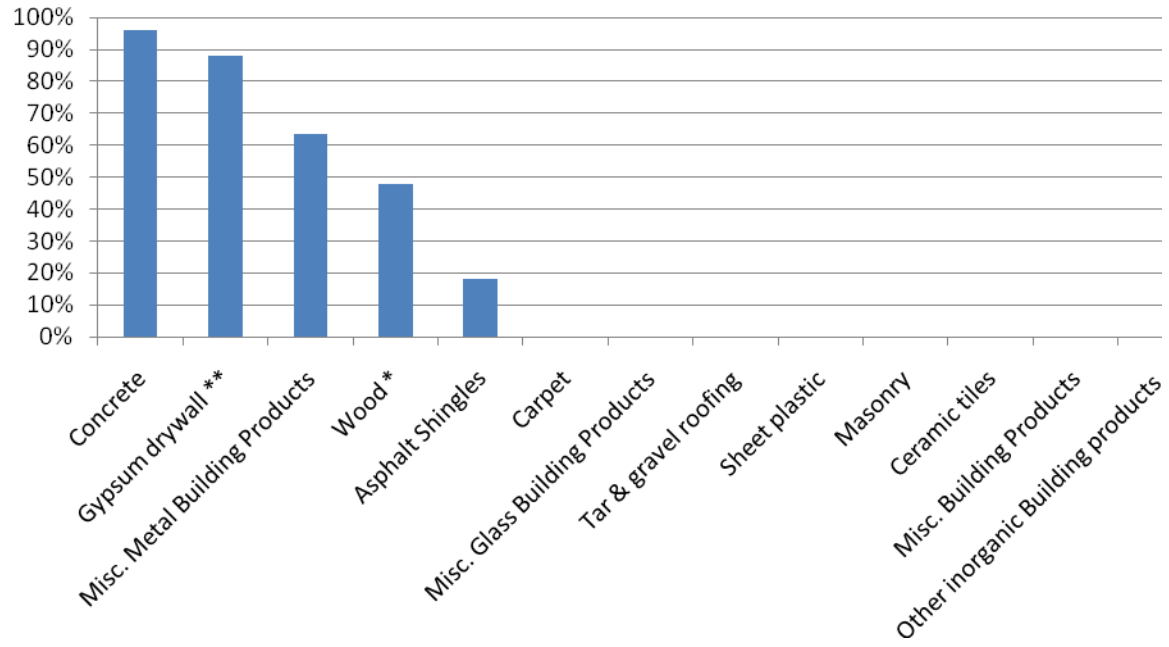


Figure 1. Construction and demolition waste disposed to landfills in years 2010 and 2011. Data for Single-Family residence (SF-RES), and Industrial, Commercial and Institutional (ICI) sectors taken from 2010 Waste Composition Study (Technology Resource Inc., 2011). Data for Multi-family Residence (MF-RES) were taken from Metro Vancouver Annual Recycling and Solid Waste Management 2011 Report (Metro Vancouver, 2011). Data for Demolition, Land-Clearing and Construction (DLC) waste were taken from AET Consultants Report (2011). Waste from Drop-off (DO) was estimated by taking the difference between waste collected from SF-RES, MF-RES, ICI curbsides and SF-RES, MF-RES and ICI taken directly to DO (Data provided by M. Kosmak, personal communication, April 1, 2013).

Diversion analysis

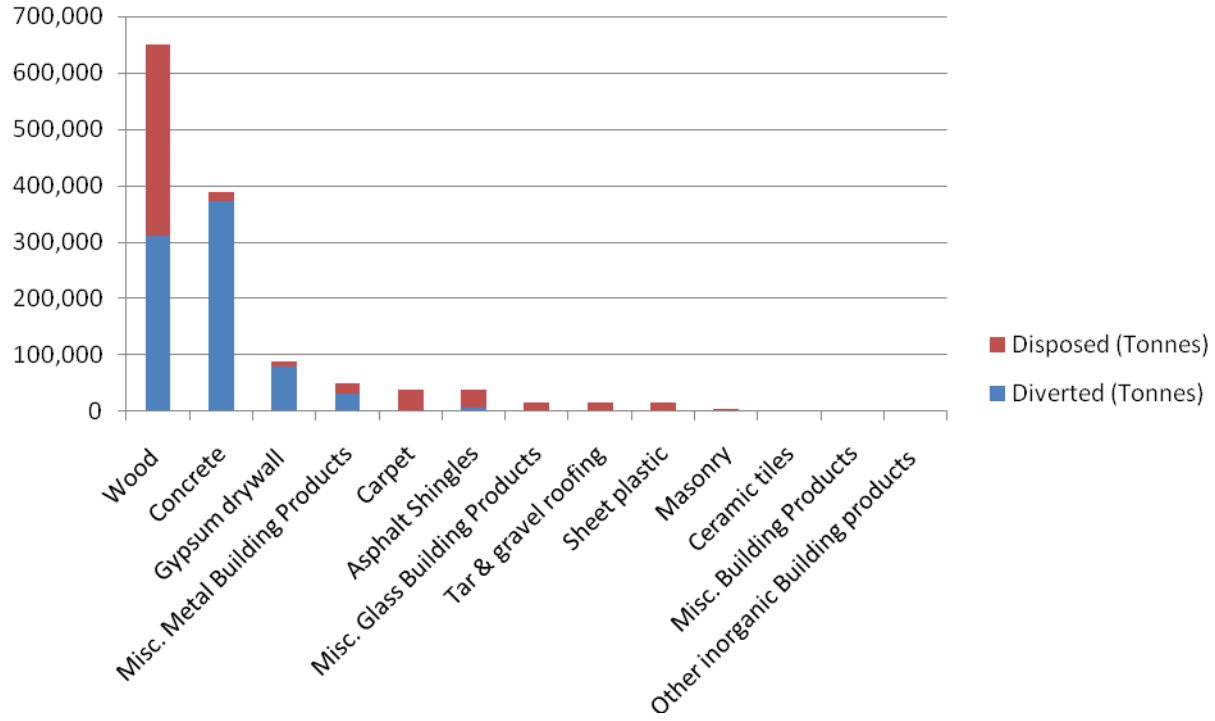
Table 8. Diversion rate by building material. Diverted tonnages were adapted from 2011 Metro Vancouver report (2011) and from personal communication with M.Kosmak (2013). Asphalt shingles data were taken from personal communication with Gemaco (2013). N/A indicates that there is no applicable data at this moment.

Building Material	**Diverted (Tonnes)**	**Disposed (Tonnes)**	**Generated (Total of disposed and diverted)**	**Diversion rate (%)**
Concrete	373,313	15,025	388,338	96.1%
Gypsum drywall **includes some plaster	78,585	10,845	89,430	87.9%
Misc. Metal Building Products	32,307	18,470	50,777	63.6%
Wood *may include some furniture	312,041	338,713	650,754	48.0%
Asphalt Shingles	7,000	31,274	38,774	18.3%
Carpet	0	38,749	38,749	0.0%
Ceramic tiles	0	1,872	1,872	0.0%
Sheet plastic	0	14,658	0	0.0%
Misc. Glass Building Products	0	16,198	16,198	0.0%
Other inorganic Building products (linoleum, etc.)	0	764	0	0.0%
Tar & gravel roofing	0	15,721	0	0.0%
Masonry	0	5,290	0	0.0%
Misc. Building Products	0	1,337	0	0.0%



***Includes some plaster*
** May include some furniture*

Figure 2. Diversion rate for some building materials/products from years 2010 to 2011. Due to limitations of data availability, only seven materials/products were able to be quantified for its diversion rates. Where data was not provided, it is assumed the diversion rate is 0%. Refer to equation 1 for methodology used to calculate diversion rate.



***Includes some plaster*
** May include some furniture*

Figure 3. Waste generated (disposed and diverted tonnages) for some building materials/products from years 2010 to 2011. Due to limitations of data availability, only seven materials/products were able to be quantified.

Raw scoring

Table 9. Raw score for each candidate material as determined by the EPR evaluation tool. The raw score is out of 100.

Candidate Material	Raw Score (Out of 100)
Wood*	76.5
Carpet	75.3
Gypsum Drywall**	70.6
Asphalt Shingles	69

Concrete	67.3
Sheet Plastic	64.9
Ceramic Tiles	50.4
Misc. glass building products	44.5
Misc. metal building products	39.9

* May include some furniture ** May include some plaster

Summary tables for each candidate material (Tables 10 to 18)

Table 10. Summary and assumptions for scoring on the current state of asphalt shingles waste in Metro Vancouver, British Columbia. Scores were assigned based on information found for each criteria subgroup in the EPR evaluation tool. Tables with "N/A" identifies that the information could not be found at the time.

