Final Report

CIF 291 Town of Markham

Polystyrene Densifier

Prepared For: Continuous Improvement Fund

Prepared By: Baleen Group

Date: May 7, 2012

Submitted By: Town of Markham

BALEEN GROUP

Funded in part by:

MARKHAM

Association Canadienne de l'Industrie des Plastiques ACIP CPIA Canadian Plastics Industry Association

Waste Diversion Ontario

CIF CONTINUOUS IMPROVEMENT FUND

Submission of Final Report

Town of Markham Polystyrene Densifier Technology Project

April 30, 2012

Table of Contents

- Name of the recipient: The Corporation of the Town of Markham
- Phone, fax, e-mail and address of lead contact:
  Claudia Marsales, Senior Manager, Waste Management
  Fax Number: 905-479-7772
  Email: cmarsales@markham.ca:
  Town of Markham
  8100 Warden Avenue
  Markham, Ontario L6G 1B4
  Date of report: February 29, 2012
- Funding Partners: Waste Diversion Ontario/Continuous Improvement Fund and Canadian Plastics Industry Association (CPIA)

1.0 Executive Summary

The following document summarizes the performance, impact and learnings from the Town of Markham Polystyrene Densifier Technology Project. The Polystyrene Densifier machine (PS Densifier) has proven to be a very effective tool in support of Markham's drive towards Zero Waste, reducing their operating costs and enabling Markham to find innovative solutions to waste management. Key metrics observed thus far include:

PERFORMANCE METRICS:

- PS Densifier Machine has been installed and in active duty since April 26, 2011
- Up till March 31, 2012, PS Densifier had processed 7,921 bags of sorted polystyrene foam cushion & food packaging (each bag is approx. 90/litres? gallons)
- PS Densifier has an average volume reduction ratio of 21.35:1. This means that:
  - prior to the use of the PS Densifier, a truckload of undensified polystyrene would carry approximately 191 bags
  - Town of Markham would pay to ship this undensified polystyrene
  - Now 1 truckload of densified polystyrene can carry the equivalent of 1,240 bags or 8,250 pounds
  - Town of Markham is now paid by recycler/end market for densified polystyrene foam as well as cost to transport

IMPACT METRICS:

- Through the use of the PS Densifier machine, Markham has been able to reduce the transportation cost component of this section of their business from 85% to 37%.
- The PS Densifier machine also creates employment for operators to process the materials in Markham prior to transport.
- By greatly reducing transportation costs and creating incremental revenue from recycled materials, town of Markham has reduced its costs in this area of its business by $28,457.
- The project Payback Period for the investment in the PS Densifier machine is 2.74 years (at current utilization)
  - The PS Densifer is currently only being utilized 5.11% of the time. There are tremendous opportunities to further improve the cost-effectiveness of this investment by increasing its utilization rates.

LEARNINGS:

While the PS Densifier machine has been working efficiently and with few problems for many months now, it was not without some significant challenges in the set up phase. Town of Markham staff, in conjunction with a Team of experts in various fields, was required to conduct a long list of unexpected extra work on both the Densifier machine, its safety mechanisms as well as the supporting electrical infrastructure connections so that the PS Densifier machine could be safely installed, configured and certified for use. A comprehensive list of these extra steps is listed in Appendix 8.4. Any party seeking to purchase PS Densifier technology should be aware of these challenges and ensure first of all that that they are purchasing CSA-approved equipment. This should be factored into their overall plans as well as preliminary discussions with suppliers. It is important to note that as a result of the lessons learned from Markham the manufacturer Matrix was able to produce a similar machine in Montreal without any need for field modifications.

Once the initial set up work was complete, Town of Markham had one operator do the majority of the materials processing. This individual was able to benefit from the experience of operating the machine on a regular basis and understand how the machine would handle a broad range of PS cushion and food foams. The operating efficiency of the machine was improved as operating experience was gained.

