

Opportunities for Promoting the Recycling of Gypsum Board
from Construction, Renovation, and Demolition in Manitoba

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ABSTRACT

This thesis is the result of a two-year (2016-2018) study through literature and document review and semi-structured interviews; many people in Manitoba from industry and government participated in the interviews, and many others in other Canadian provinces shared their knowledge and experience in the construction, gypsum manufacturing, and recycling industries.

The research aimed to explore opportunities for promoting the recycling of gypsum board in Manitoba, given that gypsum is largely landfilled despite its high recyclability. Overall, this study concludes that the establishment of recycling infrastructure and minimized distance of transport are key factors in gypsum recycling. Considering these factors of importance and regional recycling conditions and circumstances, the study highlights the fact that government initiative and support through financial (dis)incentives and regulations are at the core of promoting the recycling of gypsum board in Manitoba.

KEYWORDS: gypsum board, recycling policy, waste management, construction waste, CRD waste, gypsum to gypsum, drywall disposal.

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GLOSSARY OF ACRONYMS AND TERMS

AB/Alta	Alberta
ACA	Alberta Construction Association
BC	British Columbia
BOMA	Building Owners and Managers Association
BREEAM	Building Research Establishment Environmental Assessment Method
BSI	British Standards Institution
CAP-EPR	Canada-wide Action Plan for Extended Producer Responsibility (EPR)
CCME	Canadian Council of Ministers of the Environment
CHBA	Canadian Home Builders Association
CRD	construction, renovation, and demolition. Also often used as C&D
CSR	corporate social responsibility
DEFRA	Department for Environment, Food and Rural Affairs
EC	European Commission
EPR	extended producer responsibility. A policy approach in which a producer's responsibility for a product is extended to post-consumer stage of its life cycle
EA	Environment Agency
EEC	European Economic Community
EU	European Union
EoL	end-of-life
EoW	end-of-waste
EuroGypsum	European Association of the Gypsum Industry
EWC	European Waste Code
EWMC	Edmonton Waste Management Center
FGD	flue-gas desulfurization
GBRP	green building recognition program
GDPA	Gypsum Products Development Association
GPP	green public procurement
GRI	Gypsum Recycling International

GtoG	Gypsum to Gypsum project
HRM	Halifax Regional Municipality
ICI	industrial, commercial, and institutional
ISWRMP	Integrated Solid Waste and Resource Management Plan
LEED	Leadership in Energy and Environmental Design
LIFE	the EU's funding instrument for the environment and climate action
MSW	municipal solid waste (MSW), which includes waste generated from CRD projects from both residential and ICI sources
MB	Manitoba
MVRD	Metro Vancouver Regional District
NS	Nova Scotia
NWGR	New West Gypsum Recycling
OPC	ordinary Portland cement
PAS	Publicly Available Specification
PSP	Plasterboard Sustainability Partnership
recycle	the third priority (following reduction and reuse, and prior to recovery and disposal) in the waste management hierarchy. Recycling includes collecting, transporting, handling, storing, sorting, and processing of a thing that otherwise would be disposed of
SME	small and medium size enterprise
UK	United Kingdom
UN	United Nations
waste	any substance or object which the holder discards or intends or is required to discard
WCR	Winnipeg Capital Region
WFD	Waste Framework Directive
WRAP	Waste and Resources Action Programme
WRARS	Waste Reduction and Recycling Support

Chapter 1

INTRODUCTION

1.1 Background

1.1.1 Sustainable Development

The concept of sustainable development has become prominent in environmental policy discourse over the last several decades, especially relating to socioeconomic issues. The term “sustainable development” came into wide use in policy discourse after its presentation in *Our Common Future* by the United Nations (UN) World Commission on Environment and Development (WCED, 1987), which is also known as the Brundtland Report (Redclift, 2005). In this report, released in 1987, in an effort to adequately define global environmental challenges and formulate a global agenda for fundamental change, “sustainable development” is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. As one of the most powerful concepts in the environmental field, it has been influential in shaping environmental policy in both private and public sectors in recent decades: from *Our Common Future* (1987), via *The Future We Want* (2000), to *Transforming Our World* (2015) (UN, 2000, 2015). Envisaging the achievement of its Sustainable Development Goals (SDGs) by 2030, *Transforming Our World* (2015) calls on society to substantially reduce waste through all measures, including recycling.

1.1.2 Towards a Recycling Society

Canada records the largest ecological footprint in the world (WWF, 2014) and generates the highest volumes of solid waste per capita among industrialized countries

(ECCC, 2008). Waste generation in Canada has increased more than threefold since 1940, and waste diversion is still outpaced by waste disposal (Werf & Cant, 2012). Construction, renovation, and demolition (CRD) waste is one of the main components of the solid waste stream in Canada, accounting for 27% of the Municipal Solid Waste (MSW) that ends up in landfills (Yeheyis et al., 2012). In fact, the amount of CRD waste diverted to recycling and other uses in Canada decreased by 30% between 2004 and 2014, whereas the diversion of total MSW maintained an upward trend (Statistics Canada, 2017) (Table 1,2,3).

Table 1. Waste diversion, Canada & provinces (2004-2014)

(unit: ton)

Geography	2004	2006	2008	2010	2012	2014
Canada	7,112,735	7,626,683	8,310,570	8,096,119	8,464,645	9,057,177
Newfoundland and Labrador	35,308	x	x	x	x	29,972
Prince Edward Island	x	x	x	x	x	62,604
Nova Scotia	239,845	275,983	289,950	265,467	254,881	279,031
New Brunswick	139,262	151,827	165,249	137,515	138,364	135,791
Quebec ²	2,130,100	2,434,300	2,463,600	2,336,400	2,507,260	2,662,655
Ontario	2,414,552	2,396,856	2,781,830	2,761,116	2,829,205	3,044,657
Manitoba	157,490	152,799	165,667	178,481	184,859	184,024
Saskatchewan	114,182	106,868	122,932	142,659	156,016	173,953
Alberta	620,080	652,637	728,536	721,231	757,169	801,577
British Columbia	1,209,216	1,366,191	1,505,112	1,457,062	1,537,472	1,665,077
Yukon, Northwest Territories and Nunavut	x	x	x	x	x	17,836

Source: Statistics Canada (2017.3.24. last updated). Table 153-0043. <http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=1530043>

Table 2. Diverted materials per capita, Canada & provinces (2012-2014)

(unit: ton)

	2012		2014		2012 to 2014
	Diverted materials per capita ¹				% change
	kilograms				
Canada	244	255			4.6
Newfoundland and Labrador	x	57			x
Prince Edward Island	x	429			x
Nova Scotia	270	296			9.7
New Brunswick	183	180			-1.6
Quebec ²	310	324			4.5
Ontario	211	222			5.5
Manitoba	148	144			-2.8
Saskatchewan	144	155			8.0
Alberta	195	195			0.0
British Columbia	338	358			6.0
Yukon, Northwest Territories and Nunavut	x	153			x

Source: Statistics Canada, Environment Accounts and Statistics Division (2017.3.24. last updated). CANSIM tables 051-0001 and 153-0043, Catalogue no. 16F0023X

Table 3. CRD Waste diversion, Canada & provinces (2004~ 2014)

(unit: ton)

Geography	2004	2006	2008	2010	2012	2014
Canada	848,197	715,364	720,076	653,255	636,573	592,597
Newfoundland and Labrador	x	0	0	0	0	0
Prince Edward Island	x	0	0	0	0	0
Nova Scotia	59,355	51,263	40,368	34,163	x	x
New Brunswick	14,984	10,633	x	x	x	0
Quebec²	288,000	236,000	211,000	211,000	211,000	200,450
Ontario	303,277	187,353	209,628	154,722	174,497	153,329
Manitoba	x	2,704	2,331	x	x	x
Saskatchewan	13,234	x	x	x	x	x
Alberta	27,926	34,300	54,056	49,846	47,342	59,720
British Columbia	140,514	188,323	198,480	198,018	x	126,347
Yukon, Northwest Territories and Nunavut	x	x	0	0	0	0

Source: Statistics Canada (2017.3.24. last updated). Table 153-0043. <http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=1530043>

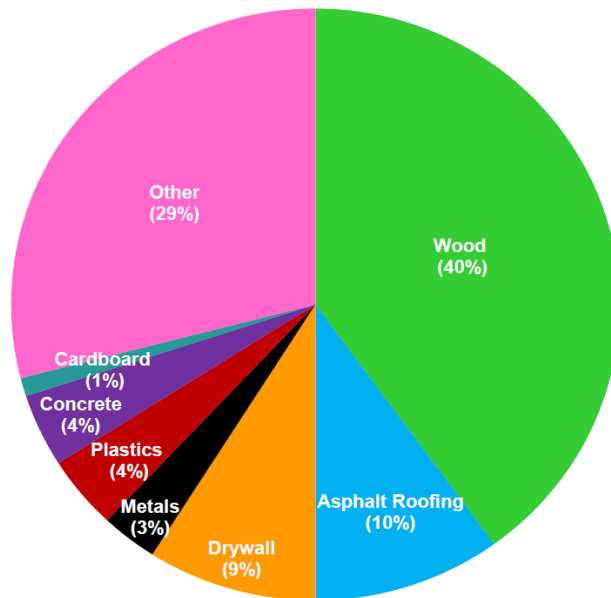
Despite the residual value of most CRD waste generated in Canada, it is estimated that only 16% of the total is being recycled while the rest is disposed of in landfills (Yeheyis et al., 2012; Perry & VanderPol, 2014). Meanwhile, intensified recycling efforts have resulted in an improved recycling rate, as has been demonstrated in other sectors in Canada. For instance, an increased number of recycling programs for electronic waste has led to a threefold increase from 2008 to 2012 in the diversion of this waste stream (Statistics Canada, 2016). There is a consensus in Canada that the current practice of CRD waste management is unsustainable (Yeheyis et al., 2012), therefore necessitating action to shift from waste disposal towards diversion for sustainable resource use.

1.2 Problem Statement

In addition to the fact that Canada generates the highest volumes of solid waste per capita among industrialized countries, most CRD waste generated in Canada is currently landfilled, even though some building materials such as concrete, asphalt, and wood have consistently been recycled (ECCC, 2008; Perry & VanderPol, 2014; Quinn, 2015; Statistics Canada, 2017).

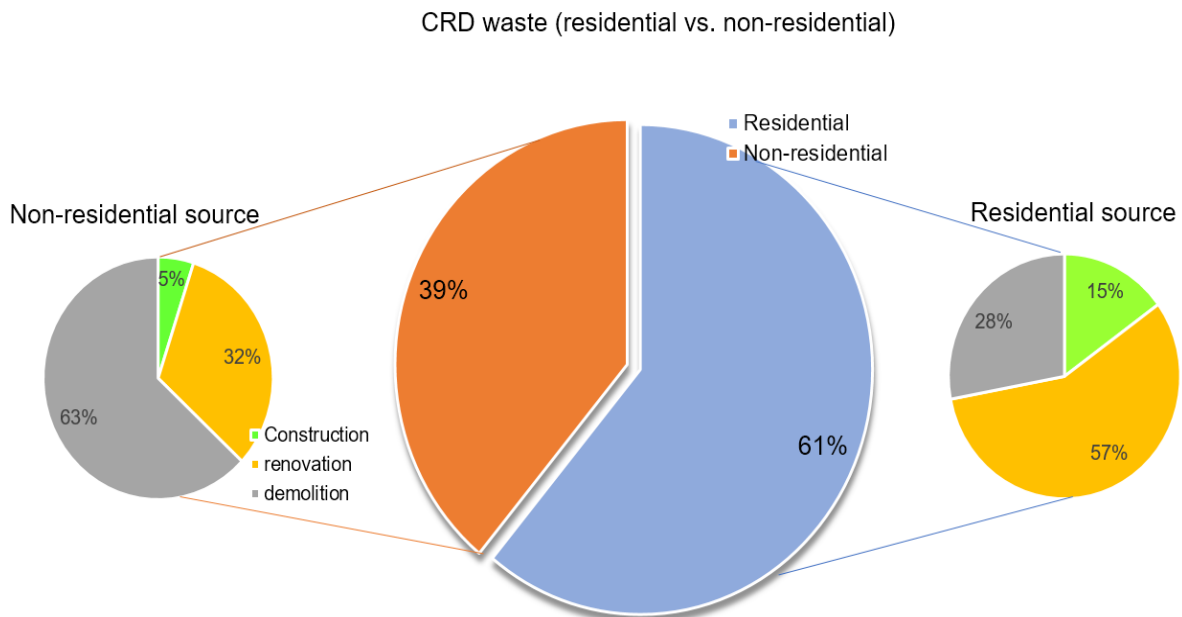
Among the various CRD wastes, gypsum, most commonly in the form of gypsum board, is largely discarded in Canada, even though gypsum itself is a non-renewable resource that can be recycled an unlimited number of times (Earle, Ergun, & Gorgolewski, 2014; GtoG, 2013). Gypsum board is the third largest contributor to CRD waste, accounting for 9% of all CRD waste generated in Canada (Perry & Vanderpol, 2014; Quinn, 2015) (Figure 1).

Figure 1. The composition of CRD waste in Canada



Source : Environment Canada (2015) ; qtd. in Quinn (2015)

Figure 2. The sources of CRD waste in Canada



(note) excluding waste from land clearing, large civil engineering, and infrastructure projects as well as waste treated on-site or exported.

Data source: Perry, G. & VanderPol, M. (2014). *Characterization & Management of Construction, Renovation & Demolition Waste in Canada*. Retrieved from https://recycle.ab.ca/wp-content/uploads/2014/10/VanderPol_Perry.pdf

Considering the heavy and bulky nature of gypsum board waste and the resulting financial burden on local governments, as well as its negative impact on the environment, it is problematic that gypsum board waste is largely landfilled in Canada. In addition, problems related to the high sulfate content of gypsum board have caused public health concerns such as the contamination of both underground and surface water by the leachate and the atmospheric release of hydrogen sulfide gas (H₂S), which is odorous, toxic, and flammable (McCamley, 2004; Calrecycle, 2007; CCOHS, 2012).

1.3 Research Purpose and Objectives

The purpose of this research was to explore opportunities for promoting the recycling of gypsum board generated from CRD sites in Manitoba (MB) and to identify applicable policy tools that can contribute to ensuring the sustainable management of gypsum board waste. With this purpose in mind, the following objectives were set for the research:

- 1) To define critical issues in current CRD waste management system that impede the recycling of gypsum board in MB;
- 2) To examine the current methods and policy tools in other jurisdictions for the best methods of managing gypsum board waste;
- 3) To establish approaches to the recycling of gypsum board that could be viable in MB; and
- 4) To recommend tools to implement diversion approaches that support the recycling of gypsum board from CRD sites in MB.

1.4 General Methods

A qualitative approach using the following methods was taken towards the above-mentioned research objectives.

1) Literature review and document review

Academic journals, as well as other document types, including primary documents and grey literature, were reviewed to identify best practices and to investigate the current management system for the diversion of gypsum board from CRD sites. The collected data was used to satisfy research objective 2; it was also used as the basis for achieving the other three objectives of this research.

2) Semi-structured interviews

Questions for semi-structured interviews were developed for core stakeholders in order to identify current issues related to the recycling of gypsum board waste and to identify key approaches that could be viable for MB. This method of data collection aided in achieving research objectives 1 and 3. The participants in the interviews were divided into the following two groups:

1) government: provincial and municipal governments

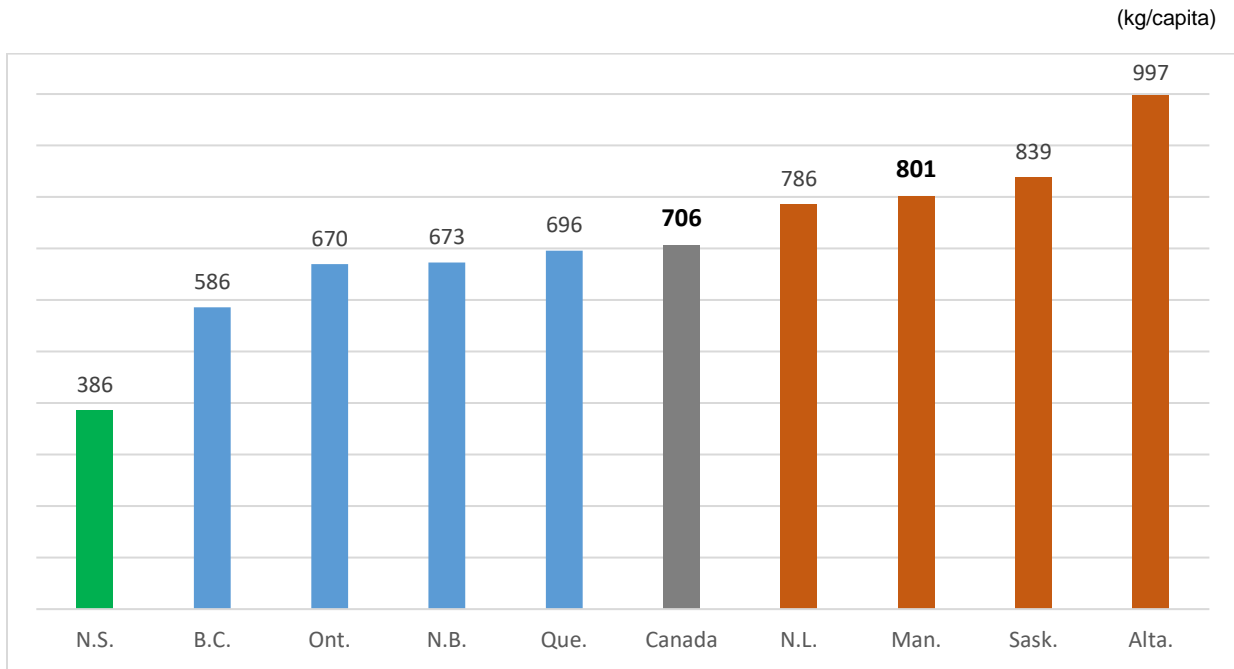
2) industry: associational and private stakeholders in the construction industry

1.5 Justification for Research

While Manitoba produces the highest level of MSW per capita among the Canadian provinces, its diversion performance is behind the average across the provinces (Table 1, 2;

Figure 3); Manitobans dispose of 801 kg of waste per capita, which is higher than the national average of 706 kg (2017, Statistics Canada).

Figure 3. Waste disposal per capita, Canada & provinces (2014)



Data Source: Statistics Canada. (2016.9.28. last updated). Disposal and Diversion of Waste.
Retrieved from <http://www.statcan.gc.ca/tables-tableaux/sum-som/l01/cst01/envir32b-eng.htm>

Although CRD waste ranks as the second largest component of the waste stream, constituting 20% to 30% of total waste, Manitoba currently lacks a tangible strategy that targets promoting its diversion (Green Manitoba, 2014). For gypsum board waste in particular, neither reliable statistical data nor a feasible provincial strategy is available.

