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Research paper

Public-private partnership in recycling: an evaluation of its climate change impact reduction benefits

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Abstract

One of the global environmental concern today is the potential climate change of our economic activities. Appropriately addressing the concern require the collective effort of all the stakeholders. This study analyzed a case of public-private collaboration that facilitates paint recycling in Alberta and the attendant climate change impact reduction benefits. The study approach involved literature search, conversation with partners, and lifecycle analysis of data collected from a corporate organization involved in the partnership. Results from the study showed that the paint recycling partnership provides a net monthly environmental benefit of reducing the potential climate change impact by 8,841.11 kg CO2-eq. It also resulted in the diversion of about 25% of paint containers and plastics from the landfills. The public private partnership in recycling provided synergetic economic and environmental benefits for the participating municipalities and the corporate organization involved in the project.

Keywords: *Environment; Paint; Public-Private Partnership; Recycling; Sustainability.*

1. Introduction

The quest for the sustainability of our industrial activities has led to several efforts being made to promote circular economy in which efforts are made to close the material cycle. The aim is to maximize resource utilization, minimize wastage and to avoid consequent environmental pollution that could have deleterious impact on human health and ecosystem wellbeing. One of the goals for attempting to close the resource cycle is to divert resources from the landfill by either reusing the component parts in varying degrees or by reusing the material of the retired product for the same or different purpose. However, recycling the material of a retired product presents both opportunities and challenges. The processes involved have economic, social and environmental implications. Several approaches have been developed by governments either by regulations or by inaction that leaves the situation for economic play out. Studies showed that the success of an approach or mixture of approaches used in a geographical location varies, and it is dependent on several factors. One of the approaches to recycling that have found common use in various places all over the world is “public-private partnerships” approach [Dunmade, 2001, 2013a and 2013b].

1.1. Public-private partnership in recycling

According to Hodge and Greve (2007), “public-private partnerships (PPPs) refer to cooperative institutional arrangements between public and private sector actors.” Governments all over the world are increasingly turning to public-private partnerships (PPPs) for infrastructure development and public service delivery. PPPs can be found in many fields and in various forms. PPPs are commonly used in fields such as transport, technology, water, prisons, health, and urban regeneration. One of the several reasons for public-private partnership is because it offers a speedy approach to delivering cost-effective public services. It also reduces lifecycle cost and foster greater innovation [Cullina, 2010]. Furthermore, it frees government from extra burden of day to day operations of some facilities that private organizations can run efficiently. Delegating such responsibilities to private businesses help keep the government small for effective governance. In general, it is a win-win approach [Dunmade, 2010, 2014, 2016 and 2017b; Honge and Greve, 2007]. There are various forms and models of public-private partnerships. According to Cullina (2010), these public-private partnership models are:

- Design-Build.
- Operation and maintenance.
- Design-build-operate-maintain.
- Design-build-finance-operate-maintain.
- Design-build-finance-operate-maintain- transfer.

However, there are other types of public-private partnership arrangements such as the case of Alberta public-private partnership in recycling. Generally, public-private partnership in recycling involves an arrangement in which government (agency) provides some logistics and play regulatory role while private business organization(s) provide other aspects of the public service. It is an arrangement that seeks to facilitate maximum recycling of a particular product or material. The approach is often used where/when the market economic instrument is not sufficient to drive the private sector’s interest in recycling the product in question. The approach is also used when the required logistic to facilitate the collection of such product from the municipalities are challenging or practically impossible for the private sector to implement. Government then facilitates the recycling of such products by providing regulatory instrument and/or infrastructure/logistics that would enhance the product take-back. The private sector then takes up the rest steps involved in seeing the recycling to a logical end. This study examined an example of public private sector collaboration in recycling and benefits of such partnership on the potential climate change impact reduction [Dunmade, 2010, 2014, 2016 and 2017a]. The research involved a case study on the collaboration between a municipal government in Alberta and a private company on paint recycling. The scenario of the case study is described in the next section. This is followed by the research method. The results and discussion is then presented. Conclusions drawn from the study is explained in the last section.