Asphalt shingles			
Criteria Subgroup		**Information summary and assumptions made for scoring**	**Score (/5)**
Environmental Impacts	**Potential toxicity and hazards to human health and environment:** Does this product, or its components or by-products, contain toxics or otherwise hazardous substances to the environment or human health?	Asphalt shingles are made with asphalt, which is derived from petroleum and can produce Hydrogen Sulphide when exposed to high temperature (Lafarge, 2011).	**3**
	Waste stream volume or weight to landfills or incinerators (For data, refer to Table 7-Combined average in % and total tonnes): *Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*	Asphalt products make up about 2.28% (31,274 tonnes) of total waste sent to Metro Vancouver landfills each year (Metro Vancouver, 2010 and 2011).	**2**

	2011 Waste diversion rate (For data, refer to Table 8-Diverted tonnes and diversion rate %): *Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*	In 2011, 7,000 tonnes of asphalt shingles were recycled at Gemaco, which is about 18.3% of total asphalt shingles waste diverted from landfills (M. Kosmak, personal communication, March 14, 2013). In 2012, the recycled tonnage increased to 11,000 tonnes (Terry Charles, personal communication, March 8, 2013).	**3**
	Problem and Nuisance Product: *Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are there problems marketing the collected product?*	Product must be clean and free of contaminants such as flashing, wood, and plastic (Gemaco, 2012). Some issues with illegal dumping of asphalt shingles Currently, there is a lack of collection infrastructure. (M. Kosmak, personal communication, March 30, 2013). Overall the benefits to recycling asphalt shingles outweigh the barriers: The existing market for recycled product is good and is expected to grow. Recycling offers a lower tipping fee compared to disposal at a landfill. A market exists for recycled shingles, with uses in paving for road work, mix-in with hot-mix asphalt, and fire for cement kilns (Gemaco, 2012).	**3**
Suitability for EPR	**Status in related EPR programs:** *Are similar products managed under an EPR?*	There is not an EPR program for asphalt shingles yet.	**1**
	Product redesign for environment: *Is it possible that an EPR program for the product could stimulate*	Current EPR programs have not resulted in many design changes. Complementary regulations are likely needed to drive this (M. Kosmak, personal communication, March 14, 2013).	**1**

	product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?		
	Political Interest: *Is there political interest in a program?*	Political interest is strong and development of an EPR program for asphalt shingles is seen to be very feasible (City of Vancouver and Metro Vancouver staff, personal communication, March 8, 2013).	**5**
Political interest	**Local Recycling Infrastructure:** *Are there recycling infrastructures within Metro Vancouver that collect and process this material?*	Gemaco Sales Ltd. is the only licensed asphalt shingle recycling facility that serves the Metro Vancouver region and is centrally located on Annacis Island. The facility has the ability to process up to 60,000 tonnes of asphalt shingles each year, diverting the waste from landfills (Gemaco, 2012).	**5**
Industry Readiness	**Processing Technology:** *Does the technology exist locally or worldwide to process the waste material into recycled products?*	Asphalt shingles are processed and all parts of the shingles are recycled at Gemaco using a Rotochopper RGI shingle grinder. Even nails left on incoming shingles are removed and recycled (Gemaco, 2012).	**5**
	Producer Readiness: *Could producers be ready to implement an EPR system for this product?*	Many tests have been conducted on the quality of asphalt products produced through mixing recycled asphalt shingles (RAS) with virgin asphalt mixes. Laboratory testing has shown that mixed products performed well enough and continuous testing is done to determine the maximum proportion of RAS that can be incorporated into new asphalt products, including new shingles (Uzarowski *et al.*, 2010).	**3**

Table 11. Summary and assumptions for scoring on the current state of carpet waste in Metro Vancouver, British Columbia. Scores were assigned based on information found for each criteria subgroup in the EPR evaluation tool. Tables with "N/A" identifies that the information could not be found at the time.

Carpets			
Criteria Subgroup		**Information summary and assumptions made for scoring**	**Score (/5)**
Environmental Impacts	**Potential toxicity and hazards to human health and environment:** *Does this product, or its components or by-products, contain toxics or otherwise hazardous substances to the environment or human health?*	Producers have put in efforts to minimize the level toxic chemicals in carpet and carpet padding but many carpets may still contain volatile organic compounds (VOCs) and air pollutants that can be harmful to the environment and human health (Hirshberg, 2005).	**3**
	Waste stream volume or weight to landfills or incinerators (For data, refer to Table 7-Combined average in % and total tonnes): *Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*	Carpet waste make up about 2.81% (38,749 tonnes) of total waste sent to Metro Vancouver landfills each year (Metro Vancouver, 2010 and 2011).	**3**
	2011 Waste diversion rate (For data, refer to Table 8-Diverted tonnes and diversion rate %): *Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*	0 %	**5**
Suitability for EPR	**Problem and Nuisance Product:** *Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are*	Used carpets are harder to recycle due to contaminants such as dirt, cleaning chemicals, and miscellaneous substances that have been collected in the carpet during the use (Mihut *et al*., 2001).	**4**

	there problems marketing the collected product?	In general, the market for the end product of carpets is lacking. Specifically, there is not an existing markets available for carpets made from recycled PET plastics since it is a fairly a new substance (Canadian Carpet Recovery Effort, 2013). Other problems include: economic and infrastructure related problems with collection, obstacles in designing recyclable carpets, technological challenges in processing, and non-existing policies and strategies favouring proper disposal (Carpet America Recovery Report, 2007). In Metro Vancouver, there have been issues with illegal dumping (M. Kosmak, personal communication, March 30, *2013).*	
	Status in related EPR programs: *Are similar products managed under an EPR?*	There is not an EPR program for carpets yet.	**1**
	Product redesign for environment: *Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*	Companies like Interface are actively developing ways to produce carpets by using less energy and raw material (Interface LLC, n.d.a). They are already utilizing various recycled materials in carpet production (Interface LLC, n.d.a). Nonetheless, complementary regulations are likely needed to drive further product redesign (M. Kosmak, personal communication, March 30, 2013).	**1**
Political interest	**Political Interest:** *Is there political interest in a program?*	With the recent establishment of the Canadian Carpet Recovery Effort (CCRE) in 2010, current data collection on sales and diversion of carpets from the companies in Stewards and Carpet Diversion sector will be used to prepare for future EPR programs for implementation in near	**5**

		future (Canadian Carpet Recovery Effort, 2013).	
Industry Readiness	**Local Recycling Infrastructure:** *Are there recycling infrastructures within Metro Vancouver that collect and process this material?*	Currently, there is no carpeting collecting or processing infrastructure in Metro Vancouver. Although, a fraction of used carpets are exported to United States to be processed for sale in end markets (EBA Engineering Consultants Ltd., 2012). However, several carpet-recycling companies have been established in Canada and several of US based companies have shown interest in operating in the Metro Vancouver region (EBA Engineering Consultants Ltd., 2012).	**2**
	Processing Technology: *Does the technology exist locally or worldwide to process the waste material into recycled products?*	Shearing is the current technology used to separate carpet fibers but there are several new technologies that are being developed which could be used in regional processing facilities (EBA Engineering Consultants Ltd., 2012).	**5**
	Producer Readiness: *Could producers be ready to implement an EPR system for this product?*	Many companies are actively developing ways to produce carpets that use less energy and raw material (Interface LLC, 2013). Utilization of various recycled materials in new carpet production is already common practice (Interface LLC, 2013). With current trend of rapid development of carpet recycling industry along with the implementation of Extended Producer Responsibility (EPR) program, there is a great potential in a significant development in the collection and processing facilities and market conditions for Metro Vancouver's carpet recycling industry (EBA Engineering Consultants Ltd., 2012).	**3**

Table 12. Summary and assumptions for scoring on the current state of ceramic tiles in Metro Vancouver, British Columbia. Scores were assigned based on information found for each criteria subgroup in the EPR evaluation tool. Tables with "N/A" identifies that the information could not be found at the time.

Ceramic Tiles			
Criteria Subgroup		**Information summary and assumptions made for scoring**	**Score (/5)**
Environmental Impacts	**Potential toxicity and hazards to human health and environment:** *Does this product, or its components or byproducts, contain toxics or otherwise hazardous substances to the environment or human health?*	Production is high-energy intensive; during the high temperature treatment process, high concentrations of potential volatile toxic pollutants are released to the environment (Nicoletti *et al.*, 2002).	**3**
	Waste stream volume or weight to landfills or incinerators (For data, refer to Table 7-Combined average in % and total tonnes): *Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*	1,872 tonnes of indoor and outdoor ceramic tile was generated in 2011, making up less than 1 % of total waste generated annually in Metro Vancouver (AET Consultants, 2011).	**2**
	2011 Waste diversion rate (For data, refer to Table 8-Diverted tonnes and diversion rate %): *Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*	N/A	**5**

Suitability for EPR	**Problem and Nuisance Product:** *Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are there problems marketing the collected product?*	Reusing ceramic tiles are difficult unless it is removed intact (Vancouver Green Capital, 2010). Certain types of tiles many contain asbestos, which requires proper disposal method (Vancouver Green Capital, 2010).	**3**
	Status in related EPR programs: *Are similar products managed under an EPR?*	There is not an EPR program for ceramic tiles yet.	**1**
	Product redesign for environment: *Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*	Current EPR programs have not resulted in many design changes. Complementary regulations are likely needed to drive this (M. Kosmak, personal communication, March 30, 2013).	**1**
Political Interest	**Political Interest:** *Is there political interest in a program?*	N/A	**1**
Industry Readiness	**Local Recycling Infrastructure:** *Are there recycling infrastructures within Metro Vancouver that collect and process this material?*	N/A	**0**
	Processing Technology: *Does the technology exist locally or worldwide to process the waste material into recycled products?*	N/A	**3**
	Producer Readiness:	N/A	**1**

	Could producers be ready to implement an EPR system for this product?		

Table 13. Summary and assumptions for scoring on the current state of concrete in Metro Vancouver, British Columbia. Scores were assigned based on information found for each criteria subgroup in the EPR evaluation tool. Tables with "N/A" identifies that the information could not be found at the time.

