UBC Social, Ecological Economic Development Studies (SEEDS) Student Reports

An Investigation into Styrofoam Recycling on Campus

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The University of British Columbia

Faculty of Applied Science

APSC 262 Sustainability Project Report:

An Investigation into Styrofoam Recycling on Campus

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Abstract:

This terms projects in APSC 262 are geared toward sustainability in engineering and design around campus. One of the sustainability concerns is the large number of labs on campus producing Styrofoam waste. The labs receive delicate equipment and materials in large Styrofoam packaging, and many of these labs send used Styrofoam packaging straight to the landfill.

The plastic that Styrofoam is made from, polystyrene (PS), is used for other types of plastic extrusion and injection molding. This demand for PS gives compressed Styrofoam a market value. Companies selling plastic products made from PS can take advantage of the low cost of recycled PS to manufacturer their products.

Recently, recycling machines for processing Styrofoam and turning it into dense, hardened PS have become relatively affordable. This persuaded a Surrey Styrofoam packaging manufacturer, Aqua-Pak, to install one of the recycling machines in their manufacturing plant. Aqua-Pak now accepts their packaging products back from customers to be recycled.

UBC started a pilot project on campus with the help of the Brain Research Center (BRC) to collect Styrofoam from BRC labs and send it to Aqua-Pak for recycling as well. The pilot projects goal is to determine if UBC should recycle Styrofoam packaging from all the labs on campus. The main concern of the university is to ensure that this process of recycling is not more harmful to the environment than simply sending the Styrofoam to the landfill. If the pilot project works well, the university will consider either sending all the Styrofoam from campus to Aqua-Pak or installing a recycling facility for Styrofoam on campus.

The finding of the students of APSC 262, after careful consideration of the situation from a triple-bottom-line assessment, is that the university should install its own recycling facility. All three assessment criteria, social, environmental and financial, point toward this method as the best avenue to properly process UBC's Styrofoam waste.

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Glossary:

Polystyrene – Aromatic polymer made from aromatic monomer styrene. This product is typically developed using petroleum within the petroleum industry and is commonly known as the most widely used type of plastic.

Extrusion – The process of shaping material by force through a die (specially shaped hole).

Injection Molding – A process in manufacturing objects, such as metals or plastics, through means of heat to liquefy material and injecting into a mold.

List of Abbreviations:

BRC - Brain Research Center, UBC

EPS – Expanded Polystyrene (Styrofoam)

LCA – Life Cycle Analysis

PMD – Pacific Mobile Depots

PS – Polystyrene

RPS - Recycled Polystyrene

5.0 Aqua-Pak's Plan

The main focus of the Aqua-Pak company is to produce quality Styrofoam containers used for a variety of products, which include food packaging for items such as fish or farm produce. Virgin polystyrene beads are purchased with an average price of $0.72 per pound (cts/lb) (Barry, 2009) and used to create Styrofoam containers through various unit operations found within the production plant. In addition to creating Styrofoam containers, Aqua-Pak has advertised to various businesses and/or organizations (which include but are not limited to: Wal-Mart, London Drugs, and UBC) that their company has the capability to accept a large number sterile Styrofoam containers for recycling. With approximately a capacity to run 400 lbs/hr of Styrofoam through a processor in their plant, Aqua-Pak's has a huge potential to increase the intake of containers per day (Dayton, 2010). However, one main issue with Styrofoam is the space required to store the countless containers transported in. The price of extruded polystyrene is approximately $0.15cts/lb (Dayton, 2010). External companies that purchase the recycled material from Aqua-Pak are aware of the non-uniform color of the extrude and are generally reworked and painted for goods such as picture frames, crown molding, and flower pots (Dayton, 2010).

5.1 The Process and Details of Recycling Styrofoam Containers

In order for Aqua-Pak to obtain used and cleaned Styrofoam containers, deliverers from recycling companies such as Pacific Mobile Depot are in charge of collecting bags of sizes ranging from 18" x 24" (Regular) to 36" x 48" (Large). These deliverers are paid approximately $5.00 per bag to store and transport the Styrofoam shipment from their origins to Aqua-Pak's central plant located in Surrey. Pacific Mobile Depot has been collecting bags of Styrofoam from UBC approximately once or twice a month as one of the deliverer's stops before reaching Aqua-Pak.

