Alternatives to Disposable Shopping Bags and Food Service Items
Volume I

Prepared for

Seattle Public Utilities

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Alternatives to Disposable Shopping Bags and Food Service Items
Volume I

Prepared for

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This report provides the City of Seattle with relevant information to inform policies being developed for disposable shopping bags, and expanded polystyrene foam (EPS) and other plastic disposable "to-go" food service items. The report concludes that actions taken within the spectrum of strategies presented will likely reduce environmentally adverse and socially undesirable implications of disposable plastics. Conclusions and recommendations include:

- The use of reusable bags instead of disposable shopping bags of all kinds provides substantial environmental benefits, and reduces unintended environmental impacts, including litter.

- All education on disposable shopping bag use should emphasize that no bag or an existing reusable bag is the preferred option, followed by a new reusable bag used for as long as possible, and finally recyclable plastic and paper bags reused often and then deposited in curbside or in-store recycling facilities.

- An Advance Recovery Fee (ARF) on all disposable shopping bags provides the most environmental gains (except for litter), and provides for much higher overall economic gains when compared to all strategies. With an ARF on all bags, consumers experience slightly less costs than with a plastic only ARF (due to an anticipated increase in the use of reusable bags), and the region experiences additional economic cost (due to decreased paper production). Again, the City and retailers both benefit from revenue under either a plastic only or all-bag ARF.

- For the environmental categories for which data exists (which notably excludes litter aesthetics and litter marine diversity), all food service item strategies result in environmental burdens higher than the status quo. However, the permanence of plastic in the environment dictates its use be minimized.

- A shift from disposable food service items to biodegradable food service items may benefit litter persistence impacts on the marine environment due to the faster rate of degradation. Their shorter persistence in the environment still has the potential to harm the marine ecosystem.

- All education on disposable food service item use should emphasize minimization of packaging and avoidance of littering when possible, then utilization of compostable products and depositing them <u>with food waste</u>

in in-store commercial organics collection bins, or utilization of recyclable products deposited in curbside or in-store recycling bins. .

- An ARF on all non-compostable, non-recyclable clamshells reflects the least environmental impacts among bans and ARFs. This is due primarily to the incentive toward compostables, e.g., polylactic acid (PLA), which results in lower impacts than paper and PET in the environmental categories considered. The exception is in eutrophication, due to nitrogen and phosphorus runoff in agriculture.

Scope and Background

In recent years, Seattle's citizens and leaders have increasingly sought to accelerate the City's progress on recycling and waste reduction, as well as to reduce pollution of terrestrial and marine environments and global warming. In response, Seattle Public Utilities was directed in July 2007 by City Council Resolution 30990 to conduct research on product bans related to disposable plastic shopping bags and food containers.

This report is comprised of five sections:

- The first section presents a summary of the environmental concerns surrounding the increasing use of these two product categories.
- The second section presents the results of research on the current strategies being used worldwide to reduce the use of or amount of these two product categories.
- The third section presents the results of research into the current availability, and future likelihood of the development of, reusable, compostable, or recyclable materials and products that can be used as alternatives to these two product categories.
- The fourth section presents the results of a review of published life cycle assessments (LCA) comparing the environmental burdens associated with these two product categories for a variety of material types.
- The fifth section presents the strategies identified as possible policies to be used in Seattle to reduce the use of these product categories. Summary results of stakeholder input regarding prospective policies are also presented. This section also presents the results of an economic cost/benefit assessment and an environmental impact assessment of each of the strategies identified.

Conclusions and recommendations are provided at the end of the report.

Environmental Concerns

There are significant environmental concerns over the use of disposable bags and food service items, including adverse effects on human health, global warming and resource consumption, terrestrial and marine ecosystems, and solid waste management. All of these concerns also require significant public funding to manage or mitigate. These concerns have prompted cities and countries worldwide to seek out alternatives to traditional bags and food service items (mainly plastic) that are less harmful to human health and the environment. These environmental concerns apply in varying degrees to all bags and food service items, including those that are recyclable, reusable, or biodegradable/compostable.

Current Strategies

The City provides extensive waste reduction and recycling education and technical assistance to residents and businesses through a variety of programs. All programs emphasize the environmental benefits associated with reducing waste, reusing or donating products to the maximum extent, and recycling or composting the remainder. The City of Seattle has an extensive recycling infrastructure that includes the ability to recycle both plastic and paper shopping bags. Some food service items are accepted for recycling, including, for example, plastic dairy product tubs. The City also maintains an extensive composting system for organic waste, including soiled compostable (un-coated) paper, and specifically-approved compostable products made from other materials. Other than Ordinance #114035, which bans the use of EPS food and beverage materials by Seattle City Government and food vendors at City facilities, no other policies or regulations are used to affect the use of disposable shopping bags or foodservice items by residents and businesses.

Strategies used by other jurisdictions to address the use of disposable shopping bags include those in Table ES-1.

Strategies used by other jurisdictions to address disposable food service items include those in Table ES-2.

Alternative Products

A variety of reusable, recyclable, and biodegradable/compostable materials are available for use in manufacturing shopping bags and food service items. Many are made from renewable resources, such as corn starch, potato starch, wheat starch, rice hulls, bagasse, cellulose fiber/limestone, palm fiber, cotton canvas, durable plastic, paper, and bamboo. They are manufactured, sold, and distributed under a variety of brand names, and in a variety of product categories including bags, lidded containers, hinged containers, cold cups and lids, hot cups lids, cutlery, plates or trays, bowls, straws and stirrers, and food wraps. Many are available in Seattle through traditional and niche food service distributors, and a number of advantages and disadvantages exist for each product/material type. While most bio-based products are in the early stages of commercial development, it is anticipated that their wider use will drive improvements in quality, versatility, environmental impacts, and cost.

Table ES-1. Summary of policy options adopted by other jurisdictions to address plastic bag use.

Policy Option	Description	Jurisdiction
Education and/or labeling requirements	Aimed at changing consumer behavior or product choices toward reusable, compostable, or recyclable alternatives	Seattle and numerous other jurisdictions
Curbside Recycling	Bags placed in curbside collection bins for later sorting and marketing. Bags including shopping, grocery, newspaper, dry cleaning, bread, produce, paper	Seattle; 25 cities in Los Angeles County
Voluntary Measures	Voluntary restrictions placed on disposable bag use by retail outlets or others. Sometimes associated with targets for use reduction or recycling	Australia, Great Britain, Hong Kong
Mandatory advanced recovery fees	A fee levied on the supplier or consumer of a product and retained by the retailer and/or government to offset the costs of disposal, discourage further use, and publicize reuse and recycling options. Paper, plastic, or both; fees range from $0.007 to $0.25 paid by supplier, distributor, retailer, or consumer; funds used by city, retailer, or both (some abuse)	California
In-store recycling	Voluntary or mandatory effort by retailers to provide facilities to accept plastic bags back for recycling. Mandatory in California but driven by the market elsewhere and favored by grocers and bag manufacturers	California; UK
Extended Producer Responsibility (EPR) mechanisms	Funds from product manufacturers are utilized to facilitate collection, processing, and advancement of end-uses.	Mostly Europe
Product bans	Ban on the sale of plastic bags; some jurisdictions also ban the production and distribution of plastic bags	San Francisco first to ban bags in the U.S., also South Africa and many other countries
Product restrictions	Restrictions on the manufacture, distribution, or sale of a specific product based on size, capacity, material type, thickness, etc. Not a complete ban. For bags, some jurisdictions limit based on a retailer’s annual sales.	San Francisco, South Africa and elsewhere
Reusable bag credits, giveaway, deposit system, or sale	Credits provided when bags are brought back to a store for reuse, displacing the need for the store to provide new bags. Often $0.01 to $0.05 in credit per bag returned to store; loyalty points awarded when shoppers bring their own bag; reusable bags offered for sale in stores (IKEA)	United Kingdom, Seattle; Many US cities

Table ES-2. Summary of policy options adopted by jurisdictions outside of Seattle to address disposable food service items.

Current Strategy	Description	Jurisdiction
Curbside recycling	Clean PS cups, containers, and packaging placed in curbside collection bins for later sorting and marketing.	Los Angeles
Private recycling	Commercial and industrial EPS collected privately (primarily packaging foam from commercial generators) though there is a nascent food service effort underway.	Portland Seattle Los Angeles
Product bans	Ban on the sale of disposable food service items (primarily EPS); some jurisdictions also ban polyvinylchloride (PVC) food contact items	Many California cities, Portland, some east coast cities, Europe
Voluntary product bans	Incentives provided for retailers to voluntarily ban disposable plastic food service items (primarily EPS). Often, mandatory bans take effect after a certain time period if voluntary ban is ineffective.	Santa Cruz
Product restrictions	Restrictions on the manufacture, distribution, or sale of a specific product based on size, capacity, material type, thickness, etc.	Taipei (dishes)
Advanced recovery fee	A fee levied on the supplier or consumer of a product and retained by the retailer and/or government to offset the costs of disposal, discourage further use, and publicize reuse and recycling options.	Germany
Environmental preferable packaging	Laws and standards that stipulate percentage recycled material content, percent to be recycled, or requirement for compostability.	California, Oregon, Wisconsin

Life Cycle Analysis

In order to inform the development of policy options under consideration by the City, the environmental impacts of existing and alternative shopping bags and food service items were reviewed and analyzed, primarily through published Life Cycle Assessment (LCA) studies. Neither a full LCA nor a partial LCA was prepared for this report. Despite acknowledged limitations to LCAs, the goal of this study's review of LCAs is to create a level of environmental comparison between alternative products (and within different policy strategies) not previously made available to the City of Seattle.

Clear trends emerged from the review of LCAs regarding disposable shopping bags, including:

- Plastic shopping bags entering the marine environment represent a threat (not quantified) to marine life along with other packaging and other littered items.
- In most instances, a switch to reusable bags provides the greatest environmental benefits if reused a minimum number of times. The environmental benefits of the reusable bag relative to those of disposable

plastic bags depend on the number of times it is reused. Policies developed to discourage disposable shopping bags should focus on consumer behavior to maximize this approach.

- There was general agreement among the studies that paper bags were shown to have the greater environmentally burden, due primarily to the greater amount of resources (materials [including water], and fuels for transport from greater weight per bag) that they require.

Based on the review of available disposable bag LCAs, four policy options aimed at reducing disposable bag use were evaluated. The policy options address both paper and plastic disposable bags, and emphasize the use of reusable bags in their place. While the use of biodegradable bags shows some potential for environmental benefit, Seattle's existing plastic bag recycling and composting systems cannot support the levels of contamination that would be expected if a mixture of plastic and biodegradable shopping bags were used throughout the City.

In contrast, few clear trends emerged from the review of LCAs regarding disposable foodservice items:

- A shift from disposable food service items to biodegradable food service items would benefit litter impacts on marine ecosystems due to the faster rate of degradation.