Meanwhile, the Canadian Council of Ministers of the Environment (CCME), in its Canada-wide Action Plan for Extended Producer Responsibility (CAP-EPR) in October of 2009, identified CRD materials as “phase 2 products” among the five products that are

subject to the implementation of EPR tools within the next eight years (Moyes, 2010, p.3; CCME, 2014). With this action plan as an impetus, an individual approach to material recycling by each jurisdiction is considered preferable, owing to the variety of CRD wastes; such variety makes a harmonized approach unsuitable for promoting the recycling of CRD waste (Giroux Environmental Consulting, 2014). Therefore, identifying critical issues in the current state of CRD waste management, particularly for gypsum board, and learning from other jurisdictions about best practices are essential in the process of policy development for MB.

1.6 Research Scope

This research focused on the recycling of non-hazardous gypsum board waste from CRD sites in MB. The sources of gypsum board encompassed industrial, commercial, and institutional (ICI) sector, as well as the residential sector. The primary interest of this research was in gypsum core, which is commonly found as the principal component in all types of gypsum board.

Through case studies of the United Kingdom (UK), with a focus on England, as well as of several Canadian provinces (British Columbia, Alberta, and Nova Scotia), this research investigated best practices of gypsum recycling and current systems for managing gypsum board waste. As the UK's policy has been developed under the umbrella of the European Union (EU)'s institution, the fundamental waste policy of the EU was examined as well.

1.7 Thesis Organization

This thesis consists of six chapters. Following this introductory chapter, the second chapter provides a literature review and document review of the key elements of CRD waste management, focusing on gypsum board waste. The third chapter describes the research methods in detail. The fourth chapter describes in detail and discusses the current methods and policy tools that are being used in other jurisdictions to promote the recycling of gypsum board. The fifth chapter analyzes regional conditions for recycling in MB and presents the results of the semi-structured interviews with key stakeholders. Finally, the sixth chapter provides recommendations for policy development for MB, based on findings from the fourth and fifth chapters. This last chapter includes suggestions for future research as well.

Chapter 2

GYPSUM BOARD WASTE MANAGEMENT

2.1 Gypsum and Gypsum Board

Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), a versatile rock-like mineral with hundreds of uses, has been predominantly used as construction material since ancient times (Sharpe & Cork, 2006, p.519). With widespread near-surface deposits worldwide, the main producers are China, the USA, Canada, and European countries including Germany, the UK, France, and Spain (Sharpe & Cork, 2006, p.532-534; BIS, 2011; EuroGypsum, n.d.). In Canada, the majority of domestic output is produced from highly productive mines in Nova Scotia, where mining in North America first occurred in the 18th century (Adams, 1993; Mazerolle, Blaney, & Belliveau, 2015).

Gypsum board¹, which is also called drywall, plasterboard, gypboard, gyproc, wallboard, or sheetrock, is the most common product made of the gypsum mineral (Alberta, 2007). Gypsum board is composed of gypsum plaster core, typically bonded to a durable paper liner, with the surfaces varying depending on the board type, such as plastic or metal. The core, which may contain additives to impart certain properties, is made of synthetic gypsum, a variety of gypsum by-products, and natural sources (BSI, 2013).

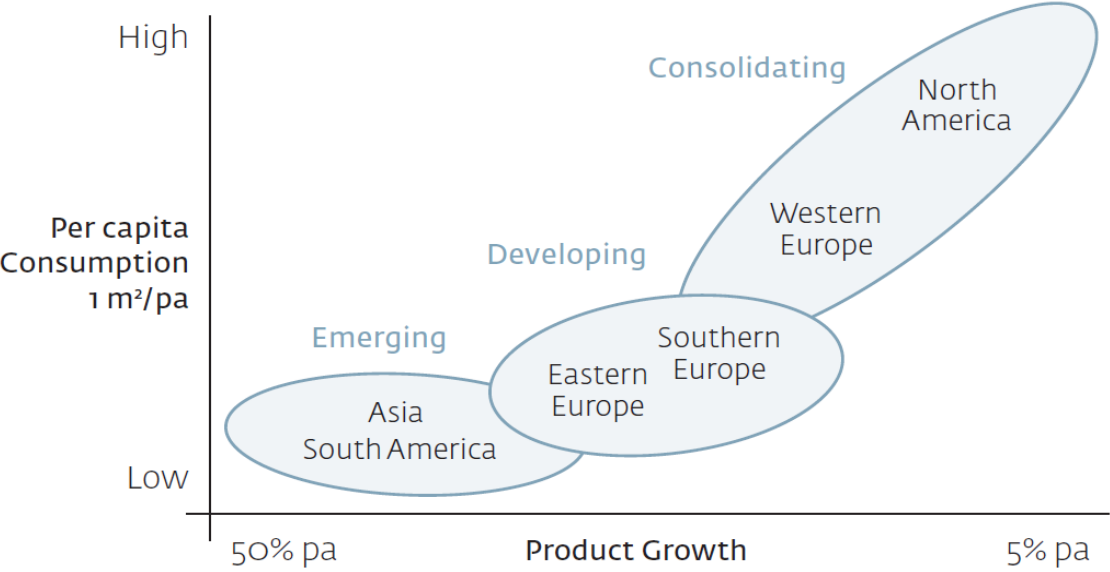
¹ Conversion (cubic meters to tons) factor: 0.4 (UK government guide, 2017)
<https://www.gov.uk/government/publications/excise-notice-lft1-a-general-guide-to-landfill-tax>

Synthetic gypsum is derived primarily from the process of flue-gas desulfurization (FGD) in coal-fired power plants in many countries, including most of Western Europe. It has been used as a substitute for natural gypsum for decades because it has a higher level of purity and is more readily available; its use is concentrated in Germany, largely in the production of gypsum boards and gypsum blocks (Sharpe & Cork, 2006, p.519; BIS, 2011; Ndukwe & Yuan, 2016).

Gypsum board has been widely used as a building material due to its merits: it is easy to install, non-combustible, fire-retardant, sound-controlling, thermal-insulating, humidity and heat-regulating, and impact-resistant (BIS, 2011). It first came into use in the late 19th century; owing to its fire-resistant quality, its use rapidly increased due to the destruction of buildings during World War I (Gypsum Association, 2013). Since World War II, when prefabricated modern style gypsum board became popular, gypsum board has been the dominant interior building material for both residential and ICI sectors in North America (Sharpe & Cork, 2006, p.519; EuroGypsum, 2008).

As markets for gypsum board products are consolidating in many developed countries of Western Europe and North America, as well as in Japan and Australia, the generation of gypsum board waste has increased in these countries (Figure 4). Currently, renovation and residential construction projects make up the major part of the markets for gypsum board in North America (EuroGypsum, 2008).

Figure 4. Emerging, developing, and consolidating markets for gypsum board



Source: ©EuroGypsum (2008). <http://www.eurogypsum.org/wp-content/uploads/2015/04/EUROGYPSUMWASTEPOLICY.pdf> “Used with permission”

2.2 Sustainability Imperative

Environmental impacts associated with gypsum board include climate change, primarily due to the energy used to manufacture the product throughout its lifecycle. The extraction and transportation process aside, the manufacturing process that uses the raw material of gypsum requires intensive energy input (Hobbs, 2009). Also, manufacturing the board from FGD gypsum is linked to high energy consumption due to the higher moisture content in FGD gypsum (BIS, 2011).

The negative impact of climate change due to gypsum board waste is reduced by processing the waste into the recycled product, rather than by manufacturing new gypsum board from raw material and landfilling gypsum board waste mixed with other waste. Moreover, the increased content of post-consumer recycled gypsum in gypsum board, from 10.5% up to 25%, presents no added negative impact of CO₂ emission (Marsh, 2008).

Gypsum board, when disposed of, has a negative impact on the environment, resulting in a significant financial burden to local governments as well. In addition, its landfilling may cause health and safety risks such as hydrogen sulfide gas (H₂S) emissions, which can occur under conditions that include a moist, anaerobic, and acidic environment (Calrecycle, 2007). As such, the traditional landfill method of discarding gypsum board is problematic. Lacking regard for its high recyclability and growing environmental awareness, the current management practice of gypsum board waste, , is both environmentally and socio-economically unsustainable. Therefore, an effort is required to shift from an existing management system towards a more sustainable scheme that promotes gypsum board recycling.

2.3 Gypsum Board Waste and the Management

For the most part, gypsum board waste ends up being landfilled. Even in many industrialized countries, including Canada, most gypsum board waste is currently undiverted; it is generally disposed of at landfill sites, occupying tremendous landfill space

(McCamley, 2004; Calrecycle, 2007). Meanwhile, gypsum board is rarely incinerated because of the potential conversion of sulfate into sulphur dioxide (SO₂). Sulphur dioxide impedes the performance of alkaline scrubbers on incinerators, possibly resulting in higher levels of acid gases such as hydrogen chloride (HCl) (EuroGypsum, 2008; Ndukwe & Yuan; 2016). Accordingly, burning or incinerating gypsum board is prohibited by many governments in North America and Europe (*Substance Release Regulation, Alta Reg 124/1993; Waste Discharge Regulation, BC Reg 320/2004; Calrecycle, 2007; EA, 2011*).

Gypsum board is classified as recyclable rather than salvageable. It is rarely re-used, due to the contaminants often attached to or contained in it; commonly found contaminants are adhesive tapes, binding materials, and paint, which can include hazardous waste such as lead and asbestos (Metro Vancouver, 2008; Earle, Ergun, & Gorgolewski, 2014; Ndukwe & Yuan, 2016). Because it is one of the most challenging materials to be recycled when it is not separated at source, the gypsum board is considered contaminated even when mixed with other recovered CRD materials. Conversely, if gypsum board waste is collected without contaminants, it is highly recyclable (Edge Environment Pty, 2012).

Although the recycling process for segregated gypsum board waste is regarded as simple, there are common obstacles to processing gypsum waste for recycling. Such obstacles include the low monetary value of the recycled material, cheap disposal options with easy access, and the required labor intensity and safety concerns of manual deconstruction. In addition, the distance to the recycling facility, as well as on-site constraints due to the time needed to separate gypsum board from other CRD and space for its storage, poses other limitations (Hogg et al., 2015; Bio by Deloitte, 2016a).

The barriers to recycling gypsum board waste could be reduced or overcome through optimal management strategies. They include legislative support to curtail the disposal of gypsum board waste, public investment in the recycling sector, industry-led voluntary initiatives, and increasing environmental awareness and recognition of EPR (McCamley, 2004; Bio by Deloitte, 2016a). In addition, the declining production of FGD gypsum, in accordance with the development of renewable energy, has a positive influence on the recycling trend by making it economically viable and competitive to recycle gypsum waste (McCamley, 2004).

2.3.1 Recycling process and technology

Demolition projects often generate a greater quantity of landfill-destined CRD waste per unit area, often up to 20-30 times that of construction projects (Jeffrey, 2011). Nevertheless, unlike conventional demolition, deconstruction saves more than 80% of building materials from landfilling (Metro Vancouver, 2016). Most of the gypsum board in its end-of-life (EoL) stage is wholly recyclable when separately collected through the deconstruction process. Deconstruction has already become a common practice in Belgium, France, the Netherlands, and the UK (UPM, 2013). However, a separate collection of gypsum board waste can often be economically prohibitive due to high labor costs and other on-site constraints.

In general, the main output materials from the processing facility for gypsum board waste are recycled gypsum (more than 90% of untreated waste by weight), paper, and a

small amount of metal. Typically, the recycling involves mechanical processes to obtain the primary material of a fine- to small-aggregate type of gypsum: removing attached metallic material or other contaminants and stripping of paper facing, and then grinding and sieving gypsum core (UPM, 2013). In recent years, small equipment with the main objectives of material separation and size-reduction of gypsum has been developed to be used directly on site, minimizing the transportation of processed gypsum for recycling (Kelleher Environmental et al., 2015, p.65).

Gypsum core has high recyclability, regardless of the sources: natural, synthetic, or recycled (Jiménez-Rivero, De Guzman-Baez, & García-Navarro, 2015). Due to the high recyclability of gypsum, gypsum board is one of the most exceptional building materials for which closed-loop recycling is feasible (UPM, 2013). In the closed-loop process, recycled gypsum is used as a source of feedstock for manufacturing new gypsum board products. So far, this has been the largest market for recycled gypsum board in many parts of the world, including North America (Jeffrey, 2011; Ndukwe & Yuan, 2016). Presently, although it has a technological limit in recycled content at around 20%, short-term trials for 30% content level are feasible with investment in new equipment (UMP, 2013; PSP, 2015).

In comparison with closed-loop recycling, open-loop practices use gypsum waste as a material in products and applications other than the manufacture of new gypsum board. Open-loop recycling of gypsum board, as a practical option for minimizing gypsum board waste in landfills, is widespread in the UK (Global Gypsum Magazine, 2008). Among these ways of recycling, recycled gypsum is most widely used as a source of SO₃ in Portland cement

manufacturing and as a soil conditioner and fertilizer in agricultural and recreational use. In addition to these primary applications, it is widely use across various industries; such uses include as sources of calcium in the food industry, additives in the pharmaceutical industry, a pH buffer and a hardness reducer in the liquor industry, a water flocculant in the environmental industry, and a plaster cast in the medical industry (Sharpe et al., 2006, p.534; Jeffrey, 2011).

2.3.2 Policy instruments for promoting recycling

Despite the variety of applications for recycled gypsum, the recycling rates of gypsum board in North America and Europe remain low (Ndukwe & Yuan, 2016; Bio by Deloitte, 2016b). However, financial disincentives or incentives, in addition to regulations, are likely to change the current practice of handling gypsum board waste, even though the construction industry has been slow to change its CRD practices. With no single policy tool offering a complete solution to promoting the recycling of gypsum board waste, a broad range of approaches, such as compatible government control and supports as well as a partnership among stakeholders, can be utilized (OECD, 2003, p.115; Bio by Deloitte, 2016b).

The landfilling of gypsum board is restricted by various means. However, certain conditions are required to make the tools workable and effective. For example, a landfill ban, which is the most direct measure of promoting the reduction and recycling of gypsum board waste, requires a rigorous system for enforcing the ban, established recycling facilities, and an end market. The rates for gypsum board disposal need to be set moderately high so that

taxes and tipping fees remain useful tools to encourage its recycling (OECD, 2003, p.100-101; Quinn, 2015).

Some strategies are embedded in the permit process, such as a building or demolition permit. They include a pre-demolition audit, compulsory sorting for recycling, mandatory delivery to recycling facilities, and obligatory reporting of waste flow information from CRD sites (OECD, 2003, p.100-103; Envirowise, 2008; Quinn, 2015; Bio by Deloitte, 2016b). Other permit-linked tools include increased building density, a fast-track permit procedure, and a fee discount (Quinn, 2015). Among these, the mandatory separation of gypsum board waste is particularly cost-effective when the currently available level of recycling technology is considered (OECD, 2003, p.101-102).

Voluntary separation is often driven by economic measures. They include different deposit-refund systems: a proportional refund based on waste diversion rates, an all-or-none system, or a hybrid. (Sonnevera International, 2006; Moyes, 2010, p.12-16; Quinn, 2015). Along with these, there are extensive financial incentives and disincentives that can be flexibly applied. They include tax credits and special loan plans for buildings certified by green building recognition programs (GBRPs), subsidies on recycling equipment, and a levy on virgin material, with zero subsidies for its extraction (OECD, 2003, p.112-114; Sonnevera International, 2006).

Another realistic policy tool is public procurement favoring environmentally sustainable buildings, which are often certified by GBRPs. While many representative GBRPs, such as LEED[®], BREEAM[®], Built Green[™], and BOMA[®] Go Green, are recognized as voluntary

mechanisms, the adoption of GBRPs may become compulsory for publicly funded projects (Sonnevera International, 2006).

The mandatory use of recycled material in new construction, as well as the requirement of material diversion for demolition projects, exemplifies environmentally responsible procurement (OECD, 2003, p.98; Sonnevera International, 2006). In other ways, established product standards or quality protocols for recycled material are likely to create a circle of gypsum board recycling, as they promote confidence in the recycled products (UPM, 2013; Bio by Deloitte, 2016a).

2.3.3 Action on gypsum board waste

Gypsum material has been used primarily in the manufacturing of gypsum board in North America and Europe, which have been the largest markets for gypsum board. As of 2012, gypsum board has consisted of approximately 81% of the gypsum products manufactured in the EU-27. However, for the most part, in 20 countries out of the EU-28, post-consumer gypsum waste is being landfilled (Jiménez-Rivero, De Guzman-Baez, & García-Navarro, 2015). As a result, overall, 87% of gypsum board waste in EU-28 is landfilled (Jiménez-Rivero & Carciá-Navarro, 2017). Even so, in some² of the EU member states, a large amount of post-consumer gypsum waste is being processed; the UK, Denmark, and the

² Belgium, Denmark, Finland, France, Luxembourg, the Netherlands, Sweden, and the UK (in alphabetical order)

Netherlands in particular show the highest diversion rate (Jiménez-Rivero & Carciá-Navarro, 2017). Some other countries³ are diverting pre-consumer gypsum waste only (Jiménez-Rivero, De Guzman-Baez, & García-Navarro, 2015). Building deconstruction is a common practice in Belgium, France, and the UK, as a market for recycled gypsum material exists. As well, mono-cell⁴ landfills are found only in these three countries as well (UPM, 2013).

The UK is one of the few countries⁵ where voluntary industry agreements are found. Further, it has normative end-of-waste (EoW) criteria for recycled gypsum (*PAS 109:2013*), which are absent in other countries in the EU (BSI, 2013; Jiménez-Rivero, De Guzman-Baez, & García-Navarro, 2015). For these reasons, this research has chosen to examine the UK's best practices of recycling gypsum board waste. Also, the EU's policy and regulatory framework concerning gypsum board waste are examined to present the background of the UK's regulatory frame.

Among Canadian provinces, a few jurisdictions have shown a strong commitment towards sustainable waste management for gypsum board. First, British Columbia (BC), where a bold landfill ban was first enforced in Canada, has been a leading province in terms of its diversion efforts for gypsum board waste. Second, Nova Scotia (NS) has taken the initiative in developing a comprehensive waste management strategy. It is the only jurisdiction that has legislated an upper limit for per-capita waste disposal and a solid waste

³ Austria, Germany, Italy, Poland, and Spain (in alphabetical order)

⁴ specially engineered landfills for gypsum waste due to its high sulfate

⁵ France, the Netherlands, and the UK

diversion goal (*Environment Act*, SNS. 1994-95, c.1; Giroux Environmental, 2014). Third, Alberta (AB) is the jurisdiction whose diversion rate of CRD waste has increased most significantly in a two-year period (2012-2014). (Statistics Canada, 2017) (Table 3). In 2008, the Alberta government took a significant step towards collaborative waste management through an MoU with the construction industry, which was the first voluntary agreement on CRD waste diversion in Canada (Moyes, 2010, p.15-16; Jeffrey, 2011).