Concrete			
Criteria Subgroup		**Information summary and assumptions made for scoring**	**Score (/5)**
Environmental Impacts	**Potential toxicity and hazards to human health and environment:** *Does this product, or its components or by-products, contain toxics or otherwise hazardous substances to the environment or human health?*	Concrete contains crystalline silica which can cause lung irritation and can be fatal if exposure is chronic (Lafarge, 2011).	**4**
	Waste stream volume or weight to landfills or incinerators (For data, refer to Table 7-Combined average in % and total tonnes): *Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*	Concrete makes up about 1.01% (15,025 tonnes) of total waste sent to Metro Vancouver landfills each year (Metro Vancouver, 2010 and 2011).	**3**
	2011 Waste diversion rate (For data, refer to Table 8-Diverted tonnes and diversion rate %): *Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*	373, 313 tonnes (96.1%) (Metro Vancouver, 2011)	**1**

Suitability for EPR	**Problem and Nuisance Product:** *Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are there problems marketing the collected product?*	Processing requires that the product is clean and free of contaminants such as plastic. In Metro Vancouver, strong market and recycling infrastructure are in place (M. Kosmak personal communication, March 30, 2013).	**1**
	Status in related EPR programs: *Are similar products managed under an EPR?*	There is not an EPR program for concrete yet.	**1**
	Product redesign for environment: *Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*	Current EPR programs have not resulted in many design changes. Complementary regulations are likely needed to drive this (M. Kosmak, personal communication, March 30, 2013).	**1**
Political Interest	**Political Interest:** *Is there political interest in a program?*	Considered a 'quick-win' material for establishing an EPR program (City of Vancouver staff, personal communication, March 14, 2013). Many municipalities use crushed concrete as a gravel replacement for road work which helps to stimulate the market for recycled concrete (Kane Consulting *et al*., 2012).	**5**
Industry Readiness	**Local Recycling Infrastructure:** *Are there recycling infrastructures within Metro Vancouver that collect and process this material?*	In total, there are 26 facilities that recycle concrete. United Lock Block is the only processing facility in Metro Vancouver that is able to crush concrete. It has the capacity to process all of the concrete waste generated each year (about 600,000 tonnes) (Kane Consulting *et al*., 2012).	**5**
	Processing Technology:	Concrete recycling facilities crush the concrete to make road fill aggregates in replace of gravel or	**5**

	Does the technology exist locally or worldwide to process the waste material into recycled products?	using a proportion of recycled concrete to make new concrete blocks for structural materials (Kane Consulting *et al*., 2012).	
	Producer Readiness: *Could producers be ready to implement an EPR system for this product?*	Producer interest is evident because producers of concrete are usually recyclers and transporting waste concrete to landfill is expensive because of its heavy weight (Metro Vancouver staff, personal communication, March 13, 2013).	**5**

Table 14. Summary and assumptions for scoring on the current state of gypsum drywall in Metro Vancouver, British Columbia. Scores were assigned based on information found for each criteria subgroup in the EPR evaluation tool. Tables with "N/A" identifies that the information could not be found at the time.

Gypsum Drywall			
Criteria Subgroup		**Information summary and assumptions made for scoring**	**Score (/5)**
Environmental Impacts	**Potential toxicity and hazards to human health and environment:** *Does this product, or its components or byproducts, contain toxics or otherwise hazardous substances to the environment or human health?*	The main environmental hazard comes from the release of Hydrogen Sulphide when gypsum drywall sits in a landfill and comes in contact with moisture from other waste. Also, gypsum drywall takes up substantial space in landfills, having land use impact by reducing the lifespan of landfills. Buildings built prior to the 1980's may have gypsum boards sealed with asbestos containing compound. When asbestos is released into the air and inhaled, it can cause serious lung diseases such as asbestosis and mesothelioma (Metro Vancouver, 2011).	**5**
	Waste stream volume or weight to landfills or incinerators (For data, refer to Table 7-Combined average in % and total tonnes): *Is this a product a significant*	Gypsum drywall makes up about 0.80% (10, 845 tonnes) of total waste sent to Metro Vancouver landfills each year (Metro Vancouver, 2010 and 2011).	**2**

	component by volume or weight to the municipal waste disposed in landfills or incinerators?		
	2011 Waste diversion rate (For data, refer to Table 8-Diverted tonnes and diversion rate %): *Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*	78,585 tonnes (87.9%) (Metro Vancouver, 2011)	**1**
Suitability for EPR	**Problem and Nuisance Product:** *Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are there problems marketing the collected product?*	No problem or nuisance associated with product. Gypsum drywall has been banned from landfills since mid 1980's. Current recycling programs are successful, with high participation rate, well established market, and recovery rates are high. (Metro Vancouver, 2012)	**1**
	Status in related EPR programs: *Are similar products managed under an EPR?*	There is not an EPR program for gypsum drywall yet.	**1**
	Product redesign for environment: *Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*	Current EPR programs have not resulted in many design changes. Complementary regulations are likely needed to drive this (M. Kosmak, personal communication, March 30, 2013). Products like synthetic gypsum-a recycled product and processing methods that increase the amount of recycled gypsum to produce new gypsum products reduces the amount of new resources needed. Product redesign has already innovatively reduced the environmental impact by reducing the need to mine for new gypsum (New West Gypsum Recycling, 2013)	**1**

Political interest	**Political Interest:** *Is there political interest in a program?*	Gypsum drywall ban has been strictly enforced since the mid 1980's. Considered a 'quick-win' material for establishing an EPR program (City of Vancouver staff, personal communication, March 14, 2013). Collection of gypsum at construction and demolition sites is the norm.	**4**
Industry Readiness	**Local Recycling Infrastructure:** *Are there recycling infrastructures within Metro Vancouver that collect and process this material?*	Since the ban was enforced in 1985, New West Gypsum Recycling in Vancouver has recycled over 4.5 million tonnes of drywall, becoming a worldwide leader in the drywall recycling industry.	**5**
	Processing Technology: *Does the technology exist locally or worldwide to process the waste material into recycled products?*	New West Gypsum has created an efficient recycling process that pulverizes and cleans old gypsum so that it can be used as a raw material to produce recycled gypsum products	**5**
	Producer Readiness: *Could producers be ready to implement an EPR system for this product?*	Cleaned recycle gypsum is sold back to drywall manufacturers to make new drywall (New West Gypsum Recycling, 2013)	**4**

Table 15. Summary and assumptions for scoring on the current state of metal waste in Metro Vancouver, British Columbia. Scores were assigned based on information found for each criteria subgroup in the EPR evaluation tool. Tables with "N/A" identifies that the information could not be found at the time.

Miscellaneous Metal Building Products			
Criteria Subgroup		**Information summary and assumptions made for scoring**	**Score (/5)**
Environmental Impacts	**Potential toxicity and hazards to human health and environment:** *Does this product, or its components or byproducts, contain toxics or otherwise hazardous substances to the environment or human health?*	In general, the potential of toxicity and hazards to human health can come from direct contact in the process of iron and steel production (Direct Emissions from Iron and Steel Production, 2003).	**5**
	Waste stream volume or weight to landfills or incinerators (For data, refer to Table 7-Combined average in % and total tonnes): *Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*	1.30% (18,470 tonnes) of metal waste was generated in Metro Vancouver in 2011 (Metro Vancouver, 2011).	**2**
	2011 Waste diversion rate (For data, refer to Table 8-Diverted tonnes and diversion rate %): *Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*	77,082 tonnes (63.6%) of metal waste was diverted away from landfills in Metro Vancouver (Metro Vancouver, 2011).	**2**
Suitability for EPR	**Problem and Nuisance Product:** *Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are*	There seems to be little barrier in recycling, reusing and collecting metal waste in Metro Vancouver. From data shown, there is a high recycling rate due to a strong market for metals. Recycling facilities buy steel waste, which	**1**

	there problems marketing the collected product?	encourages recycling and separation from other wastes (Kane Consulting *et al.*, 2012). Most contractors, demolition companies, and waste haulers" separate and send metals for recycling most of the time, as confirmed by Kane Consulting *et al.* (2012).	
	Status in related EPR programs: *Are similar products managed under an EPR?*	There is not an EPR program for metals yet.	**2**
	Product redesign for environment: *Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*	Current EPR programs have not resulted in many design changes. Complementary regulations are likely needed to drive this (M. Kosmak, personal communication, March 30, 2013).	**1**
Political Interest	**Political Interest:** *Is there political interest in a program?*	There is little evidence for political support for an EPR program for metals.	**1**
Industry Readiness	**Local Recycling Infrastructure:** *Are there recycling infrastructures within Metro Vancouver that collect and process this material?*	Currently, recycling depots that accept metal scraps act as a processing facility to divert metal waste from going into landfills. The relatively high market value of metals makes it marketable for further recycling and reuse. Furthermore, materials with metal parts such as small household appliances can be dropped off at specific recycling depots. For instance, B.C.'s product stewardship programs such as "Electro Recycle" accept such items (Kane Consulting *et al.*, 2012).	**4**
	Processing Technology:	Technology exists locally at many local infrastructures (see Local Recycling Infrastructure	**4**

	Does the technology exist locally or worldwide to process the waste material into recycled products?	above)	
	Producer Readiness: *Could producers be ready to implement an EPR system for this product?*	N/A	**1**

Table 16. Summary and assumptions for scoring on the current state of sheet plastic in Metro Vancouver, British Columbia. Scores were assigned based on information found for each criteria subgroup in the EPR evaluation tool. Tables with "N/A" identifies that the information could not be found at the time.

Sheet Plastic			
Criteria Subgroup		**Information summary and assumptions made for scoring**	**Score (/5)**
Environmental Impacts	**Potential toxicity and hazards to human health and environment:** *Does this product, or its components or byproducts, contain toxics or otherwise hazardous substances to the environment or human health?*	Vinyl chloride, the chemical used to make polyvinyl chloride (PVC), is a known common carcinogen, according to the World Health Organization's International Agency for Research on Cancer (IARC, 1997). Some studies have found higher rates of testicular cancers and a rare form of liver cancer among workers in PVC plants. Also, lead is often added to PVC and results in nerve damage. Plasticizers such as phthalates used in PVC are being studied as possible carcinogens and hormone disruptors. Many foamed plastics were produced using ozone-depleting chemicals such as CFCs and HCFCs, but these are now largely phased out (Plastics in the Building Industry, 2013) Benzene in polystyrene is also a known carcinogen, and styrene itself is a possible cause of cancer (Plastics in the Building Industry, 2013) Asbestos is widely used in building products	**4**

		because of its tensile strength and chemical and thermal resistance. It is extremely hazardous to workers and is a known carcinogen that causes lung cancer and mesothelioma. Common asbestos materials include steam pipes, floor tiles with vinyl asbestos, vinyl sheet flooring and the adhesives used for installing floor tile (Jeffrey, 2011)	
	Waste stream volume or weight to landfills or incinerators (For data, refer to Table 7-Combined average in % and total tonnes): *Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*	1.07% (14,658 tonnes) of sheet plastic was generated in Metro Vancouver in 2011 (Metro Vancouver, 2011).	**2**
	2011 Waste diversion rate (For data, refer to Table 8-Diverted tonnes and diversion rate %): *Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*	0%; Sheet plastic is not currently being recycled in Metro Vancouver (Metro Vancouver, 2011).	**5**
Suitability for EPR	**Problem and Nuisance Product:** *Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are there problems marketing the collected product?*	Although plastics represent a low percentage of the total construction and demolition waste, their environmental impact can be significant once they are disposed of (APPRICOD, 2004). They can take hundreds of years to biodegrade and the chemicals in them are serious threats to air and water quality when the plastic waste is brought to the landfill for disposal or incinerated.	**4**
	Status in related EPR programs: *Are similar products managed under an EPR?*	There is an EPR program for plastic beverage containers, but not for other forms of plastic waste yet. In May 2014, the EPR program for packaging materials will be put in place and is expected to include plastic film and Styrofoam, but not sheet plastic (Recycling Council of British Columbia, 2011).	**2**