- Reports showed that environmental trade-offs exist when considering a switch to alternative materials for foodservice items. For some materials and in some product applications, either polyethylene (PE)-coated paperboard (standard paper coffee cups are usually PE-coated), reusable EPS, polycarbonate (PC), polypropylene (PP), paper, or PLA performed best in the environmental categories considered.

Based on the review of available food service items LCAs, four policy options aimed at reducing disposable food service items use were evaluated. The policy options address both EPS and other disposable food service items, and emphasize the reduction of litter and environmental impacts from disposable food service items through the use of biodegradable products. The absence of a comprehensive labeling system for compostable and biodegradable plastics is less of a problem related to these products, since the target is much narrower and aimed at commercial establishments using "take-away" packaging.

Waste Reduction Program Strategies

Disposable Shopping Bags

The strategies to address disposable shopping bags were narrowed to the following four for further life cycle cost/benefit and environmental assessment.

- Enhanced education: Begin a public education and promotional campaign specifically focused on encouraging consumers to use reusable bags in place of disposable bags. This would become part of Seattle Public Utilities'(SPU) ongoing reduce-reuse-recycle messaging. Activity may include varying degrees of technical assistance.

- Enhanced education plus ban on disposable plastic shopping bags only at all stores in Seattle.

- Enhanced education plus a mandatory advanced recovery fee (ARF) (likely range, 10 to 25 cents) on disposable plastic shopping bags only. The ARF could be remitted entirely to the City, split by the City and merchants who would use their share to promote reusable alternatives and recycling, or retained entirely by merchants for promotion and administrative costs.

- Enhanced education plus advanced recovery fee (ARF) (likely range, 10 to 25 cents) on all disposable shopping bags. The ARF could be remitted entirely to the City, split by the City and merchants who would use their share to promote reusable alternatives and recycling, or retained entirely by merchants for promotion and administrative costs.

Cost benefit analysis of these policy options provides an insight to the likely impacts of the measures — if implementation and consumer behavior proceeds as expected. According to research, the intent of LCAs is to show the relative importance of the different environmental categories for improvement analysis (Rosselot, 2004), in our case, for each of the strategies evaluated. Table ES-3 shows a comparison between all environmental categories and the net present value (NPV) economic costs and benefits calculated earlier.

Table ES-3. Economic and environmental costs and benefits normalized to status quo.

	Units	Status Quo	Education	Ban Plastic	ARF on Plastic	ARF on Both Paper and Plastic
NPV	$	100%	97%	77%	79%	60%
Non-Renewable Energy	Megajoules (MJ)	100%	96%	70%	72%	48%
GHG Emissions	kg CO2 eq.	100%	96%	79%	77%	49%
Resource Depletion (Abiotic)	kg Sb eq.	100%	96%	65%	69%	48%
Eutrophication	kg PO4 eq.	100%	96%	100%	87%	48%
Litter Marine Diversity	kg	100%	96%	26%	50%	47%
Litter Aesthetics	Square meters	100%	96%	28%	51%	47%
Waste Generated	Tons	100%	96%	86%	80%	47%

Notes: 1. Environmental category units produced summed over a 30-year time frame
2. (NPV) economic costs and benefits over a 30-year time frame
3. Discount rate: 3 percent

The shaded fields in the Table ES-3 show those strategies with highest reductions in each of the economic cost and environmental burden categories, compared to the status quo. An ARF on all disposable shopping bags provides the most environmental gains (except for litter), and provides for much higher overall economic gains when compared to all strategies. With an ARF on all bags, consumers experience slightly less costs than with a plastic only ARF (due to an anticipated increase in reusable bags), and the region experiences much more economic cost (due to decreased paper production). Again, the City and retailers may both benefit from revenue under either a plastic only or an all-bag ARF

Disposable Food Service Items

The strategies to address disposable food service items were narrowed to the following five for further life cycle cost/benefit and environmental assessment:

- Enhanced education: Begin a public outreach, education and promotional campaign specifically focused on owners/managers of restaurants, cafes, and coffee shops to encourage replacement of disposable food service items with recyclable or compostable alternatives managed through recycling and food waste composting programs. This would become part of SPU's ongoing reduce-reuse-recycle messaging. Expanded polystyrene (EPS) products would be especially discouraged.

- Enhanced education plus ban on expanded polystyrene (EPS) products: Implementation of mandatory ban on EPS food service items only at all food vendors in Seattle. Ban to be phased in plus a later deadline for all food service items to be compostable or recyclable with restaurants enrolled in composting or recycling programs.

- Enhanced education plus advanced recovery fee (ARF) on expanded polystyrene (EPS) products only. The ARF (likely range, 10 to 25 cents) could be remitted entirely to the City, split by the City and merchants who would use their share to promote reusable alternatives and recycling, or retained entirely by merchants for promotion and administrative costs.

- Enhanced education plus advanced recovery fee (ARF) on all non-compostable and non-recyclable food service ware items. The ARF (likely range, 10 to 25 cents) could be remitted entirely to the City, split by the City and merchants who would use their share to promote reusable alternatives and recycling, or retained entirely by merchants for promotion and administrative costs.

Table ES-4 shows a comparison between all environmental categories and the NPV economic costs and benefits calculated earlier. These results were derived from a case study of hot food "clamshell" type containers and may not apply in other cases. (See page 6-23 for the assumptions regarding vendor and consumer behavior when required to switch products.)

Table ES-4. Economic and environmental costs and benefits normalized to status quo.

	Units	Status Quo	Education	Ban EPS	ARF on EPS	ARF on All Types
NPV	$	100%	119%	169%	176%	199%
Non-Renewable Energy	Megajoules (MJ)	100%	105%	214%	173%	156%
GHG Emissions	kg CO2 eq.	100%	105%	234%	185%	162%
Ozone	g ethylene eq.	100%	100%	134%	120%	105%
Acidification	kg SO2 eq.	100%	104%	179%	149%	142%
Eutrophication	kg PO4 eq.	100%	101%	104%	103%	108%
Waste Generated	Tons	100%	105%	240%	189%	162%

Notes: 1. Environmental category units produced summed over a 30-year time frame
2. (NPV) economic costs and benefits over a 30-year time frame
3. Discount rate: 3 percent

The shaded fields in Table ES-4 show that all strategies have increases in each of the economic cost and environmental burden categories, compared to the status quo. However, the permanence of plastic in the environment dictates its use be minimized. An ARF on all non-compostable, non-recyclable clamshells reflects the least environmental impacts among bans and ARFs. This is due primarily to the incentive toward compostables (e.g., polylactic acid, PLA), which results in lower impacts than paper and polyethylene terephthalate (PET) in the environmental categories considered. The exception is in eutrophication potential, due to nitrogen and phosphorus runoff in agriculture.

Higher composting rates for compostable products, and the potential increase in organics composted with compostable food service products, would likely provide additional energy and greenhouse gas benefits, and cost savings.

1 Introduction

The principles of "reduce, reuse, and recycle" have long been established in the City of Seattle's solid waste plans. In recent years, Seattle's citizens and leaders have increasingly sought to accelerate the City's progress on recycling and waste reduction, as well as to reduce pollution of terrestrial and marine environments and global warming.

In November 2006, in response to these interests, the City produced a report entitled "Seattle Solid Waste Recycling, Waste Reduction, and Facilities Opportunities" that investigated three major facets of the solid waste management program: collection of waste and recyclables; existing/proposed solid waste facilities; and zero waste principles and product stewardship (Seattle 2007a).

The primary focus of the study was to evaluate the flow of resources and waste through the City's solid waste system to identify opportunities to create enhanced and/or more efficient waste reduction and recycling programs, and facilities, for the future. The study also looked beyond recycling using a "whole system" approach that attempts to guide people to emulate sustainable natural cycles, where discarded materials become resources for others to use, and are not burned or landfilled. The study also highlighted the desire of the City to target additional areas for product stewardship. Product stewardship (also known as extended producer responsibility, EPR) requires those involved in the life cycle of a product (e.g., designers, suppliers, manufacturers, distributors, retailers, consumers, recyclers and disposers) to share responsibility for the environmental effects of the products, and to minimize the impacts of that product on the environment.

During the study process, one of the paramount issues raised by the public were the solid waste disposal and environmental problems – including greenhouse gas emissions – that result from the use of designed-for-disposal plastics and other materials, particularly shopping bags and food service items. City staff had previously evaluated a ban on polystyrene food packaging in September 2006, including a discussion of the following issues:

- Background on policies and environmental issues
- Alternative food packaging
- Economic analysis
- Enforcement strategies
- Case studies – other cities' ordinances

During preparation of the City's Solid Waste study, preliminary research on several options for addressing plastic bags, food service items, and other materials in Seattle's municipal solid waste were conducted. The options related to plastic bags and food service items included:

- Enforcing existing disposal bans in commercial and residential waste for recyclable materials such as plastic bags (Options #152 and #349)

- Implementing an ordinance that mandates the use of compostable plastic bags (Option #353)
- Developing a public/private initiative with local grocery chains to reduce plastic bag use (Option #193)
- Creating a deposit program targeting common items in our waste stream (Option #246)
- Requiring shoppers to pay a fee for paper or plastic grocery bags, but offer reusable canvas bags for sale at the checkout counter (Option #396)
- Banning polystyrene take-out containers and require a switch to plates, and cups, etc. made from products such as compostable corn (PLA) and sugar cane fiber (bagasse)(Option #228)
- Developing an anaerobic digestion reactor facility to process organic waste (including items such as compostable food service containers) and produce biofuels for energy production (Option #350).

However, the research was not at a level of detail sufficient to evaluate the environmental trade offs in terms of environmental impacts and cost.

City Council and Mayor’s Action

On July 16, 2007, after the study results were published, the City Council and Mayor Greg Nickels passed Resolution 30990, which strongly recommitted the City to waste reduction and applying innovative recycling strategies to address components of the City’s solid waste stream. It was intended and anticipated that programs and initiatives to be developed would yield significant environmental gains and not just tonnage diversion (Seattle 2007a). Under Attachment A of the resolution, *Waste-reduction Actions*, SPU was specifically directed to conduct research on product bans related to plastic bags and food containers:

> “Initial products for review will include non-compostable plastic shopping bags and Styrofoam food containers, for which SPU will complete its study and recommendations by the earlier deadline of December 2007.”

This report is the result of collaboration between SPU and Herrera Environmental Consultants in response to the Resolution 30990 directive.

Contents of this Report

This report is comprised of five sections, each contributing research results and context in order to provide the City of Seattle with relevant information to inform policies being developed for two product categories: 1) disposable plastic and paper shopping bags; and 2) expanded polystyrene foam (EPS) and other plastic disposable "to-go" food packaging (including, but not limited to "clamshells," tableware, plates and trays, bowls, and hot and cold beverage containers). City staff determined early that this report should include all products in use for a particular function (e.g., serving hot food, carry purchases home from a store) in order to avoid unintended adverse environmental consequences that might arise from a focus only on particular materials.