2.4 CRD Waste Management in Europe

A strengthened recycling industry through legislative support, as well as the growing market for reprocessed gypsum, is observed in Europe (Hogg et al., 2015). However, the levels of CRD waste recycling and material recovery across the EU show large differences: from less than 10% to over 90% (EC, 2016). For example, while countries such as Germany, Denmark, the Netherland, and the UK have already reached the EU's CRD recycling target of 70%, countries such as Spain and Greece show poor performances (Jeffrey, 2011). Although the EU's waste framework, which pursues a high level of resource efficiency, encourages all its member states to strengthen the measures for sustainable waste management, its implementation is not consistent due to their local interests and specific situations (Burgy, 2013; EC, 2016).

In this situation, there is also a distinct dissimilarity regarding factors that influence the post-consumer recycling of gypsum board waste among the recycling countries and non-recycling countries. That is, in non-recycling countries like Germany, Greece, and Spain, the post-consumer recycling of gypsum is heavily affected by economic factors such as recycling or disposal costs and gypsum material prices, whereas recycling countries show a better balance among economic, social, and environmental factors (Jiménez-Rivero & García-Navarro, 2017). Even so, with the estimated portion of CRD waste being 25-30% out of all waste generated in the EU, international comparisons between the member states are cumbersome, owing to different definitions and inclusions of CRD waste and recycling including backfilling operations, as well as varied degrees of controlling and reporting waste handling (BIS, 2011; EC, 2016).

2.4.1 The European Union's strategies and Waste Framework Directive

The original waste framework for European society dates back to *Directive 75/442/EEC*. Prior to the formal establishment of the EU, this first Directive was substantially amended to *91/156/EEC*. In 2008, the updated Waste Framework Directive (WFD) replaced *Directive 2006/12/EC*, to clarify key concepts such as the application of waste hierarchy, EoW status, and EPR (*WFD, 2008/98/EC*, art 4, 6, 8).

This latest Directive requires the member nations to establish necessary measures to reach its diversion goal of 70% by weight for CRD waste by 2020, for which re-use and

recycling are applied, while energy recovery is not. In doing so, a controversy has arisen over the 70% diversion target in the absence of reliable EU data. Despite the on-going controversy, the EU's waste framework lays the foundation for the handling of waste in the EU (BIS, 2011).

There is no individually established diversion target for gypsum waste. However, its diversion is estimated to be far behind in contributing to the overall target for CRD waste (Burgy, 2013; UPM, 2013). As well, despite its close connection to a 70% CRD waste diversion goal by 2020, gypsum board waste is not subject to mandatory separate collection under the *WFD* (*WFD, 2008/98/EC*, art 11.2 (b); BIS, 2011).

The final disposal of gypsum waste is regulated by the *Council Directive 1999/31/EC*, which aims to satisfy Article 4 (waste hierarchy). In addition, the *Council Decision 2003/33/EC* controls the operation of a landfill in the EU countries by prescribing criteria and procedures for waste disposal. The Decision specifically requires non-hazardous gypsum to be disposed of "only in landfills for non-hazardous waste in cells where no biodegradable waste is accepted" (*Council Directive 1999/31/EC; Council Decision 2003/33/EC*, Annex, s 2.2.3).

These criteria on waste acceptance and disposal procedures have a direct impact on waste disposal in the EU. To illustrate, the inexpensive method of discarding gypsum waste in inert landfills has become unavailable due to the increased cost of operating mono-cell landfills. Moreover, the scarcity of mono-cells, which is attributed to the preference for

landfill operations involving more lucrative waste such as asbestos, has significantly limited the options for disposing of gypsum board waste in Europe (BIS, 2011; Jiménez-Rivero, De Guzman-Baez, & García-Navarro, 2015). To sum up, pursuant to the EU's policy towards a circular economy for a sustainable future, recycling gypsum board has become a necessity for the EU countries due to the subsequent limitation in disposal options.

2.4.2 Gypsum to Gypsum

Since the rapid growth in the construction use of gypsum board in the 1960s and 1970s, it has become the interior building material in highest demand in Europe (EuroGypsum, n.d.). In Western Europe, where the gypsum industry is well developed, several large businesses operate on an international basis (Henkels, 2006, p.1143). The applications of gypsum board in Europe are estimated to be 30% for both residential and non-residential construction use, and 40% for refurbishment (BIS, 2011). In this construction application, roughly 5% of the gypsum board used in new construction is turned into waste mainly because of off-cuts, with higher estimates expected from renovation and demolition (Jeffrey, 2011; EuroGypsum, n.d.). However, in most producer countries in Europe, a low level of gypsum board recycling is observed (UPM, 2013).

In this situation, the European gypsum industry has taken a collaborative approach towards a resource-efficient society. A LIFE project, the GtoG, exemplifies an effort displayed by the industry. Focusing on the closed-loop recycling of gypsum board from demolition, the

project aims to achieve a maximum of 30% recycled gypsum re-incorporated into gypsum board manufacturing (EuroGypsum, 2011; EC, 2017). Pilot projects (2014-2015), from building deconstruction to reprocessing gypsum board waste at manufacturing facilities, have been conducted in France, Germany, Belgium, and the UK (Marlet, 2014).

2.5 CRD Waste Management in the United Kingdom

Waste management responsibility in the UK falls under the jurisdiction of individual countries making up the UK: England, Scotland, Wales, and Northern Ireland. Each government is responsible for developing waste-handling and waste-reduction strategies, with the Department for Environment, Food and Rural Affairs (DEFRA) taking the overarching responsibility for environmental protection for the UK, as well as for a cooperative system among the governments. In England in particular, the Environment Agency (EA) of the non-departmental government body takes responsibility for enforcing environmental regulations (Bio by Deloitte, 2016a)

The CRD waste produced in the UK was estimated to reach 100 million tons in 2012. After excluding excavation waste (54%) and hazardous waste (1%) from this total, roughly 87% of non-hazardous CRD (45 million tons) waste is produced in England, with 89.2% of it estimated to be diverted from disposal. For the UK as a whole, the diversion rate of non-

hazardous CRD is slightly lower at 86.5%. For gypsum board specifically, the UK is again a leading jurisdiction in its management. In addition, because both legislative and non-legislative instruments for gypsum board recycling are well developed (Bio by Deloitte, 2016a), world-leading gypsum board plants are being operated by major European manufacturers in the UK in an international partnership (PSP, 2013).

2.5.1 Regulation of gypsum board waste

Under the influence of the EU's WFD, the UK aligns its domestic regulations primarily with the WFD for definitions of key concepts and for criteria such as a waste hierarchy (*Waste (England and Wales) Regulations 2011*, s 3(2), 12). Whereas no national or regional obligations exist regarding the deconstruction of gypsum board in the UK, waste producers are legally bound to the segregation of gypsum board waste on-site or through a licensed business, whenever applicable (Bio by Deloitte, 2016a).

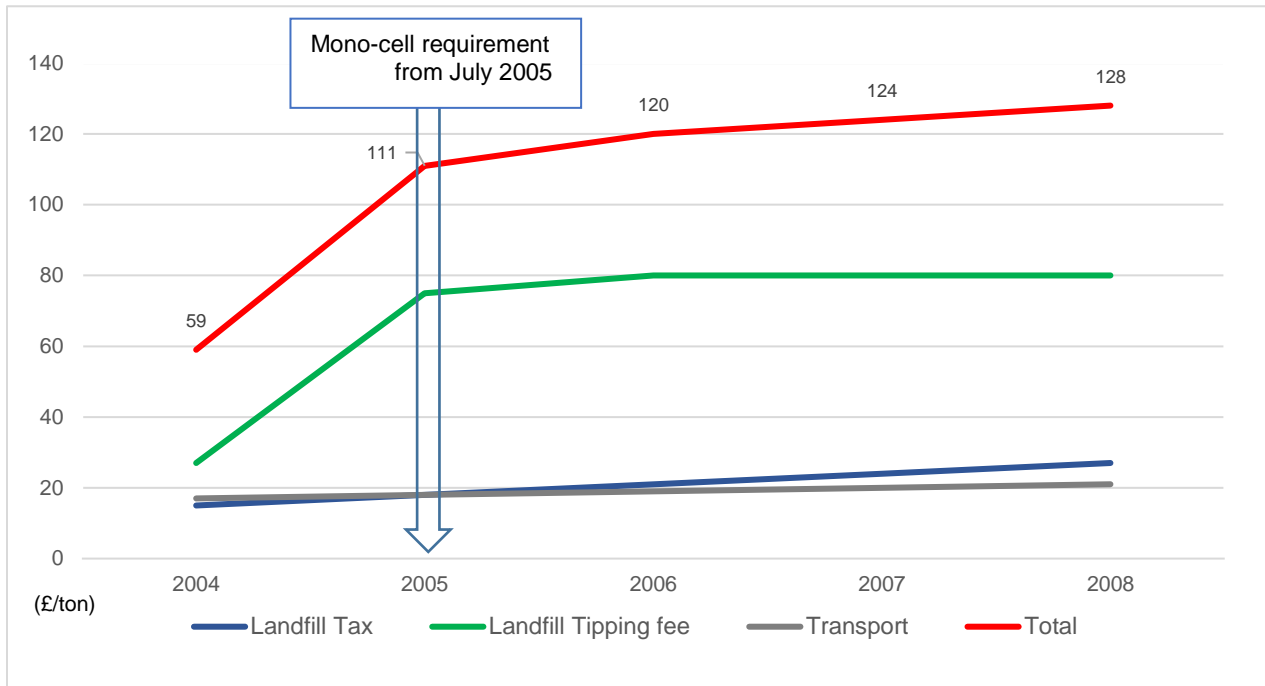
If gypsum board at the EoL stage⁶ is subject to a final disposal operation, gypsum material is required to be disposed of in a mono-cell that is separated from biodegradable waste. With this requirement clarified in the UK's domestic guidance⁷, which is based on the EU's Landfill Directive⁸, landfilling gypsum board in the UK has become less attractive from an economic point of view (Oakdene Hollins, 2006; EA, 2011) (Figure 5).

⁶ European Waste Code (EWC) 17-08-02, non-hazardous gypsum-based construction material (EA, 2011; UK,2017b)

⁷ EA's guideline, *Treatment of Waste for Landfill*

⁸ Council Directive 1999/31/EC

Figure 5. The estimated cost for disposing of gypsum board in a landfill.



Data Source: Oakdene Hollins. (2006). *Diverting plasterboard waste from landfill in the UK*. Retrieved from http://www.oakdenehollins.com/pdf/Diverting_plasterboard_waste_booklet.pdf

Although the UK has many restrictions governing gypsum disposal, there is no mandatory SWMP at present, due to the repeal of the *SWMP Regulations 2008* in 2013. Previously, SWMP was required for all CRD projects above £300,000 in value⁹. For projects above £500,000, the Regulations obligated the principal contractors to prepare an advanced SWMP, which included a half-yearly formal review of the plans and an estimate of final cost savings (Envirowise, 2008; DEFRA, 2013).

While the UK has no regulated requirement for SWMP at present, the country has a quality protocol in place for recycled gypsum. The provision of EoW status for gypsum board

⁹ excluding land value and VAT

waste has enabled recycled gypsum to be recognized as a raw material (UPM, 2013). The purpose of the British Standards Institution (BSI)'s Publicly Available Specification, *PAS 109* (2013) is the enhancement of user confidence in recycled gypsum material, possibly leading to market expansion. The *PAS 109* defines the minimum quality requirements for recycled gypsum, along with the normative criteria about procedures and frequencies for its sampling and inspection. The specific requirements to suit the intended end uses of reprocessed gypsum include various aspects: the distribution of particle sizes, the level of physical contamination, its chemical composition, its purity, and its color and smell.

Moreover, the UK's waste exemption lists¹⁰ show wastes that do not require an environmental permit for their operation, stipulating limits and specified conditions for the exemption. For gypsum waste specifically, its use as animal bedding is illegal in the UK, because this usage is not included in *U8-Waste Exemption*¹¹ by the EA (UK, 2014). Likewise, the *PAS 109* does not list animal bedding as an end use of reprocessed gypsum (EA, 2012). Thus, the amount of gypsum board waste used for animal bedding is currently estimated as none, with this use banned in 2015 (PSP, 2015).

2.5.2 Economic instruments in practice

The landfill tax in the UK, which the landfill site operator is liable to pay, was first introduced in the *Finance Act 1996* and the *Landfill Tax Regulation 1996*. This tax of two

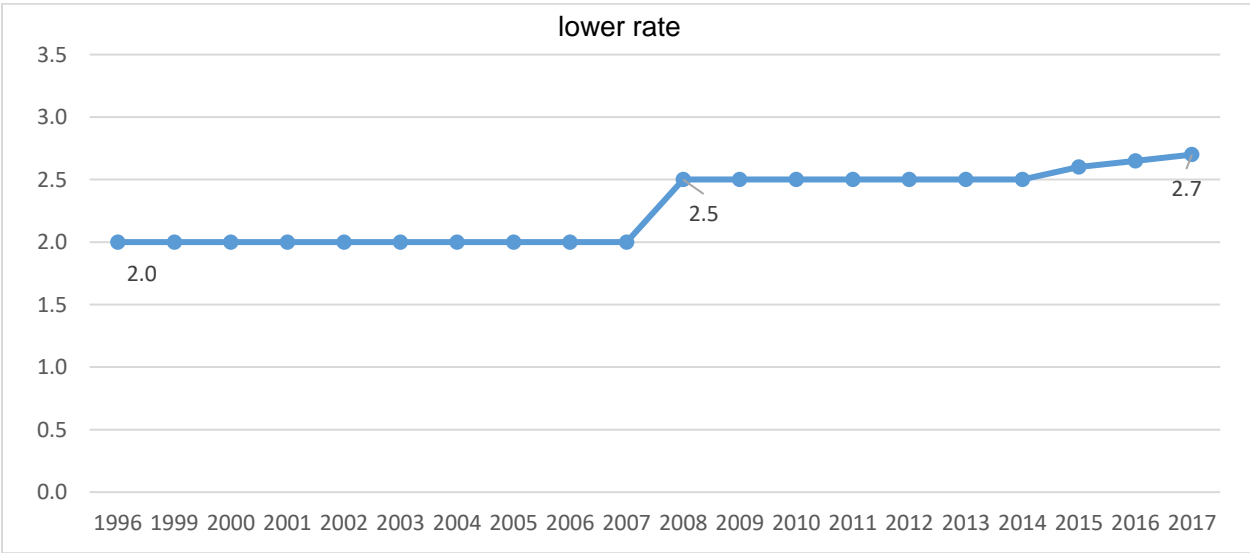
¹⁰ legal guidance on waste exemption (U1~U16)

¹¹ U8- using waste for a specified purpose

differential rates is charged by weight, with the lower rate applied primarily to non-hazardous inert waste (figure 6). For the disposal at landfill of non-hazardous gypsum-based waste, for which the lower rate is applicable, the waste carrier should declare in the waste transfer note that no gypsum board is included (UK, 2017b).

Figure 6. The UK’s landfill tax rates (1996-2017)

(unit: £/ton)



Data source: Government of the UK. (2017b). Retrieved from <https://www.gov.uk/government/publications/excise-notice-lft1-a-general-guide-to-landfill-tax>

In the UK, commercial exploiting of aggregate is subject to the aggregate levy of £2 per ton, which is an environmental tax in the UK. Gypsum material obtained from aggregate and by-products including waste, spoil, and offcuts from the process of gypsum extraction are largely subject to the levy. However, gypsum that is used for an intended product such as gypsum board is not taxable under this levy (UK, 2017a).

2.5.3 Other instruments and initiatives

Sustainable CRD waste management has been linked to GBRPs, of which BREEAM[®] has been the most representative in the UK for decades. While a pre-demolition audit of CRD waste is voluntary in the UK, it tends to be conducted in the certification process of BREEAM[®] (Bio by Deloitte, 2016a). In addition to GBRPs, there are many other cases of voluntary participation in the sustainable management of CRD waste in the UK, including industry-led agreements on recycling CRD waste. Among the agreements, the Ashdown Agreement is especially notable.

The Ashdown Agreement was signed by the Gypsum Product Development Association (GDPA) and Waste and Resource Action Program (WRAP) in March of 2007, after the GDPA had proposed that its members voluntarily reach an agreement on reducing and recycling gypsum board waste in 2006. The agreement focuses on gypsum board waste from new construction being diverted into the process of manufacturing gypsum board. Four main targets were established for the period of 2007 up to 2015: engaging with all stakeholders to reduce and divert gypsum board waste, reducing the waste to zero by 2015, incorporating

50% of gypsum board waste generated from new construction by 2015, and collaborating with all parties in the supply chain towards zero waste to landfill. Notably, the annual review of the agreement makes its targets challenging, yet achievable (PSP, 2015).

In February of 2009, industry representatives across the gypsum board supply chain established a partnership with the Plasterboard Sustainability Partnership (PSP) (Hobbs, 2009). The PSP is a non-profit voluntary initiative specifically for the sustainable management of gypsum board; the parties include both industry stakeholders throughout the lifecycle of gypsum board and relevant government departments and agencies. In October of 2010, the PSP set up the *Plasterboard Sustainability Action Plan*, which is implemented, monitored, and reviewed by the PSP (PSP, 2013). Importantly, the PSP facilitates individual commitments such as the Ashdown Agreement 2¹², the Contractors Agreement on Reducing Waste, and the EoL Plasterboard Waste Agreement. It brings all stakeholders under its umbrella by providing a single point of contact and by serving as a focal point of practical knowledge (PSP, 2013).

2.6 CRD Waste Management in Canada

Due to a lack of reliable data on CRD waste, waste management practices have largely been unsustainable in Canada (Earle, Ergun, & Gorgolewski, 2014; Kelleher Environmental

¹² New Ashdown Agreement revised 2012

et al., 2015, p.1). However, there are no homogeneous policies for CRD waste that are being implemented in Canada, as the federal government's involvement in the management of CRD waste is limited. With the responsibility split among different levels of government, the provinces take responsibility for approval and licensing of waste handling, while supervising, operational, and managerial responsibilities belong mainly to the municipal governments (ECCC, 2017a).