2.0 Background

Markham operates 4 recycling depots, which accept clean loose Polystyrene foam cushion and food foam packaging. Previously, the material was bagged, transported to a central location, and then loaded into a trailer for transport to market. Markham was managing over 37 tonnes of material annually resulting in approximately 75 trailer loads per year and the costs associated with the trucking. The goal of the project was to determine if cold densification of could cost effectively produce a marketable material with reduced transport and handling costs.

PHASE 1 – Trial Phase

- 60 day trial to assess the effectiveness of cold densification was facilitated by the Canadian Plastics Industry Association. Matrix Manufacturing Inc. Utah USA was able to offer favorable terms for the trial period supplying the Polymax 2500 densifier system.
- Markham will provide separate building, upgrade electrical, provide trained staff to operate machine.
- Goal is to achieve cost savings by reducing shipments and assessing the marketability of cold densified material.
- Determine viability of processing material for other municipalities from central location.
- Prepare report to be shared with municipalities.

PHASE 2 – Purchase densifier and establish in permanent processing location.

3.0 Developing Baseline Evaluation

Prior to embarking on this project, Markham did a thorough analysis of the actions and cost structure of their previous operations. It is important to note that the most significant prior program cost factor was the cost to transport loose PS foam to market. The poor economics are due to the high volume and low weight of loose PS Foam. As such, Markham's previous cost structure saw 85% of all costs going towards the transportation of the polystyrene. Furthermore, the market for undensified polystyrene is such that

some recyclers will accept the material provided it is clean but will often not pay for the material and any shipping costs.

The following is a breakdown of the "Pre-Test Baseline" volumes and costs

Pre-test Baseline

Volume	**Weekly**		**Monthly**		**Annual**		
Average volume of bag		cu. M					
Total PS Collection	220.00	bags	953.33	bags	12,393	bags	
Total packaging PS Collection	160.00	bags	693.33	bags	9,013	bags	
Total food container PS Collection	60.00	bags	260.00	bags	3,380	bags	
Mass							
Average weight of bag	3.02	kg	13.08	kg	170	kg	
Total PS Collection	664.04	kg	2,877.50	kg	37,408	kg	
Total packaging PS Collection	482.94	kg	2,092.73	kg	27,205	kg	
Total food container PS Collection	181.10	kg	784.77	kg	10,202	kg	
Transportation Costs							
	Weekly		**Monthly**		**Annual**		
Transport of PS to Central location	$ 369		$ 1,600		$ 20,800		
Average cost per truck	$ 750						
	Weekly		**Monthly**		**Annual**		
Average number of trucks sent	1.25		5.42		65		
Average cost for trucking	$ 938		$ 4,063		$ 48,750		
Transportation Costs Sub-total	**$ 1,307**		**$ 5,663**		**$ 69,550**		
Other Handling Costs:							
Labour for PS Handling	$ 60		$ 260		$ 3,380		
Share of Recycling Depots overhead	$ -		$ -		$ -		
Cost for bags	$ 152		$ 659		$ 8,563		0.95
Other Costs	$ -		$ -		$ -		
Total Other Handling Costs	**$ 212**		**$ 919**		**$ 11,943**		
PS Recycling Costs Sub-total	**$ 1,519**		**$ 6,581**		**$ 81,493**		
PS Recycling Revenues							
Average price per kg for PS	$ -						
	Weekly		**Monthly**		**Annual**		
Average Revenue for PS	**$ -**		**$ -**		**$ -**		
PS Recycling Profit/Loss							
Average Profit/Loss for PS	**$ (1,519)**		**$ (6,581)**		**$ (81,493)**		

4.0 Results of PS Densifier Use

Upon successful completion of the installation process, Markham brought in third party contractor to operate the PS Densifier Machine. The results were quickly seen where trucks that earlier had been regularly outbound full with undensified polystyrene were now significantly reduced by densification of the polystyrene foam. Densified polystyrene "logs" were stored in 1.08 cubic metre "Gaylords" that could each hold an average of 375 pounds. The quality and consistency of the densified polystyrene logs can vary based upon the polystyrene that is being processed but thus far the recyclers purchasing and using the densified polystyrene logs have been pleased with the product. Furthermore, Markham has been able to develop a solid knowledge base of how to best process the materials as well as safe and efficient operation of the PS Densifier machine.