1.2. Alberta paint recycling process

Paints have great potential for reuse, recycling and recovery. Public-private partnership in paint recycling enhances handling and recycling of leftover paints in an environmentally safe manner, thereby reducing their impact on the environment. The Alberta public private partnership in paint recycling involves the collaboration of the municipal governments with paint processors and Alberta recycling management authority. The Alberta paint recycling program is funded through environmental fees charged on the sale of new paint in Alberta. The fees are put into a dedicated fund that can only be used to manage the paint recycling program. Paint recyclers are paid from the fund to recycle the old paints. Any processor that receives paint must be registered with the Paint Recycling Program and meet all applicable environmental, transportation, health & safety, and local requirements [ARMA, 2018a and 2018b].
According to Alberta recycling management authority [ARMA, 2018a], “Prior to 2008, Albertans took their paint to a household hazardous waste roundup for disposal. However, latex paint can be remade into new paint and oil-based paint can be used as a fuel source in the energy recovery process. Since 1st April 2008, homeowners and painting contractors alike have flocked to Alberta's paint recycling program because they want their leftover paint and paint containers safely recycled instead of incinerated. Most household paints, varnishes and stains are accepted in the program. Paint aerosols (or 'spray paint cans') are also accepted.” “Alberta’s registered paint processors pick up the paint from municipal collection sites and commercial painting companies across the province, and take it to their facilities where it is separated and packaged for shipment. Processing of paint and paint containers is handled by downstream processors approved by Alberta Recycling.” “Latex paint is recycled into usable paint, the majority of it processed and then sold right here in Alberta for environmentally conscious purchasers. Oil based paint is most often used in fuel mixes to provide alternative fuel sources. Aerosol containers, paint cans and plastic pails are also recycled as metals and plastics” [ARMA, 2018a and 2018b; Bloch, 2007; CEL, 2018; Dunmade, 2012; Look, 2009]. This case study evaluated the climate change impact of the partnership of the City of Calgary with a paint recycling company.

1.3. The case study scenario

The City of Calgary is a medium sized city in Southern Alberta. Its population is about 1.1 million. It is the oil capital and 5th largest city in Canada. The city has witnessed massive growth in population and significant spatial expansion as a result of the oil boom of the 2000s. During the period, there were a lot of construction activities. Due to the flourishing economy that translated into increased personal income, many people either bought new homes or refurbished their existing houses. All these placed enormous demand for paints. About 30 million liters of paint is sold in Alberta each year. Consequently, there were paint containers and paint left-over to be disposed off. Many householders are thus saddled with what to do with residual paints and containers in their homes. On average, 5 to 10 percent of this ends up as waste, which can pose environmental and health risks if disposed of improperly. In view of the potential health impacts, Calgary municipal government started paint collection drive in 2003 [Fig. 1]. The piles of residual paints and paint containers provided business opportunities for paint recycling. As a result, a number of entrepreneurs seized the opportunity for paint recycling and allied businesses [Fig. 2]. Today there is Alberta selected paint and paint containers’ recycling program involving many towns and cities in the province [ARMA, 2018a & 2018b].

2. Methodology

The study involved literature review of paints recycling in Alberta and the operational systems involved. Models of public-private partnership (PPP) and non-PPP systems were developed and analyzed. Lifecycle Analysis (LCA) method based on the ISO 14040 and ISO 14044 was then used for the climate change impact analysis of the case studied model. LCA method was used because it provides comprehensive information on the environmental burdens associated with products and processes. It also enables us to assess impacts of those burdens on humans and various ecosystems [ASMI, 2008; Couillard, Bage and Trudel, 2009; Jensen et al., 1997; Jeroen, 2002; Jolliet et al., 2004]. Figure 3 is an illustration of the LCA process.

Fig. 1: Municipal Paint Round-Up/Collection Program.
Source: http://www.lethbridge.ca/living-here/Waste-Recycling/PublishingImages/Waste%20and%20Recycling%20Centre/paint.jpg

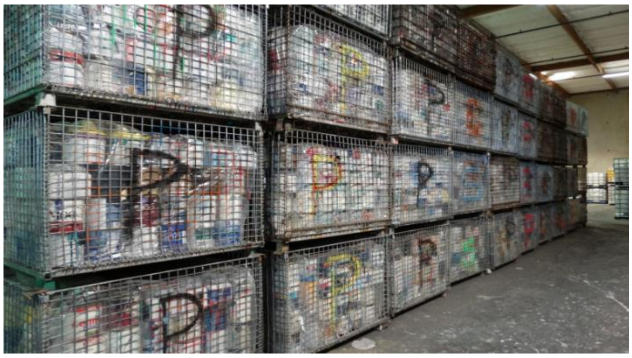

Fig. 2: Paint Leftovers Storage at A Recycling Centre. Source: https://earth911.com/wp-content/uploads/2009/04/Metro-Paint-Recycling.jpg.