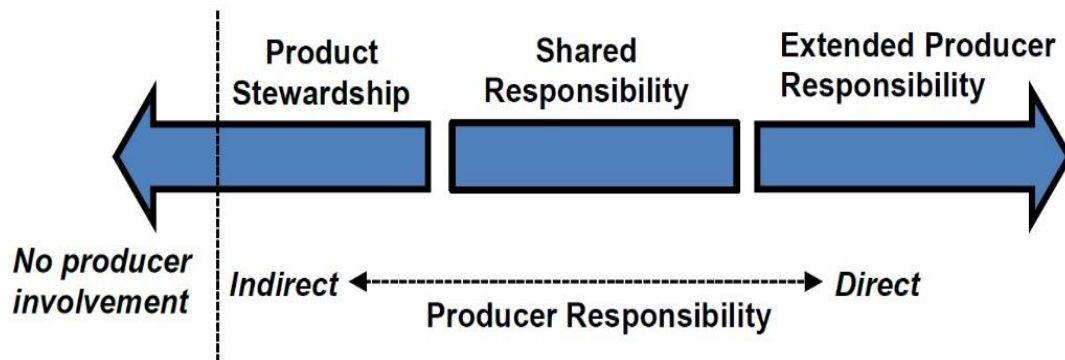
In this situation, the CCME member jurisdictions across Canada have committed to working on operational EPR programs for CRD materials by 2017, with approval of the CAP-EPR in October, 2009. With the first EPR program in Canada being the paint stewardship program in BC in 1994, Canada is now taking the first steps to apply EPR instruments primarily to CRD materials (Moyes, 2010, p.5-12; CCME, 2014).

However, the definition of "product" as well as "producer" is complex for C&D materials. Importantly, not just individual building materials and products, but also the newly created or renovated buildings, can be deemed "products" (Moyes, 2010, p.6). In the CAP-EPR, a producer is defined as follows:

"the highest responsible entity in the distribution chain in a jurisdiction and may include but is not limited to the brand owner, manufacturer, franchisee, assembler, filler, distributor, retailer or first importer of the product who sells, offers for sale or distributes the product in or into a jurisdiction, as defined in the Acts and/or regulations applicable in Canadian jurisdictions".

Because of the ambiguity in these critical definitions, Canadian jurisdictions require further specifications regarding the CAP-EPR in order to take the EPR approach for CRD materials (Moyes, 2010, p.10) (Figure 7).

Figure 7. Variations of producer responsibility in EPR approach



Source: CCME (2014). *Progress Report on the Canada-wide Action Plan for Extended Producer Responsibility*. Retrieved from <http://www.ccme.ca/files/Resources/waste/extended/CAP-EPR%20Progress%20Report.pdf>

2.6.1 Gypsum board waste in Canada

Roughly a half million tons or more of gypsum board waste is generated yearly in Canada; this amount includes offcuts from new installations, comprising about 10-12% of the new application of gypsum board (Ndukwe & Yuan, 2016; Enviros & CIRIA, n.d.). With insufficient data on gypsum board waste treatment in Canada, there is a variation in strategies used by provincial governments and the extent to which they currently reduce and divert gypsum board waste.

Since the BC government took the initial step for waste diversion in 1984, many jurisdictions have been seeking optimal policies of their own, with the expected practice of CAP-EPR (McCamley, 2004; CCME 2009). Currently, Canadian facilities for gypsum board recycling are operating in British Columbia, Alberta, Ontario, and Quebec (Perry & Vanderpol, 2014). The two representative operators are New West Gypsum Recycling (NWGR) and Recycle Gypse Québec (Ndukwe & Yuan, 2016).

2.6.2 CRD Waste management in British Columbia

Certain disposal methods for gypsum board are prohibited within BC for the entire province or in specified regions. While burning or incinerating it is banned throughout BC (*Waste Discharge Regulation*, BC Reg. 320/2004, schedule 1, s 2), landfill disposal is regionally banned.

In the Metro Vancouver Regional District (MVRD), gypsum board is not accepted for landfill operations, as it is classified as an operational impact material (MVRD By-law No. 302, schedule C). This 1984 ban resulted in the establishment in 1985 of NWGR in MVRD, which is one of the world leaders in the recycling of gypsum (McCamley, 2004; Burgy, 2013). Currently, NWGR recycles nearly all gypsum board waste from both manufacturing and CRD projects in the district (McCamley, 2004; Metro Vancouver, 2008). By locating their recycling facilities close to the manufacturing plants, NWGR incorporates all the reprocessed gypsum into new gypsum board (Enviros & CIRIA, n.d.).

In the Capital Regional District, restricting gypsum board from landfill has been implemented since 1991. Currently, only contaminated gypsum board is accepted at the disposal site at a high cost¹³, as gypsum board is classified as controlled waste in the District (Sonnevera International, 2006; CRD By-law No. 4100, Schedule E).

At the municipality level, in pursuance of meeting the 80% MSW diversion target that has been established in MVRD's Integrated Solid Waste and Resource Management Plan (ISWRMP), the City of Vancouver has identified CRD waste reduction as a priority task for achieving its goal¹⁴ of reducing MSW by 50% from 2008 levels (Vancouver, 2017). Such an effort, in its bid to become the world's greenest city, is demonstrated in the City's *Green Demolition By-law*. It mandates 75% or 90% reuse and recycling of CRD waste for one- and two-family homes built before 1940, with a mandatory refundable deposit¹⁵. Also, to cover the cost of reviewing the compliance of the by-law, the city has been charging a non-refundable "waste compliance fee"¹⁶ in the demolition permit process since April, 2016 (Vancouver, 2017).

In detail, for those homes built in and after 1940, an expedited demolition permit is applicable when the minimum reuse and recycling rate of 75% is voluntarily met. For multi-family homes and commercial buildings in the City, no such requirement exists, as these buildings have typically demonstrated higher diversion rates due to a systematic on-site

¹³ Disposal fee is CAD 311 per ton, for 2017 (for gypsum board originating outside the District, CAD 500)

¹⁴ In *Greenest City Action Plan 2020*

¹⁵ CAD 14,650 (as of 2017)

¹⁶ CAD 350 as of 2017

separation of dominant building materials such as concrete and metal (Vancouver, By-law No. 11023, 11450; Vancouver, 2017).

Still other economic measures are being utilized in BC to reduce gypsum board waste and to shift waste handling responsibilities from municipalities to producers. For example, large cities such as Vancouver and Kelowna maintain high levels of tipping fees for gypsum board waste. Their rates are relatively high in comparison with the rates in other cities in Canada, and with the average rate of all states in the US (Ndukwe & Yuan, 2016) (Table 4).

Table 4. Tipping fees for sorted gypsum board waste (2017)

(unit: CAD/ton)

City, Province	Tipping fee	Remarks
Vancouver, BC	150 ⁽¹⁾	\$200 for 2019
Kelowna, BC	145 ⁽²⁾	\$175 for 2018
Toronto, ON	110 ⁽³⁾	\$120 for 2019
Guelph, ON	70 ⁽⁴⁾	
Calgary, AB	80 ⁽⁵⁾	If mixed, \$113 for residents, \$175 for business
Edmonton, AB	44 ⁽⁶⁾	\$48; \$90 for min. 75% CRD waste; \$125 for mixed waste for 2019
Halifax, NS	100 ⁽⁷⁾	\$ 115 for mixed CRD waste

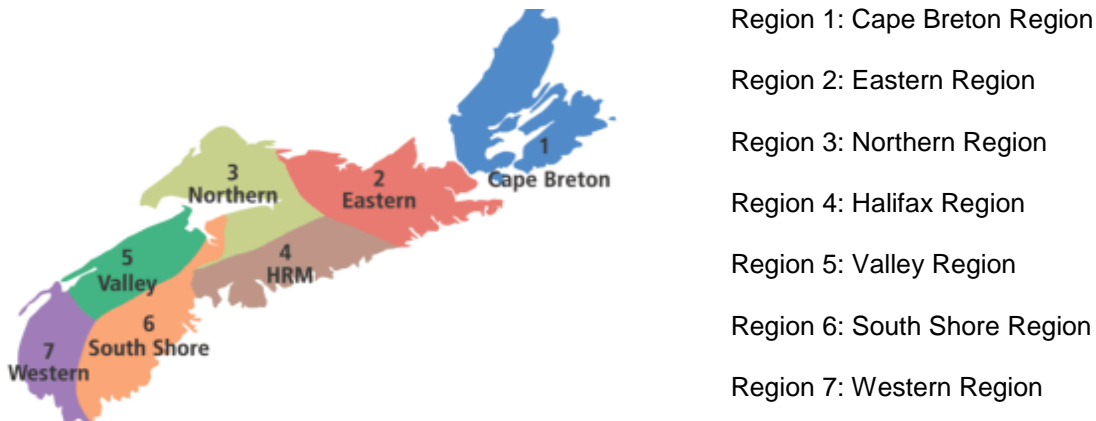
Source: (1) City of Vancouver (<http://vancouver.ca/home-property-development/landfill.aspx>) (2) City of Kelowna (<https://www.kelowna.ca/city-services/garbage-recycling-yard-waste/glenmore-landfill/tipping-fees-or-rates>) (3) City of Toronto (<https://www.toronto.ca/services-payments/property-taxes-utilities/utility-bill/solid-waste-rates>) (4) City of Guelph (<http://guelph.ca/living/garbage-and-recycling/public-drop-off/>) (5) City of Calgary (<http://www.calgary.ca/UEP/WRS/Pages/Landfill-information/Landfill-Rates.aspx>) (6) City of Edmonton (https://www.edmonton.ca/programs_services/garbage_waste/disposal-rates.aspx) (7) Halifax C&D Recycling Ltd (<http://halifaxcdrecycling.ca/tipping-fees>)

2.6.3 Strategies for CRD waste in Nova Scotia

Nova Scotia has made notable advancements in CRD waste management over the last few decades. Its commitment to a sustainable waste future is displayed through the establishment of a target of an upper limit of 300 kg per capita by 2015 for solid waste disposal, contributing to its MSW diversion goal of a minimum 50% (*Environment Act*, SNS. 1994-95, s 93, 93(1); Jeffrey, 2011). In pursuing this goal, the Resource Recovery Fund provides municipalities or regions with a minimum of 50% of the net revenues, based on their diversion performances (*Solid Waste-Resource Management Regulations*, NS. Reg. 172/2016, s 8(1)).

Meanwhile, the Nova Scotia government has divided the province into seven administrative regions for waste management. (Figure 8). These regions were established to ensure appropriate levels of cost-efficient environmental protection and to promote close cooperation both among the regions and with the province (Nova Scotia, 2014; *Solid Waste-Resource Management Regulations*, NS. Reg. 172/2016, s 39(1)).

Figure 8. Waste Management Regions of NS



Source : Nova Scotia. <https://novascotia.ca/nse/waste/muncollection.asp>

In the Halifax Regional Municipality (HRM), even though licensed facilities under jurisdiction can accept gypsum board waste, they are required to recycle at least 75% of all received CRD waste (Jeffrey, 2011; Halifax, 2001; Nova Scotia, By-law L-200, *By-law on Material Recycling and Disposal License*, s 9(2), 2001). This is a significant measure that goes beyond the *Solid Waste Resource Management Regulation*; comprehensive disposal bans by the provincial by-law (L-200) apply not only to designated CRD wastes but also to other CRD wastes, including gypsum board (Jeffrey, 2011; *Solid Waste-Resource Management Regulations*, NS. Reg. 172/2016, schedule B).

2.6.4 Management efforts in Alberta

In Alberta, burning gypsum board is prohibited (Substance Release Regulation, Alta Reg. 124/1993, s 1(1); Waste Control Regulation, Alta Reg. 192/1996, s 26), and its recycling is supported by the Recycling Fund (Environmental Protection and Enhancement Act, RSA 2000, c 171(1)). As well, its recycling is promoted by differential tipping fees in cities such as Calgary, Canmore, and Edmonton. To illustrate, in Calgary, gypsum board waste that includes less than 2% of contaminants is subject to a lower tipping fee¹⁷, but attracts a higher rate as a designated material when mixed with other CRD waste (Sonnevera International, 2006; Calgary, 2017).

¹⁷ CAD 80/ton compared with the higher rate of \$175/ton for business, or \$113 for resident (as of 2017)

In Edmonton, both segregated and mixed gypsum board waste is accepted with differential tipping fees¹⁸ at the Edmonton Waste Management Center (EWMC) collective waste processing facilities¹⁹, which the city owns and directly operates. Due to its CRD waste recycling facility with high operational flexibility, the city can segregate up to nine different types of CRD wastes, including gypsum board, from a mixed waste load (Edmonton, 2012; EWMC, 2017).

Following the province's MoU on CRD waste reduction and recycling with the Canadian Home Builders' Association (CHBA)-AB and Alberta Construction Association (ACA) in 2008, the government and industry have discussed the establishment of a deposit and refund system as well as a CRD fund. However, so far, no provincial program has specifically targeted CRD waste, although Alberta had planned for a system for CRD waste diversion to be in place by 2010 (Alberta Environment, personal communication, Apr.17, 2017).

2.6.5 Gypsum board waste in Manitoba

In MB, landfilled CRD waste from both residential and ICI sectors is subject to the Waste Reduction and Recycling Support (WRARS) levy²⁰, which is a provincial disincentive first introduced in July 2009. The collected levy is deposited in the WRARS Fund, with 80% of the amount rebated to municipalities designated for recycling and supporting sustainable

¹⁸ CAD 44/ton for clean waste, \$72/ton for mixed waste with minimum 75% CRD waste, and \$100 for other mixed waste (as of 2017)

¹⁹ 97,400 ton of CRD waste accepted at the EWMC for recycling (as of 2015)

²⁰ CAD 10/ton for all solid waste disposed at landfills

waste management. (*Waste Reduction and Prevention Act*, 1990, CCSM, c. W40. s 2, 14.2(1); Green Manitoba, 2014).

Currently, no CRD waste diversion program has been established for MB. However, the province intends for 100,000 tons of CRD waste to be diverted from landfills by 2020. Towards this target, mandatory on-site separation and recycling for large CRD projects, and the phasing-in of a landfill ban for CRD waste, have been under discussion as future options for MB. With the thirteen province-wide EPR programs being administered by Producer Responsibility Organizations (PROs), gypsum board waste is currently one of the candidates likely to be controlled by the EPR programs in 2020 (Manitoba, 2014).

2.7 Summary

This chapter examined the current practice of handling gypsum board waste in Canada and the UK. Waste framework and various policy instruments, as well as voluntary initiatives by the industry in the study areas, were also examined in this chapter. Documents and literature were reviewed to deliver the present status and up-to-date development of the policies. The intent of this chapter was to provide a range of possible policy options that may contribute to formulating optimal strategies for the sustainability of gypsum board in MB.

Chapter 3

RESEARCH METHODS

3.1 Introduction

This chapter describes the research approach and specific designs and methods adopted for this study and explains why they were used to satisfy the research objectives. The chapter also addresses how the collected data was managed and validated, what the ethical considerations of conducting the research were and how they were resolved, and finally, how the results of the study will be disseminated.

3.2 Research Approach

Qualitative research is the process of finding hidden meanings, suggesting various interpretations, and searching for implied significance and “unheard voices” in research materials that include images, journals, and field notes (Have, 2011). In contrast to quantitative research, a qualitative approach of inquiry provides complex descriptions that rely on textual data, rather than on a concise description in numeric form (Creswell, 2014, p.157, 183). A qualitative approach, having a wide variety of styles of techniques, enables researchers to have insights into the current state of the issue under study (Have, 2011). Through adopting a holistic approach, the researcher, as a “key instrument” of qualitative research, typically gathers data from sources in multiple forms (Creswell, 2014, p.185-186).

Due to the exploratory and contextual nature of this study, a qualitative research methodology was employed. In designing this qualitative research, several methods of data collection were incorporated to satisfy the objectives of this research (see Chapter 1.3): literature review, document review, and semi-structured interviews.

3.3 Literature Review

Defined as “an interpretation and synthesis of published work”, the literature review engages in examining secondary sources of information, which often provide additional opinions by processing primary sources (Merriam, 1988, p.6; Eamon, 2004). This procedure is “a pivotal element of any research enquiry”. That is, it provides extensive and in-depth knowledge across a wide range of fields, thus helping researchers see the broader pictures of research topics by connecting the specific topics to broader ranges of previous work. Meanwhile, literature review also assists in situating research focuses, sharpening research questions, and in some case, suggesting new research questions (Adams, Khan, Raeside, & White, 2014).

Through the process of literature review, secondary materials with relevance to the subject of this research contributed to the framing of the research questions and methods. They also provided background and primary themes for the analysis of information collected for this research and the discussions based on it.

At the beginning of the literature review, the strategy of a random search of web pages and databases was used by entering the names of jurisdictions and the keywords, including the ones listed on page i. The results of the search led to a wide range of sources of information on related topics. Institutional reports were first reviewed and other reading materials on more detailed content were reviewed based on the literature and documents.

When deciding on which jurisdictions would be chosen to be studied, the maturity of the gypsum board market of the jurisdictions was first considered. After that, many other factors were counted, including the degree of social development and the cultural similarity in housing forms and institutions, the levels of waste management policy, and the abundance of relevant high-profile data. Among the European countries, both their global status and populations, as well as levels of institutional development regarding CRD waste management, were taken into consideration. As a result, the types of examined literature for this study included journal articles, books, news articles, and conference papers. The literature review often led to reviewing documents in order to investigate the background and rationale of the literature.

3.4 Document Review

Document review involves the scrutiny of primary sources of information giving broad coverage. As a direct account of the information, primary sources are usually created “at the time of” or “very soon after” the event, and they are often “rare or one-of-a-kind” (Eamon, 2004).

This method of data collection was chosen to assist in developing adaptive interview questions as well as in providing background information on the studied topics. The method was used as a means of finding the context and background of the information obtained from literature review. For this research, document review was conducted using written materials in both electronic and printed forms. The sources of the document included governmental, institutional, and private entities. The types of documents reviewed for this research included legislative documents, governmental reports, administrative records, position papers, consulting reports, and associational publications.

The intent of the document review was also to triangulate the information obtained from secondary sources, as well as to find the context and background of the previously examined literature. As well, this procedure helped to determine if there was a convergence of the information collected by different methods. Primary sources were preferred for legislative information and legal guidelines. The primary documents were useful to identify the trend and the direction of change, as they presented the intent behind the revision and increased the reliability of the information by capturing the most recent information available.

3.5 Semi-structured Interviews

Conducting interviews is one of the most popular research methods in qualitative research because of its many advantages. Primarily, it allows researchers to collect “on-target” information with minimal effort and time; the researchers need not wait for the

emergence of target phenomena. Also, unlike either a standardized interview with a restricted format that the researcher administers or an unstructured interview that allows respondents to talk freely on one topic or more in a lengthy conversation, a semi-structured interview is less restrictive but guided by a list of interview questions. The semi-structured interview, to effectively collect the desired data, invites the interviewee to answer rather specific questions. Most importantly, it allows the researcher to ask adaptive questions based on the interviewee's response, thus allowing the interviewee to add in-depth opinions. (Have, 2011).

Given their potential benefits and suitability to the aims of this research, semi-structured interviews were chosen as the best fit for data collection. In order to include main stakeholders' opinions and perspectives regarding the recycling of gypsum board in MB, semi-structured interviews were completed with seven participants from local governments and the industry.