The used Styrofoam is thrown into a processor that specifically churns and chops the Styrofoam into small pieces and heats to specific high temperature where the polystyrene melts into a melted-sugarcane-like consistency. With the final phase of the extruded polystyrene, the size of a pound of the extruded material is approximately 13 times more concentrated than the size of a pound worth of Styrofoam containers. In other words, roughly 40,000lbs of the extruded polystyrene can fit inside the same truck that was originally used to carry around 3000lbs of used Styrofoam containers. Despite the potentially large ability Aqua-Pak has to recycle tens of thousands of pounds of used Styrofoam containers, storage of the EPS remains an issue. Unfortunately, the cost of space and warehouse to contain the maximum shipments of Styrofoam are economically unfeasible.

Below is a simple block flow diagram outlining a typical process of creating Styrofoam containers to its end life in either the consumer's hands or in the landfill. With more awareness of possible alternatives for used and unwanted Styrofoam, landfills can begin to slow down and a sustainable consumption cycle can progress into society.

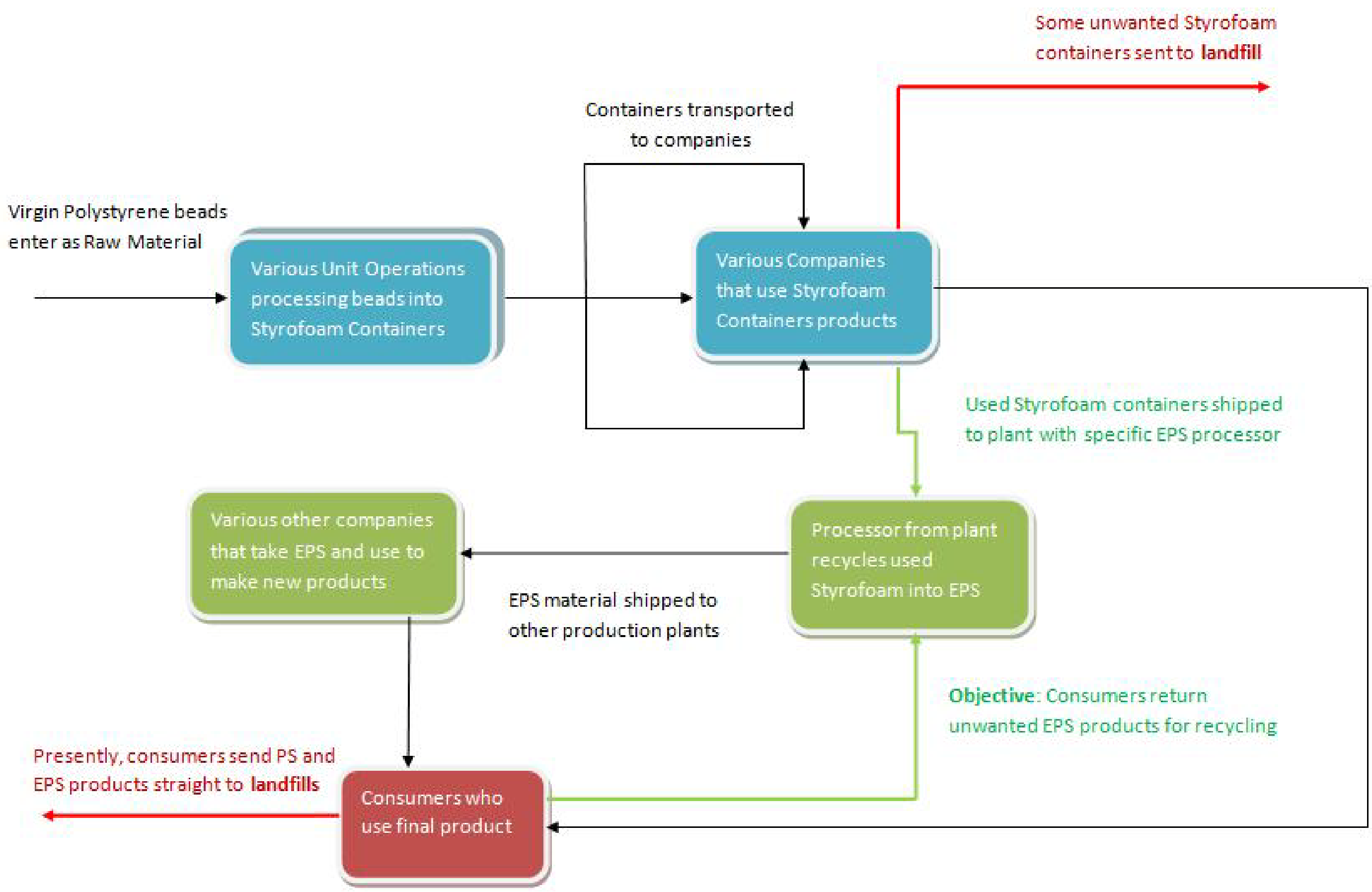

Figure 1: Simple block-flow diagram outlining process of polystyrene (PS) related products. Red arrows represent unfavorable end-of-life states for PS products where green represents favorable sustainable objectives for consumers and producers.

5.2 Economics of Recycling Styrofoam

As explained by Tim Dayton, General Manager of the Aqua-Pak service, the intent for including the processor to extrude the used Styrofoam containers was "not to make money from selling the extruded material, but to take responsibility for their products after its original use." Dayton also explains that they don't expect this process to produce revenue at their plant. In terms of economics, it is expected that that by selling the material Aqua-Pak will only experience a revenue neutral result.

With the purchase of the virgin polystyrene beads as raw material to create Styrofoam boxes at roughly $0.72/lb, the additional credit of $0.15/lb due to selling the extruded material to other companies do not contribute to any profit or losses to the Aqua-Pak service. However, purchase of the recycling polystyrene processor is approximately $20,000 up to $40,000. Without considering time value of money, with each shipment of Styrofoam per week coming in from all over Metro Vancouver, approximately $6000 can be generated back to the company's revenue.

5.3 Environmental Impact of Recycling Styrofoam