	Product redesign for environment: *Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*	Current EPR programs have not resulted in many design changes. Complementary regulations are likely needed to drive this (M. Kosmak, personal communication, March 30, 2013).	**1**
Political Interest	**Political Interest:** *Is there political interest in a program?*	Strong political support is evident with the push for an EPR program for packaging materials and printer paper set for May 19th, 2014 (Recycling Council of British Columbia, 2011).	**5**
Industry Readiness	**Local Recycling Infrastructure:** *Are there recycling infrastructures within Metro Vancouver that collect and process this material?*	Locally, processing facilities exist for plastic beverage containers and plastic packing (not sheet plastic) only (PVC, 2013).	**1**
	Processing Technology: *Does the technology exist locally or worldwide to process the waste material into recycled products?*	The PVC industry in Europe tackles a wide range of recycling efforts for PVC used in construction. In fact, APPRICOD is a pilot project done in Spain and Portugal that aims to research ways to collect and recycle plastic waste in the most sustainable way (PVC, 2013)	**2**
	Producer Readiness: *Could producers be ready to implement an EPR system for this product?*	Manufacturers have developed a first group of plastics known as metallocene polyolefins, which can be a viable replacement for PVC. There is potential for a wide range of metallocene polyolefin based building products, from window frames and roofing membranes to wall cladding and cable sheathing. A second group is bio-plastics, which are biodegradable and renewable (Jeffrey, 2011).	**2**

Table 17. Summary and assumptions for scoring on the current state of window glass in Metro Vancouver, British Columbia. Scores were assigned based on information found for each criteria subgroup in the EPR evaluation tool. Tables with "N/A" identifies that the information could not be found at the time.

Miscellaneous Glass Building Products			
Criteria Subgroup		**Information summary and assumptions made for scoring**	**Score (/5)**
Environmental Impacts	**Potential toxicity and hazards to human health and environment:** *Does this product, or its components or byproducts, contain toxics or otherwise hazardous substances to the environment or human health?*	Greenhouse gas emissions are released through combustion of natural gas and the decomposition of raw materials, such as sand and minerals, during the melting process. Sulphur dioxide and Nitrogen oxide are released from the fuel and the high temperature melting process Volatile emissions can be released from the application of coatings on glass (AGC Glass Europe, 2012).	**2**
	Waste stream volume or weight to landfills or incinerators (For data, refer to Table 7-Combined average in % and total tonnes): *Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*	Glass waste (includes sources other than windows) make up 1.17% of total waste volume (16,087 tonnes) generated in Metro Vancouver (Metro Vancouver, 2011).	**1**
	2011 Waste diversion rate (For data, refer to Table 8-Diverted tonnes and diversion rate %): *Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*	0%; window glass is currently not being recycled in Metro Vancouver (Metro Vancouver, 2011)	**1**

Suitability for EPR	**Problem and Nuisance Product:** *Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are there problems marketing the collected product?*	Glass in building materials is known as plate glass and differs from those found in beverage containers and jars. While there are facilities to recycle glass beverage containers, building glass is more difficult to recycle (M. Kosmak, personal communication, March 30, 2013). Metro Vancouver lacks a building glass collection infrastructure. The desire for "energy efficient" buildings have imposed a barrier to re-using windows because older windows are generally less energy efficient than new ones. That being said, re-using windows is applicable to unheated buildings such as sheds and warehouses (Kane Consulting *et al.*, 2012).	**3**
	Status in related EPR programs: *Are similar products managed under an EPR?*	EPR program currently exists for glass beverage containers but glass from construction/demolition is mostly sent to landfills. Very few users knew of glass recycling (Kane Consulting *et al.*, 2012).	**2**
	Product redesign for environment: *Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*	Current EPR programs have not resulted in many design changes. Complementary regulations are likely needed to drive this (M. Kosmak, personal communication, March 30, 2013).	**1**
Political Interest	**Political Interest:** *Is there political interest in a program?*	Window glass is banned from landfills and recycling in blue box (Recycling Council of British Columbia, 2013)	**3**
In du	**Local Recycling Infrastructure:**	There are currently 11 facilities in Metro	**3**

	Are there recycling infrastructures within Metro Vancouver that collect and process this material?	Vancouver that take in windows for recycling and reusing (Recycling Council of British Columbia, 2013).	
	Processing Technology: *Does the technology exist locally or worldwide to process the waste material into recycled products?*	N/A	**1**
	Producer Readiness: *Could producers be ready to implement an EPR system for this product?*	N/A	**1**

Table 18. Summary and assumptions for scoring on the current state of wood waste in Metro Vancouver, British Columbia. Scores were assigned based on information found for each criteria subgroup in the EPR evaluation tool. Tables with "N/A" identifies that the information could not be found at the time.

Wood Waste			
Criteria Subgroup		**Information summary and assumptions made for scoring**	**Score (/5)**
Environmental Impacts	**Potential toxicity and hazards to human health and environment:** *Does this product, or its components or byproducts, contain toxics or otherwise hazardous substances to the environment or human health?*	Potential source of toxicity can come contamination due to surface treatments, adhesive, bindings, etc. Chromate Copper Arsenate (CCA) is a chemical used as a preservative. Improper disposal of wood contaminated with CCA may lead to leaching of chromium, arsenic and other toxins into the environment. Paul Cooper (1999) states that usage of wood preserved with CCA may be in the rise due to an increasing demand. He also adds that eventually a take-back program such as collected blue-box bins or EPR should be implemented for treated wood due to its increasing usage in the construction sector	**4**

		(Cooper, 1999).	
	Waste stream volume or weight to landfills or incinerators (For data, refer to Table 7-Combined average in % and total tonnes): *Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*	Wood waste makes up 24.66% (338,033 tonnes) of total waste sent to Metro Vancouver landfills each year (Metro Vancouver, 2010 and 2011). It is the most waste being produced, in comparison to other building materials such as metals, glass, concrete, and etc.	**5**
	2011 Waste diversion rate (For data, refer to Table 8-Diverted tonnes and diversion rate %): *Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*	312,041 tonnes (48%) (Metro Vancouver, 2011).	**3**
Suitability for EPR	**Problem and Nuisance Product:** *Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are there problems marketing the collected product?*	One of the barriers to wood recycling is the high labour cost required to salvage, source, and transport the wood for recycling when the return value for the recovered product is low. Consequently, industry workers are unlikely to practice wood waste recovery because it is not economically feasible to put in the effort, time, and money in exchange for a minimal profit. Even with the option of turning the waste into an alternative energy source, there is an associated collection fee at the expense of those disposing the waste (Kane Consulting *et al.*, 2012). It has been noted that market for wood fluctuates (e.g. economic crisis in 2008 and falling house market) and as a result, waste generation fluctuates as well (N. Tawfik, personal communication, March 13, 2013). Wood treated with coating or paint can be problematic for recycling and process. Therefore,	**5**

		current recycling facilities only collect untreated and unpainted wood or that it is in good condition so that it can be sold or reused for other purposes (RCBC Recyclepedia - Dimensional Lumber (Reusable), 2013). A possible product redesign could be labelling wood whether it is treated or not treated so that construction contractors know what to do once the material is ready for disposal.	
	Status in related EPR programs: *Are similar products managed under an EPR?*	There is not an EPR program for wood waste yet.	**1**
	Product redesign for environment: *Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*	Current EPR programs have not resulted in many design changes. Complementary regulations are likely needed to drive this (M. Kosmak, personal communication, March 30, 2013).	**1**
Political Interest	**Political Interest:** *Is there political interest in a program?*	EPR program was recommended by a Metro Vancouver to be established for wood waste (N. Tawfik, personal communication, March 13, 2013)	**5**
Industry Readiness	**Local Recycling Infrastructure:** *Are there recycling infrastructures within Metro Vancouver that collect and process this material?*	However, there are existing facilities that recycle wood. For instance, Recycling Council of British Columbia (RCBC) has an extensive database of municipalities and private companies that recycle reuse and/or resell wood. However, facilities only collect untreated and unpainted wood or that it is in good condition so that it can be sold or reused for other purposes (RCBC Recyclepedia - Dimensional Lumber (Reusable), 2013). Many industry workers sell recovered wood through their own private network of buyers or through public markets, such as online through	**4**

		classifieds (Kane Consulting *et al.*, 2012).	
	Processing Technology: *Does the technology exist locally or worldwide to process the waste material into recycled products?*	Various technologies exist worldwide and are used in local facilities to burn wood waste into fuel or used as raw material for pulp and paper (Kane Consulting *et al.*, 2012).	**5**
	Producer Readiness: *Could producers be ready to implement an EPR system for this product?*	Engaging producers has been mentioned to be challenging because of the weak market for recovered wood waste (N. Tawfik, personal communication, March 13, 2013).	**1**

Sensitivity Analyses

Table 16 a-d. Sensitivity analyses were done for each major category from the EPR evaluation tool. The score is out of 100 points.

a) Emphasis on Environmental Impact	Total score /100
1. Wood *	81.0
2. Gypsum Drywall**	70.4
3. Carpet	69.3
4. Concrete	68.2
5. Sheet Plastic	63.3
6. Asphalt Shingles	62.6
7. Ceramic tiles	50.2
8. Misc. Metal Building Products	43.2
9. Misc. Glass Building Products	39.7

* May include some furniture
** May include some plaster

b) Emphasis on Extended Producer Responsibility	Total score /100
1. Carpet	72.7
2. Wood *	67.7
3. Sheet Plastic	63.3
4. Asphalt Shingles	59.3
5. Gypsum Drywall**	53.7
6. Concrete	51.5
7. Misc. Glass Building Products	48.0
8. Ceramic tiles	41.9
9. Misc. Metal Building Products	36.6