The process involves defining the goals and the scope of analysis, preparing a lifecycle inventory of the product data, analyzing the potential lifecycle human and environmental impacts, and interpretation of the results of the analysis.

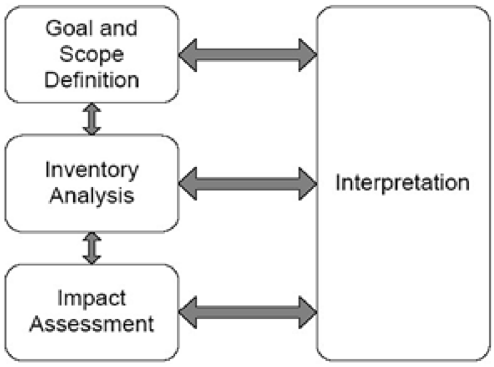

Fig. 3: An Illustration of LCA Process. (Source: Eco-Efficiency-Action-Project.Com).

2.1. Goal and scope definition

The main goal of this case study is to showcase/provide information on the benefits of public-private partnership in recycling to all and sundry (whether governments, entrepreneurs or the public), and thereby encourage more public-private collaborations for products recycling where such partnership is not yet in existence. The results of this study are also expected to guide stakeholders in their choice and use of the "best" end-of-life management options for their products.

The aforementioned goal was pursued by analyzing the reduction in the potential climate change impact resulting from the public-private partnership as opposed to what the situation would have been without the recycling partnership.

2.1.1. Functional unit and system boundaries

The function of the recycling process used in the case study is reduction of potential climate change impact of paint by diverting it from landfill. The functional unit was defined as the mass of the old paint and containers diverted from the landfill every month. The functional unit is approximately 49,800kg by mass of 60000 litres of recycled paint produced every month for sale to the clients.

The technosphere boundaries of the paint recycling process studied is illustrated in Figure 4. Although raw materials are sourced by the company from the municipalities spread across the province of Alberta, but for this case study the focus is on the old paint from the city of Calgary's drop-off centres. Their recycled paints are sold across various provinces in Canada. Thus, the geographical boundaries consist of the entire country Canada. The temporal boundary is one year of data collection from the company and covering one year recycling activities involving public-private partnership between the City and the organization.

The entire lifecycle was composed of the following stages:

- Old paint collection/transfer from the municipal paint roundup/drop-off centre to the company's recycling facility in Calgary.
- Sorting and inspection of the paints into oil based paints, reusable latex paint, and non-reusable latex paint.
- Emptying of reusable latex paints into one of the 12 totes based on the paint colour.
- Compression and transportation of metallic and plastic containers for recycling.
- High speed mixing of each full tot of latex paint.
- Filtration of the paints to remove particles and to comply with industry standard.
- Storage tank mixing of the paints.
- Packaging of the processed paints into 4, 10 and 18.9 litres containers.
- Distribution of reprocessed latex paint to retailers.
- Transportation of oil paints and non-reusable latex paint for disposal in landfills.
- Transportation of recovered paint containers to their recyclers.

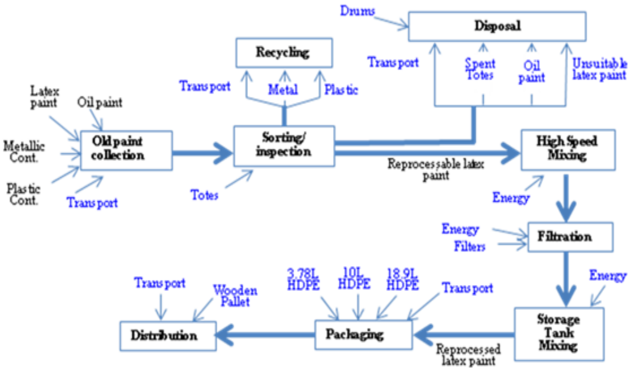

Fig. 4: The System Diagram of Recycled Latex Paint Lifecycle.