A more official term for the extruded polystyrene material is Expanded Polystyrene (EPS) (British Plastics Federation, 2009). Several companies have done their own analysis of this product and have gone into deep research obtaining life cycle analysis (LCA) reports on the feasibility of EPS with regards to:

- Energy Consumption
- Air Pollution
- Water Pollution
- Global warming potential
- Volume of Solid Waste

As shown in figure 2 below, a table depicting the scaled dimensionless impact of pulp and fiber usage for shaped/molded packaging is used to demonstrate the greater degree of environmental degradation typical raw materials cause compared to EPS.

Using the EPS creates a demand for the end-life of Styrofoam and reduces the necessity to throw used Styrofoam containers into the landfill. Companies such as Wal-Mart have taken the initiative to reduce their amount of waste shipped to the landfill and have implemented programs to have their Styrofoam, which was used to package their selling goods, to processing plants to turn into EPS that can be sold for the production of a fire-resistant insulation product. This program was done to further achieve their "sustainability goal as a company of producing zero waste" (Wal-Mart, 2008).

SHAPED / MOULDED PACKAGING (2)	EPS	PULP AND FIBREBOARD
ENERGY CONSUMPTION	1	2·3 – 3·8
AIR POLLUTION	1	3·1 – 4·1
WATER POLLUTION	1	2·3 – 2·8
GLOBAL WARMING POTENTIAL	1	4·0 – 4·4
VOLUME OF SOLID WASTE	1	0·69 – 0·79

Figure 2: Table comparing EPS and Pulp & Fibreboard using naturalized dimensionless values to evaluate its impact towards environmental degradation. *http://www.eps.co.uk/downloads/index.html*

5.4 Social Impact of Recycling Styrofoam

Generally with the sustainability movement heavily being implemented all around Metro Vancouver, a common desire or need to be more sustainable within each company is evident. Society is attracted to the most popular movement at any given moment, and currently society gravitates towards organizations that are the most environmentally friendly so that people may have the benefit to assume top status as a sustainable city. With EPS becoming more and more evident with big companies such as Wal-Mart and London Drugs, society may become more aware of their consumption of Styrofoam products and unsustainable practices of simply tossing containers away. Creating a greater awareness that several companies are running programs that recycle Styrofoam to a new raw material for other commercial goods may increase understanding that society must and can change their current lifestyle in order to reduce the amount of substances going into the already overflowing landfills.