* May include some furniture
** May include some plaster

c) Emphasis on Political Interest	Total score /100
1. Wood *	84.3
2. Carpet	82.7
3. Gypsum Drywall**	80.4
4. Asphalt Shingles	79.3
5. Sheet Plastic	76.6
6. Concrete	71.5
7. Ceramic tiles	66.9
8. Misc. Glass Building Products	49.7
9. Misc. Metal Building Products	33.2

* May include some furniture
** May include some plaster

d) Emphasis on Industry Readiness	Total score /100
1. Gypsum Drywall**	77.9
2. Concrete	77.8
3. Asphalt Shingles	74.6
4. Wood *	73.0
5. Carpet	71.3
6. Sheet Plastic	56.5
7. Misc. Metal Building Products	46.4
8. Ceramic tiles	42.4
9. Misc. Glass Building Products	40.7

* May include some furniture
** May include some plaster

Table 17. Summary of raw score and sensitivity analyses

Raw Score Results	Equal Weight	Sensitivity 1 – Emphasis on Environmental Impact	Sensitivity 2 – Emphasis on Extended Producer Responsibility	Sensitivity 3 – Emphasis on Political Interest	Sensitivity 4 – Emphasis on Industry Readiness
1. Carpet 2. Wood* 3. Asphalt Shingles 4. Concrete 5. Gypsum Drywall** 6. Sheet Plastic 7. Misc. Glass Building Products 8. Misc. Metal Building Products 9. Ceramic Tiles	1. Wood* 2. Carpet 3. Gypsum Drywall** 4. Asphalt Shingles 5. Concrete 6. Sheet Plastic 7. Ceramic Tiles 8. Misc. Glass Building Products 9. Misc. Metal Building Products	1. Wood* 2. Gypsum Drywall** 3. Carpet 4. Concrete 5. Sheet Plastic 6. Asphalt Shingles 7. Ceramic Tiles 8. Misc. Metal Building Products 9. Misc. Glass Building Products	1. Carpet 2. Wood* 3. Sheet Plastic 4. Asphalt Shingles 5. Gypsum Drywall** 6. Concrete 7. Misc. Glass Building Products 8. Ceramic Tiles 9. Misc. Metal Building Products	1. Wood* 2. Carpet 3. Gypsum Drywall** 4. Asphalt Shingles 5. Sheet Plastic 6. Concrete 7. Ceramic Tiles 8. Misc. Metal Building Products 9. Misc. Glass Building Products	1. Gypsum Drywall** 2. Concrete 3. Asphalt Shingles 4. Wood* 5. Carpet 6. Sheet Plastic 7. Misc. Metal Building Products 8. Ceramic Tiles 9. Misc. Glass Building Products

Discussion

Implications of Raw Score and Equal Weight Analysis

In the raw score analysis, where each individual evaluation criterion is given equal weight, (shown in Table 9), the top five ranked products are (in order of indicated priority): Carpet, wood, asphalt shingles, concrete and gypsum drywall.

Comparatively, when all four evaluation categories are given equal weight (environmental impact, EPR, public/political/producer interest, industry readiness), the top five candidate products are (in order of the indicated priority): wood, carpet, gypsum drywall, asphalt shingles, and concrete (Appendix A4).

This discrepancy in the rankings reveals the effects of the weighting and sensitivity analyses on the raw scores. Thus, the prioritization of the candidate products requires many factors to be considered, as described in the sensitivity analyses below.

Implications of Sensitivity Analyses

Emphasis on Environmental Impact

In the first sensitivity analysis, emphasis on environmental impact prioritizes the top three candidate materials for EPR as (in order of priority): wood, gypsum drywall, and carpet (Table 16a and Appendix A5).

Wood waste makes up a significant component of the total tonnage of wastes sent to landfills and/or incinerators each year, while gypsum drywall and carpet waste contribute to a

lower proportion of the total waste stream. If wood waste can be successfully managed under an EPR program, a potentially large volume of waste could be diverted, which would bring Metro Vancouver closer to achieving its overall 80% waste diversion goal for 2020 and the City of Vancouver closer to achieving its zero waste target of cutting landfill and incinerator waste in half by 2020. Unfortunately, wood waste faces some of the most challenging barriers in initializing sustainable management under an EPR program. Mainly, wood waste is largely influenced by fluctuations in the economic recycling market (N. Tawfik, personal communication, March 13, 2013). Currently, recovered and recycled wood fetches low prices on the market, which makes the expensive recycling and recovery efforts unappealing for contractors. To overcome the weak market, promoting the practice of deconstruction in replace of demolition could potentially stimulate the market for recycled wood waste, as deconstruction recovers higher quality lumber.

Unlike wood waste, gypsum drywall is prioritized because of its high toxicity risk to human and environmental health. The main environmental hazard comes from the release of Hydrogen Sulphide when gypsum drywall sits in a landfill, and comes in contact with moisture from other waste. When asbestos is released into the air and inhaled, it can cause serious lung diseases such as asbestosis and mesothelioma (Metro Vancouver, 2011).

Lastly, carpet waste is equally ranked between its toxicity and waste volume. It is prioritized over higher volume materials, such as concrete, because of it is currently not diverted (Table 8).

Emphasis on Suitability for EPR

Emphasis on Suitability for Extended Producer Responsibility would see that carpet, wood, and sheet plastics are the top three priorities for program implenmentation (Table 16b and Appendix A6). While carpet is a minor component of the overall annual waste sent to landfills, establishing the program is likely not difficult because many programs exist worldwide. For example, California already has a stewardship program for carpets (California Product

Stewardship Council, n.d.), where under this law, carpet manufacturer adds a stewardship assessment of 5 cents per square yard to retailer, retailer then bills customer, and manufacturer pays the carpet stewardship organization (CARE) (Carpet America Recovery Effort, n.d.). This assessment is then used towards making carpet recycling easier, developing recycled product, increasing ways to reuse carpet, and increasing recycling and diversion rate in California (Carpet America Recovery Effort, n.d.).

As a result, the number of carpet-recycling companies has increased in California and approximately 36 percent of carpet is collected for recycling in Southern California (California Product Stewardship Council, n.d.). The success of these programs demonstrates the feasibility of EPR for carpet waste.

Wood scores high because it is a significant nuisance or problem waste that is high in volume, with limited recycling options. However, in practice, developing an EPR program for wood may be challenging because of the variety of potential product categories (lumber to flooring), the longevity of wood in buildings, and the difficulty in identifying brandowners. (M.Kosmak, personal communication, April 30, 2013.)

Sheet plastic scores high because a packaging EPR program will be introduced in May 2014. Although the program is currently limited to residential and streetscape packaging, there is potential to expand it to the ICI and construction and demolition sector. (M. Kosmak, personal communication, April 30, 2013).

Emphasis on Political Interest

Emphasis on political interest results in wood, carpet, and gypsum drywall as the top three categories (Table 16c and Appendix A7). Results based on political interest may differ amongst provinces and territories because regions vary in their environment, population size, and available resources. These factors affect the perspective of the governing body on which

criteria to place importance on. Specifically in British Columbia, a greater emphasis is placed on toxic and health hazardous products (M. Kosmak, personal communication, March 14, 2013). As seen in the prioritized list, emphasis on political interest produced similar results to the top three materials for environmental impacts and suitability for extended producer responsibility.

Emphasis on Industry Readiness

The top three ranking by industry readiness reveals that gypsum drywall, concrete, and asphalt shingles should be prioritized (Table 16d and Appendix A8). These three materials are considered a "quick-win" in terms of implementation. Characteristics of these "quick-win" materials are those with strong emphasis placed on industry readiness: they are currently a readily recyclable material with high user rate and an established market for the recycled product (M. Kosmak, personal communication, April 18, 2013).

As the top two ranked products, gypsum drywall and concrete had similar high scores of 77.8 and 77.9, respectively, differentiated by only 0.1 (Table 16d). The similarity in total scores between the two building materials is attributed to both having a high diversion rate. Therefore, despite the resulting high total scores, we would not suggest either material to be a prioritized over the other candidate materials for an EPR program.

For gypsum drywall, the high diversion rate of 88.10% (Table 8) is driven in part by its health and environmental risk associated with asbestos contamination. Since the 1980's, concerns of asbestos in the joint compound used to seal joints between sheets of drywall have resulted in its prohibition from disposal facilities through strict enforcement of fines for violations (Metro Vancouver, 2012). In addition, local processing facilities exist, and include Vancouver-based New West Gypsum Recycling-the world leader in recycling gypsum (New West Gypsum Recycling, 2013). The facility received 65, 000 tonnes of gypsum drywall waste from Metro Vancouver in 2012 and all of it was processed and sent back to the gypsum board manufacturers (New West Gypsum Recycling Inc., personal communication, April 3, 2013). Given the current recycling successes of gypsum drywall, an EPR program would not be

expected to greatly improve waste diversion. Instead, an EPR program would serve to formalize the existing program, which is an action that can be taken later in the future.

As seen in Figure 3, the amount of concrete waste generated is four times the tonnage of gypsum drywall, but it has an even higher diversion rate of 96.10%. At most concrete recycling facilities, concrete waste that is sorted and uncontaminated are not charged a tipping fee, which motivates demolition contractors and waste haulers to bring in concrete waste for recycling. On the other hand, concrete recycling facilities will close down during peak seasons because an abundance of concrete is received and the market for the recycled product is weak. While concrete facilities are capable of processing the amount of concrete waste that exists, concrete is still being sent to the landfills because of the lack of market that exists for the recycled product (Kane Consulting *et al.*, 2012). There is potential for the market to expand if municipalities and provincial governments stimulate the recycled concrete market by using the products as road fill in replacement of gravel. Since the barrier for concrete recycling lies in the weak market for its recycled product, it is not likely that an EPR program would increase the waste diversion rate of concrete closer to 100%.