This research used a purposive sampling technique, which relies on the judgement of the researcher and the selection criteria that are at the discretion of the researcher (Lavrakas, 2008). Through this sampling method, 40 potential interviewees were identified, based primarily on the member directories of the trade associations of construction businesses, home builders, and drywall contractors in Manitoba; four were identified by government employee lists and personal references directed by the organization. Still others were identified through a reference directed by people in the same profession and industry. During this process, efforts were made to include participants from various sub-sectors of the industry.

Of the 44 people initially contacted by email with an introductory letter to seek their intent to participate, seven interviewees participated. Follow-up emails were used as a reminder or for further communication when necessary. The individual interviews were conducted with participants from government and industry. The government group included provincial and municipal government; the industry group included an industry association and private businesses. This research considered both groups to be of equal significance regarding shaping a system for sustainable waste management and increasing the feasibility of the system. The interviewees were selected from among people in managerial positions from both government and industry, as they represented the two sides that are sometimes in an adversarial relationship but closely connected in managing gypsum board waste.

Interview questions were developed and refined over many months; some questions were removed when the answers to the questions could be given directly and indirectly as document and literature review continued during the period. In the end, a set of ten preliminary interview questions were developed for all participants in order to collect opinions about current issues and policy measures that could be viable for the province of MB (Appendix A). With different interviewees focusing on different issues according to their interests, interviews were conducted with questions that were adapted to each interviewee's interests.

3.6 Record and Transcription of Interviews

Six interviews were recorded upon the interviewee's consent for the use of both a digital voice recorder and an application on a mobile phone; one interview was recorded by hand at the site. For the former type of record, the audio information was transcribed using voice-to-text software and was then supplemented manually. Non-verbal communication was not included in the transcripts. Within the next few weeks, the interim transcripts were emailed to the interviewees to be reviewed and verified, allowing them to add comments if wished.

3.7 Research Ethics

Before the interviews were conducted, ethics approval for this research proposal was obtained from the Joint Ethics Review Board of the University of Manitoba. According to the approved research ethics, a consent form was sent to all participants to ensure that their participation was voluntary and that they had been informed of a summary of the research and their rights as a participant. This form made them aware that the interview data would be kept confidential, and that the results would be released without identifying them.

The form, either in a physical or an electronic copy, was retrieved from six participants after being signed by the individual; a piece of voice recording was made for a participant who chose to agree verbally to have an interview for the research instead of signing the form that had been sent at the time of recruitment, and later, around the time when the interview was scheduled. In this case, it was confirmed in the voice recording that the participant had read through the consent form prior to the interview.

3.8 Data Analysis and Validation

Data collected for this study, both from document and literature and through interviews, was managed manually. Most of the data was progressively analyzed; compiling interview data started before all the interviews were completed. An overall analysis of interview results was undertaken to identify meaningful data pertaining to relevant regional problems and significant issues, in addition to the interviewees' perception of those.

To improve the accuracy of the data and to ensure its quality, several common strategies suggested by Creswell were used (Creswell, 2014, p.201-202). Data collected from multiple sources and in different forms were examined and compared in order to enhance validity. In some cases, close attention was paid to tracking changes and to ensuring the validity of the data, depending on when the data and information were created and released, because issues and discussions of certain literature have been nullified by changes in policy. For instance, the UK's legal guidelines were changed and strengthened in accordance with the EU's policy direction.

To increase the reliability of this research, interview transcripts were closely checked to eliminate obvious mistakes and errors in transcription; subsequently, interim interview results were sent to the participants to determine that their descriptions and the findings from the interview communications were accurate. While some data, such as interview data, could be verified near the end of the data collection phase, other data were confirmed to be valid in the earlier stage of the research through the triangulation of multiple sources of literature and documents.

As reflectivity is a key feature of qualitative research, despite all the efforts to maintain the objectivity of this study, the researcher declares that this research is possibly biased, due to the researcher's many years of experience in public administration. The researcher's professional background and previous exposure to discussions on the related issues may have affected interview questions and the expectations of interview results. Before the interviews were conducted, the researcher had expected conflicting opinions between the two groups of interviewees: government and industry. However, there was no remarkable disagreement between them. Lastly, as for the research methods, there was no change in the original design of the research methodology.

3.9 Dissemination

Data collected for the research will be disseminated through this thesis, and possibly through academic articles and conference presentations. Names of interviewees will be not be released in compliance with the Tri-Council Policy Statement (TCPS2, Ethical Conduct for Research Involving Humans).

Chapter 4

EXPLORING OPTIONS FOR GYPSUM BOARD RECYCLING IN MANITOBA

4.1 Introduction

After the review of the various tools used in other jurisdictions to manage gypsum board waste, as presented in Chapter 2, this chapter includes important features and discussions of the policy tools. Chapter 4 focused on the regulatory and financial systems that are regarded as significant in terms of effectiveness, as overviewed in Chapter 4.2.

4.2 Overview

Up until now, gypsum board waste has been legitimately landfilled in many areas in Europe and North America. Further, the waste has frequently been illegally discarded, despite the explicit prohibition of such dumping. Under these circumstances, poor enforcement of the regulations in the UK, where the recycling industry and culture have been developed by legislative support, has been a source of frustration to businesses and the public (Hogg et al., 2015; SpecFinish, 2015).

Regulatory instruments have been identified as the most effective governmental interventions to encourage the recycling of gypsum board waste, even though they are less favored by the ICI sector stakeholders than are voluntary and economic options (OECD, 2003, p.103; Hogg et al., 2015). Therefore, it is crucial that regulations be strictly enforced once

restrictions are imposed on managing gypsum board waste, since the rigorous enforcement of regulations not only leads to the success of the individual policy, but in a broader context also contributes to solidifying the confidence in legislative policy held by both the construction industry and governments (Shiers et al., 2014).

Together with regulatory factors, economic factors are often the most powerful elements influencing gypsum waste recycling. Economic instruments that offer both incentives and disincentives contribute to the promotion of gypsum board recycling. Voluntary segregation of CRD waste on site is likely to be facilitated by these financial tools, and conventional demolition practice is more likely to change under enhanced environmental taxing on landfill operation of waste (Bio by Deloitte, 2016b). However, financial disincentives, rather than incentives, may be more effective, even though incentives, which are often preferred over financial disincentives, are recommended by ICI stakeholders (Sonnevera International, 2006; Calgary, 2013; Manitoba, 2014).

4.3 Regulatory Instruments

4.3.1 Deconstruction and waste segregation

Separating gypsum board at source is a cost-effective way to recycle it, when currently available recycling technologies are counted (OECD, 2003, p.101, 102). Since mixed CRD waste from demolition is generally difficult to recycle, deconstruction and segregation at source together enable the maximum level of recycling for gypsum board waste (Jiménez-Rivero, De Guzman-Baez, & García-Navarro, 2015; Jiménez-Rivero & García-Navarro, 2017).

However, although the separate collection of gypsum board waste is ideal for quality recycling, the high labor costs associated with the labor-intensive process sometimes make it cost-prohibitive in many countries in North America and Western Europe. Even after the gypsum board is separately collected, if it is mixed again with other recyclables in a single container due to the common constraint of on-site space, gypsum recycling becomes problematic; gypsum may crumble into fragments when other materials impose weight on it, possibly limiting the quality recycling of other resources (Hogg et al., 2015).

Abundant sources of gypsum mineral in Canada are viewed as one of the main obstacles to its recycling (Jeffrey, 2011). Even with deconstruction, when it is incomplete, much of what remains, including gypsum board, is largely mixed and contaminated after the selective reclamation of highly valued materials such as metal. Accordingly, regulatory options can be a promising means to make source separation for the recycling of gypsum board a more likely choice (Hogg et al., 2015; Bio by Deloitte, 2016b). Assuming that regulations are necessary for resource recycling, stakeholders of the ICI sector have favored mandatory source separation as the best option among various regulatory options (Calgary, 2013).

4.3.2 Site waste management plan

Multiple direct and indirect benefits that SWMPs potentially bring include improved efficiency in using material resources, a structured approach to on-site waste management, reduction in waste production, and the prevention of fly-tipping (DEFRA-CIOB, 2007; Envirowise, 2008). Waste management based on SWMPs can be either voluntary or

compulsory; however, in the UK, the voluntary system turned into a compulsory mechanism with mandatory recycling requirements and compliance audits (DEFRA-CIOB, 2007; Metro Vancouver 2008; Vancouver, 2017).

Certain waste management mechanisms are linked to permit processes such as building or demolition permits and development approval. For example, in the City of Vancouver, recycling requirements based on the *Green Demolition By-law* have been developed as compulsory waste diversion mechanisms since 2014. Starting in January 2018, all renovation projects for single- and two-family homes are subject to the requirement of a waste reuse/recycling plan with a 75% diversion target. Individual case audits to investigate compliance with the legislation have also been announced (Vancouver, 2017).

In England, before 2013, all CRD projects above £300,000 in value²¹ were subject to mandatory SWMPs. According to the Regulations, each waste type and the estimated quantity under intended waste management actions were to be specified for all SWMPs before the commencement of a project. For CRD projects above £500,000, the actual performance on individual waste management had to be confirmed within three months of their completion. However, although waste management responsibilities were comprehensive and shared among all parties involved in applicable CRD projects, for the most part, responsibilities to ensure compliance with the SWMPs were assigned to the applicable principal contractors (*SWMPs Regulations*, Eng. 314/2008). Furthermore, even though waste handling was subject to detailed control by legislation, it was not properly enforced (Hogg et al., 2015).

²¹ excluding land value and VAT

Such “implementation deficit” was primarily blamed for the UK’s repeal of the *SWMPs Regulations*. The poor enforcement of these regulations was attributed to a few main factors. First, administrative mechanisms were lacking in detail in terms of both how to achieve the objectives and who was ultimately responsible for the enforcement and monitoring. Unfortunately, the responsibility of enforcement was left largely to local authorities, who had little part in the policy-making stage; in addition, the central government offered insufficient instrumental, technical, and financial support. As well, locally available infrastructure was unequal to the task of effectively responding to the level of requirements within the SWMPs (Shiers et al., 2014).

Eventually, during the process of repealing the *SWMPs Regulations 2008* in 2012, DEFRA, in response to the government’s Red Tape Challenge²², has summarized the key factors and main contributors to the repeal:

1. the administrative burden of nationwide enforcement and associated inconsistent enforcement, which resulted in no prosecution by local authorities and the EA
2. the bureaucracy of SWMPs and their overlap with GBRPs, such as BREEAM® and the Code for Sustainable Homes; the expectation was that businesses should continue to use both SWMPs and GBRPs.
3. the lack of engagement with the green-designing of buildings, and falling short of expectations to achieve optimal reduction in waste generation by the “designing out of waste” (DEFRA, 2013).

²² The UK government’s deregulation policy for business

In addition, a discrepancy has been found between the CRD projects subject to the regulations and specified key issues that the UK's mandatory SWMPs aimed to address: "improving material resource efficiency" and "reducing fly-tipping". In a typical case, during CRD waste handling, illegal acts are committed by two groups: sub-contractors who are employed by principal contractors in sizable CRD sites and small builders who use no contractors (DEFRA-CIOB, 2007; DEFRA, 2008). Although SWMPs may help some subcontractors become more aware of compliance responsibilities, small-scale CRD projects that self-employed builders and subcontractors work on were not covered by the *SWMPs Regulations*. To sum up, the UK's short-lived SWMPs regulations were rescinded because they were ineffective and onerous to both businesses and governments, with potentially negative outcomes outweighing the benefits (DEFRA-CIOB, 2007).

4.3.3 Quality requirements

Gypsum board waste diversion is affected by many factors besides the local value of both virgin and reprocessed gypsum material (Jeffrey, 2011). Such factors include user perception of reprocessed material and recycled products, which has been a much-discussed issue in the recycling industry. Negative perceptions about recycled products may relate to liability concerns, lack of specification and experience with the products, and unique costs that may be associated with probable requirements of the additional permit and handling (IWMB, 1996).

However, the provision of EoW criteria reduces administrative burdens and avoids confusion over determining "when waste ceases to be waste". As such, a quality protocol for

certain uses of reprocessed gypsum increases user confidence in the secondary material by assuring the defined quality of reprocessed gypsum. As a result, the development and expansion of markets for recycled gypsum will be promising if the negative perception of recycled gypsum can be minimized (DEFRA, 2012; BSI, 2013).

Such a protocol for the quality recycling of gypsum board is uncommon in Canada and many European countries. In fact, EoW criteria are clearly defined in the EU level²³ for only some materials, such as glass and certain metals, making it unnecessary for the member states to transpose the EU's regulations to national legislation (DEFRA, 2012). Nevertheless, the UK transposed the EU's WFD (Directive 2008/98/EC), in relation to EoW criteria for gypsum waste, to its legal guidance (DEFRA, 2012).

The economical use of gypsum resource for different end uses has been made possible in the UK by the minimum standard specifications of the *PAS 109* for reprocessed gypsum. On the other hand, the *PAS 109* facilitates decision-making on the acceptability of waste loads as well by supporting clear communication between the potential suppliers of reprocessed gypsum and its recipients. With improved communication and business transactions, thanks to the composite code²⁴, a quality protocol provides a standardized description of gypsum board in the EoL stage (BSI, 2013). As such, the demand for reprocessed gypsum can be further activated and increased by virtue of the stated EoW criteria and enhanced communication regarding the waste.

²³ The EU's Council Regulation No. 333/2011, Commission Regulation No. 11749/2012, No. 715/2013. Details are at http://ec.europa.eu/environment/waste/framework/end_of_waste.htm

²⁴ A composite code consists of four different codes: board type code, source code, site code, collection code. [http://www.wrap.org.uk/sites/files/wrap/PAS109%20\(2013\).pdf](http://www.wrap.org.uk/sites/files/wrap/PAS109%20(2013).pdf)

4.3.4 Landfill bans and restrictions

Bans and restrictions on landfilling have been utilized as policy options that directly impact the reduction and recycling of gypsum board. The expected results have been well demonstrated through many cases, including landfill bans in August of 1991 at the Hartland landfill in B that resulted in landfilled gypsum board waste being reduced by 91% (from 4,197 to 379 in tonnage) between 1990 and 2001 (Sonnevera International, 2006).

However, these measures have no strong impact on the design of construction projects when such prohibitions are not combined with other strategies for waste diversion. Rather, such regulatory measures are administratively burdensome, especially to the municipalities (Sonnevera International, 2006). Illegally dumped waste has been sourced significantly from CRD waste of low to negative economic value, and unfortunately, these landfill restrictions potentially heighten the incidence of the illegal dumping of gypsum board waste in cases where there is neither a raised level of awareness nor strict sanctions (OECD, 2003, p.100; DEFRA-CIOB, 2007).

Even so, it is unrealistic to closely monitor the waste management conditions of all CRD sites, because handling CRD waste usually involves many small-scale contractors (OECD, 2003, p.103). In this situation, the mandatory reporting of waste information from CRD sites has been discussed as a preventive measure against illegal waste dumping. However, its practicality is debatable due to the associated administrative burden created by this potentially complementary measure and the lack of solid evidence of its effectiveness (OECD, 2003, p. 103).

The availability of recycling facilities within a reasonable distance is another important factor for waste diversion. Nova Scotia allowed a grace period of a few years for industry to develop the necessary infrastructure prior to the enforcement of landfill bans for certain CRD wastes, whereas such landfill restrictions for the Capital Regional District in BC were put in place after viable options were identified (Sonnevera International, 2006). In any case, once recycling infrastructure is in place, the stringent enforcement of bans and restrictions is crucial in ensuring the fairness and credibility of a policy. Lastly, it should be noted that landfill bans and restrictions, factors that generally result in increases in recycling, can also hinder quality recycling of gypsum board waste by resulting in a deterioration in the quality of materials collected for gypsum recycling (Hogg et al., 2015).

4.4. Economic Instruments

4.4.1 Taxes, fees, and levies

Economic instruments have been the driving force behind efficient waste management in the private sector; thus, they have been utilized as extended policy tools for a long period. Economic tools such as landfill taxes and other levies are often imposed more transparently and are relatively inexpensive to enforce, in comparison with voluntary tools and regulatory tools. The effectiveness of these economic measures has been assured in many cases, where many countries have utilized economic tools as their primary instrument in effectively promoting the recycling of CRD waste. For example, the addition of items that are readily reusable and recyclable to landfill waste is subject to higher monetary charges in

many provinces in Canada and other countries (OECD, 2003, p.10; Sonnevera International, 2006: Calgary, 2013). In the UK, the effectiveness of landfill tax in reducing landfilling of CRD waste has been affirmed with empirical evidence and publicized in the process of repealing the *SWMPs Regulations* by DEFRA (OECD, 2003, p.10; Shiers, et al., 2014).

In utilizing these tools, however, the tax rate needs to be set high enough to effectively function for the promotion of waste reduction and diversion; if it is too low, it may be ineffective in impacting current practices of handling waste. On the other hand, economic instruments such as landfill taxes and levies are often blamed for illegal dumping, which is their main side effect (OECD, 2003, p.10). Besides, they are also blamed for an unexpected negative result: quality recycling is hindered by unwanted materials, which are mixed into collections for recycling purposes to avoid financial charges (Hogg et al., 2015).

4.4.2. Green procurement

In a public area, legislation to encourage the purchase of “green products” is common in many countries. Similarly, the government can create a demand for less-waste-generating buildings through green public procurement (GPP) policies. In this regard, procurement specifications are often used to force contractors to adapt to renovative and sustainable building practices. Contractors are required to use materials with recycled content above certain levels when building facilities of government ownership or of public investment. In this way, the government can demonstrate its commitment towards a recycling society

through GPP, giving a clear signal to the construction industry through its strong purchasing power. In doing so, the government may provide the best examples of models for the industry to follow in private building markets (Sonnevera International, 2006).

Often, achieving certain levels of waste diversion is made compulsory for a bid on a demolition project of a publicly-owned building. For example, the City of Vancouver requires contractors to achieve heightened levels of waste diversion in demolition projects based on the deconstruction specifications developed by the authority; these levels must exceed 75% for city-owned facilities. As such, demonstrating leadership through GPP can be a realistic and effective choice from among limited feasible instruments in the upstream stage for reducing CRD waste destined for final disposal (OECD, 2003, p.98; Vancouver, 2017).

On the other hand, this policy option may result in creating a competitive advantage for large companies. Although small and medium-size enterprises (SMEs) might be regarded as more flexible in responding to certain changes in a market, they are likely to have limited corporate resources to mobilize for compliance with criteria in GPP. Even with existing policies that intend to facilitate the participation of SMEs in GPP, the support may be insufficient or too disconnected to effectively support the capacity enhancement for the SMEs. Under certain circumstances, even when SMEs have access to the competitive market, they may be reluctant to assume the initial large costs associated with compliance. Consequently, despite the heterogeneity of their sizes and strategies, the competitiveness of SMEs is susceptible to the negative impacts of GPP (Aguliar, 2016).