The following is a breakdown of the "Post-Test Results" volumes and costs:

Post-test Results

Volume	**Weekly**		**Monthly**		**Annual**	
Total PS Collection	166.17	bags	720.09	bags	8,641	bags
Mass						
Total PS Collection	1,165.24	lbs	5,049.35	lbs	60,592	lbs
Densification						
Total estimated packaging PS Densified	2.95	Gaylords	12.78	Gaylords	153.33	Gaylords
Total estimated packaging PS Densified	1,106	lbs	4,792	lbs	57,500	lbs
Average Densification Factor	**21.35**					
Transportation Costs						
Shipping costs from Depot to Processing Facility	$ 369		$ 1,600		$ 20,800	
Average cost per truck	$ -					
	Weekly		**Monthly**		**Annual**	
Average number of trucks sent	0.13		0.58		6.97	
Average cost for trucking	$ -		$ -		$ -	
Total Trucking Costs	$ 369		$ 1,600		$ 20,800	
Other Handling Costs:						
	Weekly		**Monthly**		**Annual**	
Labour for PS Handling	$ -		$ -		$ -	
Share of Recycling Depots overhead	$ -		$ -		$ -	
Cost for bags	$ 152		$ 659		$ 8,563	
Capital Cost of Equipment	$ -		$ -		$ -	
Energy cost for operating equipment	$ 15		$ 63		$ 761	
Training Costs	$ -		$ -		$ -	
Labour costs for operating Equipment	$ 347		$ 1,503		$ 18,036	
Equipment Depreciation	$ 100		$ 434		$ 5,206	
Equipment Insurance	$ -		$ -		$ -	
Equipment Maintenance/Program	$ 19		$ 83		$ 1,000	
Land cost	$ -		$ -		$ -	
Cost of gaylords + skids	$ -		$ -		$ -	
Cost to remove Residual Polystyrene	$ 33		$ 142		$ 1,700	
Total Other Handling Costs	$ 666		$ 2,884		$ 35,265	
PS Recycling Costs Sub-total	**$ 1,035**		**$ 4,484**		**$ 56,065**	
PS Recycling Revenues						
Average price per lb for PS	$ 0.05					
	Weekly		**Monthly**		**Annual**	
Average Revenue for PS	**$ 58.26**		**$ 252.47**		**$ 3,029.61**	
PS Recycling Profit/Loss						
Average Profit/Loss for PS	**$ (976)**		**$ (4,231)**		**$ (53,036)**	

5.0 PS Densifier Upfront Costs

As mentioned in Section 1.0 above, perhaps the most significant challenge of this Project was in getting the machine modified to meet ESA standards and the installation designed to fulfill the requirements of the PSR commissioned by the Town of Markham. Town of Markham staff, were involved with knowledgeable persons in various fields to complete the work detailed in Appendix 8.4. Purchasers of such equipment should consider all installations costs, some of which may be unique to their facility and circumstances, in calculating the full installed price of a system. . A summary of the costs to purchase, modify and install the PS Densifier machine is as follows:

Upfront Costs

Machine Purchase	$	42,000
Initial wiring set-up	$	10,000
Additional Machine re-wiring and safety requiremer	$	15,000
CSA Compliance/Approval and pre-start	$	5,500
Consultant's Fees	$	5,594
Town of Markham staff costs	$	-
Other Costs	$	-
Sub-total	**$**	**78,094**

6.0 Financial Considerations/Business Case

As outlined in Sections 3, 4 and 5, Markham took great care to capture original baseline costs and then measure all measurable set up costs as well as ongoing usage and operational costs. At the very highest level the success of this Project is dependent on the following key components:

- Greatly reducing transportation costs
- Creating a finished product that has a market value
- While labour costs do increase this is more than offset by the decrease in transportation costs as well as incremental revenue from marketing the densified product. It is important to note that this Project affirms the “business case” for Zero Waste and recycling in that investing in recycling creates more jobs than investing in landfills.