In addition to these main unit processes, each stage of the process lifecycle included energy utilization. Allocation is not necessary in this case study because it is a single output process.

Two dimensions of impact analyses were carried out: absolute impact analysis and comparative/relative impact analysis. The absolute impact analysis examined the potential environmental impacts of the recycled paint production on its own. The comparative analysis assessed the recycled paint production process in relation to avoided disposal and avoidance of the need to produce same amount of new virgin paint to replace the disposed old paint.

The comparative/relative impact analysis aspect of this study was based on the average composition, resource use and emissions from the various brands of residual latex paints used as input by the company.

Environmental impacts of packaging, distribution and disposal from the paint recycling process were excluded on the premise that new virgin paint production would also require the same number and type of packaging. It was also reasoned that environmental impacts of distribution would be the same for the new virgin paints as well as for the recycled paint. This is because the company has the same client base. So, the impact would be the same if the company is to manufacture and/or distribute the same amount of new virgin paints that they are recycling.

2.1.2. Limitations and exclusions

This study only evaluated the environmental burdens associated with the recycling of wooden pallets, metallic containers, and plastic containers. The environmental burden is expressed in kg mass value of each material recycled. Furthermore, to simplify the study, materials and emissions less than 0.01% of the functional unit were not included in the analysis. In addition, only impacts of substances that we have their characterization factors were analyzed. Moreover, production, maintenance and disposal of machinery and buildings as well as their environmental burdens were also excluded from the study. Non-material values, economic aspects, and human resources were also not considered.

3. Results and discussion

This study was carried out to determine the climate change reduction benefit of public-private recycling partnership as opposed to disposing it off in a landfill. Table 1 shows a sample of inventory analysis results while Tables 2 and 3 show sample results of lifecycle impact analyses of the inventory data collected for this task. Figure 5 showed the percentage contribution of each recycling process stage to potential climate change impact. In addition, 9000kg of metallic containers, 900kg of plastic containers, and 750 kg of wooden pallets are diverted from the landfill every month.

3.1. Lifecycle inventory

Inventory data compilation was implemented by using database included in Simapro 8.4 software. Process specific data used for the analysis was collected from the paint recycling company. The primary data on material and energy use as well as solid waste emissions was collected from the company. Secondary data was obtained from literature and eco-invent database. Table 1 is a sample of inventory data for the paint recycling process.

3.2. Impact assessment

The focus of this study is the climate change reduction benefit of the recycling partnership. Therefore the relevant impact category to be analyzed is only the global warming potential (GWP). All the inventory data that could be found on the available conversion tables and that are greater or equal to 100 mg were mapped into the affected impact categories. 100 years-time horizon conversion data were used for the characterization of inventory data for the analysis of the global warming potentials. Table 2 is a sample of the potential climate change impact of each stage in the paint recycling process lifecycle. The contribution of each lifecycle stage is diagrammatically illustrated in Figure 5.

3.3. Interpretation

The LCA standards (ISO 14040 and 14044) stipulated a three step process for LCA results interpretation: (i) identification of environmentally significant issues from the inventory data and from the lifecycle impact assessment results, (ii) evaluation of those significant issues, and (iii) drawing conclusion from the evaluated significant issues.
Contribution analysis approach was used in identifying significant issues from the inventory and lifecycle impact tables. Nitrogen oxides was found to be the most significant emission. Others are Sulfur oxides and Methane (Table 1). One could also see from Table 2 and Figure 5 that distribution stage of the paint recycling process has an overwhelming influence on the total potential global warming impact of the process. Disposal, packaging and collection are other paint recycling process stages that are major contributors to potential climate change impact.

Table 1: Samples of Inventory Data for the Paint Recycling Process

Substances	Unit	Quantity
Butane	g	78.048095
Butene	g	25.573004
Dinitrogen monoxide	g	335.09789
Ethane	g	23.853359
Ethene	g	775.88079
Formaldehyde	g	1.838449
Heptane	g	17.961586
Hexane	g	37.782941
Methane	kg	5.6203882
Nitrogen oxides	kg	32.189457
Sulfur oxides	kg	7.8781966

These findings confirm transportation as an important contributor to potential climate change that needs to be addressed in order to reduce our ecological footprint [Dunmade, 2017a]. The consistency and completeness of the LCA analysis method and data used for this study were evaluated. They were found to be consistent with the requirements of ISO 14040s. Figure 3 showed percentage contribution of each recycling process stage to the potential climate change impact category.