4.4.3 Subsidies and other benefits

Economic instruments are extensive and are usually flexibly applicable. Among them, subsidies are commonly proposed to reduce waste and to promote the use of recycled material, as they affect many elements related to recycling. Various subsidies can be provided in both the upstream and downstream stages; also varying levels of subsidies may be provided, based on the quantity of recycled waste, or with the purchase of a recycling plant, the collection of the targeted CRD waste, and the purchase of recycled products. However, designing an effective subsidy policy in the upstream stage is more difficult, due to the characteristics of buildings and building materials (OECD, 2003, p.98, 115; Chang, Fan, Zhao, & Wu, 2016). High administrative costs and demands on additional tax revenues are some of the common barriers to enforcing a subsidy policy. In addition, satisfying prerequisites, such as the necessity for a labelling system for recycled material, may result in increased complexity and additional costs of the operation of some such systems (OECD, 2003, p.114; Chang, Fan, Zhao, & Wu, 2016).

Further, it is important to establish appropriate subsidy levels in maintaining a balance between the long-term environmental and socio-economic benefits from subsidies. Thus, in determining the level and duration of a subsidy, policy makers should consider various factors, including consumer sensitivity to the environmental impact of the product and the market impact of a subsidy. As well, to enhance the effectiveness of a subsidy policy, interactions among different market factors throughout the product lifecycle and the significance of policy dynamics need to be understood (OECD, 2003, p.114-115; Chang, Fan, Zhao, & Wu, 2016).

On the other hand, premium loans such as additional or differential loans and capital investment for the recycling industry, as well as tax benefits through tax exemptions on rebates on buildings of GBRPs, are available to boost waste diversion. While these tools also require significant revenues, administrative costs may be less due to the limited number of beneficiaries and the necessary duration of subsidy payments until a market develops for recycled materials (OECD, 2003, p.114-115).

4.5 Voluntary and Mandatory Approaches

As gypsum board waste is the most challenging material to be collected for recycling due to its inherent low monetary value, typically there have been economic incentives and legal requirements in areas where its recycling is active. However, the government's involvement and intervention vary in creating conditions for sustainable waste management. Depending on jurisdictions and their regional conditions, the obligation for segregation and waste diversion differs in level, and the outcomes of voluntary approaches for sustainable waste management vary as well. Regardless, although both voluntary and mandatory approaches have merits and demerits, the pros and cons are debatable (Bio by Deloitte, 2016a, 2016b).

Voluntary measures are often utilized to obtain improved public recognition of the company, to expand the market share, and to potentially lower business costs. In other cases,

as a means of avoiding institutional regulations, such measures are chosen by those stakeholders who do not recommend regulatory options and by the government, which tends to avoid confrontational relations with industry. Meanwhile, industry seems to attach little significance to voluntary measures, whereas it usually places the utmost importance on compliance with regulations (McLaren, 1998; Quinn & Sinclair, 2006).

Voluntary approaches often have difficulty in securing objectivity in reviewing the performance of such approaches and in establishing appropriate and realistic goals. They have been a target of criticism for their lack of credibility and transparency, as well as lack of authority demonstrated by their enforcement bodies. In addition, concerns about many voluntary programs have been raised over attracting free-riders, while compulsory measures are assessed to provide a level playing field for all parties involved in the programs supported by regulations (McLaren, 1998; Quinn & Sinclair, 2006).

Despite all these criticisms, some voluntary programs have been evaluated as being successful in reducing and diverting CRD waste directly or indirectly. For example, various GBRPs have been used voluntarily all over the world, with some being widely used for more than a decade (Sonnevera International, 2006; Bio by Deloitte, 2016a). Also, some voluntary initiatives dedicated to gypsum board waste have achieved tangible results in reducing and recycling DRD waste. For instance, the Ashdown Agreement has produced the desired outcome of a significantly increased diversion of gypsum board from new construction for new gypsum board manufacturing in the UK; the diversion rate has increased each year until the target year, from less than 20% in 2008 to 42% in 2015 (PSP, 2015). Major gypsum board

manufacturing companies have played an active role in this agreement for the reduction and recycling of gypsum board waste. For example, direct access to the manufacturer's recycling infrastructure has been allowed to support its contractors' subcontractors, to whom waste management responsibility is increasingly passed on. In addition, a bespoke product calculator has been developed by a large manufacturer to minimize waste in the project design stage (WRAP, 2010). As such, the Ashdown Agreement has resulted in visible success in reducing and recycling gypsum board waste, with the support of regulatory and economic drivers.

In comparison, an MoU signed in 2008 between Alberta Environment and ACA-CHBA has not resulted in the establishment of a solid program for diverting target waste (Jeffrey, 2011; Alberta Environment & Park, personal communication, Apr.17, 2017). As shown by this case, which lacked both legislative guidance and economic traction, business efforts often prove limited when they lack financial incentives or legal requirements. As indicated by the stakeholder consultation of ICI waste diversion for the city of Calgary in 2013, corporate stakeholders have shown their preference for voluntary and economic options over regulatory options.

4.6 EPR Policy

The application of EPR policy to construction materials presents a unique challenge due to their EoL stage expected in the distant future, usually decades after the construction,

implying that that levels of available technology for the treatment of individual waste are largely unpredictable in the future of demolition points (OECD, 2003, p.98). In this situation, to discourage the creation of CRD waste and to pay for the recycling of construction materials, a front-end charge has often been debated for some CRD products. However, a front-end charge itself cannot be a complete solution, whether the fee is integrated or visibly separated from the price of the product; moreover, the visibly separated charge is not considered a program of genuine EPR, as the financial and administrative responsibility is passed on to local authorities and sellers, as well as consumers (Sonnevera International, 2006; Kelleher Environmental et al., 2015, p.99).

A front-end charge is limited in exercising optimum effectiveness for gypsum board waste in Canada. Canada's market for gypsum board products has already matured; also gypsum board waste, for the most part, is released from renovation and demolition rather than from new construction, typically mixed and combined with other types of waste (EuroGypsum, 2008; Hogg et al., 2015). As well, identifying "the producers" and imposing the EPR on them is challenging, considering that the waste from renovation and demolition projects has been created with no clear definition drawn for the "producers", who are held accountable for the management of waste (Moyes, 2010, p.6). Besides, at this point, there exists no appropriate substitute for gypsum board predominantly used and needed in building interiors. Under these circumstances, the government of Alberta has determined that the application of EPR for most construction materials is administratively complex (Kelleher Environmental et al., 2015, p.99).

4.7 Target Management

The establishment of waste reduction and diversion goals has been one of the factors influencing gypsum recycling (PSP, 2015; Jiménez-Rivero & Carciá-Navarro, 2017). Meanwhile, there has been a controversy over defining quantitative targets for waste reduction and diversion due to the poor reliability of waste statistics and discrepancies in key definitions around waste and related terms (BIS, 2011; Bio by Deloitte, 2016b). For example, the EU's 70% diversion goal for CRD waste has been criticized for lacking reliable disaggregated data by the source of waste, thus provoking controversy over the need for an individual approach for specific materials due to the variety of CRD waste (BIS, 2011; Giroux Environmental, 2014).

Nonetheless, waste reduction and diversion targets have been utilized as useful tools often linked to economic and regulatory mechanisms such as government permission or public procurement (Sonnevera International, 2006; Vancouver, 2017). With most CRD projects being subject to a permit process within municipal boundaries, the management of CRD waste is significantly influenced by governments, which have strong purchasing power (Kelleher Environmental et al., 2015, p.99). As such, the government's commitment to waste reduction and diversion, as revealed through the established targets, plays an important role in bringing stakeholders in line with the waste policy by presenting clear direction for the future (Vancouver, 2017).

Chapter 5

TOWARD GYPSUM BOARD RECYCLING IN MANITOBA

5.1 Introduction

This chapter presents the results of the research and analysis of the data collected using the research methods described in Chapter 3. After the most common recycling methods were reviewed with some added details, findings from the previous chapters (Chapter 2 and 4) and the recycling conditions in MB were discussed to reveal the implications for the recycling of gypsum board waste in the area. Chapter 5 also summarizes and analyzes the results of the semi-structured interviews. It shows how the interview results have converged with findings from the literature review and reveals the specific expectations and perspectives of the local stakeholders who participated in the research. Next, as a result of discussions from the literature and document review and the interview results, this chapter suggests a framework for managing gypsum board waste in MB to promote recycling.

5.2 Reprocessing and Recycling

As reviewed in Chapter 2, clean off-cuts and most of the gypsum board in its EoL stage that is separately collected through deconstruction process can be recycled. Along with other main output materials of gypsum board, which are separated typically through mechanical

processes such as stripping and grinding, gypsum core is reprocessed through a common treatment of crushing, grinding, and screening and sieving. Gypsum is currently processed both in large plants and by mobile machines. Various types of commercial equipment of mobility are available in many countries and are utilized in crushing, screening, and grinding to process bulky gypsum core into size-reduced material (UPM, 2013; Kelleher Environmental et al., p.65).

Currently, the largest demand for reprocessed gypsum is for new gypsum board manufacturing, followed by agricultural use as an additive in soil conditioning and composting, and by cement production as a substitute for virgin gypsum (Jeffrey, 2011; U.S. EPA, 2015). Among these applications, 19% and 81% of recycled gypsum have been used for gypsum board manufacturing and for agricultural purposes respectively in the U.S, with the application to cement manufacturing excluded due to conflicting reported data (U.S. EPA, 2015). Likewise, in Canada, both new gypsum board manufacturing and soil amendment have been identified as predominant markets for recycled gypsum (Earle, Ergun, & Gorgolewski, 2014).

5.2.1 Closed-loop recycling

Highly processed gypsum is chemically similar to the raw material in gypsum board production and is cheaper than virgin gypsum in the market. Given these advantages, Gypsum Recycling International (GRI), one of the few worldwide leaders in Europe that are

dedicated to gypsum recycling²⁵, foresees the emergence within the next few decades of a new recycling plant that uses 100% recycled gypsum (Lund-Nielsen, 2010).

Reprocessed gypsum material can replace virgin material with 25% or more of raw gypsum used in gypsum board with no real challenges at recycling facilities. Gypsum board waste that is sorted at source can be processed into gypsum powder of relatively high homogeneity, which is often brought back to gypsum board manufacturers by recyclers (UPM, 2013; Kelleher Environmental et al., 2015, p.64). The price of recycled gypsum is well below that of virgin material in the market; thus there is high chance that the recycled material can be well accommodated in the gypsum manufacturing process. Meanwhile, locating traditional gypsum board plants requires careful balancing between the proximity of the source of raw gypsum material and closeness to the material's end market; the raw material is usually found in a remote area, whereas the end market is generally located in an urban area (Lund-Nielsen, 2010; Burgy, 2013). When the recycled material is usually received from a location near the end market, the benefits of using recycled gypsum include the lower cost of inbound and outbound logistics.

At many locations in Canada, CertainTeed Gypsum has been practicing closed-loop recycling for years, although there are differences in the acceptability of recycled gypsum depending on the levels of investment in the production plants and product characteristics. In MB, the gypsum manufacturing industry is located near the end market, and recent trials have demonstrated that the plant at the Winnipeg location can recycle post-consumer

²⁵ NWGR and GRI

gypsum waste. Even though the routine process of recycling for the purpose of producing new gypsum board has not been reported up to now, the local plant can recycle post-consumer gypsum material, as there are no physical or technical problems that constrain recycling. Rather, due to the shortage of processed post-consumer gypsum, producing gypsum board by CertainTeed Gypsum with 25% or more post-consumer recycled material content has been limited (Sulkiewicz, A., personal communication, Oct. 3, 2018; Anonymous, Jul. 3, 2018). Moreover, the establishment of a recycling plant in MB had already been considered by the private sector years ago, but the amount of post-consumer gypsum expected to be collected at that time was insufficient for the operation of a recycling plant (McCamley, M., personal communication, Dec. 7, 2017 & Oct. 15, 2018). This suggests that the likelihood of closed-loop recycling of gypsum board can be anticipated in the future if the collection system becomes complete in the area.

5.2.2 Open-loop recycling

In the absence or lack of infrastructure available for closed-loop recycling, open-loop recycling of gypsum material serves as a feasible way of improving material resource efficiency. Among the hundreds of open-loop applications, the use of gypsum in agriculture and in ordinary Portland cement (OPC) manufacturing is predominant in North America (Sharpe & Cork, 2006, p.519; U.S. EPA, 2015).

Agricultural use aims chiefly for improved water infiltration of the soil and the addition of calcium and sulfur to the soil. For agricultural purposes, with the facing made

from recycled paper in the most common type of gypsum board products, paper can be mixed in or screened out, depending on the specific purpose of the operation. Despite widely varied specifications for applying reprocessed gypsum to soils, a broader range of size distribution of gypsum particles and chemical composition can be allowed for agricultural and horticultural purposes (BSI, 2013; U.S. EPA, 2015). Accordingly, using mobile grinders, which obtain relatively lower homogeneity in reprocessed gypsum material, is feasible when the use of size-reduced gypsum results in benefits for both the soil and plant species (CDRA, n.d).

Gypsum is commonly added in ordinary Portland cement (OPC) manufacturing to regulate the setting time of the products; the added percentage is typically around 5% or less (Hassan,1988; Chandara, Azizli, Ahmad, & Sakai, 2009). Considering the quality of the recycled gypsum currently available, reprocessed gypsum can technically be used to replace raw gypsum in OPC manufacturing. The substitution rate in the industry can be up to 100%, with a great variation in the degree of substitution. However, the maximum portion that can be utilized to replace mined gypsum has yet to be proved for some products for the ready-mix concrete market (Clamp, 2008).

In MB, the agricultural industry is vital to the province's economy, along with other major industries that include mining and manufacturing. Its robust agricultural industry, in southern and western MB in particular, is expected to accommodate generous amount of reprocessed gypsum. However, routine open-loop recycling for agricultural use in the area is known to be very limited²⁶ (Square, 2015). Also, while there are many companies in the

²⁶ Size-reduced gypsum is used as an additive to compost in Winkler, MB,

ready-mix concrete business, there has been no cement manufacturing industry in the province since 1994 (Manitoba, n.d. c).

5.2.3 Logistics

Transporting gypsum board waste to a recycling facility can be made economically viable in Canada by limiting hauling distance (i.e., less than 400 km) and by utilizing transfer stations to bulk up gypsum board for areas where waste generation is low (Enviros & CIRIA, n.d). Because the excessive transportation of bulky CRD waste increases the negative impacts rather than the expected environmental and economic benefits from material recycling, reprocessed gypsum needs to be made readily available at close proximity to end users (Bio by Deloitte, 2016a; Hogg et al., 2015).

Under these circumstances, in Nova Scotia, reprocessed gypsum of a quality suitable for closed-loop recycling is being used for open-loop recycling. Due to excessive transportation previously experienced beyond the provincial boundary, recycled gypsum is currently used in open-loop applications, such as in animal bedding and for agricultural use (Laroche, Sept. 24, 2015; Chassie, M., personal communication, Oct. 3, 2018).

In new construction projects²⁷ in North America, it is estimated that gypsum board that is wasted during installation is more than 10% (Ndukwe & Yuan, 2016). The debris from large construction projects is commonly traded at the business-to-business level by utilizing

²⁷ The off-cut rate is estimated to be approximately 5% in Europe (<http://www.eurogypsum.org/wp-content/uploads/2015/04/livingwithgypsum.pdf>)

rationalized logistics. For small or medium-sized projects as well, a dedicated collection system can be exploited in the same way. For example, a take-back program based on reverse logistics has been developed by a distribution company²⁸ in the UK. Its scheme of retrieving off-cuts has been made available by strong partnerships among multiple players in the industry. In this system, proprietary pay-bags are used for easy recognition and traceability, and the bagged off-cuts are retained outside each plot of construction to be transferred to the next plot for the purpose of reuse. The filled bags are eventually consolidated at the distribution center and delivered to NWGY for closed-loop recycling (Figure 9).

Figure 9. EJ Berry's take-back process for collecting gypsum board waste

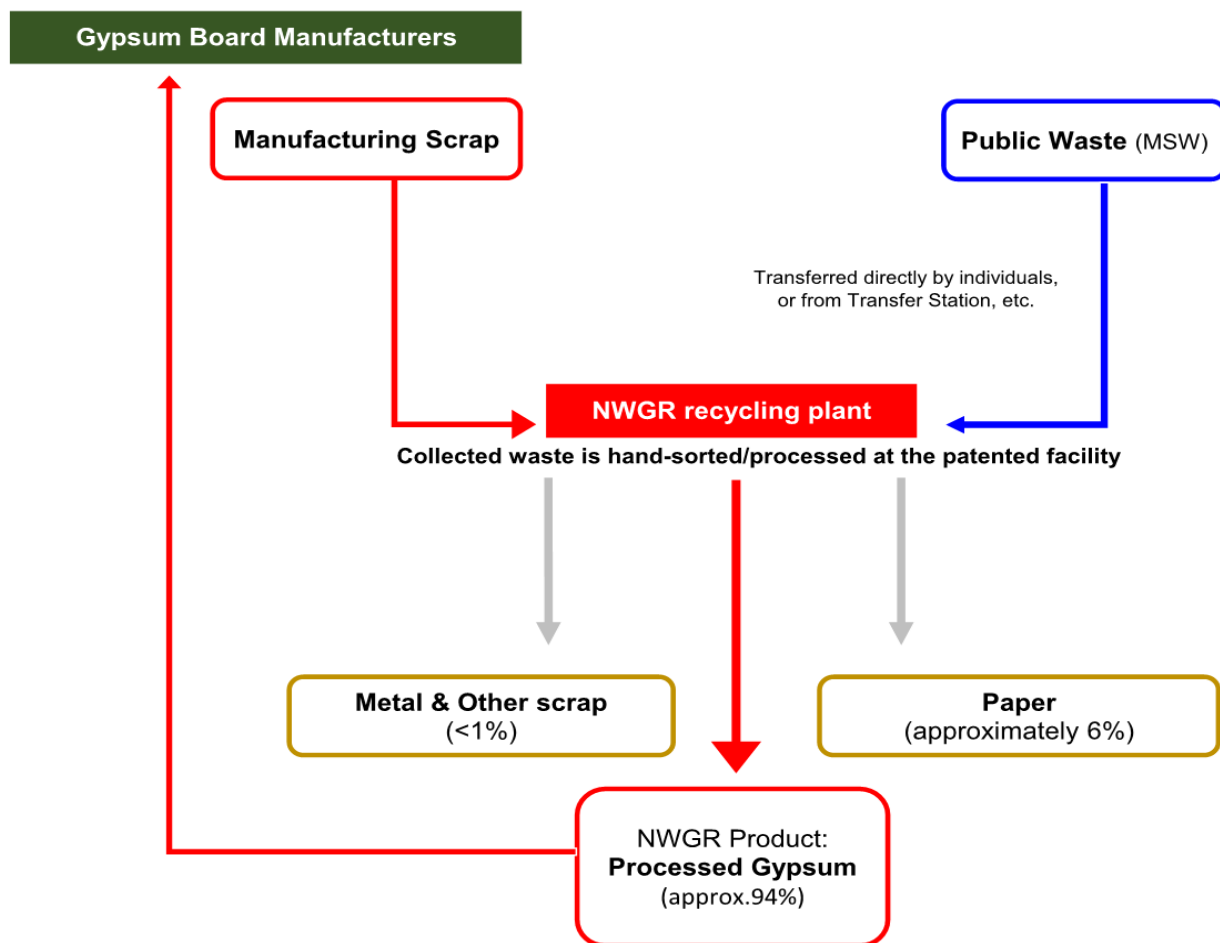


Source: Oakdene Hollins. (2008). © 2008 by the WRAP (a UK registered charity no 1159512). *Plasterboard Case Study: EJ Berry – Plasterboard take-back using reverse logistics.*
<http://www.wrap.org.uk/sites/files/wrap/EJB%20Case%20study%20-%20APPROVALS%20FINAL.pdf>.