Overall, usage of the PS Densifier technology will result in estimated annual cost savings of $28,457 with a Projected Program Payback Period of 2.74 years following the initial investment. This is summarized in the following:

Summary

Pre			
	Weekly	**Monthly**	**Annual**
Total PS Collection	220 bags	953 bags	12393 bags
	Weekly	**Monthly**	**Annual**
Average number of trucks sent	1.25	5.42	65.00
Transportation Costs Sub-total	$ 1,307	$ 5,663	$ 69,550
PS Recycling Costs Sub-total	$ 1,519	$ 6,581	$ 81,493
Average Revenue for PS	$ -	$ -	$ -
Average Profit/Loss for PS	**$ (1,519)**	**$ (6,581)**	**$ (81,493)**
(Pro-rated) Post			
	Weekly	**Monthly**	**Annual**
Total PS Collection	220 bags	953 bags	12393 bags
	Weekly	**Monthly**	**Annual**
Average number of trucks sent	0.19	0.83	10.00
Transportation Costs Sub-total	$ 369	$ 1,600	$ 20,800
Current Densifier Utlization Rate	5.11%	5.11%	5.11%
Labour costs for operating Equipment	$ 347	$ 1,503	$ 18,036
PS Recycling Costs Sub-total	$ 1,035	$ 4,484	$ 56,065
Average Revenue for PS	$ 58	$ 252	$ 3,030
Average Profit/Loss for PS	**$ (976)**	**$ (4,231)**	**$ (53,036)**
Net savings of	**$ 542**	**$ 2,350**	**$ 28,457**
Projected Program Payback Period	**2.74 years (assuming current Program structure/utilization)**		

Some further observations and notes to this analysis include the following:

- All 90 gallon(litre) bags that are used to collect PS are now being recycled
- This analysis does not include CO emissions reduction in truck transport
- Densification ratio subject to change based on breakdown of materials between cushion packaging and food service packaging foam.
- Densification Ratio calculation assumes all bags are completely and tightly filled
- Higher value markets could be accessed with a more uniformly packaged end product (e.g. palletized and stretched wrapped – no Gaylords).
- Labour time and cleanness of materials subject to change as Team gains experience working with Densifier and adjusts staffing and education accordingly.
- Economics of Project subject to change if PS Densifier is to be utilized at a higher rate with possible charge back to other partners.

7.0 Other Considerations/Next Steps

As with any similar Project, being one of the first to adopt and apply this technology had a number of positive outcomes as well as outcomes in need of improvement. Some key considerations for Groups looking to implement PS Densifier technology in this regard would include, but not be limited to, the following:

Positive Outcomes:

a) Once installed, the PS Densifier reliably compacts polystyrene with few no significant maintenance and operating problems
b) The savings in transportation costs due to the compaction has been realized and has been significant
c) The machine turns out a high quality densified log that has been well accepted by recyclers
d) The learning curve for operators has been a relatively short one
e) Processing Markham's own recyclable materials creates jobs in Markham
f) Can promote more PS Foam diversion to residents now that densifer is operational to mitigate transport costs;

Opportunities for Improvement

a) The installation process requires a significant overhaul so that future users of this technology do not have to experience the lengthy, costly and unexpected process experienced here.
b) Ideally this project's success should not detract from efforts to reduce the amount of polystyrene both in use as well as in Markham's waste stream
c) Markham Depots and their capability to manage more PS Foam need to be assessed.
d) Enhancing material handling capabilities (e.g. ability to double stack pallets in truck would further decrease number of shipments and shipping costs)

Next Steps:

Markham will continue to use the PS Densifier machine to process its polystyrene waste. A possible next step to improve its cost-effectiveness would be to expand the machine's hours of use and receive and process more materials. This material could come from expanded traffic at Markham's Recycling Depots or from neighbouring Municipalities where Markham would charge back for the use of the PS Densifier machine.