Compared to gypsum drywall and concrete, asphalt shingles does not have a diversion rate as high as gypsum drywall and concrete. The current recycling rate is 13.80% (Table 8) but there is potential for increasing the diversion rate through an established EPR program. The management of asphalt shingles under an EPR program would likely be successful and have long term viability. Gemaco is the leading asphalt shingles recycling facility that serves the Greater Vancouver area (Gemaco, 2012) and it has the capacity to recycle 100,000 tonnes of asphalt shingle waste annually. Given that 11,000 tonnes was recycled in 2012 (Terry Charles, personal communication, March 8, 2013), there is potential for increased diversion. Furthermore, the recycled product has many uses in paving for road work, mix-in with hot-mix asphalt, and fire for cement kilns (Gemaco, 2012). With a favourable market that is expected to grow and the capability to process more waste, asphalt shingles would be favoured as a “quick-win” for EPR.

Deconstruction as complementary to building material EPR

A possible complementary policy for higher diversion rates through building material EPR is deconstruction, which is the practice of dismantling buildings and removing materials. Compared to demolition, material quality is preserved so that it can be viable for reuse and/or recycling. The City of Vancouver has adopted a deconstruction policy and pilot program to encourage deconstruction over demolition (City of Vancouver, 2012).

Deconstruction complements EPR by extracting clean materials for reuse and recycling. Similarly, EPR could complement deconstruction by creating strong recycling markets that are funded through eco-fees collected through the EPR programs. For example, British Columbia's EPR programs for tires, electronics, paint and used oil have proactively developed local recycling markets for these materials (M. Kosmak, Personal communication, April 29, 2013).

According to Barry Joneson, Director of Shrinking Footprints and an industry figure in the deconstruction sector, raising awareness and increasing education about deconstruction are highly encouraged (B. Joneson, personal communication, March 31, 2013). However, there is a lack of skilled labourers in deconstruction at this time, and perhaps the implementation of deconstruction in trade schools would increase the interest for an alternative to increase diversion rates for certain building materials (B. Joneson, personal communication, March 31, 2013). Also, recycling markets for many deconstructed materials do not exist or are weak (Kosmak and N. Tawfik, personal communication, March 13, 2013). For example, wood waste faces a weak market, in part due to a proportion of the recovered wood waste being low in quality and therefore, not desirable for use. One way of stimulating the market for wood waste would be to have trained "lumber graders" to license whether recovered wood from deconstructed buildings are safe to be reused for new buildings (B. Joneson, personal communication, March 31, 2013).

Options/Approaches to Implement EPR for Building Materials

The British Columbia's Post-Consumer Paint Stewardship Program Regulation that initiated in 1994 was modeled based on the German EPR program and is the first EPR program in Canada (Recycling Council of British Columbia, 2011). Different forms of EPR and product stewardship has been implemented and considered across Canada (Canadian Council of Ministers of the Environment, 2009). There are more than 40 programs of EPR and product stewardship that are already implemented within Canada (Canadian Council of Ministers of the Environment, 2009). Current EPR practice in B.C. has advanced into a collection, recovery and management system designed to divert various end-of-life products according the specifics of each product (Recycling Council of British Columbia, 2011). The industry stewardship associations manage their related products based on a stewardship plan that has been submitted to and approved by the Ministry of the Environment (Recycling Council of British Columbia, 2011).

Different countries have been adopting different tools to implement EPR (Walls, 2006):

1. Mandatory take back policy along with a diversion/recycling rate target approach: The government sets a policy that mandates manufacturers/retailers to take back their products after use and sets a diversion/recycling rate target for a specific product (Walls, 2006). Once the take back of the product becomes mandatory and diversion/recycling rate is set, a "producer responsibility organization" (PRO) is often established to meet the desired goal (Walls, 2006). PRO manages collection, recycling and oversees the processes to make sure that the diversion/recycling target is reached (Walls, 2006). An example of this approach is the German packaging law (Walls, 2006).

2. Mandatory take back policy and a diversion/recycling rate target along with a tradable recycling credit approach: This approach is similar to the previous approach but the target applies to the industry instead of individual producers (Walls, 2006). In addition, credits that are

tradable within the industry are given to the companies (Walls, 2006). The United Kingdom's packaging system using "packaging waste recovery notes" would be an example of this approach (Walls, 2006).

3. Voluntary take back program with diversion/recycling rate target approach: There are no laws or regulations implemented by the government but the companies within the industry voluntarily set up a take back program along with a diversion/recycling goal (Walls, 2006). Some examples of this approach include, the United States' Rechargeable Battery Recycling Corporation (RBRC) and Carpet America Recovery Effort (CARE) (Walls, 2006).

4. Advance recycling fees (ARF): Previously known as an advance disposal fee (ADF). A tax used to cover the recycling cost is applied on a product (Walls, 2006).

5. Advance recycling fees (ARF) with a recycling subsidy: An advance recycling fees approach that raises money that can be used in a variety of ways (Walls, 2006). The Western Canada used oil program is an example of this approach (Walls, 2006).

Barriers to EPR

Initiating an EPR program for candidate materials comes with a number of challenges. For instance, as discussed above, wood waste is a high priority in terms of waste volumes, yet the fluctuating economic market is a challenge to overcome due to its weak market value. A reason for a weak market value could be that there is a lack of market in the region. Clearly, the lack of market for such products is a factor that could influence the role of EPR for building materials discussed in this project. Breaking wood down into manageable product categories and identifying producers associated with them is also another major challenge.

Another factor that is a barrier to EPR is the lack of processing technology and infrastructure in Metro Vancouver. For instance, carpet is a potential candidate for EPR because there are existing technologies that could process it once it reaches the disposal stream.

However, such technologies only exist in other countries at this moment and no existing infrastructure could support it in Metro Vancouver. Nevertheless, addressing barriers to a complex and integrated system like EPR is a productive way to discuss how B.C. can implement such program for building materials in the near future.

Recommendations

Extended Producer Responsibility Programs for building materials

- Asphalt shingles, carpet, sheet plastic, and wood waste should be prioritized for management under EPR. These materials were found in the top five rankings for all four sensitivity analyses. Also, all of these materials, except for sheet plastic, were in the top five materials in the raw score analysis where all criteria were weighted equally.

- Considering all four sensitivity analyses, prioritization should be based on industry readiness, and of these, the product with the greatest potential to increase diversion. It is recommended that EPR should be implemented first for asphalt shingles, even though it was ranked third because there is local recycling technology and significant room to improve diversion rates. This would be considered a "quick-win" for EPR. Although the top two materials under this sensitivity analysis were gypsum drywall and concrete, no significant improvement in waste diversion would be expected to result from establishing an EPR program for these two materials. Gypsum drywall already benefits from a successfully regulation enforced recycling program. The barrier to increasing diversion rate for concrete waste is the weak market for recycled concrete product. Therefore, an EPR program would not be expected to stimulate the concrete market. Instead, the government should support stimulating the market for recycled concrete products, specifically using recycled concrete as road fill base for road work.

- Following the quick-win material (asphalt shingles), an EPR program for carpets should be the next priority and would be feasible given its success in other countries. Recently established EPR programs in California can serve as model programs to learn from. More work is needed on bringing carpet recycling companies, technology, and infrastructure to Metro Vancouver.

- Sheet plastic should be included in the EPR program for packaging and printer paper, currently scheduled to begin for residential packaging in May 2014, as soon as possible.

- Management of wood waste through EPR could be explored as a longer term strategy. Stable reuse and recycling markets for both clean (uncontaminated) and treated (contaminated) wood would have to be developed, along with mechanisms to identify wood producers. This work should be carried out closely with government and industry support for deconstruction practices as opposed to demolition. The high recovery of good quality, clean wood would help the wood waste market gain grounds.

Waste composition analysis and reporting

- Through our project we also realized the need for more detailed categories for construction and demolition products within annual waste composition reports. We recommend designing a report format that is consistent from year to year in the products that they contain. We noticed a discrepancy in the level of detail that each category contained. For example, in some reports plastics was listed as a material without any further breakdown, whereas others reported specific products like linoleum flooring or PVC pipes.
- Leading on from our last point, the categories we used in this study were chosen because of the current format in which diversion tonnages are reported by Metro Vancouver. The limitation to this approach is that some categories are specific products,

more suitable for EPR (e.g. asphalt shingles and carpets), whereas others are just reported as materials (e.g. plastic, wood, metals) without breaking them down. These categories need a lot more detail in order to complete a refined analysis and successfully implement EPR policy.

Evaluation tool

- Through the course of this exercise, the greatest lesson learned for the evaluation tool is to consider including evaluation criteria that deal with the ability to break down a material into discrete products (e.g. types of wood building products) and identify their associated producers.

Implementation of Extended Producer Responsibility

- Overall, to implement EPR programs in British Columbia, we recommend taking a phased approach - first push forward EPR for quick win products and then conduct more research to develop EPR programs for other construction and demolition waste materials. This would involve identifying material producers and consumers, develop recycling and waste management infrastructure and preparing the framework necessary to allow for successful future programs.

Conclusion

The evaluation tool allows us to determine how the prioritization of building materials for an EPR program should be assessed in different scenarios. The four major categories discussed in this project (i.e. Environmental Impacts, Suitability for EPR, Public, Producer and Political Interest, and Industry Readiness) are assessed in a way so that the local government or municipalities may consider how to establish EPR programs to meet or exceed the waste diversion goals for Metro Vancouver.

Based on the criteria that we have formulated, the top four (4) materials that are highly recommended for an EPR program in British Columbia are: asphalt shingles, carpet, sheet plastic, and wood waste. It is hoped that the results and discussions made in this project will contribute to progressive management of construction, renovation and demolition waste in Metro Vancouver and beyond.

Acknowledgements

We would like to express our great appreciation to Monica Kosmak (Zero Waste Planning, City of Vancouver) for her invaluable input, advice and constructive comments throughout the project. We would also like to thank Nermine Tawfik (Metro Vancouver) and Jonathan McDermott (City of Vancouver) for taking their time to give us additional input in the construction and demolition sectors. We would like to thank the following companies for their contribution in our data collection: Terry Charles (President of Gemaco Sales) and New West Gypsum Recycling. Advice and recommendation from Barry Joneson (Director of Shrinking Footprints) were greatly appreciated. We would also like to thank Dr. Gregory Dipple for his invaluable time and input by helping us complete our ethics approval from the University's Behavioural Research Ethics Board (BREB). Finally, we would like to thank Dr. Sara Harris and Dr. Tara Ivanochko and the rest of ENVR 400 class for their support and constructive comments throughout the school year.