- The first section presents a summary of the environmental concerns surrounding the increasing use of these two product categories.
- The second section presents the results of research on the current strategies being used worldwide to reduce the use of or amount of these two product categories.
- The third section presents the results of research into the current availability, and future likelihood of the development of, reusable, compostable, or recyclable materials and products that can be used as alternatives to these two product categories.
- The fourth section presents the results of a review of published life cycle assessments (LCA) comparing the environmental burdens associated with these two product categories for a variety of material types.
- The fifth section presents the strategies identified as possible policies to be used in Seattle to reduce the use of these product categories. Summary results of stakeholder input regarding prospective policies are also presented. This section also presents the results of an economic cost/benefit assessment and an environmental impact assessment of each of the strategies identified.

Conclusions and recommendations are provided at the end of the report.

2 Environmental Concerns

There are significant environmental concerns over the use of disposable bags and food service items, including adverse effects on human health, global warming and resource consumption, terrestrial and marine ecosystems, and solid waste management. All of these concerns also require significant public funding to manage or mitigate. These concerns, highlighted in this section, have prompted cities and countries worldwide to seek out alternatives to traditional bags and food service items (mainly plastic) that are less harmful to human health and the environment. These environmental concerns apply in varying degrees to all bags and food service items, including those that are recyclable, reusable, or biodegradable/compostable. The relative environmental impacts of traditional shopping bags and food service items and alternative products are described later in this report.

Human Health

Human health is affected in many instances by both paper and plastic product production and use. The plastics industry has made consistent gains in "lightweighting" products in recent decades, using less material in product applications with no loss of quality or function. These advances have helped lessen many environmental impacts. However, other concerns persist. The U.S. Environmental Protection Agency (EPA) has suggested that there is evidence of styrene leaching into food and drinks that are stored in polystyrene (PS) containers. A study conducted for the California Integrated Waste Management Board (CIWMB) concluded that many reports support the contention that the styrene monomer used in the production of polystyrene food containers migrates into food and drinks. (CIWMB 2004) A study conducted by the Harvard Center for Risk Analysis concluded that "Styrene's carcinogenicity in humans cannot be ruled out at this time. However, styrene exposure levels among the general population and among most workers are for the most part very low." The study also concluded "… that occupational exposure to styrene does have a subtle effect on color vision." (as cited in CIWMB 2004). As a result, styrene is a suspected neurotoxin and is labeled carcinogenic by the Washington Department of Ecology (Ecology) (WTRI 2006; SPU 2006).

In addition, phthalates are a ubiquitous family of chemicals used as plastic softeners or as solvents in numerous different consumer products including polyvinylchloride (PVC) food service items. Phthalates are known to cause reproductive system and sexual developmental abnormalities, birth defects, and damage to the liver, kidneys, and lungs (SGS 2005).

The paper industry has also made progress environmentally in the last decade, using its own waste as biomass energy for production (a long standing practice), recycling production water, recovering pulping chemicals, and reducing bleaching chemicals. However, the paper industry is still a major source of toxic chemical pollution. According to the Washington Toxic Release Inventory for 2004, paper and allied products manufacturing accounted for 7.8 million pounds of toxic releases in that year (26% of the total). Releases were primarily methanol, hydrochloric acid, ammonia, and nitrate compounds, but included dioxins, polycyclic aromatic compounds, lead, acetaldehyde, formaldehyde, benzene, toluene, mercury, and arsenic among others. (WTRI 2006). This represents a decrease of 50% from 1995.

Global Warming and Resource Consumption

Global warming is the ongoing heating (currently considered to be primarily anthropogenic) of the Earth's atmosphere. Humans contribute to global warming by consuming non-renewable resources such as fossil fuels/energy, as well as water during plastics production (IFEU 2006). Fossil fuels are also consumed during manufacture of paper bags and food service items, and are used extensively in agriculture to grow crops (e.g., corn, potato, sugar cane) from which compostable plastics are derived.

High-density polyethylene (HDPE), low-density polyethylene (LDPE), and PS are made from non-renewable fossil fuels (e.g., natural gas and oil) and do not biodegrade. Raw materials extraction; refining; chemicals used during manufacturing; and the use of water for process or cooling (particularly for paper manufacturing) pose a variety of environmental impacts. In the 1990s, expanded polystyrene (EPS) manufacturing used methods that emitted chlorofluorocarbons (CFCs), an ozone depleting gas. Now pentane is commonly used as the new manufacturing agent. Pentane is currently not attributed to ozone depletion but does create earth-level smog and contributes to global climate change (SPU 2006).

Producing traditional plastics also contributes to eutrophication (as does the production of biodegradable plastics) and oxygen depletion, acidification, and smog/ozone production. Eutrophication occurs when excessive amounts of nutrients (e.g., nitrogen) are released to soil or surface water by atmospheric emissions or industrial effluents; the oversupply of nutrients in soil or surface water can lead to an imbalance in aquatic systems that depletes oxygen causing the death of aquatic organisms. Acidification of air and land also occur when fossil fuels are burned and acid-forming gases such as sulfur dioxide are released. Acidification is related to photochemical smog and poor air quality conditions that cause asthma and other respiratory conditions as well as weakened immune systems (IFEU 2006).

Paper and biodegradable plastics production requires harvesting of trees and other crops (i.e., corn, sugarcane, potato). Most researchers generally assume that the carbon dioxide originating from biomass is equivalent to the amount which was previously withdrawn from the atmosphere during growth and that it therefore does not contribute to global warming. However, fossil fuels required for transport, processing the crops and producing auxiliaries (e.g. fertilizers), do contribute (Franklin 2006). Deforestation also has impacts on forest plant and animal communities separate from the global warming implications.

The manufacturing process for pulp and paper mills are also large sources of air pollutants, such as CO2, nitrous oxides, sulfur dioxides, carbon monoxides, and particulates. The pollutants contribute to global warming, as well as ozone, acid rain, and respiratory problems (WTRI

2006). Finally, the manufacturing of paper, plastics, and biodegradable plastics products are particularly energy intensive. Though many paper mills burn biomass for energy, electricity used in production also contributes to greenhouse gas emissions (for coal, biomass, and natural gas fired power generation).

Terrestrial and Marine Ecosystems

The 2004 Washington State Litter Study indicated that disposable plastic bags, disposable paper bags, and plastic and paper “one-time fast food service items” represented almost 7% of the litter stream. This accounts for almost 500 tons of litter in Washington State. (Ecology 2005) Bags and food service items discarded on city streets (or that are fugitive from public trash receptacles, garbage and recycling trucks, or from events) are often blown away or get washed away in storm water. A pilot study of the composition and sources of marine litter in Lake Union concluded that in most categories, lake litter was similar to that found in land settings, except for increased levels of miscellaneous plastic, and decreased levels of paper. This was attributed to the persistence of plastic (i.e., a longer “half-life”) and the sinking or biodegradation of paper in water. (Bagley 2004)

The Algalita Marine Research Foundation reports that land-based discharges of human-made debris (much of it as various kinds of plastics) comprise up to 80 percent of marine debris in oceans world-wide (Algalita 2007). EPS in particular is a unique management issue due to its light weight that allows EPS to float easily on water and be taken by the wind even when disposed of properly. Petroleum-based plastics in the ocean break down via the forces of tides and ultra violet into small pieces, but do not biodegrade; marine mammals and birds confuse polystyrene as a food source which often results in appetite loss and depleted nutrient absorption. In some cases, the ingestion of polystyrene by animals leads to death by starvation (Reany 2002).

Small plastic pellets, from which plastic products are produced, often escape into storm drains, and eventually end up floating out to sea. In 2007, California Governor Arnold Schwarzennegar signed Bill AB 258 that requires plastics manufacturers to prevent pellets from escaping into storm drains (Heal the Bay 2007). Pellets can be attractive to marine life because they look like fish eggs, yet they can also be highly poisonous because they have a high surface area and concentrate toxic pollutants such as polychlorinated biphenyls (PCBs). Tokyo University geochemist Hideshige Takada has found that plastic pellets eaten by birds concentrate toxic chemicals to as high as one million times their normal levels in seawater (FEE 2007).

According to the City of Oakland, California, 15% of the litter collected in storm drains is polystyrene foam. In a study by the EPA in nine coastal U.S. cities, including Seattle, plastic pellets and spheres or polystyrene pieces were the most common floating debris items encountered in all but one case. In Santa Monica and other cities EPS and other plastics have clogged storm drains (causing flooding) and littered otherwise scenic beaches (Santa Monica 2007). In Seattle, polystyrene pieces were the largest contributor to floating debris (EPA 1990).

Los Angeles County studied plastic carryout bag litter and found that indiscriminate littering of plastic carryout bags was an increasing blight. (Los Angeles County 2007) The report found that due to the light weight and expansive nature of the bags, they easily became airborne and were often caught on fences and tangled in bushes. Los Angeles County estimates that tens of millions of dollars are spent annually on cleanup, but plastic bag litter is still a serious problem even though thousands of residents annually volunteer hours in beach, roadside (e.g., Adopt-A-Highway programs), park, and neighborhood cleanup projects. (Los Angeles County 2007)

There is uncertainty as to whether bags or food service items made from degradable plastics will help solve the litter problem. Biodegradable plastic bags will disintegrate relatively quickly if exposed to heat, ultraviolet (UV) light, mechanical stress and/or water, but will not biodegrade in the absence of microorganisms (Nolan-ITU 2003). It is also uncertain whether degradable items will have an impact (positive or negative) on littering behavior. The potential impacts on fish and other marine life are also not clear; although the items may degrade more quickly into small pieces that may make them less likely to be ingested by larger animals, smaller pieces might be mistaken as food for smaller animals (Nolan-ITU 2003).

Solid Waste Management

The City of Seattle is constantly expanding and implementing new waste reduction and recycling programs. These programs are focused on raising environmental awareness; promoting environmental stewardship; and, promoting sustainable use of resources. Together, disposable shopping bags and food service items make up less than 1 percent of Seattle's residential and commercial waste stream. While the tonnage is not significant, the lightest plastics (polyethylene (PE) bags, EPS, PS, and other plastics that shopping bags and food service items are made from) in the waste stream complicate waste handling procedures, increase equipment maintenance needs, decrease other recycled commodity quality, and generally add cost to waste management programs (SF Environment, 2007b).

Many plastics such as PS and EPS are considered contaminated if encrusted with food, and are difficult or costly to recycle. According to the CIWMB, "there is no meaningful way to recycle food service PS. It also poses a transportation challenge due to its light weight and other collection difficulties" (CIWMB 2004). In 1989, industry established the National Polystyrene Recycling Company (NPRC) to recycle PS food service and molded packaging. Due to food contamination, and the light weight resulting in high transportation costs and other collection challenges, there was a reluctance to collect the food service PS for recycling from all sectors including the commercial food service industry. It was also difficult to compete with cheaper virgin resins that had higher quality. Corporations involved with the NPRC invested $85 million between 1989 and 1997 to operate the recycling facilities, yet never achieved profitability (CIWMB 2004).