Table 2: Contribution of Each Process Lifecycle Stage to Potential Climate Change Impact

Process Lifecycle Stages	Potential Climate Change Impact (GWP) kg CO_2-eq
Old paint transfer	13952.4
Sorting/ inspection	6402.7
High speed mixing	1220.9
Filtration	732.5
In-storage tank mixing	87.708
Packaging	16444.5
Distribution	62772.9
Disposal	21147.2
Gross env. impacts of the process	122760.7

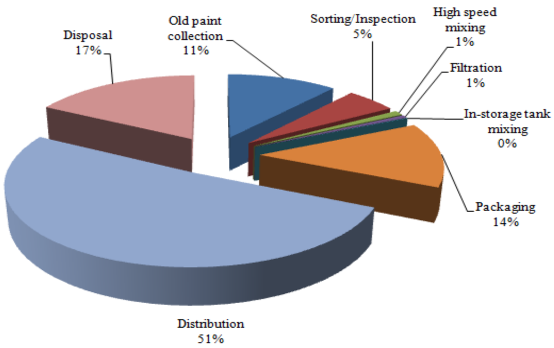

Fig. 5: Percentage Contribution of Each Recycling Process Lifecycle Stage to Potential Climate Change Impact.

3.4. Potential climate change impact reduction benefits

To determine whether it is environmentally better to recycle than to dispose off residual latex paint in the landfill, the difference between total impact of landfilling the residual paint (EI_L) and the impact of the latex paint recycling process (EI_{RP}) was calculated. A lower value of EI_{RP} than EI_L showed that it is better to recycle than to landfill the paint. The results of the environmental costs and benefits calculation are in Table 3. The negative values indicate environmental benefits. These results showed that the public-private partnership in recycling latex paint brought significant reduction in the potential climate change impacts.

3.4.1. Other benefits

According to Calibre (2018) “when paint is left over from a commercial or residential project, the surplus paint is often destroyed, sometimes by hardening the paint and dumping it in a landfill, or incinerating it, thereby releasing pollution into the atmosphere. Our recycling process makes use of this left-over paint so that it can be used to beautify a surface instead of ending up in the air or a landfill.” Therefore, paint recycling results in preservation of resources and reduction of environmental impact.

Table 3: Monthly Environmental Savings from the Recycling Process

Process Lifecycle Stages	Potential Climate Change Impact (GWP) kg CO_2-eq
Environmental impacts of the process (excluding packaging & distribution)	22396.2
Monthly environmental savings from metal & plastic recycling	-31,113.48
Monthly environmental savings from latex paint recycling instead of disposal	-61.905
Monthly environmental savings from latex paint recycling instead of producing virgin paint	-61.905
Total environmental savings by avoiding landfill disposal, avoiding producing equivalent amount of virgin paint and carrying out container recycling	-31237.3
Net monthly environmental benefits of paint recycling	-8,841.1

3. Conclusion

Recycling leftover paint by municipal administration would have brought extra burden on municipal government in terms of not just focusing on governing but also taking up the nitty-gritty of the day to day operations of such facilities. Discountenancing paint recycling could also imply not taking the potential health and environmental effects of inadequate end-of-life management of paint seriously. Furthermore, leaving the recycling for market opportunities without government incentive/support would not have resulted in the high level of paint recycling attained. The infrastructure/logistic cost of old paint collection would have possibly discouraged private businesses investment in the old paint reprocessing. Public-private partnership between municipalities and recyclers resulted in significant benefit of reducing the potential climate change impact. By partnering in recycling old paint, the virgin raw materials needed in producing the same amount of paint recycled are saved from being exploited. Potential soil and water contamination that would have resulted from landfilling old paint and from exploitation of resources to produce the same amount of virgin paint are avoided. Thus, public-private partnership in paint recycling in Alberta, Canada brought the benefits of resources preservation and reduction of environmental impact.

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