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Appendices

A1. List of Candidate Materials

Candidate Material
Asphalt Shingles
Carpet
Ceramic tiles
Concrete
Gypsum Drywall**
Misc. Metal Building Products
Sheet Plastic
Misc. Glass Building Products
Wood*

* May include some furniture
** May include some plaster

A22. Terminologies

The following terms and definitions are adapted Metro Vancouver 2011 Solid Waste Composition Monitoring (TRI Consulting, 2012):

Single Family Residential (SF-RES)

- Large municipal haulers with loads from regular residential garbage curbside pick-up routes where waste is collected from garbage cans.
- Primarily detached single-family, duplex, triplex, and fourplex homes.

Multi Family Residential(MF-RES)

- Both municipal haulers and private paid account haulers with loads collected from dumpsters into front loading hauling trucks or -bins from primarily residential garbage pick-up routes.
- Primarily apartments and condominiums with five or more units.

Waste is collected from dumpsters, or roll-off bins.

Industrial, Commercial, Institutional (IC&I)

- Load > 1,000 kg.
- Large paid account haulers for commercial businesses and industries.
- Municipal haulers with loads from city facilities, offices, schools, and hospitals.

Self-haul Drop Off (DO)

- Load < (less than) 1,000 kg.
- Small pick-up trucks.
- Small vehicles with trailers.
- Non-account residential AND non-account commercial drop-off.

A3.CCME EPR Evaluation Tool

Criteria Group:	**Environmental Impacts**								**Extended Producer Responsibility**								**Public/Political Interest & Industry Readiness**						**Total Score (out of 100)**
Criteria Group Score (out of 100)	**50**								**40**								**10**						
Criteria Sub-Group:	***Toxicity/Hazard Impact***				***Global Impact***		***Waste Stream Volume or Weight Impact***		***Resource***		***Product***				***DfE***		***Public Interest***		***Producer Interest***		***Political Interest***		
Criteria:	Does the product, or its components or by-products, contain toxics or otherwise hazardous substances to the environment or human health?		Is the anticipated duration of the environmental or human health effects likely to be significant?		Are reductions in greenhouse gas emissions possible if the product were managed through an EPR program?		Is this product a significant component by volume to the municipal waste stream? *OR* Is this product a significant component by weight to the municipal waste stream?		Is this a wasted resource that is not currently recycled, reused or otherwise marketed?		Is this a nuisance product in terms of: litter; curbside collection or other infrastructure difficulties; or are there problems marketing the collected product?		Are similar products managed under an EPR system?		Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous and hazardous waste generation, and toxics usage?		Is there public support for an EPR system for this product?		Could producers be ready to implement an EPR system for this product?		Is there political interest in a program?		
Possible Scores for each Criteria:	Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		
Criterion Weighting:	50%		20%		10%		20%		25%		25%		25%		25%		33.33%		33.33%		33.33%		
Candidate Products	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	
automotive																							

automobiles	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
anti-freeze	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
oil, oil containers and filters	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
tires or tire tubes	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
C&D material																							
aggregate material	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
building material																							
asphalt shingles	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
drywall	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
wood	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
e-waste																							
electrical equipment																							
electrical and electronic tools	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
monitoring equipment	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
small household appliances	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
large household appliances (white goods)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
electronics																							

audio and video equipment	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
communications equipment	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
computer and electronic products	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
leisure equipment (game-boxes or other)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
furniture																							
mattresses	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
upholstered (couches)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
non-upholstered (wooden or metal, or glass)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
hazardous materials																							
batteries																							
lead/acid	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
non-rechargeable	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
rechargeable	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
mercury containing products																							
lamps or compact fluorescent bulbs	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
thermometers	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
switches	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
other measuring devices	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
paint	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0

pesticides	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
pharmaceuticals	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
propane tanks	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
medical sharps	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
chemicals or products with hazard symbols	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
packaging																										
plastics																										
plastics numbered 1,2,4	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
plastics numbered 3,5,6,7 or other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
shopping bags	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
steel cans	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
aluminum cans	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
glass bottles or jars	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
layered packaging (chip bags, tetra-paks)	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
boxboard/ cardboard	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
printed material																										
magazines	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
newsprint and flyers	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

office paper	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
textiles																							
carpets	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
clothing	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
leather	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
other																							
incandescent light bulbs	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0
other	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0

A4.Evaluation matrix with equal weighting for all four criterion

Criteria group	**Environmental Impacts**				**Extended Producer Responsibility**								**Political Interest**		**Industry Readiness**						**Total Score**	
Criteria group score (out of 100)	**25**				**25**								**25**		**25**							
Criteria sub-group	**Potential toxicity and hazards to human health and environment**		**Waste stream volume or weight to landfills or incinerators (Refer to Table 7)**		**Waste diversion rate (Refer to Table 8-Diversion analysis)**		**Problem and Nuisance Product**		**Status in related EPR programs**		**Product redesign for environment**		**Political Interest**		**Local Recycling Infrastructure**		**Processing Technology**		**Producer Readiness**			
Critera	*Does this product, or its components or byproducts, contain toxics or otherwise hazardous substances to the environment or human health?*		*Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*		*Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*		*Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are there problems marketing the collected product?*		*Are similar products managed under an EPR program?*		*Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*		*Is there political interest in a program?*		*Are there recycling infrastructures within Metro Vancouver that collect and process this material?*		*Does the technology exist locally or worldwide to process the waste material into recycled products?*		*Could producers be ready to implement an EPR system for this product?*		**Raw Score**	**Overall Score**
Possible score for each criteria	Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		**Out of 50**	**Out of 100**
Criterion Weighting:	50%		50%		25%		25%		25%		25%		100%		33%		33%		33%			
Candidate products	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score		
Asphalt Shingles	3	7.5	2	5	3	3.75	3	3.75	1	1.25	1	1.25	5	25	5	8.25	5	8.25	3	4.95	31	69.0
Carpet	3	7.5	3	7.5	5	6.25	4	5.00	5	6.25	1	1.25	5	25	2	3.3	5	8.25	3	4.95	36	75.3
Ceramic tiles	3	7.5	2	5	0	0.00	3	3.75	1	1.25	1	1.25	5	25	0	0	3	4.95	1	1.65	19	50.4
Concrete	4	10	3	7.5	1	1.25	1	1.25	1	1.25	1	1.25	4	20	5	8.25	5	8.25	5	8.25	30	67.3
Gypsum Drywall**	5	12.5	2	5	1	1.25	1	1.25	1	1.25	1	1.25	5	25	5	8.25	5	8.25	4	6.6	30	70.6
Misc. Metal Building Products	3	7.5	2	5	2	2.50	1	1.25	2	2.50	1	1.25	1	5	4	6.6	4	6.6	1	1.65	21	39.9
Sheet Plastic	4	10	2	5	5	6.25	4	5.00	2	2.50	1	1.25	5	25	3	4.95	1	1.65	2	3.3	29	64.9
Misc. Glass Building Products	2	5	1	2.5	5	6.25	3	3.75	2	2.50	1	1.25	3	15	3	4.95	1	1.65	1	1.65	22	44.5
Wood *	4	10	5	12.5	3	3.75	5	6.25	1	1.25	1	1.25	5	25	4	6.6	5	8.25	1	1.65	34	76.5

* may include some furniture ** includes some plaster

A5. Sensitivity Analysis 1: Evaluation matrix with emphasis on Environmental Impacts

Criteria group	**Environmental Impacts**				**Extended Producer Responsibility**								**Political Interest**		**Industry Readiness**						**Total Score**	
Criteria group score (out of 100)	**50**				**16.67**								**16.67**		**16.67**							
Criteria sub-group	**Potential toxicity and hazards to human health and environment**		**Waste stream volume or weight to landfills or incinerators (Refer to Table 7)**		**Waste diversion rate (Refer to Table 8-Diversion analysis)**		**Problem and Nuisance Product**		**Status in related EPR programs**		**Product redesign for environment**		**Political Interest**		**Local Recycling Infrastructure**		**Processing Technology**		**Producer Readiness**			
Critera	*Does this product, or its components or byproducts, contain toxics or otherwise hazardous substances to the environment or human health?*		*Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*		*Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*		*Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are there problems marketing the collected product?*		*Are similar products managed under an EPR program?*		*Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*		*Is there political interest in a program?*		*Are there recycling infrastructures within Metro Vancouver that collect and process this material?*		*Does the technology exist locally or worldwide to process the waste material into recycled products?*		*Could producers be ready to implement an EPR system for this product?*		**Raw Score**	**Overall Score**
Possible score for each criteria	Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		**Out of 50**	**Out of 100**
Criterion Weighting:	50%		50%		25%		25%		25%		25%		100%		33%		33%		33%			
Candidate products	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score		
Wood *	4	20	5	25	3	2.50	5	4.17	1	0.83	1	0.83	5	16.67	4	4.4	5	5.5	1	1.1	34	81.0
Gypsum Drywall**	5	25	2	10	1	0.83	1	0.83	1	0.83	1	0.83	5	16.67	5	5.5	5	5.5	4	4.4	30	70.4
Carpet	3	15	3	15	5	4.17	4	3.33	4	3.33	1	0.83	5	16.67	2	2.2	5	5.5	3	3.3	35	69.3
Concrete	4	20	3	15	1	0.83	1	0.83	1	0.83	1	0.83	4	13.33	5	5.5	5	5.5	5	5.5	30	68.2
Sheet Plastic	4	20	2	10	5	4.17	4	3.33	2	1.67	1	0.83	5	16.67	3	3.3	1	1.1	2	2.2	29	63.3
Asphalt Shingles	3	15	2	10	3	2.50	3	2.50	1	0.83	1	0.83	5	16.67	5	5.5	5	5.5	3	3.3	31	62.6
Ceramic tiles	3	15	2	10	0	0.00	3	2.50	1	0.83	1	0.83	5	16.67	0	0	3	3.3	1	1.1	19	50.2
Misc. Metal Building Products	3	15	2	10	2	1.67	1	0.83	2	1.67	1	0.83	1	3.33	4	4.4	4	4.4	1	1.1	21	43.2
Misc. Glass Building Products	2	10	1	5	5	4.17	3	2.50	2	1.67	1	0.83	3	10.00	3	3.3	1	1.1	1	1.1	22	39.7