8.0 Appendix

Appendix 8.1 – pictures of PS Densifier Machine

Image 8.1.1: Densifer and Extruder

Image 8.1.2: Overhead Storage Bag

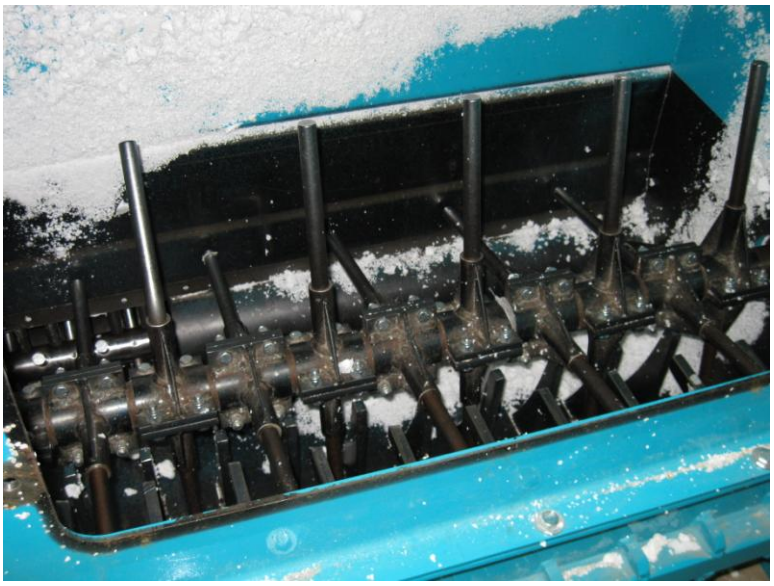

Image 8.1.3: Grinder

Image 8.1.4: Conveyor

Appendix 8.2 – pictures of PS Densifier Machine electrical and safety components

Image 8.2.1: Electrical Panel and Transformer

Image 8.2.2: Conveyor and Grinder Electrical Panels

Image 8.2.3: Safety Lockout Switch on Grinder

Image 8.2.4: Denisfier Electrical Panel

Appendix 8.3 – pictures of PS Densifier material inputs and outputs

Image 8.3.1: Loose Bagged Polystyrene

Image 8.3.2: Denisfied Polystyrene Blocks

Image 8.3.3: Gaylord Containers

Image 8.3.4: Densified

Appendix 8.4 –PS Densifier Commissioning Tasks

Town of Markham

Densifier ESA/PSR & Commissioning Tasks

March 3, 2011 (E&EO)

ESA = Electrical Safety Authority

PSR = Pre-Start Safety Review

E-contractor = Licensed Electrical Contractor

M-contractor = Approved Mechanical Contractor

Pre-Breaker				
	Description	**ESA**	**PSR**	**Responsibility**
1	Install warning label "Disconnect Power Before Working Within	X		E-contractor to supply and install
2	Install permanent clearly visible label on the exterior to show manufacturer, serial no. Voltage, Amps, HP etc.	X		Matrix to supply label
3	Install label "Caution This Unit is Fed By More Than One Source of Power"	X		E-contractor to supply and install
4	Provide approved branch circuit fusing for each motor circuit – supply and install fusing for 2HP, 5HP and 15HP 3 phase 460 volt motors in existing panel	X		E-contractor to supply and install
5	Supply and install safety rated contactor to remove power to 15 HP motor		X	E-contractor to supply and install
6	Supply and install safety monitoring relay to drive 2 HP, 5HP, 15HP motor, monitor the status of motor starters and safety rated contactor.		X	E-contractor to supply and install
7	Remove existing conveyor e-stop and conduit. Supply and install 3 dual channel e-stops on each side of conveyor: connect		X	E-contractor to supply and install