Both the paper industries and the plastics industries perform well at utilizing post-industrial scrap back into production processes. However, apart from the solid waste issues associated with product use, both paper fibers and plastic resins can be recycled only a limited number of times. For paper production, recycled fibers eventually become too short or weak to make high quality paper and bags. Wastes from paper recycling, known as "sludge," contribute to the overall solid waste stream, and depending on disposal techniques, could raise concerns about trace contaminants building up in soil or water, or potentially contributing to air pollution problems. For plastics production, recycled resins eventually build up a heat history that breaks down polymer chains and diminishes their performance. Eventually, all of these materials end up in a landfill (as in the Northwest), or incinerated. So, while recycling is the preferred option for these products if they are produced and used, the City of Seattle and Washington State prescribe to the "reduce first" hierarchy.

3 Current Strategies for Reducing the Use of or Amount of Disposable Shopping Bags and Food Service Items in the Waste Stream

This section discusses current strategies used by the City of Seattle and other jurisdictions, both within and outside of the United States, to reduce the use of or amount of disposable shopping bags and food service items in the municipal solid waste stream.

Seattle Strategies

Since 1988, Seattle has implemented different strategies to increase the diversion of recyclable and compostable materials from landfills. The policies adopted to address disposable shopping bags and food service items, existing infrastructure for handling these materials, and the effectiveness of the strategies adopted are summarized below.

Policies Adopted

Seattle’s current policy for addressing shopping bags in the municipal waste stream was adopted at the inception of curbside recycling in 1988 (for paper), and in 2000 (for plastic). For both, the policy is a focus on waste reduction and recycling education and services to allow for recycling of those items. Beginning in 2005, the City allowed Seattle residents to commingle food scraps and other non-meat organics including compostable paper with yard waste for curbside collection and composting (SPU 2005). At the time, the City did not adopt measures to address compostable plastic bags or compostable food service items, although the policy and existing infrastructure could potentially allow for future use of these emerging technologies. In 1988 Seattle passed Ordinance #114035 banning the use of expanded polystyrene (EPS) food and beverage materials by Seattle City Government and food vendors at City facilities.

Existing Infrastructure

Collection of municipal solid waste in the City of Seattle is currently handled by two contracted waste haulers; Waste Management, Inc. provides collection of garbage, recycling and yard waste to the north half of the city; and U.S. Disposal (a subsidiary of Allied Waste) provides these services to the south half of the city. These contracts are currently being re-bid. Allied Waste also provides recyclables processing services to the City under contract. The City is currently in the process of redesigning the South and North Recycling and Disposal Stations ("SRDS" and "NRDS") to accommodate expanded recycling, a retail re-use facility, and self-haul waste and collection trucks in roughly the same proportions that these activities are currently handled by the existing stations.

The existing collection and processing infrastructure is designed to allow and handle, along with paper shopping bags, the curbside collection of plastic shopping bags that are bundled and commingled with other recyclables (except glass). There is no infrastructure for recycling disposable food service items. Although the infrastructure could handle compostable plastics, the City has not adopted a policy to encourage people to compost these materials because only some of the available products on the market today are approved by Cedar Grove Composting. Cedar Grove is contracted to process (through composting) the City's organics waste stream.

Recycling

Seattle's curbside recycling program for single family through fourplex sized structures began in February 1988. At the start of the program, the materials collected were newspaper, mixed paper (including paper bags), glass, aluminum and tin food cans. PET bottles were added in 1989, high density polyethylene (HDPE) plastic bottles were added in 1991, and ferrous metals were added in 1993. With implementation of new collection contracts in 2000, residents were allowed to commingle recyclables including bundles of plastic shopping bags in one container (except for glass which is collected in a separate curbside tote)(SPU 2007).

Seattle accepts clean and dry plastic shopping bags, dry cleaning bags, and newspaper bags for recycling in its curbside residential and commercial collection program. Plastic bags must be stuffed into one bag, tied securely, and put into the commingled recyclables container. In addition to residential and commercial curbside collection of plastic bags, many Seattle-area grocers have voluntarily set up collection bins where costumers can take back plastic shopping bags for recycling.

Seattle has not established recycling for polystyrene (PS) or EPS, but the technology exists and other jurisdictions do recycle these materials. One reason Seattle does not recycle PS and EPS food service is that food residue is a contaminant that makes it very difficult and expensive to recycle the material. However, a recycling process being used in Los Angeles and elsewhere utilizes a pre-wash, wash, and drying procedure to clean the polystyrene prior to remolding it into new products (PDR 2007).

EPS from industrial manufacturing and packing of products such as consumer electronics is currently recycled by some private companies. EPS densifiers, which condense the material by grinding and then melting it into a recyclable patty that is 1/80th the volume of the original scrap foam, help enhance the economics of recycling this material (AFPR 2007). At least one Seattle-area recycler is considering the addition of polystyrene packaging to the items accepted for recycling, and another area recycler is considering accepting post-consumer EPS food service items for recycling.

A Portland-based company has incorporated Extended Producer Responsibility (EPR) into its business model in response to Portland's ban on EPS. The company distributes disposable food service items manufactured of polystyrene plastic and recycled products to schools, health care facilities, correctional facilities, and other institutions that use large volumes of these materials; the company provides a service to pick up and recycle any products it sells (RP 2007).

Composting

Seattle Public Utilities (SPU) began a curbside yard waste collection program in 1989 that quickly achieved a participation rate of over 60%, and rose to 63% by 2005. Beginning in 2005, the City allowed Seattle residents to commingle food scraps and other non-meat organics, and including compostable paper, with yard waste for curbside collection and composting (SPU 2005). A December 2005 survey found that 49% of residents said that they use the service, and 26% reported that they used it for most or all of their food waste. One result of the curbside collection of compostables was that home composting dramatically decreased in favor of curbside composting (SPU 2005).

Although the City does not encourage consumers to recycle clean paper bags via the yard waste bins, other paper products, such as paper cups, plates, and napkins are acceptable. Whether or not certain compostable products are acceptable in the organics collection system is heavily dependent on the acceptance criteria of Cedar Grove. Cedar Grove utilizes their own testing protocol to assure decomposition in their own system. In addition, their system is sensitive to how much of the collected material is comprised of organic material (such as food and yard waste) versus compostable paper, plastic, etc. (CG 2007). Furthermore, Cedar Grove also has concerns that if compostable plastic bags and food service items were accepted in the organics waste stream destined for their facility, non-compostable plastics would likely be mixed together and cause product quality problems and/or higher processing costs.

Policy Effectiveness

Seattle's 2004 residential waste composition study indicates that an estimated 1,901 tons of plastic bags and 3,198 tons of paper bags were generated in 2007. Calculations are shown in Table 3-1. (Seattle 2007a) The plastic bag recycling rate is an estimated 13%, higher than the national average of 3-5%, but this rate still leaves approximately 1,650 tons to be disposed. The net cost to the City and ratepayers of collecting, transferring and disposing of waste is approximately $121 per ton (including applicable City fees and taxes) or approximately $200,000 for plastic grocery bags. Appendix O contains a summary of all costs attributable to plastic bags, using a methodology originating with the City of San Francisco. A comparison with the City of San Francisco's analysis is also provided. The information is presented for information only, since a number of assumptions used in the methodology are not applicable to the City of Seattle." The paper bag recycling rate is estimated at 82% (residential sector only), reflecting the longer period for program education and participation.

The total amount of food service items generated for 2007 is difficult to estimate, as SPU's waste composition study distributes these items across several categories due to their differing materials: compostable/soiled paper, expanded polystyrene, and other rigid packaging. Seattle's 2004 residential and commercial waste composition studies estimate the total amount for these categories at 30,000 tons (24,000 tons paper, 2,000 tons EPS, and 4,000 tons other rigid plastic). An unknown percentage of the compostable paper is included in curbside organics collection. None of the EPS or other rigid packaging tonnage is recovered. (See SVA Seattle 2007; Seattle 2007)

It is difficult to ascertain how much effect Seattle's recycling programs have had on decreasing litter compared to decreases that are attributable to successful anti-litter campaigns. For example, in 2001, Ecology began planning a comprehensive litter prevention strategy to change the behavior of residents, and in 2005 launched the "Litter and it will hurt" campaign with a series of news conferences (SPU 2005). Notably, this campaign was launched just after Seattle implemented "new" solid waste contracts in 2000 that expanded its recycling program.

Table 3-1. Estimated shopping bag recycling program effectiveness (residential only).

	Percent of Residential Waste Disposed 2004 Comp.	2007 Estimate	Estimated Percent of Waste Comp. Category
Est. 2008 SF/MF Waste Generated (Tons) [a]		291,578	
Grocery/Bread Bags	0.82%	2,377	80%
Plastic Grocery Bags Generated (Tons)		1,901	
Plastic Grocery Bags Recycled (Tons)		240	
Recycling Rate		13%	
Old corrugated cardboard (OCC)/Kraft Paper	6.03%	17,592	15%
Mixed Low Grade	9.59%	27,950	2%
Paper Bags Generated (Tons)		3,198	
Paper Bags Recycled (Tons)		2,622	
Recycling Rate		82%	

[a] See (SPU 2007) Seattle Solid Waste Recycling, Waste Reduction, and Facilities Opportunities. May 2007; and (SPU 2006) *"Copy of Revised 60% projections_March 24_ 2006 Update"* prepared by SPU Staff, March 2006.

A state litter study conducted in 2004 found a strong downward trend in overall litter generation between 1999 and 2004 on county roads and on interchanges, especially in the winter. The decrease in accumulation of fast-food containers on interchanges was statistically significant. On all road types, littering of these containers showed a strong downward trend: paper one-time take out food containers comprised 102 tons (1.6% of the total litter collected), plastic one-time take out food containers comprised 52 tons (0.9%), paper bags comprised 104 tons (1.7%), and plastic bags and film totaled 183 tons (2.9%) (Ecology 2005).

Other Strategies

Jurisdictions other than Seattle, in the United States and in other countries, have used a variety of strategies to reduce consumption of plastic (or paper bags) and plastic food service items. These strategies are briefly summarized below and described in detail later in this report.

Disposable Shopping Bags

Strategies used by other jurisdictions to address the use of disposable shopping bags include curbside recycling, in-store recycling, in-store credits when customers bring their own bag, a deposit system, education, fees, taxes, producer responsibility mechanisms, product bans, mandatory and voluntary product restrictions, reusable bag giveaways, and labeling requirements (i.e., whether bags are recyclable or compostable).

Some examples of jurisdictions that have taken action to address plastic bag use include San Francisco, and many other California cities; cities in Maine, Michigan, New York, New Jersey, Oregon, and Rhode Island; Australia; Bangladesh; Britain; Denmark; Ireland; Italy; New Zealand; South Africa; Taiwan; Hong Kong, and Shanghai, China.

Policies Adopted

Table 3-2 summarizes policy options adopted by other jurisdictions to address the use of disposable shopping bags. These options are summarized in greater detail in Appendix A.