* may include some furniture ** includes some plaster

A6. Sensitivity Analysis 2: Evaluation matrix with emphasis on Extended Producer Responsibility

Criteria group	**Environmental Impacts**				**Extended Producer Responsibility**								**Political Interest**		**Industry Readiness**						**Total Score**	
Criteria group score (out of 100)	**16.67**				**50.00**								**16.67**		**16.67**							
Criteria sub-group	**Potential toxicity and hazards to human health and environment**		**Waste stream volume or weight to landfills or incinerators (Refer to Table 7)**		**Waste diversion rate (Refer to Table 8-Diversion analysis)**		**Problem and Nuisance Product**		**Status in related EPR programs**		**Product redesign for environment**		**Political Interest**		**Local Recycling Infrastructure**		**Processing Technology**		**Producer Readiness**			
Critera	*Does this product, or its components or byproducts, contain toxics or otherwise hazardous substances to the environment or human health?*		*Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*		*Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*		*Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are there problems marketing the collected product?*		*Are similar products managed under an EPR program?*		*Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*		*Is there political interest in a program?*		*Are there recycling infrastructures within Metro Vancouver that collect and process this material?*		*Does the technology exist locally or worldwide to process the waste material into recycled products?*		*Could producers be ready to implement an EPR system for this product?*		**Raw Score**	**Overall Score**
Possible score for each criteria	Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		**Out of 50**	**Out of 100**
Criterion Weighting:	50%		50%		25%		25%		25%		25%		100%		33%		33%		33%			
Candidate products	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score		
Carpet	3	5.00	3	5.00	5	12.50	4	10.00	4	10.00	1	2.50	5	16.67	2	2.2	5	5.5	3	3.3	35	72.7
Wood *	4	6.67	5	8.33	3	7.50	5	12.50	1	2.50	1	2.50	5	16.67	4	4.4	5	5.5	1	1.1	34	67.7
Sheet Plastic	4	6.67	2	3.33	5	12.50	4	10.00	2	5.00	1	2.50	5	16.67	3	3.3	1	1.1	2	2.2	29	63.3
Asphalt Shingles	3	5.00	2	3.33	3	7.50	3	7.50	1	2.50	1	2.50	5	16.67	5	5.5	5	5.5	3	3.3	31	59.3
Gypsum Drywall**	5	8.33	2	3.33	1	2.50	1	2.50	1	2.50	1	2.50	5	16.67	5	5.5	5	5.5	4	4.4	30	53.7
Concrete	4	6.67	3	5.00	1	2.50	1	2.50	1	2.50	1	2.50	4	13.33	5	5.5	5	5.5	5	5.5	30	51.5
Misc. Glass Building Products	2	3.33	1	1.67	5	12.50	3	7.50	2	5.00	1	2.50	3	10.00	3	3.3	1	1.1	1	1.1	22	48.0
Ceramic tiles	3	5.00	2	3.33	0	0.00	3	7.50	1	2.50	1	2.50	5	16.67	0	0	3	3.3	1	1.1	19	41.9
Misc. Metal Building Products	3	5.00	2	3.33	2	5.00	1	2.50	2	5.00	1	2.50	1	3.33	4	4.4	4	4.4	1	1.1	21	36.6

* may include some furniture ** includes some plaster

A7. Sensitivity Analysis 3: Evaluation matrix with emphasis on Political Interest

Criteria group	**Environmental Impacts**				**Extended Producer Responsibility**								**Political Interest**		**Industry Readiness**				**Total Score**	
Criteria group score (out of 100)	**16.67**				**16.67**								**50.00**		**16.67**					
Criteria sub-group	**Potential toxicity and hazards to human health and environment**		**Waste stream volume or weight to landfills or incinerators (Refer to Table 7)**		**Waste diversion rate (Refer to Table 8-Diversion analysis)**		**Problem and Nuisance Product**		**Status in related EPR programs**		**Product redesign for environment**		**Political Interest**		**Local Recycling Infrastructure**		**Processing Technology**		**Producer Readiness**			
Critera	*Does this product, or its components or byproducts, contain toxics or otherwise hazardous substances to the environment or human health?*		*Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*		*Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*		*Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are there problems marketing the collected product?*		*Are similar products managed under an EPR program?*		*Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*		*Is there political interest in a program?*		*Are there recycling infrastructures within Metro Vancouver that collect and process this material?*		*Does the technology exist locally or worldwide to process the waste material into recycled products?*		*Could producers be ready to implement an EPR system for this product?*		**Raw Score**	**Overall Score**
Possible score for each criteria	Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		**Out of 50**	**Out of 100**
Criterion Weighting:	50%		50%		25%		25%		25%		25%		100%		33%		33%		33%			
Candidate products	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score		
Wood *	4	6.67	5	8.33	3	2.50	5	4.17	1	0.83	1	0.83	5	50.00	4	4.4	5	5.5	1	1.1	34	84.3
Carpet	3	5.00	3	5.00	5	4.17	4	3.33	4	3.33	1	0.83	5	50.00	2	2.2	5	5.5	3	3.3	35	82.7
Gypsum Drywall**	5	8.33	2	3.33	1	0.83	1	0.83	1	0.83	1	0.83	5	50.00	5	5.5	5	5.5	4	4.4	30	80.4
Asphalt Shingles	3	5.00	2	3.33	3	2.50	3	2.50	1	0.83	1	0.83	5	50.00	5	5.5	5	5.5	3	3.3	31	79.3
Sheet Plastic	4	6.67	2	3.33	5	4.17	4	3.33	2	1.67	1	0.83	5	50.00	3	3.3	1	1.1	2	2.2	29	76.6
Concrete	4	6.67	3	5.00	1	0.83	1	0.83	1	0.83	1	0.83	4	40.00	5	5.5	5	5.5	5	5.5	30	71.5
Ceramic tiles	3	5.00	2	3.33	0	0.00	3	2.50	1	0.83	1	0.83	5	50.00	0	0	3	3.3	1	1.1	19	66.9
Misc. Glass Building Products	2	3.33	1	1.67	5	4.17	3	2.50	2	1.67	1	0.83	3	30.00	3	3.3	1	1.1	1	1.1	22	49.7
Misc. Metal Building Products	3	5.00	2	3.33	2	1.67	1	0.83	2	1.67	1	0.83	1	10.00	4	4.4	4	4.4	1	1.1	21	33.2

* may include some furniture ** includes some plaster

A8. Sensitivity Analysis 4: Evaluation matrix with emphasis on Industry Readiness

Criteria group	**Environmental Impacts**				**Extended Producer Responsibility**								**Political Interest**		**Industry Readiness**						**Total Score**	
Criteria group score (out of 100)	**16.67**				**16.67**								**16.67**		**50.00**							
Criteria sub-group	**Potential toxicity and hazards to human health and environment**		**Waste stream volume or weight to landfills or incinerators (Refer to Table 7)**		**Waste diversion rate (Refer to Table 8-Diversion analysis)**		**Problem and Nuisance Product**		**Status in related EPR programs**		**Product redesign for environment**		**Political Interest**		**Local Recycling Infrastructure**		**Processing Technology**		**Producer Readiness**			
Critera	*Does this product, or its components or byproducts, contain toxics or otherwise hazardous substances to the environment or human health?*		*Is this a product a significant component by volume or weight to the municipal waste disposed in landfills or incinerators?*		*Is this a wasted resource that is not currently recycled, reused or used for an alternative energy?*		*Is this a nuisance product for municipal operations (in terms of litter; curbside collection or other infrastructure difficulties) Or are there problems marketing the collected product?*		*Are similar products managed under an EPR program?*		*Is it possible that an EPR program for the product could stimulate product redesign (Design for Environment) to reduce material and resource usage, non-hazardous waste generation, and toxics usage?*		*Is there political interest in a program?*		*Are there recycling infrastructures within Metro Vancouver that collect and process this material?*		*Does the technology exist locally or worldwide to process the waste material into recycled products?*		*Could producers be ready to implement an EPR system for this product?*		**Raw Score**	**Overall Score**
Possible score for each criteria	Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		Score Using Scale of 1-5		**Out of 50**	**Out of 100**
Criterion Weighting:	50%		50%		25%		25%		25%		25%		100%		33%		33%		33%			
Candidate products	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score		
Gypsum Drywall**	5	8.33	2	3.33	1	0.83	1	0.83	1	0.83	1	0.83	5	16.67	5	16.5	5	16.5	4	13.2	30	77.9
Concrete	4	6.67	3	5.00	1	0.83	1	0.83	1	0.83	1	0.83	4	13.33	5	16.5	5	16.5	5	16.5	30	77.8
Asphalt Shingles	3	5.00	2	3.33	3	2.50	3	2.50	1	0.83	1	0.83	5	16.67	5	16.5	5	16.5	3	9.9	31	74.6
Wood *	4	6.67	5	8.33	3	2.50	5	4.17	1	0.83	1	0.83	5	16.67	4	13.2	5	16.5	1	3.3	34	73.0
Carpet	3	5.00	3	5.00	5	4.17	4	3.33	4	3.33	1	0.83	5	16.67	2	6.6	5	16.5	3	9.9	35	71.3
Sheet Plastic	4	6.67	2	3.33	5	4.17	4	3.33	2	1.67	1	0.83	5	16.67	3	9.9	1	3.3	2	6.6	29	56.5
Misc. Metal Building Products	3	5.00	2	3.33	2	1.67	1	0.83	2	1.67	1	0.83	1	3.33	4	13.2	4	13.2	1	3.3	21	46.4
Ceramic tiles	3	5.00	2	3.33	0	0.00	3	2.50	1	0.83	1	0.83	5	16.67	0	0	3	9.9	1	3.3	19	42.4
Misc. Glass Building Products	2	3.33	1	1.67	5	4.17	3	2.50	2	1.67	1	0.83	3	10.00	3	9.9	1	3.3	1	3.3	22	40.7

* may include some furniture ** includes some plaster