	devices in series to safety relay			
8	Remove existing door interlock. Supply and install dual channel latched type safety switch		X	E-contractor to supply and install
9	Connect e-stops, door interlock and safety relay in series		X	E-contractor to supply and install
10	Label all relays, push buttons, fuses etc	X		E-contractor to label in accordance with code requirements
11	Supply and install approved protective fusing for control circuit wiring	X		E-contractor to supply and install
12	Supply CSA/CUL approved bin level switch	X		Matrix to supply
13	Install CSA/CUL approved bin level switch			E-contractor to install
14	Extend barrier (guard) at entrance of pre-breaker hopper to minimum of 1600mm from floor level			M-contractor to supply and install
Densifier				
15	Supply and install safety monitoring relay – relay contact shall remove 120 volt control power from both sides		X	E-contractor to supply and install
16	Supply and install safety rated contactor to remove power to 15HP densifier motor; connect to feedback circuit of safety relay		X	E-contractor to supply and install
17	Remove existing e-stop; supply and install dual channel e-stop connected to safety relay; re-locate e-stop to densifier discharge area; provide bonding conductor if flexible conduit is used	X	X	E-contractor to supply and install
18	Install warning label “Disconnect Power Before Working Within	X		E-contractor to supply and install
19	Install permanent clearly visible label on the exterior to show manufacturer, serial no. Voltage, Amps, HP etc.	X		Matrix to supply label

20	Install label "Caution This Unit is Fed By More Than One Source of Power"	X		E-contractor to supply and install
21	Supply and install control circuit fuse with 10 amp/230 volt approved style fuse	X		E-contractor to supply and install
22	Supply CSA or CUL approved hydraulic valves	X		Matrix to supply valves
23	Remove non-approved valves hydraulic and replace with approved valves	X		M-contractor to install; original valves to be kept clean and repacked for return to Matrix
24	Remove control transformer and limit switch; supply and install CSA or CUL approved replacements	X		E-contractor to supply and install
25	PLC not CSA or CUL approved – provide documentation of electrical certification for entire PLC assembly	X		Matrix to provide certification
26	Label all relays, push buttons, fuses etc	X		E-contractor to label in accordance with code requirements
27	Supply and install fuse protection for control transformer	X		E-contractor to supply and install
28	Supply CSA/CUL approved level switch for densifier hopper	X		Matrix to supply
28	Install level switch c/w bonding conductors in flexible conduits	X		E-contractor to install
29	Provide pinch point guard at lower side of hydraulic push frame		X	M-contractor to supply and install
30	Provide pinch point guards at top and bottom of extrusion tube		X	M-contractor to supply and install
31	Provide extension of extrusion tube guarding past extrusion discharge point		X	M-contractor to supply and install
General				
32	Supply 45KVA step-up transformer 230/460/3/60			Markham to supply

33	Supply and install 200 Amp splitter, 30 Amp fused disconnect, 60 Amp fused disconnect (all 460 VAC); supply and install input power to densifier and pre-breaker panels			E-contractor to supply and install
34	System shall be equipped with energy isolating device suitable for lock-out/tag-out)		X	Markham to confirm that fused disconnects in item 33 comply with this requirement
35	Shorten hopper legs to fit within height limitations			M-contractor to provide site modifications; remove base plates, cut uprights, re-weld base plates, prime and paint to prevent corrosion
36	Assemble hopper frame			M-contractor
37	Final placement and anchoring of equipment			M-contractor
38	Final ESA and PSR inspections	X	X	Markham
38	Supply hydraulic oil			Markham
39	Install hydraulic oil			Matrix
40	Commission equipment, provide operating instruction			Matrix
41	Lock out/tag out procedure; training, awareness, administrative controls, warning signs		X	Markham

Appendix 8.5 –Breakdown of Pre and Post Costs