Implementation Strategies and Lessons

In the European Union, plastic bags are not specifically targeted for recycling; all packaging material is targeted for recycling using Producer Responsibility mechanisms under a Packaging Directive. Different Member States use different approaches, but in most countries producers in the packaging industry (referred to as 'Green Dot' bodies for the green dots placed on recyclable packaging after the pioneering program in Germany) make payments to designated bodies (third party or government agencies) who are responsible for arranging for the collection, separation, recycling and recovery of the required amount of packaging (Nolan-ITU 2002).

Voluntary strategies implemented by supermarkets and advocacy organizations concentrate on reducing demand for the bags through education. These programs show limited success since retailers and consumers have little incentive to participate or limit their demand for bags (ICLEI 2005). In contrast, supply-side actions such as bans, taxes, and levies or voluntary or mandatory take back programs have been successful in countries such as Australia, Bangladesh, Denmark, Taiwan, Ireland, South Africa, and the United States. These programs place more of the burden for bag choice and their disposal on the producers and suppliers.

Ireland instituted the "Plastax" in March 2002 to help eliminate plastic bag litter and as a waste minimization measure (Nolan-ITU 2004). The fee amounted to approximately $0.21 (US) per bag, to be paid by the consumer and itemized on the sales receipt. Certain types of bags were excluded (e.g., reusable bags, produce bags). A significant educational component was introduced well in advance of the effective date to inform consumers and to explain the environmental rationale behind the fee. In South Africa, the threat of a ban on plastic bags prompted industry representatives to become proponents of a levy as a means to supplant the proposed ban (Nolan-ITU 2002). A framework for a levy was subsequently drafted in 2003 between labor and business organizations and the Minister of the Department for Environmental Affairs and Tourism (DEAT). As part of the agreement, light weight plastic bags thinner than 30 microns were banned since this type of bag is most prone to being spread as litter.

Table 3-2. Summary of policy options adopted by other jurisdictions to address plastic bag use.

Policy Option	Description	Jurisdiction
Education and/or labeling requirements	Aimed at changing consumer behavior or product choices toward reusable, compostable, or recyclable alternatives)	Seattle and numerous other jurisdictions
Curbside Recycling	Bags placed in curbside collection bins for later sorting and marketing. Bags including shopping, grocery, newspaper, dry cleaning, bread, produce, paper	Seattle; 25 cities in Los Angeles County
Voluntary Measures	Voluntary restrictions placed on disposable bag use by retail outlets or others. Sometimes associated with targets for use reduction or recycling	Australia, Great Britain, Hong Kong
Mandatory advanced recovery fees (ARF)	A fee levied on the supplier or consumer of a product and retained by the retailer and/or government to offset the costs of disposal or recycling, discourage further use, and publicize reuse and recycling options. Paper, plastic, or both; fees range from $0.007 to $0.25 paid by supplier, distributor, retailer, or consumer; funds used by city, retailer, or both (some abuse)	California
In-store recycling	Voluntary or mandatory effort by retailers to provide facilities to accept plastic bags back for recycling. Mandatory in California but driven by the market elsewhere and favored by grocers and bag manufacturers	California; UK
EPR mechanisms	Funds from product manufacturers are utilized to facilitate collection, processing, and advancement of end-uses.	Mostly Europe
Product bans	Ban on the sale of plastic bags; some jurisdictions also ban the production and distribution of plastic bags	San Francisco first to ban bags in the U.S., also South Africa and many other countries
Product restrictions	Restrictions on the manufacture, distribution, or sale of a specific product based on size, capacity, material type, thickness, etc. Not a complete ban. For bags, some jurisdictions limit based on a retailer's annual sales.	San Francisco, South Africa and elsewhere
Reusable bag credits, giveaway, deposit system, or sale	Credits provided when bags are brought back to a store for reuse, displacing the need for the store to provide new bags. Often $0.01 to $0.05 in credit per bag returned to store; loyalty points awarded when shoppers bring their own bag; reusable bags offered for sale in stores (IKEA)	United Kingdom, Seattle; Many US cities

In 2004, the City of San Francisco conceived a user fee for all shopping bags used in the City. After objections by the retail industry, the City compromised with a 17-cent fee that would only apply to plastic shopping bags given out at large supermarkets and pharmacies. Furthermore, the City agreed to delay implementing the fee if supermarkets reduced the number of bags given to shoppers by 5 percent. However, by 2006, supermarkets had failed to prove that the goals had been reached. The plastics industry successfully lobbied the California State Legislature to pass a bill (AB 2449) that prohibits any local government from requiring stores to collect, transport, or recycle plastic carry out bags; require auditing on the number of bags used; or impose a plastic carry out bag fee on stores. San Francisco responded by implementing a City-wide ban on HDPE plastic bags that took effect in November 2007 (Dmitriew 2007). Additional examples of policies implemented are contained in Appendix A.

A number of key implementation lessons can be derived from the experiences of these other jurisdictions.

- Voluntary initiatives result in less participation than other strategies, both from retailers and consumers (GHK 2007).
- Some changes to consumer behavior could be expected by education alone, but the changes in consumption of disposable bags are likely to be modest if not combined with a ban or an ARF, and the environmental benefits would be minimal.
- Strategies such as enhanced litter control measures by local authorities may be effective in addressing litter but this approach is typically more costly than a bag fee and does not change consumer behavior away from consuming bags (Nolan-ITU 2002).
- Most research indicates that fees placed on suppliers or manufacturers are administratively simpler but less likely to reduce plastic bag consumption, since most fees do not affect habits unless passed on to consumers.
- Fees on consumers provide incentive to alter consumer behavior and have shown good results in doing so (Nolan-ITU 2004). Without a similar ARF on all disposable bags, retailers and consumers may switch to alternative bags and increased pre-packaging, resulting in negative environmental impacts (GHK 2007).
- The administration and implementation of an ARF are anticipated to be more complex, and the costs larger, than those for a ban or for education only, but approximately equal to an ARF on plastic only. In Ireland, administration costs on Irish industry have been minimal. The levy enjoys strong on going support from consumers, retailers, and government. (Nolan-ITU 2002).

- Research shows that a minimum fee is required to result in a comprehensive change in consumer behavior. The Elway research shows that 70% of Seattle respondents would be unwilling to pay more than $0.10 per bag fee. Any ARF fee should start at this level.
- Though the Elway research shows general support for action on disposable bags, voluntary reductions were favored over fees or bans. There was no majority for or against fees or bans, however.
- Regardless of the strategy, the need for an education and awareness campaign and strong political backing to build public understanding of a strategy's objectives (and compliance) is critical (GHK 2007).
- Regardless of the strategy, phasing implementation can help encourage compliance, and a period of voluntary effort prior to introducing legislation can result in stronger stakeholder ownership of the strategy (GHK 2007).
- Most strategies, including bans, display a J-curve effect, whereby plastic bag use falls dramatically initially but then partially rebounds (GHK 2007).
- Retailers may abuse the system by retaining the bag charge to boost profits (GHK 2007).
- Evasion and non-compliance issues during implementation can be a problem (GHK 2007).

Additional discussion of the pros and cons of disposable bag policy options, and available evidence of effectiveness, is contained in Appendix A.

Disposable Food Service Items

Strategies used by other jurisdictions to address disposable food service items include curbside recycling/composting, advanced recovery/disposal fees, education, environmental labeling, and product bans.

Examples of jurisdictions or entities that have implemented strategies to address the use of plastic food service items include the American Public Health Association; New Jersey; Alameda County, San Francisco and Santa Monica, California; Portland, Oregon; Germany; Sweden; Switzerland; and St. Jerome's College in Ontario, Canada.

Policies Adopted

Table 3-3 summarizes policy options adopted by other jurisdictions to address the use of disposable food service items. These options are summarized in greater detail in Appendix B.

Table 3-3. Summary of policy options adopted by jurisdictions outside of Seattle to address disposable food service items.

Current Strategy	Description	Jurisdiction
Curbside recycling	Clean PS cups, containers, and packaging placed in curbside collection bins for later sorting and marketing.	Los Angeles
Private recycling	Commercial and industrial EPS collected privately (primarily packaging foam from commercial generators) though there is a nascent food service effort underway	Portland Seattle Los Angeles
Product bans	Ban on the sale of disposable food service items (primarily EPS); some jurisdictions also ban PVC food contact items	Many California cities, Portland, some east coast cities, Europe
Voluntary product bans	Incentives provided for retailers to voluntarily ban disposable plastic food service items (primarily EPS). Often, mandatory bans take effect after a certain time period if voluntary ban is ineffective.	Santa Cruz
Product restrictions	Restrictions on the manufacture, distribution, or sale of a specific product based on size, capacity, material type, thickness, etc.	Taipei (dishes)
Advanced recovery fee	A fee levied on the supplier or consumer of a product and retained by the retailer and/or government to offset the costs of recycling or disposal, discourage further use, and publicize reuse and recycling options.	Germany
Environmental preferable packaging	Laws and standards that stipulate percentage recycled material content, percent to be recycled, or requirement for compostability.	California, Oregon, Wisconsin

Implementation Strategies and Lessons

Many of the food service strategies we have reviewed in published reports are newly implemented or are not yet implemented, and so many lessons learned are still being formulated. Anecdotal information was documented from the City of Santa Monica, City of San Francisco, City of Los Angeles, and the City of Portland.

The City of Portland banned PS food service containers in 1989. The Ordinance prohibited retail food vendors from serving prepared food in any polystyrene foam (PSF, EPS) products, and provides penalties for violation. "Food vendor" means any restaurant or retail food vendor. According to the City of Portland, the ban was immediately met with a lawsuit by the McDonalds Corporation. The company subsequently lost the case, but the challenge provided ample publicity for the program and public support. Following the loss, McDonalds moved away from EPS clamshells at all of their stores nationwide (Schneider 2007). After some period of evasion and non-compliance, ongoing non-compliance is being addressed in many cases with a concerned citizen phone call, a letter to the offending business, followed by a site visit within 30 days to confirm compliance. Portland does not provide support to businesses for finding alternative products to replace EPS (Schneider 2007). Cedar Grove provides a similar program for commercial organics composting for the City of Portland as they do for the City of Seattle. The City of Portland also suggested that compostable products suffer a bit from the confusion created by multiple standards (i.e., Biodegradable Products Institute (BPI), American Society of Testing and Materials (ASTM), and those of Cedar Grove) (Schneider 2007).

The Recycling Professionals, a Portland-based company, incorporated EPR into its business model in response to Portland's ban on EPS. The company distributes disposable food service items manufactured of EPS and recycled products to schools, health care facilities, correctional facilities, and other institutions that use large volumes of these materials. The company provides a service to pick up and recycle any products it sells and works with its own washing system and the processing capabilities of a local firm to produce recycled PS resin (RP 2007). The resin is used to produce other PS products.

In November 2006, the City of San Francisco passed Ordinance 29506 prohibiting the use of polystyrene foam disposable food service ware. The Ordinance requires the use of biodegradable/compostable or recyclable disposable food service ware by restaurants, retail food vendors, City departments, and the City's contractors and lessee, but stipulates that the requirements be met unless there is "no affordable alternative." The Ordinance also provides for penalties for violation. "Affordable" means purchasable for not more than 15% more than the purchase cost of non-biodegradable, non-compostable, or non-recyclable alternatives. Compostable means that the alternatives used must break-down in San Francisco's composting system, meet ASTM standards for biodegradability, and provide a label that indicates it is ASTM certified for compost collectors. Though "biodegradable" products may not meet the compostabiliy standards set locally by companies such as Cedar Grove in the Northwest and other companies California, the terms are often used interchangeably.