²⁸ Ernest J Berry & Son Ltd, based in England and Wales.

To maximize the collection of post-consumer gypsum board waste, NWGR has developed diverse strategies that include utilizing a waste transfer station already established on the grounds of the facilities, building its own stations, and supplying skips on-site for large CRD projects. In addition, as an ideal solution that requires no transport for receiving dry and wet pre-consumer waste from gypsum board manufacturers, NWGR has co-located some facilities, including its plant in Calgary, with gypsum board manufacturing plants (Enviros & CIRIA, n.d; NWGR, 2017).

Figure 10. Collection and recycling of gypsum board waste by NWGR



Source : NWGR. (2017). <http://www.nwgyypsum.com/our-process/>

As post-consumer recycling of gypsum board waste relies heavily on tipping fees for its collection, economics is one of the most significant factors in recycling gypsum board in Canada (NWGR, 2017). Under these circumstances, a certain distribution of the population may provide positive conditions for the collection of gypsum board waste by limiting hauling distance in the region. In MB, densely-populated areas are relatively limited, with the majority of the population concentrated around the City of Winnipeg. Such a concentration of the population suggests improved economic feasibility of recycling gypsum in densely-populated areas.

5.2.4 Quality protocol and harmonization

The government of Canada handed over the authority and responsibilities regarding the environment to the provinces through the Canada-wide Accord on Environmental Harmonization²⁹ in 1998. Regarding this agreement reached by CCME members with no measures of financial provision by the federal government, concerns have been raised over the effectiveness of the Accord; The Accord depends solely upon voluntary compliance by local governments, who are often unable or unwilling to take a strong position on protecting the environment under their jurisdiction. As a result, environmental standards based on the Accord, which include “qualitative or quantitative standards, guidelines, objectives and criteria” are very limited to date. Moreover, regarding CRD waste diversion, there exist

²⁹ The Canada-wide Accord on Environmental Harmonization about environmental inspections, enforcement, standards and assessment was signed by the federal Minister of the Environment and other CCME members except Quebec and came into effect on Jan 29,1998.

neither required standards nor a harmonized approach across Canada (McLaren, 1998; ECCC, 2017b). Likewise, Manitoba has no criteria controlling the quality of reprocessed gypsum and no compulsory measures regarding the deconstruction of buildings.

Canada has a guideline for “design for disassembly and adaptability in buildings” (CSA Z782-06) that provides a framework for enhancing the sustainability of all types of buildings. Having been developed by the Canadian Standard Association in 2006, it seeks to prolong the life of a building as well as to promote the reduction of CRD waste generation and energy consumption. However, this guideline depends on the voluntary compliance of architects, planners, and buildings owners (CCOHS, 2018).

5.3 Recycling Conditions in Manitoba

Manitoba is the world’s second most attractive area for mining investment, based on related public policy such as taxation and regulations, as well as on mining potential. Economic support by the province for the mining industry includes progressive profit-based taxation, tax credits, and other financial assistance such as the Mineral Exploration Assistance Program (MEAP). Also, the mining of gypsum, along with certain resources such as oil and gas, is exempt from the Mining Tax in MB. Virgin gypsum is being mined in large open quarries in MB at two locations in close proximity: one by CertainTeed Gypsum Canada

Inc., a leading operator of gypsum mining in Canada³⁰; and one by Lehigh Inland Cement Ltd. (Manitoba, n.d.- a & b).

However, Manitoba has no recycling facility for gypsum board, and the waste is accepted for landfill disposal at a relatively low cost ³¹ (Winnipeg, 2018). Landfills are classified according to three criteria: disposal capacity, the source of received waste, and operating entity. This classification is unlike the one used in the UK and Alberta, which categorizes landfills according to waste types and characteristics, with a focus on managing specific materials at engineered disposal sites (EA, 2010; Alberta, 2017).

As such, an available landfill option with easy access in the area has proven to be an obstacle to sustainable waste management. As well, disrupted gypsum board recycling for MB has been attributed to the lack of available recycling facilities. Limited access to recycling facilities, which are located mostly on the West Coast, has been identified as one of the significant barriers to gypsum board recycling in Canada (Earle, Ergun, & Gorgolewski, 2014).

On the other hand, Manitoba has a gypsum board manufacturing plant operated by the only gypsum board manufacturer in Canada. CertainTeed Gypsum operates six manufacturing plants across Canada³², and recycled gypsum material can be used at all these locations. Although there are differences in levels of acceptance for recycled gypsum at each

³⁰ CertainTeed Gypsum Canada is extracting gypsum from two mines in Invermere (BC) and Amaranth (MB)

³¹ Flat disposal fees: 65 and 78 CAD per metric ton, for residential and commercial disposal respectively, effective January 2019 (<http://winnipeg.ca/waterandwaste/billing/fees.stm#garbagedisposal>)

³² Delta (BC), Calgary (AB), Winnipeg (MB), Mississauga, Oakville (ON), Ville Ste-Catherine (QC), and McAdam (NB)

facility and in the recycled material content in its hundreds of gypsum products, CertainTeed Gypsum has the capability to have 33% recycled material content in its products. However, the current availability of reprocessed gypsum falls short of acceptability levels. In MB, the plant uses no post-consumer gypsum material in manufacturing new gypsum board (A. Sulkiewicz, personal communication, Oct. 3, 2018; EcoScorecard, 2018).

CertainTeed Gypsum's domestic supply of gypsum board product by has been limited, satisfying only 40 to 60% of the needs in Western Canada. In recent years, because of the high rates of anti-dumping tariffs (125~276%) against US products imported into Canada, market prices for gypsum board products have surged in the area (Meissner, Sept. 14, 2016). Then again, in Canada, increasing prices and the accompanying instability in the industry may have the potential to further promote gypsum board recycling, thus providing a favorable environment for its recycling.

To summarize, Manitoba has both positive and negative regional conditions. These conditions for gypsum board recycling are outlined below (Table 5).

Table 5. Regional conditions for gypsum board recycling in MB

Positive	Negative
<ul style="list-style-type: none"> • Acceptability of gypsum board waste for closed-loop recycling at the existing gypsum board manufacturing plant • Proximity of a gypsum board manufacturer to areas where the generation rate for gypsum board waste is high • Existing industries where the operation of predominant open-loop recycling is applicable: agricultural/horticultural business 	<ul style="list-style-type: none"> • Availability of abundant gypsum material mined by a leading company in the gypsum industry • Relative closeness of a gypsum board manufacturing plant to the gypsum mine • Favorable political conditions for the gypsum mining industry • No recycling plant dedicated to gypsum board waste; easy access to low-cost disposal facilities • No significant mechanism in place that targets the diversion of gypsum board waste; insufficient government support through policies for CRD material diversion

5.4 Interviews with stakeholders

The semi-structured interviews, as described in Chapter 3, invited seven people in managerial positions to participate in this study; two participants were government employees, and five were from various sub-sectors of the construction industry (Table 6). The results of the interviews, which were categorized according to major themes, are summarized as follows (Table 7-13, see footnote #33).³³

Table 6. Backgrounds of interviewees

Total N=7	Government		Industry	
	2		5	
Sub-sector	Provincial	1	Homebuilder	1
			Industry association	1
	Municipal	1	Construction material distributor	1
			Drywall contractor (large, medium)	2

Key motivation for gypsum board recycling

Most participants mentioned financial (dis)incentives as one of the key motivations for promoting gypsum board recycling. In particular, a respondent noted that the financial incentives are necessary, at least initially, if GBRPs are not tied to the CRD project. A different participant advocated extremely high financial disincentives, while another chose a disposal ban for regulating the waste (Table 7).

³³ The numbers marked in parentheses in Table 7-13 correspond to the number of responses from government participants (P1 and P2).

Table 7. Key motivations for gypsum board recycling

(Participants N=7, Unit: number of response)

Financial		GBRPs	Regulation	Education	Others
Incentives	disincentives				
4 (1)	3 (2)	1	2	0	0

Primary challenges of gypsum board recycling

Transportation was identified as the main barrier of recycling, followed by waste segregation and lack of recycling capacity in MB. The lack of a recycling market was also cited as an obstacle to gypsum board recycling while one participant expected no barriers as the government's will to support recycling is anticipated (Table 8).

Table 8. Main barriers to gypsum board recycling

(Participants N=7, Unit: number of response)

Transportation	Segregation	Recycling facility	Recycling market	No barriers
3 (2)	2 (1)	2	1	1

Effective financial tools for promoting gypsum board recycling

Most participants chose capital investment in recycling facilities and financial disadvantages given to mixed waste. In addition, a broad range of financial incentives that cover the total cost of recycling was expected to be effective as well. However, one participant considered that financial incentives could be less effective for the commercial sector (Table 9).

Table 9. Effective financial tools for promoting gypsum board recycling

(Participants N=7, Unit: number of response)

Capital investment	Higher charge on mixed waste	Subsidy	Grant	Comprehensive benefit	No answer
3 (1)	3 (1)	1	1 (1)	1	1

Scope of regulating recycling

Most participants chose exemptions from mandatory recycling for small-scale renovation or demolition. One considered that recycling should not be mandatory for any CRD projects, as it creates an unlevel playing field among competitors when there is insufficient enforcement of regulations (Table 10).

Table 10. Targets of exemption from recycling gypsum board

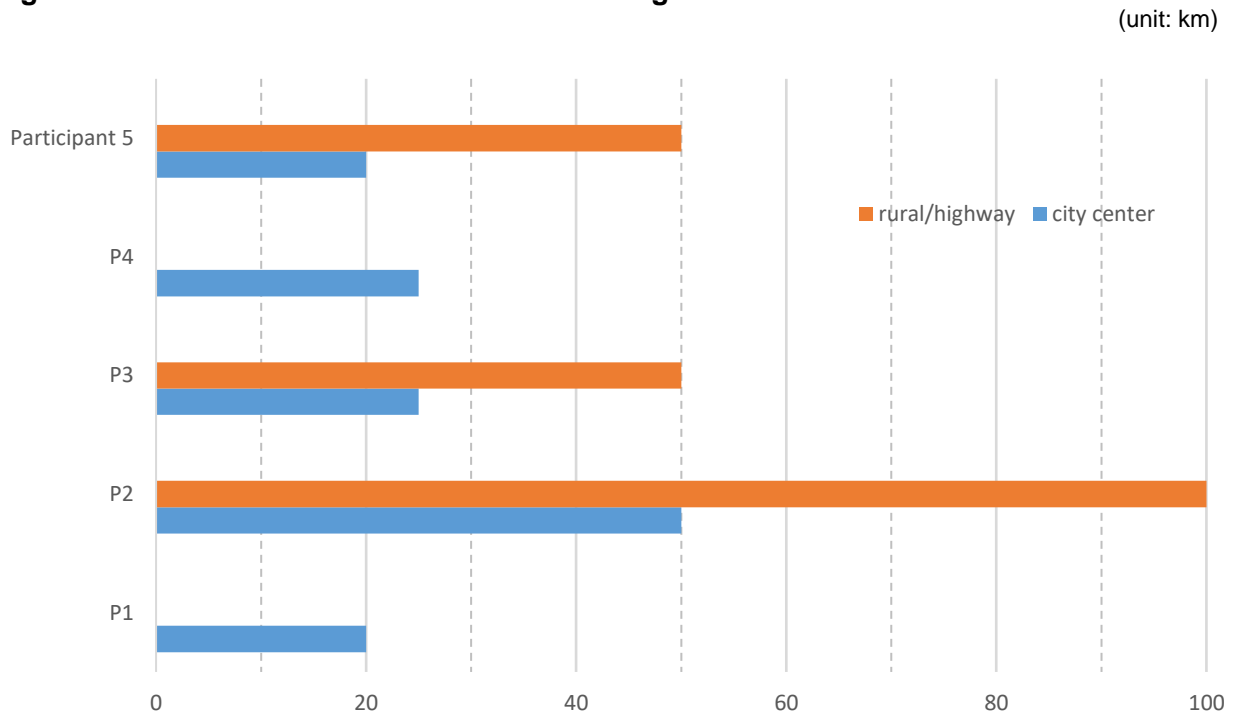
(Participants N=7, Unit: number of response)

No exemption allowed	Exemptions are necessary			No answer
	residential demolition	small-size home renovation	unspecified	
2 (1)	1	3	1	1

Accessibility to a recycling facility

Five out of seven participants provided numerical answers regarding maximum distances of waste hauling (Figure 11). The other two did not suggest a specific range of distance, due to factors such as economics and recycling regulations, which determine the physical distance considered feasible.

Figure 11. Maximum distances for waste hauling



Introduction of financial incentives

Regarding the introduction of financial incentives that aim to promote recycling, most of the interviewees preferred incremental incentives. With short-term increments preferred in three responses, annual increments that reflect yearly inflation rates were most highly regarded (Table 11).

Table 11. Introduction of financial incentives

(participants N=7)

Large from the beginning	Incremental		
	annually	every 2-3 years	not specified
2 (1)	2 (1)	1	2

Introduction of financial disincentives

Interviewees were divided on the issue of introducing financial disincentives. In one response, yearly increments were considered transparent and least-resisted, allowing some time for companies to bear the cost for recycling. However, in another opinion, large-scale disincentives were supported, as they can be effectively directed towards recycling facilities (Table 12).

Table 12. Introduction of financial disincentives

(participants N=7)

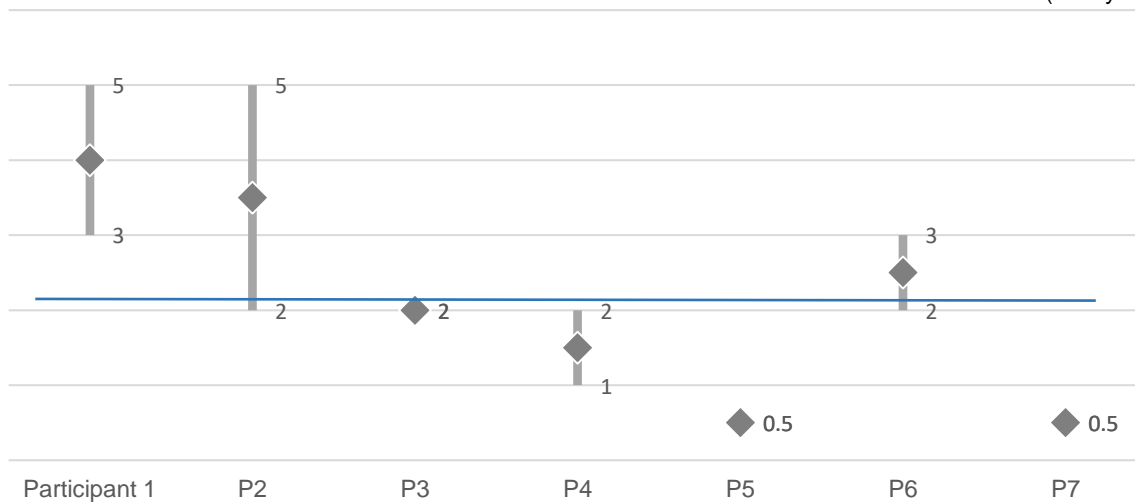
Large from the beginning	Incremental	No answer
3 (1)	3 (1)	1

Notice periods of introducing disposal restrictions or bans

Concerning a reasonable period of notice before introducing a disposal restriction or ban, the interviewees' answers varied, ranging from a half year up to five years. The average was approximately two years (Figure 12).

Figure 12. Notice Periods before disposal restrictions or bans

(unit: year)



Gaps to be minimized between government and industry

Five participants suggested that financial gaps need to be minimized to successfully manage gypsum board waste in MB. According to some respondents, such gaps were attributed to a discrepancy in analysis around recycling costs versus benefits, as well as to different ways of seeking financing to establish a recycling facility. In addition, the communication gap between the two groups was identified as one of the gaps to be bridged. However, it was thought that a general communication gap could be minimized by having industry actively engaged early on with the establishment of an overall recycling system (Table 13).

Table 13. Gaps to be minimized between industry and government

(participants N=7)

Communication gap	Financial gap	Gap around building a recycling infrastructure	No identifiable gap
1 (1)	4 (1)	1	1

Industry stewardship

Five participants gave positive responses regarding the necessity of industry stewardship for managing gypsum board waste, while the other two did not respond. However, there was a concern that, in a stewardship model, a significant quantity of imported gypsum board product, mostly from the US and other Canadian provinces, would result in some difficulties for local industry in managing the waste.

5.5 Advancing toward Sustainability

The recycling conditions and the interview results were discussed in this chapter, while considering multi-faceted policy options discussed in Chapter 4. As a result, a draft framework for recycling gypsum board in MB has been developed in reference to the points reviewed and discussed in these two chapters. The framework is presented as follows.

5.5.1 Developing a framework for gypsum board recycling in MB

A framework that includes the following components is suggested for sustainable management of gypsum board waste in MB.

A system for efficient waste collection and handling

- Travelling distances for transporting gypsum board waste are minimized; the number of transfers of the waste is limited.
- The existing 4R Depot facilities and public transfer stations are initially utilized for the collection and temporary storage of the waste; along with the institutional advancement of the EPR approach, additional recycling sites are secured by the manufacturers and distributors.
- The annual maximum amount of accepted residential gypsum board waste at public facilities is limited; commercial enterprises handle the waste exceeding the limit and the ICI waste.

The Recycling Council of MB

- Recycling Council of MB is formed to manage and supervise CRD waste recycling.

A differential fee system

- Differential fees are introduced as soon as possible and expanded. The different fees are applied depending on the types of waste: clean sorted to mixed load.
- The rates are guaranteed to be set high enough to cover the cost of waste diversion; they are reviewed periodically by the board of the Recycling Council of MB to determine whether any recommendations are needed regarding the fee level.