6.0 UBC's Plan

The goal of this section is to determine the feasibility of the Styrofoam recycling program for the laboratories on the Vancouver UBC campus, and to analyze the possibility of extending said program to the entire campus, including Food Services, IT services, bookstores and other business units. This section will also look into possible sustainable alternatives to recycling for Styrofoam on campus.

Polystyrene is a 100% recyclable material, as demonstrated by several Fortune 500 companies have already taken initiatives to implement recycling and sustainability programs, including IKEA, Wal-Mart, Sears Holding Corporation, Sanofi Pasteur and Helios Biosciences.

In addition, many businesses in the UK have set up recycling schemes for their used EPS. Some have their material collected in expanded form, which is recycled into insulation boards for use in construction. Others invest in compacting machinery which reduces the size of their EPS by 40-95%. The material is then transportable and can be sold to a recycler. This compacted material can be transformed into recycled polystyrene pellets. These pellets are used to manufacture coat hangers, picture frames, replacement hardwood and CD cases. Some of the members of the EPS Packing Group have set up consumer recycling points on their sites so that local people and small businesses can recycle their used polystyrene. This material is ground down and put back into new packaging.

In addition to recycling used Styrofoam into secondary products, an alternative way proposed to UBC is not to recycle used Styrofoam but to clean burn it to produce heat energy and avoid the flow of waste to landfill. Waste combustion for electricity or heat generation is an effective way to maximize usage and benefit of plastic material resources and is widely used in Europe. EPS has a high calorific value. One kilogram of expanded polystyrene contains as much energy as 1.3 liters of heating fuel. There are no toxic emissions in this method of waste management, the polystyrene is incinerated in modern plants and at high temperatures. The byproducts are steam, carbon dioxide and very low levels of non-toxic ash, whose emissions are less contaminating than the typical camp fire.

Landfill is the least desirable option among all the waste management alternatives considered up to now. Putting EPS into landfill means not making the best of natural resources either through recycling or energy recovery, which is unsustainable. But, if there is no feasible alternative EPS can be safely put into landfill. It is inert, non-toxic and stable. As it does not decompose, EPS does not contribute to the formation of methane or any other chemicals in the atmosphere and it does not pollute subterranean water supplies. Contrary to popular belief polystyrene foam does not clog landfills, it accounts for less than 1% by weight of the entire US solid waste stream.

6.1 Current Plan

UBC has currently established recycling of the following forms: paper pick-up, cans and bottles pick-up, compost pick-up and residences pick-up. However, in all of these services, Styrofoam is not an acceptable candidate, meaning it goes to the landfill.

Having approximately 350 laboratories, UBC will have to pay approximately $25,000 per year to recycle each 18” X 24” bag of polystyrene, taking into account of transportation, storage and staff resources. The Brain Research Lab has been running a 4-month pilot project with Pacific Mobile Depot and Aqua-Pak. The result of this project will allow UBC Styrofoam-free Committee to obtain learning and statistics from the project implementation to inform the creation of a campus-wide Styrofoam recycling program.

However, in order to analyze the amount and cost of Styrofoam recycling, a better monitoring system is needed. Improved diagnostic details will be provided and lead to better decision making. Additional data points collected from a continuous system will allow for better analysis. UBC will be able to more efficiently determine potential improvements and measure the impact of changes to the system. Steps should be taken to move to a continuous data collection and analysis system with the most appropriate technology.

6.2 Future Plan

UBC should work hard to support and encourage the responsible waste management of used EPS. By enforcing the packaging curriculum from suppliers, the amount of excess EPS that needed to be recycled can be reduced at the first place, whilst still doing its job as packaging. In reality, our major environmental problems are not caused by packaging waste, but rather by the material and energy usage related to both the packaging and the product it protects. It's what happens before disposal that is important. The primary solution is to design and use packaging that minimizes weight (Lilienfeld, 2008).