- For the City of San Francisco, compliance with their ban on EPS has been approximately 77 percent for EPS and 65 percent for polystyrene. Data is based on visits to about 900 of the 4,400 restaurants in the City by City personnel. The City is looking to a 311 phone directory to generate questions, comments, and citizen complaints on restaurants that are not complying with the ban. The City also receives information from its waste hauler on non-complying restaurants, and is hoping to do the same with the health department (Dmitriew 2007).

- While the City currently accepts #2, #4, and #5 plastics for recycling, some biodegradable plastics are problematic due to their similar look and feel to clear polystyrene – non-recyclable in San Francisco. Labeling is seen as a solution, but is not available on all product types. Labeling cups with a green stripe to indicate that the cups are compostable has been a success (Dmitriew 2007).

- For the first 6 months of the ban, San Francisco is focusing on education; subsequent steps will include warnings, and then fines for non-compliance. Fiber-based alternatives are problematic because they leak liquids and do not insulate well. Uncertified food service wares imported from China and used in some neighborhoods are reportedly biodegradable, but have unknown amounts of plastic mixed with biodegradable polymers.

- The City of Santa Monica's impending ban on polystyrene (#6) and EPS plastics will go into effect in February 2008. They have found initial education and outreach efforts successful in a number of ways.

- A City website created an online gallery that highlights restaurants that are successfully switching over to compostable plastics in advance of the impending 2008 ban.

- Competing restaurants are participating in the city gallery and more restaurants are banning all forms of plastics and using 100% compostables (including straws and lids) as a major part of their marketing campaigns.

- A number of food service product distributors are already distributing alternative compostable products and marketing them (Miller 2007).

- The City has also found some challenges in addressing all concerns. According to the City:

- Restaurants have concerns about elderly or disabled people getting burned by hot liquids from compostable containers that may not insulate well. Restaurants also have a concern/perception that switching to compostables will cost more money. This concern may prove to be short-lived if more local distributors participate and the cost of compostables drops.

- Straws and lids were exempted from the ban, resulting in contamination of the compostables stream. Care should be taken to consider the range of products in the ban, and the effects of exemptions.

- Ban programs should be staffed adequately in order to provide outreach, meet with food vendors, community leaders, distributors, and entrepreneurs to facilitate switching to compostable products (Miller 2007).

- The representatives of both the City of Portland and the City of Santa Monica who were contacted for this study suggested that the City of Seattle should work aggressively with its composting contractor to accept a wider range of compostable products if a ban on EPS or other plastics was considered. Technical innovation on the part of product manufacturers should help, and is being seen in the marketplace (Miller 2007; Schneider 2007).

The City of Los Angeles recently added clean cups, containers, and packaging such as polystyrene egg shell cartons, polystyrene block packaging, and polystyrene clamshell packaging to their curbside collection program. Their approach stopped short of legislation banning or creating a fee around EPS, and is relying on education around behavior and establishing appropriate collection, processing, and market outlets. A City of Los Angeles contact was unavailable for comment on any lessons learned.

Finally, many of the lessons pertaining to disposable bags apply to food service items, though the participants are different (see Implementation Strategies and Lessons under Disposable Shopping Bags on p. 14). Additional discussion of the pros and cons of disposable food service policy options, and available evidence of effectiveness, is contained in Appendix A.

4 Alternative Products

The section provides a summary of various alternative products currently available or under development that can be used as substitutes for existing disposable shopping bags or disposable food service items. The alternative products include reusable, recyclable, and biodegradable/compostable items.

A variety of reusable, recyclable, and biodegradable/compostable materials are available for use in manufacturing shopping bags and food service items. Many are made from renewable resources, such as corn starch, potato starch, wheat starch, rice hulls, bagasse, cellulose fiber/limestone, palm fiber, cotton canvas, durable plastic, paper, and bamboo. They are manufactured, sold, and distributed under a variety of brand names, and in a variety of product categories including bags, lidded containers, hinged containers, cold cups and lids, hot cups lids, cutlery, plates or trays, bowls, straws and stirrers, and food wraps. Appendix C contains a list of alternative products found during the initial research for this report. It likely does not include all manufacturers or distributors of these products.

Reusable

Reusable alternative products apply mostly to shopping bags. Traditional reusable food service items (e.g., china or plastic plates, and stainless steel utensils) are being reintroduced as the most environmentally preferred type of product for serving food in hospitals and similar institutions due to the potentially significant cost savings (i.e., less waste to incinerate) and environmental benefits (HCWH 2007). However, it is generally not practical or allowed by local health codes for restaurant customers to provide their durable containers for food ordered to-go. For example, the Code of the King County Board of Health stipulates that for temporary food establishments, reuse of “single-service articles” is prohibited (COKCBOH 2007).

It is also unlikely that a take-back program for to-go food service items would be considered practical by the general public, or economically viable for restaurants and food vendors. Therefore this section focuses on the various types of reusable shopping bags that are available or under development.

Several types of reusable shopping bags are currently available as alternatives to thin plastic film and paper shopping bags. These include bags made from natural fibers such as cotton canvas, wicker, hemp, jute, and bags made from synthetic materials such as polypropylene, polyethylene, and nylon. These reusable bags are extremely durable, and it is estimated that they can be used hundreds or thousands of times compared to disposable bags designed for single use (reusablebags.com 2007).

A 2007 study of plastic shopping bags in Los Angeles County reached the following conclusions concerning the advantages of using reusable bags (Los Angeles County 2007):

- Reusable bags would offer significant environmental benefits over traditional alternatives (see section titled Life Cycle Assessment)
- Citizens would be actively participating in practices that promote a clean and sustainable environment
- Retailer costs for purchasing plastic and paper shopping bags would no longer be passed on to customers
- Significant cost savings would accrue to taxpayers (e.g., less money spent on litter prevention, cleanup, and enforcement)
- Development of the emerging "green economy" would be assisted by spurring the reusable bag industry.

Disadvantages of reusable bag use may include:

- Decreased revenue for the plastics and paper industry and loss of jobs in bag manufacturing
- Inconvenience for some shoppers (i.e., too heavy when packed)
- Lack or decrease in water repellency
- Difficulty for retailers in determining if customers have been through check-out line, with consequent potential increase in theft.

New types of reusable bags are under development and appear on the market almost daily. These bags are made from a variety of natural and synthetic fibers and are designed to be more durable, convenient, and have a lower life cycle cost than disposable or reusable bags that are currently in use.

Recyclable

This section summarizes the types of shopping bags and food service items that are generally considered recyclable. Whether or not certain materials are recyclable depends on several factors including the type of material from which the product is made, whether a local collection system is in place for the material, whether food residue or other contamination affects the recycler's ability to process the material, and whether a market exists for the material.

Several types of bags on the market are recyclable. In Seattle, the most readily recyclable bags are made from polyethylene, polypropylene, and paper. Current recycling outlets for paper bags are well established. Low-density polyethylene (LDPE) and high-density polyethylene (HDPE) bags have found growing markets domestically, primarily from composite building product manufacturers, pipe manufacturers, garden edging and corner board manufacturers. Overseas markets include other injection grade applications for consumer products and component parts, and lower quality (and/or black) bags.

Bags made from other recyclable materials (e.g., non-woven polypropylene (PP), woven LDPE, canvas, etc.) suffer from the fact that they are technically recyclable or compostable, but do not have a collection or processing infrastructure, and have few end markets. The reuse channel (e.g., through second hand stores) may be a viable option, but this channel would not be viable for those bags that are past their useable life.

In Seattle, uncoated paper food service products are compostable in organics collected from residential and commercial curbsides. Some food service containers made from PP or HDPE are also recyclable in the curbside collection system (e.g., dairy product tubs). Markets for these containers are generally low value. Other recyclable food service items include aluminum foil.

Neither expanded polystyrene (EPS) food service items nor block packaging are currently recycled in the residential or commercial curbside collection system in Seattle. Again, food service EPS is technically recyclable, but the collection and processing infrastructure is either nonexistent, or in its infancy in Seattle. However, more and more EPS from industrial manufacturing and from commercial sources is being recycled rather than being landfilled. At least one Seattle-based recycling company is ramping up to recycle EPS and ship it to a plastics recycler in Portland, Oregon.

According to the Association of Foam Packaging Recyclers (AFPR), over 100 collection locations for EPS have been established nationwide. A 2006 recycling rate study commissioned by the AFPR concluded that of 166 million pounds of EPS sold, 56 million pounds were recycled. The AFPR report shows that of the 56 million pounds recycled, 32 million was post-consumer, and 24 million pounds was post-industrial. Of the 32 million pounds recycled from post-consumer sources, 26 million was post-commercial. All of the material cited is described as “packaging material” as opposed to food service items.

Despite the successes cited above, and the technical feasibility of recycling EPS, it is likely that food contamination, the high volume-to-weight ratio of the product, and available end markets will limit food service EPS recycling for the near- to mid-term future. The AFPR indicates that most recycling activity will focus on large volume, commercial sources of post-consumer EPS (AFPR 2006).

Advantages of recyclable shopping bags or food service items may include the following:

- Recycling collection and processing infrastructure exists for plastic and paper bags
- Recycling products at end of life is generally environmentally preferable to disposal

Disadvantages of recyclable shopping bags or food service items may include:

- Recycling collection and processing infrastructure does not currently exist for disposable food service items
- Recycling for different items may develop differently, causing confusion as to which items are recyclable and which are not, resulting in contamination of recycling streams
- Recyclable items do not provoke a change in the "disposable" consumption mentality
- Recyclable items may be confused with compostable items, and add contamination to the compostable organics stream
- Space constraints may impede location of recycling containers

Recyclable bags and food service items depend on a collection and processing infrastructure, and end markets, in order to be recycled. New technologies are constantly being developed, and older technologies are being applied to newer products and materials. Advances in the economics of densifying, washing, drying, and blending materials will promote additional recycling. New end-use technologies will also drive demand for recycled materials, depending on general economic conditions, virgin feedstock prices, consumer attitudes, and in some cases, government action.

Biodegradable/Compostable

Based on an Australian study on degradable plastic bags, degradable materials can be classified in two ways: "according to the way that they degrade, for example whether they require the actions of microorganisms (i.e. are biodegradable), or whether they require heat, ultraviolet light, mechanical stress or water in order to break down; and according to the materials they are manufactured from, for example whether they are made from natural starch polymers, from synthetic polymers or from a blend of a conventional polymer with an additive to facilitate degradation (Nolan-ITU 2003)."