A recycling infrastructure

- Revenues from collected tipping fees are invested in expanding the gypsum recycling infrastructure, which includes recycling plants, processing equipment, and collection sites and transfer stations.
- Closed-loop recycling is encouraged for the WCR; reprocessed gypsum is used in open-loop recycling in sparsely-populated areas in northern MB whenever feasible, considering the hauling distances to a recycling infrastructure in the area.

Regulations for the sustainable management of gypsum board

- Provincial regulations are formulated to define targets regarding waste reduction and recycling, and to provide detailed guidelines for supporting the recycling industry.
- At least for the early years of implementing regulations, an enforcement body is created to prevent and crack down on the illegal dumping of gypsum board waste.
- A rigorous system of tracking gypsum board waste is developed to provide information on waste management and to discourage unlawful waste management.

A cooperative system engaging different levels of institutions

- CCME members work together to establish harmonized quality requirements for reprocessed gypsum material and a green-labelling system for recycled gypsum products.
- Provincial and municipal governments work together to promote gypsum board recycling and to support the recycling industry.
- Governments and institutions cooperate to support training programs that focus on reducing waste generation in the stages of both designing buildings and installing gypsum board products.

A communication channel between the government and the industry

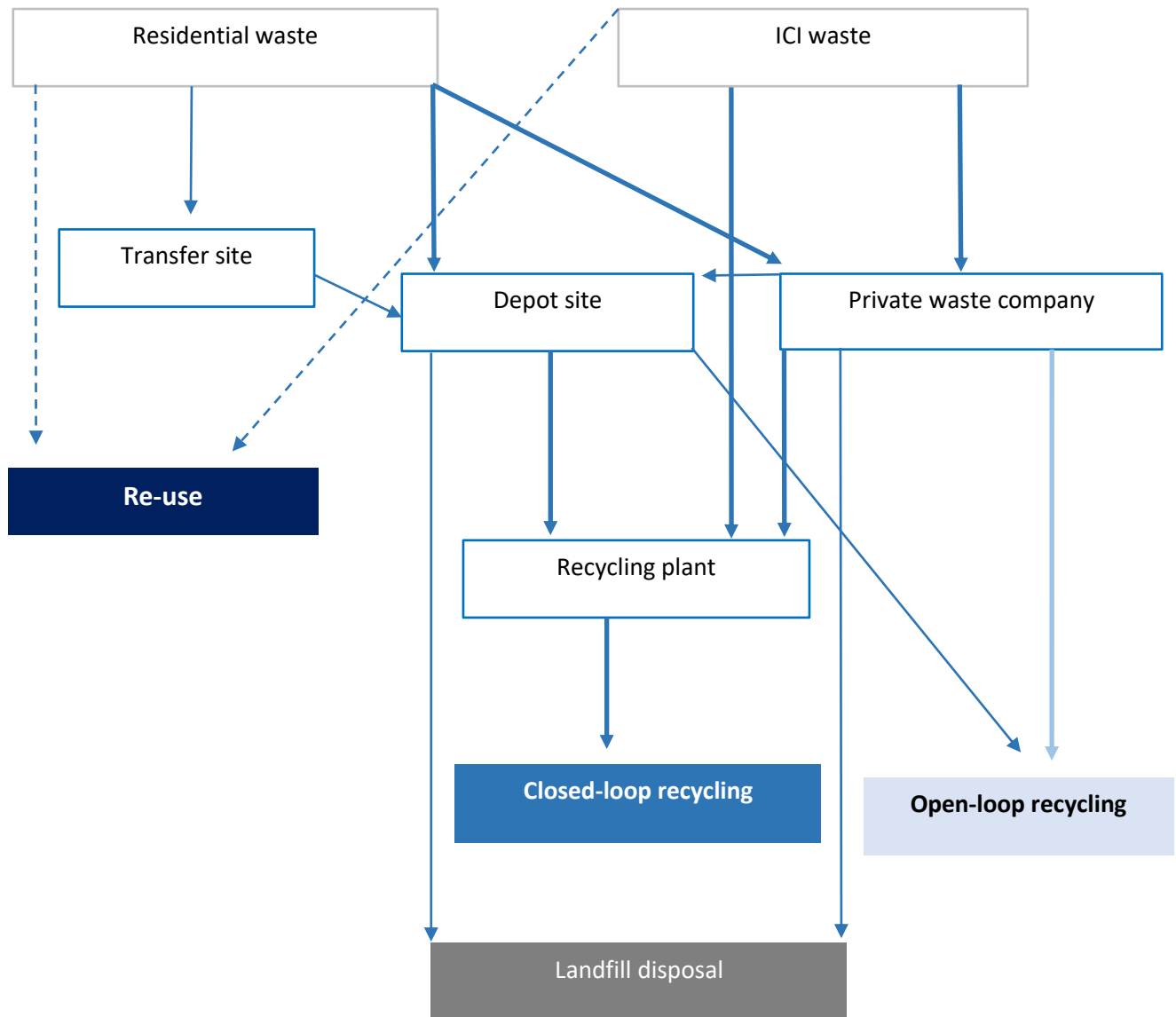
- The provincial government supports forming consultative and associational bodies that represent all sub-sectors of the gypsum industry, including contractors; the government works more efficiently through the integrated channel of communication; pilot projects may be conducted through such bodies.

Industry stewardship

- The development of an industry stewardship model is encouraged, with opportunities provided for benchmarking the best practices in Canada and abroad.

Once this framework has been established, the schematic flow of gypsum board waste in MB will proceed as envisioned in Figure 13.

Figure 13. Envisioned flow of gypsum board waste in MB



5.5.2 The roles of key players in implementing the framework

Government

[Federal]

- Provide financial and technical support for research on the reduction and recycling of gypsum board waste.
- Set harmonized standards for quality control of reprocessed gypsum and introduce a green-labelling system for recycled gypsum products, in consultation with provincial governments.
- Provide a guide³⁴ for a waste classification system that is simplified but similar to the hazardous waste classification system; compile and manage statistics on CRD wastes based on consistent and unified classification criteria, such as composition and physio-chemical characteristics.

[provincial]

- Establish the Recycling Council of MB and a governmental body that enforces the regulations to create a level playing field.
- Set reduction and recycling targets for CRD waste and major CRD items, including gypsum board.
- Build a system for tracking the handling of gypsum board waste in MB.
- Establish an electronic data system that can produce reliable statistics that provide readily available data for managing major CRD waste items.

³⁴ EoL hazardous materials (<https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/permit-hazardous-wastes-recyclables/classify.html>)

- Provide funding for education and training in reducing and recycling gypsum board waste.
- Collaborate with related industry associations and the Association of Manitoba Municipalities to develop a workable industry stewardship model.

[Municipal]

- Set appropriately high levels of differential tipping fees and collect the fees.
- Prepare a by-law to manage CRD wastes effectively and sustainably.
- Work with the provincial government, if necessary, to secure space for waste collection and transfer at highly accessible locations.

Industry

- Actively participate in programs based on government-industry, pan-industry, and industry-academic partnerships for sustainable waste management.
- Work with the government to develop a product stewardship model.
- Provide funding for training, research, and pilot projects in the field of gypsum waste reduction and recycling.

Consumers

- Participate in utilizing GBRPs when ordering construction and renovation projects.
- Actively engage with project managers and contractors to ensure that CRD projects are managed to minimize negative environmental impacts.

5.5.3 Steps for implementation

All parties continue to collaborate and encourage each other in implementing the framework. The following steps are suggested to be taken in order, with on-going efforts to provide financial and technical support in training and research on waste reduction and recycling being made throughout the steps and in the future.

1. Recycling facilities and effective collection systems are established to manage gypsum board waste.
2. The Recycling Council of MB and a governmental enforcement body are established.
3. A system for regulating and tracking gypsum board waste is established.
4. Financial (dis)incentives, including differential tipping fees, are implemented; an industry stewardship model is developed
5. Appropriately challenging target levels are set for the reduction and recycling of CRD waste and gypsum board waste.
6. Levels of minimum quality for reprocessed gypsum are defined; a green-labelling system is established for gypsum board products made from recycled gypsum.

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

6.1 Summary of the Research

As Manitoba has a relatively low diversion rate for CRD waste, of which gypsum board waste comprises a large portion, this study explored potentially available options for MB in promoting the recycling of gypsum board. While many factors affect and contribute to local recycling performances for gypsum board waste, this research focused on economic and regulatory instruments and some voluntary efforts by the industry.

The purpose of this research was to explore opportunities for promoting the recycling of gypsum board generated from CRD sites and to identify applicable policy tools that can contribute to ensuring the sustainable management of gypsum board waste for MB. The objectives of the research were as follows:

- 1) to define critical issues in a current CRD waste management system that impede the recycling of gypsum board in MB;
- 2) to examine the current methods and policy tools in other jurisdictions for the best methods of managing gypsum board waste;
- 3) to establish approaches to the recycling of gypsum board that could be viable in MB; and
- 4) to recommend tools to implement diversion approaches that support recycling gypsum board from CRD sites in MB.

The research adopted a qualitative approach for research design. Research methods for data collection were literature and document review and semi-structured interviews. The interviews were conducted with seven key stakeholders from both government and industry in MB, with the interview transcripts and the summaries used for content analysis. Through literature and document review about other jurisdictions, the cases that provided implications and suggestions for effective waste management strategies were identified. The findings resulting both from literature and document review and from semi-structured interviews were presented in Chapters 4 and 5, in discussions of MB's recycling conditions. Stakeholders' perspectives and expectations were included in Chapter 5. In these two chapters, the issues involved in creating strategies for promoting recycling were summarized in four main points: 1) where the market for recycled gypsum material would be 2) what regional recycling conditions are like, 3) what challenges and barriers to the recycling of gypsum board are expected for Manitoba, and 4) how such obstacles and negative impacts can be minimized. Finally, conclusions based on the research findings and recommendations in this study are presented as follows.

6.2 Conclusions

Together, regulatory measures and financial tools have been identified as the most effective policy instruments in promoting the recycling of gypsum board waste from CRD sites in MB. These are the tools consistently recognized to be useful in other jurisdictions, based on the literature and document review for this research. Financial disincentives are considered particularly useful for regulating waste disposal. According to the results of the

interviews with various stakeholders in MB, both regulations and financial support are expected to be effective for promoting gypsum board recycling in the province.

The absence of a recycling facility for the closed-loop recycling of gypsum waste was recognized as an issue of immediate concern by the majority of the participants in this study. They anticipated that the establishment of such a recycling plant would require public investment. Additionally, transportation was one of the main challenges identified by the interviewees, as well as the literature describing cases within other jurisdictions. There was no indication of concerns about possible technical obstacles, nor about the limitations associated with reprocessing segregated gypsum board for recycling. As a result, even though the projection of the acceptability of reprocessed gypsum is unavailable at this point, well-coordinated industry efforts combined with governmental policy instruments, mainly financial and regulatory tools, will likely facilitate the expansion of gypsum board recycling in MB.

6.2.1 Gypsum board recycling in Manitoba

This study explored the potential for reprocessing gypsum board into new gypsum products, as well as for establishing gypsum recycling systems with policy and financial support under varying regional conditions. With well-established recycling facilities and carefully planned transportation systems, the main difficulty associated with recycling gypsum board waste could be overcome. Meanwhile, until the recycling market expands in the region, policy progress and financial support by the government and industry are expected to play a key role in the success of gypsum board recycling in MB.

However, as observed in the WCR in recent years, success in the recycling market is difficult to achieve solely through the efforts of private businesses. As such, government initiatives and support are essential for reducing the challenges involved for gypsum board recycling in MB.

6.2.2 Challenges and opportunities

Due to the mature market for gypsum products, securing financing for the management of gypsum board waste is challenging for MB. Given a large amount of gypsum board waste, the relatively small gypsum production capacity in the Winnipeg Capital Region (WCR) is expected to limit closed-loop recycling in the province. However, the proximity of MB's most populated areas to the gypsum board manufacturing industry is expected to provide the recycling industry with increased financial benefits from recycling gypsum waste. While efforts are put forward to maximize closed-loop recycling in the WCR, concurrently, open-loop recycling in the agricultural sector is expected to expand gypsum recycling by reducing both economically and environmentally costly transportation of post-consumer gypsum board.

Unlike closed-loop recycling, which requires investment for specialized large-scale infrastructure, the agricultural use of reprocessed gypsum is possible with relatively small capital investments in mobile equipment. Open-loop recycling generally allows a broader range of size distribution of gypsum particles and chemical composition, sometimes without necessitating removing paper facing. Therefore, for open-loop recycling, utilizing social enterprises in such a labor-intensive recycling process is worth considering. As well, further exploration of a broader range of feasible applications of reprocessed gypsum board may contribute to reducing the loss of material during the recycling process.

6.3 Recommendations for Managing Gypsum Board Waste in Manitoba

Policy recommendations in relation to objective 4 have been made as follows.

First, targeted gypsum board waste should be expanded in stages. Strategies for promoting recycling should first focus on clean off-cuts of gypsum board generated from new construction and later for renovation and demolition waste. Publicly funded quantitative research is suggested as a pilot project to estimate target volumes before expanding the application. When the strategies are implemented, the following points should be duly considered.

- A balance of regulatory and economic policy instruments should be used without negatively impacting fiscal policies; tools that involve a heavy administrative burden on the government can be utilized as part of voluntary efforts by the private sector (see Chapter 4.3.2, 4.3.4, and 4.4.3).
- Economic instruments should be carefully designed, considering their mid- to long-term ripple effects; when determining levels of support and the degree of disadvantage, close attention should be paid to their scale, potential beneficiaries, specific targets, and expected duration. Gradual steps may be taken to reduce any unintended negative consequences associated with the introduction of such instruments. Future research is necessary for designing individual economic tools and improving the efficiency of operating such systems (see Chapter 5.4; see also Chapter 4.4.3)
- Differential tipping fees should be introduced in 2020 or as early as possible, with a brief annual or biennial review of the rates to ensure that they are high enough to effectively promote gypsum recycling. A thorough review of the rates may be conducted every five to ten years. The maximum amount accepted at the public collection and transfer sites should be limited to one ton per household (see Chapter 2.6.1, 4.4.1, and 5.4 “*introduction of financial disincentives*”).
- Government funds that are secured through collecting financial disincentives or punitive fees should first be used for projects such as expanding recycling facilities and

collection sites, while existing landfill sites and transfer stations³⁵ should be used to collect post-consumer gypsum board.

- Upon or before the establishment of gypsum recycling infrastructures, public funding of the installation and maintenance of facilities that accept gypsum board for landfill disposal should be minimized and eventually eliminated (see Chapter 5.4 *“Effective financial tools for promoting recycling”*; also see Chapter 2.3).
- Financial disincentives should be implemented incrementally to reduce public resistance. The disincentives should gradually increase to the point at which the landfilling of gypsum board waste becomes economically prohibitive. After this point, landfill restrictions and bans should be examined as a potential mid- to long-term task, depending on regional recycling conditions (see Chapter 2.3 and 2.6.2; see Chapter 5.4 *“Introduction of financial disincentives,”* and also *“Accessibility to a recycling facility”*).
- The immediate introduction of strict EPR and front-end charges on gypsum board products is challenging, due to the unique challenges presented for construction materials and the industry’s limited capacity for waste management. Instead, industry stewardship should be employed in collecting and handling waste. Further research and consultation should be conducted in cooperation with the government and industry in order to build an optimal stewardship model. The application of such a model as a pilot project may be useful (see Chapter 4.6 and 5.4 *“Industry stewardship”*)

Second, active intervention and proactive measures by the government are recommended, taking the following points into consideration.

- Barriers that prevent SMEs from entering competitive GPP markets should be either minimized or removed. The conditions for participating in public bids, such as a requirement regarding forming a consortium that includes SMEs, should be stipulated when necessary (see Chapter 4.4.2).
- Established voluntary schemes (e.g., GBRPs or similar programs with enhanced waste management standards of waste reduction and recycling) should be flexibly utilized in

³⁵ 183 landfill sites and 80 transfer stations in MB (9 landfills in 6 municipalities and 11 transfer stations in 7 municipalities within the WCR) (Green Manitoba, personal communication, Oct.18, 2016)

public bids (see Chapter 2.3.2, 4.4.3, and Chapter 5.4 “Key motivations for gypsum board recycling”).

- Strategies for efficient waste handling and for maximizing the return on investments in the waste management infrastructure should be developed in the mid- to long- term; the provincial government may consider establishing waste management regions beyond municipal boundaries in order to promote cost-efficient environmental protection by eliminating an overlap (see Chapter 2.6.3 and 5.4 “Primary challenges of recycling”)

- By preparing a sample by-law regarding sustainable waste management, the provincial government could facilitate the development of harmonized municipal by-laws that are complete with essential elements.

6.4 Limitations of the Study

As this paper has limitations in the scope of its research, future research in potential study areas is suggested.

- 1) Discussions on corporate social responsibility (CSR) are diverse; moreover, the concepts around CSR and its scope vary widely. Therefore, discussions on CSR, whether voluntary or not, were excluded from this study.
- 2) The number of interviewees from industry was limited, due to their unresponsiveness when approached for interviews. Due to the limited scope and scale of this study, opinions from the social sector were not captured.

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Appendix A. Interview Questions - for both Government and Industry

1. What do you think is the key motivation behind gypsum board recycling? What should we attach importance to when promoting recycling?

- ① financial incentives or disincentives ② green-building recognition programs ③ education programs for stakeholders such as project managers ④ strict regulations regarding waste disposal ⑤ others: _____

2. What primary challenges do you expect in regulating the recycling of gypsum board in Manitoba?

3. If financial incentives or disincentives are provided, what kind of financial tools would be efficient? ① (dis)incentives based on recycling performance ② higher flat-tipping charges on mixed waste ③ subsidies for or public investment in recycling facilities

4. If gypsum board recycling is mandatory, do you think ① all CRD projects should be subject to mandatory recycling or ② certain projects should be exempt from mandatory recycling, based on the project scale?

5. What is your position regarding a reasonable distance to a recycling facility? (e.g. how many km?)

6. If financial measures were to be taken, what would you say?

6-1. Should disincentives be ① incremental to allow the industry some time to acclimatize, or ② high enough to give the industry a clear signal?

6-2. What about incentives? Should they be ① incremental, or ② large from the beginning?

7. If a disposal restriction or ban were to be introduced, how many years would be required (how many years would you need to prepare your business) prior to its enforcement?

8. What do you think is the largest gap that needs to be bridged between industry and government to successfully manage the gypsum board waste from CRD sites?

9. [government] Certain policy tools are implemented at different levels (e.g., tipping fees). Could you suggest effective ways for the provincial and municipal governments to cooperate in promoting recycling?

[industry] Can you think of a model of industry stewardship for gypsum board that you may work for Manitoba? Would you explain it?

10. Do you have any further comment?