The University of Melbourne has already established a polystyrene recycling program on campus. Collection bags were distributed to departments who collect large amounts of polystyrene. Due to the large volumes of polystyrene waste, a compactor was purchased to reduce the volume of polystyrene.

Similarly, UBC can purchase a polystyrene compactor on campus, or choose to ship campus-wide Styrofoam wastes to Aqua-Pak via Pacific Mobile Depot. The decision will depend on the cost-revenue ratio, as well as the triple-bottom-line assessment between the two methods.

By continuing polystyrene shipment to Aqua-Pak for recycling, the university will burden itself with $25,000 direct annual cost for transportation, staff resources and storage.

In this section, the GreenMax™ C200 EPS Recycling machine model, which has a purchase price of $30,000, is evaluated as an example on the feasibility of a polystyrene compactor. Adding in machine transportation cost and assuming the installation cost to be four times the purchase price, the total initial cost will be approximately $150,000. Because this model is able to recycle used polystyrene into dense, hardened blocks at a rate of 200kg per hour, it is safe to assume that a single machine will satisfy polystyrene recycling across the entire campus. Because the current market price of recycle processed polystyrene is around $0.15/lb this model has the potential to generate an income of $66 per hour. However, in order to make this analysis more conservative and minimize the risk, we will assume the machine is running at ½ efficiency and generating $33 per hour. In addition, we will assume this machine operates for 40 hours per week, and 4 weeks per month with the annual maintenance, energy consumption staff resource cost to be 10% of the initial investment. Using the annual inflation rate of 1.5% taken from the Bank of Canada, the payback period is calculated to be approximately 3.2 years. Adding in transportation, freight and storage costs, and staff resources cost of about $10,000 per year, the payback period will be 4 years. Note that most of the situations are taken as worse-case scenarios. For example, the storage cost maybe neglected because of an already available storage building, the inflation rate may not be as high as 1.5%, or the machine may operate at an efficiency greater than ½.

7.0 Conclusions and Recommendations

In researching this proposed recycling system for the campus, the best alternative became clear very quickly. In terms of the triple-bottom-line assessment, the best choice in all three categories was clearly the installation of the university's own Styrofoam recycling facility.

The positive social impacts of a facility on campus like this would be increased community awareness about Styrofoam and polystyrene's lifecycle and jobs for a small group of university employees. The campus would be able to add another distinct "green" facility to its list of awards and achievements, and would help set a trend for the lower mainland and campuses around the globe. There are no negative social impacts to speak of, as Aqua-Pak and PMD will still have large demand for Styrofoam collection and recycling services from businesses within the lower mainland and on the island.

The major environmental impact of a facility like this would be a decreased amount of trucking and/or shipping compared to sending the university's waste EPS to Aqua-Pak. The required shipping within the lower mainland would be approx. $1/13^{th}$ that of sending waste EPS all the way to Surrey for processing. Although we found that polystyrene is inherently inert in a landfill, the energy costs associated with producing it in the first place clearly outline that sending EPS back into the production stream as RPS is the best overall choice. There is a small amount gaseous discharge from the heating process used to turn EPS into RPS which may have negative environmental impacts. However, being as the polystyrene is not being burned in any way during this process we are confident that a simple gas discharge filtration system will be enough to counteract the problem.

Lastly, and most interestingly, the economic impact of a recycling system like this on campus also looks very promising. Now that these recycling machines are so compact and relatively inexpensive, the university could see a complete return on its investment in a relatively short period of time. The initial investment could be as high as $150,000 to install the facility and machinery to process EPS on campus. However, collecting EPS from the labs around campus and processing it on campus will save the university approximately $25,000 annually on processing fees from Aqua-Pak and Pacific Mobile Depots. Selling the RPS to manufacturing companies then further offsets the cost of installation and operation, to the point where the university can expect to be making money from the recycling system within 4-6 years. Finally, as one of only very few EPS recycling centers in the lower mainland, UBC will be able to accept EPS from individuals and vendors in Vancouver for a nominal processing fee.

In summary, after examining the different avenues available to the campus, we as Applied Science students suggest that UBC find buyers for bulk RPS and install a processing facility on campus. Having a processing stream in place to divert EPS from the landfills back into the production stream fits very well with the universities policies on sustainability and net-zero energy use.

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