The Australian study goes on to describe the ways that polymers can degrade, based on whether they are biodegradable, compostable, oxo-biodegradable, photodegradable or water-soluble:

- "Biodegradable polymers are those that are capable of undergoing decomposition into carbon dioxide, methane, water, inorganic compounds or biomass in which the predominant mechanism is the enzymatic action of microorganisms, that can be measured by standardized tests, in a specified time, reflecting available disposal conditions.

- Compostable polymers are those that are degradable under composting conditions. To meet this definition they must break down under the action of microorganisms (bacteria, fungi, algae), achieve total mineralization (conversion into carbon dioxide, methane, water, inorganic compounds or biomass under aerobic conditions) and the mineralization rate must be high and compatible with the composting process.

- Oxo-biodegradable polymers are those that undergo controlled degradation through the incorporation of prodegradant additives (additives that can trigger and accelerate the degradation process). Degradation for these polymers is initiated by natural daylight, heat and/or mechanical stress, and they embrittle in the environment and erode under the influence of weathering.

- Photodegradable polymers are those that break down through the action of ultraviolet (UV) light, which degrades the chemical bond or link in the polymer or chemical structure of the plastic. This process can be assisted by the presence of UV-sensitive additives in the polymer.

- Water-soluble polymers are those that dissolve in water within a designated temperature range and then biodegrade in contact with microorganisms (Nolan-ITU 2003)."

- The study also describes the varied composition of degradable materials, with the main categories including:

- Thermoplastic starch-based polymers made with at least 90% starch from renewable resources such as corn, potato, tapioca, or wheat.

- Polyesters manufactured from hydrocarbons (oil or gas). All polyesters degrade eventually, with degradation rates ranging from weeks for aliphatic polyesters (e.g. polyhydroxyalkanoates (PHA)) to decades for aromatic polyesters (e.g. polyethylene terephthalate, PET).

- Starch polyester blends that mix thermoplastic starch with polyesters made from hydrocarbons.

In the 1990's several new polymers entered the market, most notably starch-filled polyethylene. The U.S. Federal Trade Commission, the U.S. Congress, several state attorneys generals, and other entities became concerned about claims that the products were biodegradable (when in fact, polymers remained in small particles after degradation of the starch), and concerned that there were no established standard testing procedures to establish and quantify the degradability of polymers. As a result, the American Society of Testing and Materials (ASTM) began developing standards to test degradable plastics, and in 1999 published ASTM D 6400-99 (ASTM 2000).

According to ASTM D 6400-99 a biodegradable plastic degrades via the action of naturally occurring microorganisms such as bacteria, fungi, and algae. Per ASTM D 6400-99, in order for a plastic to be considered compostable, three criteria need to be met:

- Biodegrade - break down into carbon dioxide, water, biomass at the same rate as cellulose (paper).
- Disintegrate - the material is indistinguishable in the compost, that it is not visible and does not need to be screened out
- Eco-toxicity - the biodegradation does not produce any toxic material and the compost can support plant growth (ASTM 2000).

In addition ASTM D 6868, “Specification for Biodegradable Plastic used on Paper and other Compostable Substrates” applies to packaging and food service items made of plastic coated paperboard, and other fibers.

Currently, several international organizations have established standards and testing methods for compostability, including:

- American Society for Testing and Materials (ASTM-6400-99)
- European Standardization Committee (CEN) (EN13432)
- International Standards Organization (ISO) (ISO14855 (only for biodegradation))
- German Institute for Standardization (DIN) (DIN V49000)

The ASTM, CEN, and DIN standards specify the criteria for a plastic to be called compostable. In the United States, the Biodegradable Products Institute (BPI) certifies bioplastics under the ASTM D 6400-99, and ASTM D 6868 standards for "compostable plastics" and awards the BPI logo to products that pass this certification. A summary of the materials used to produce biodegradable products is contained in Table 4-1.

Local Availability and Use

Local distributors of compostable bags and food service items (including uncoated paper, which is widely available) are Simplybiodegradable.com in Wenatchee, Service Paper Co. in Renton, Sysco Foods in Kent, US Foodservice in Fife, United Grocers in Seattle, Food Services of America in Kent, Xpedx in Kent, West Coast Paper in Kent, Willis Marketing in Gig Harbor, and Bunzl in Renton, among others. A variety of web distributors are also available (e.g., Biodegradable Foods, www.bdfs.net).

Table 4-1. Summary of materials used to produce disposable plastic bags and disposable food service items.

Polymer Category, Degradation Pathway	Composition	From Renewable or Non-Renewable Resources
Biodegradable Starch-based Polymers	Thermoplastic starch derived from corn, potato or wheat, blended with additives (e.g. plasticizers)	Mostly renewable
	Thermoplastic starch derived from corn, potato or wheat, sometimes blended with polyester (polylactic acid (PLA) or polycaprolactone (PCL))	Starch component renewable, but hydrocarbon-based plastics and energy for agriculture are non-renewable.
	Thermoplastic starch derived from tapioca, corn, potato or wheat, blended with polyethylene	As above
	Thermoplastic starch derived from corn, blended with polyvinyl alcohol (PVOH)	As above
Biodegradable Polyesters	Polybutylene succinate (PBS)	Non-renewable
	Poly (butylene succinate-co-adipate) (PBSA) copolymers	Non-renewable
	Polybutyrate adipate terephthalate (PBAT))	Non-renewable
	Adipic acid aliphatic/aromatic copolyesters (AAC)	Non-renewable
	Polylactic acid (PLA)	Renewable
	Polycaprolactone (PCL)	Non-renewable
	Polyhydroxy-butyrate-valerate) (PHB/V)	Renewable
	Blends of polyhydroxybutyrate (PHB) with PCL	Combination renewable and non-renewable
	Modified PET	Non-renewable
Controlled Degradation	Polyethylene with a thermal and/or UV prodegradant additive	Non-renewable
Water soluble Polymers	Polyvinyl alcohol (PVOH) and ethylene vinyl alcohol (EVOH)	Non-renewable
Photodegradable Polymers	Thermoplastic synthetic polymers or copolymers	Non-renewable

Source: Nolan-ITU 2003

As discussed earlier, the use of biodegradable items is dependent on an adequate composting system to accept the material once used. Cedar Grove maintains a list of products that have passed its compostability criteria, and are acceptable for composting in their system. The list is included in Appendix D. For comparison, the list of acceptable compostable products in San Francisco's composting system is also included in Appendix D, as well as a list from the Biodegradable Products Institute (BPI).

For comparison purposes, general information on the costs of traditional plastic versus compostable clamshell take-out food containers, and hot and cold cups was gathered from three websites; www.WEBstaurantStore.com, www.biodegradablestore.com, and www.worldcentric.org (see Table 4-2 below). It is notable that the WEBstaurantStore.com did not appear to carry alternative compostable food service products. Pricing of traditional versus alternative food service products is highly variable and depends on volume ordered, shipping costs, and negotiations at the discretion of the distributor.

Table 4-2. Cost comparison of plastic versus compostable cups and clamshell take-out food containers.

Item	Material Type	Number per Case	Cost per Case	Unit Cost	Information Source
6-inch clamshell	EPS	500	$18.99 [b]	$0.04	WEBstaurantStore.com (Dart Container Corp)
6-inch clamshell	GPPS	125	$10.99 [b]	$0.088	WEBstaurantStore.com (Dart Container Corp)
6-inch clamshell	Bagasse	500	$62.90 [a]	$0.13	Biodegradablestore.com
6-inch clamshell	Paper (sugarcane, grass, and reed plasma)	100	$13.99 [a]	$0.14	Biodegradablestore.com (GreenWave)
6-inch clamshell	PET	200	$36.30	$0.18	Waresdirect.com (GenPak Corp)
6-inch clamshell	PLA	250	$51.50 [a]	$0.21	Biodegradablestore.com (Natureworks PLA)
6-inch container	Paper	160	$49.99 [a]	$0.31	WEBstaurantStore.com
6-inch clamshell	PP	100	$38.49 [b]	$0.38	WEBstaurantStore.com (Anchor Packaging)
12-ounce cold cup	Bagasse	1000	$81.50	$0.08	WorldCentric.org 12-ounce cup is largest they carry
16-ounce cold cup	PLA clear	1000	$101.50 [a]	$0.10	Biodegradablestore.com (Eco-products)
16-ounce cold cup	PE-coated paper	1000	$38.99 [b]	$0.04	WEBstaurantStore.com (Solo)
16-ounce cold cup	PET colored	1000	$119.00 [b]	$0.12	WEBstaurantStore.com (Solo)
16-ounce cold cup	PS translucent	1000	$28.99 [b]	$0.03	WEBstaurantStore.com (Dart)
16-ounce cold cup	EPS	1000	$29.99 [b]	$0.03	WEBstaurantStore.com (Dart)
16-ounce hot cup/lid	Paper with green stripe and PLA lining	1000	$113.10 [a]	$0.11	Biodegradablestore.com (Ecotainer)
16-ounce hot cup/lid	EPS	1000	$66.99 [b]	$0.07	WEBstaurantStore.com (Dart)
16-ounce hot cup/lid	PE-coated paper	1000	$63.99 [b]	$0.06	WEBstaurantStore.com (Solo and Chinet)

[a] Free shipping on orders over $995.
[b] Does not include standard shipping charges by UPS or FedEx

Advantages of compostable shopping bags or food service items may include the following:

- Composting collection and processing infrastructure currently exists
- Compostable food service items could significantly increase food scrap and greenwaste diversion because food service items could be composted

along with food scrap, and bags would not need to be separated before composting

- Compostable items provide some environmental benefits compared to traditional alternatives, even if not composted (see section Life Cycle Assessment).

Disadvantages of compostable shopping bags or food service items may include:

- Compostable products can be more costly, and distributors less available
- Compostable items provide some environmental disadvantages compared to traditional alternatives, even if composted (see section Life Cycle Assessment)
- Composting for different items may develop differently, causing confusion as to which items are compostable and which are not, resulting in contamination of the composting process
- Bags or items may contaminate the existing plastic recycling stream if they are not properly collected and composted, thus reducing plastic recycling opportunities or increasing sorting costs and subsequently increasing the cost of post-consumer resins
- A clear distinction between "compostable" and "biodegradable" does not exist on the part of the public. Education would be needed.
- Composting collection and processing infrastructure has limits to the proportion of non-organic material going into the system
- Compostable items do not provoke a change in the "disposable" consumption mentality
- Compostable items may be confused with recyclable items, and add contamination to the recycling stream
- Discrepancies exist between product standards and Seattle's contracted processing regarding suitability for acceptance
- Compostable items do not handle hot foods and liquids as well as traditional alternatives (>110 degrees F)
- Compostable items may have a lower shelf life if exposed to heat, light, or moisture.

Future Product Development

Most biobased products are in the early stages of commercial development. Medium and long term progress both in agriculture and production will likely lead to more efficient production systems for these products (Patel et. al.2003). Advances in the fermentation and recovery process for corn production systems are making corn-based plastics more favorable in terms of non-renewable energy and global warming. Technological improvements and use of alternative crops, crop production systems, or agricultural wastes will significantly reduce environmental impacts. One problem arising from the use of crops such as corn to produce compostable food service products may be upward pressure on food prices (EPOBIO 2006).

Products under development include next-generation versions of existing biodegradable / compostable plastic films and food service items. For example, Natureworks PLA is a compostable plastic produced from corn produced by NatureWorks LLC, an independent company formed by a joint venture of Cargill and Dow and now wholly owned by Cargill. The product continues to be refined to improve several characteristics including strength, weight, and compostability. Examples of the specific improvement progression (i.e., PLA-1 to PLA-NG) in the product can be reviewed in (Natureworks, LLC 2006).

New products include those made with foamed starch. Foamed starch can be blown by environmentally friendly means into a foamed material using water steam. Foamed starch is antistatic, insulating, and shock absorbing, and is a potential replacement for polystyrene foam (Nolan-ITU 2004).

5 Life Cycle Assessment

The previous sections of this report detailed the strategies and the availability of alternative products being employed to reduce the use of disposable shopping bags and food service items around the world. It is the City's goal to lessen the environmental impacts created by disposable plastics in Seattle, while being careful to avoid solutions that inadvertently create other, or more severe, environmental impacts.

In order to inform the development of policy options under consideration by the City, the environmental impacts of existing and alternative shopping bags and food service items were reviewed and analyzed, primarily through published Life Cycle Assessment (LCA) studies. LCA is a widely acknowledged approach to characterize the environmental impact of products and processes, and its methodology has been standardized under the International Standards Organization (ISO) 14040 series.

Definition of Life Cycle Assessment (LCA)

Life Cycle Assessment is an assessment tool that examines the whole life cycle of a product or service, and quantifies its environmental impacts. The life cycle of a product or service includes extraction of natural resources (the "cradle"), production of raw materials, transport, production of the product, transport and use, and waste management/recycling (the "grave.") In a life cycle assessment, the environmentally relevant input and output flows of the life cycle of the studied products, and their environmental impacts are calculated and evaluated (Fridge, 2002). More recently, the term 'cradle-to-cradle' has been used to emphasize the continued reuse, composting, and recycling of a resource.

The U.S Environmental Protection Agency (EPA) defines a Life Cycle Assessment as "an objective process used to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and materials used and wastes released to the environment, and to evaluate and implement opportunities to affect environmental improvements (EPA, 1993).

The International Standards Organization (ISO) identifies key uses of LCA that apply to the objective of this analysis, including:

- Identifying opportunities to improve the environmental aspects of products at various points in their life cycle
- Assisting decision-making in industry, governmental or non-governmental organizations

- Providing relevant indicators of environmental performance (ISO 14040 2006 as cited in IFEU 2006).

ISO defines an LCA as having four phases:

- Goal and scope assessment. The goal of the study includes the intended application and audience, and the reasons for carrying out the study. The scope of the study includes the study limitations, the functions of the systems investigated (e.g.,, carrying groceries and products home from stores), the functional unit (e.g., 10,000 bags, or the amount of a product necessary to achieve a certain function, such as a weekly shopping trip for an average household), the systems investigated (e.g., plastic bags, paper bags, compostable bags, reusable bags), the system boundaries (e.g., raw materials, manufacturing, disposal, but not consumer use), the allocation approaches (e.g., energy and material inputs between multiple products from the same material feedstocks), the data requirements, the key assumptions, the impact assessment method (e.g., the environmental categories analyzed), the interpretation method, and the type of reporting.

- Inventory analysis. Inventory analysis involves data collection and calculation procedures to quantify the total system's inputs and outputs that are relevant from an environmental point of view (i.e. mainly resource use, atmospheric emissions, aqueous emissions, solid waste, and land use) (Patel, 2003).

- Impact assessment. Impact assessment involves examining the production system from an environmental perspective, and evaluating environmental significance using category indicators, such as energy use, global warming, acidification, and eutrophication. Some of the LCAs reviewed in this report also apply single-score aggregation methods (e.g., Eco-indicator '95, see Dinkel et al., 1996). Finally, some LCAs (though none reviewed for this report) aggregate the results determined for the various impact categories monetarily for incorporation into cost benefit analysis. However, this valuation step is based not only on scientific facts but also on subjective choices and societal values (Patel, 2003).

- Interpretation. Interpretation is the final step of the LCA where conclusions are drawn from both the inventory analysis and the impact assessment in relation to the goal of the study. An analysis of major contributions, sensitivity analysis and uncertainty analysis is also conducted (ISO 2006). Limitations of the results are presented and recommendations can be directed to producers or policy makers. (Patel, 2003). Sometimes an independent critical review is necessary, especially when comparisons are made that are used in the public domain. (ISO 2006)

Review of Existing LCA Studies

To create a detailed view of the environmental impacts of disposable shopping bags, disposable food service items, and their alternatives, a wide array of reports, articles, presentations, and standards were reviewed (see References). The main findings are contained in the following section of this chapter.

Neither a full LCA nor a partial LCA was prepared for this report. LCA studies that cover cradle-to-grave assessments based on a 'functional unit' of product and are conducted in accordance with ISO 14040 series (or equivalent best-practice guidance) are referred to as 'full' LCAs. Studies that are limited, for example by cradle-to-factory-gate assessments[1] or where only limited environmental impact categories are used (e.g. greenhouse gases only) are considered to be 'partial' LCAs (Murphy, 2004).

In order to provide comparisons between alternative product types of the range detailed in the last chapter, it was necessary to review comparative studies. The literature review conducted for this report found several studies that dealt with direct comparisons between paper, plastic, reusable, and/or biodegradable disposable shopping bags, including but not limited to:

- Environmental Assessment of Bio-Based Polymers and Natural Fibres. Dr. Martin Patel, Dr. Catia Bastioli, Dr. Luigi Marini Dipl.Geoökol. Eduard Würdinger (2003)
- Environmental Impact Assessment of Carrefour Bags. (2003)
- Environment Australia – Plastic Shopping Bags-Analysis of Levies and Environmental Impacts (2002)
- The Impacts of Degradable Plastic Bags in Australia – Final Report to Department of the Environment and Heritage (2004)
- Resource and Environmental Profile Analysis of Polyethylene and Unbleached Paper Grocery Sacks (1990).

In addition, the literature review conducted for this report found several studies that dealt with direct comparisons between paper, plastic, and or biodegradable disposable food service items, including but not limited to:

- Environmental Assessment of Bio-Based Polymers and Natural Fibres. Dr. Martin Patel, Dr. Catia Bastioli, Dr. Luigi Marini Dipl.Geoökol. Eduard Würdinger (2003)

[1] Cradle-to-factory gate analyses evaluate the inputs and outputs only to the point prior to use in a product manufacturing system (e.g., plastic pellets)

- Life Cycle Inventory of Polystyrene Foam, Bleached Paperboard, and Corrugated Paperboard Food service Products (2006)
- Life Cycle Inventory of Five Products Produced From Polylactide (PLA) and Petroleum-Based Resins (2006)
- Life Cycle Assessment of Polylactide (PLA). A Comparison of Food Packaging Made From Natureworks® PLA and Alternative Materials. Final Report (2006)
- Comparative LCA of 4 Types of Drinking Cups Used At Events (2004).

These studies represent both full and partial LCAs. Despite their more limited scope, partial LCAs also contribute to a better understanding of environmental impacts because they address materials that have not been studied from this perspective before.

In addition to the few U.S. research publications detailing environmental impacts from the target products addressed in this report, several additional published studies were reviewed that were conducted in Europe and Australia.

Goal of the Review

The goal of this study's review of LCAs is to create a level of environmental comparison between alternative products (and within different policy strategies) not previously made available to the City of Seattle. LCA experts admit that direct comparison of different LCA studies is difficult because they 1) commonly deal with different products, 2) differ in what is included or excluded from the analysis, and 3) may adopt differing approaches to environmental impact assessment (Murphy, 2004). Notable limitations of LCAs are discussed in the next subsection. Despite these limitations, the outcomes of LCAs provide important decision support information for the City of Seattle in the move to encourage more environmentally sound practices by and for its citizens. LCAs also reinforce the concept of whole life cycle thinking when addressing environmental and sustainability matters (Murphy, 2004).

Assumptions and Limitations

There is some disagreement among experts about the utility of life-cycle concepts in comparing products. This study's review of existing LCAs highlighted a variety of assumptions and limitations that are applicable to all LCAs. These limitations affect how complete a picture can be achieved of environmental impact, particularly when comparing products from different LCAs. Assumptions and limitations include the following:

- All of the decisions made during the Goal and Scope Assessment phase of an LCA are determined by the sponsor of the analysis and the LCA practitioner. The ISO standards themselves indicate that LCAs are restricted by value judgments and available scientific knowledge (ISO 2006). As a result, the impact assessment and interpretation often depends on the environmental priorities of the industry segment or public agency, and may affect the subjective ranking of impacts (Fridge, 2002).

- LCA studies set their own system boundaries according to the goals of the analysis and may not be readily comparable if different. Some studies look at "cradle-to-cradle" systems, while others look at "cradle-to-cradle" systems but exclude the consumer use phase (most common). Some look only at the "cradle-to-factory gate" system, which evaluates the inputs and outputs only to the point prior to use in a product manufacturing system (e.g., plastic pellets). "Cradle-to-factory gate" studies do not take account of:

    - Materials processing, where the amount of material required to manufacture a certain end product might be higher or lower
    - Transportation, which can be substantial for end products with a low density such as plastic bags versus paper bags
    - Consumer use, where behavior can play a role
    - Waste management, where logistics and recycling processes can be tailored to a specific product or product group (Patel 2001)

- Once the system boundaries are set, data details differ for each supplier, specific process used, location, and dominant methods of primary production that are to be included in the LCA (Fridge, 2002)

- Life cycle inventory (LCI) data often relies on a whole series of smaller process data sets, either for individual processes or collections of individual processes. However, collection of inventory data can be extremely costly and time consuming and often results in inventory data that is incomplete or inaccurate (Fridge, 2002; Rosselot, 2004). Sometimes inventory data is proprietary, or is only available in an aggregated format (e.g., air and water emissions quantified as totals rather than given as quantities for individual constituents). The result can make a thorough impact assessment difficult (Rosselot, 2004).

- During life cycle inventory, manufacturing systems provide complex allocation problems (i.e., to which systems inputs and outputs can be attributed).

    - Difficulties in conducting an inventory arise when processes that generate more than one product are studied (Fridge, 2002).

  - When products are made from many materials, the environmental inputs and outputs of each significant component (all potentially very different) must be inventoried (Rosselot, 2004).

  - When products are recycled they are converted back into the same product (closed-loop recycling) or into another product (open-loop recycling) and life cycles become linked, making the analysis more complex (Rosselot, 2004).

  - When a disposal process generates a certain output (e.g. energy from landfill gas capture or recycling of the product or its materials) this not only causes emissions, but also saves emissions (Rosselot, 2004). Some studies introduce the concept of energy or emission credits to account for the avoided impacts of a process and they are deducted from the emissions caused by other processes.

- In addition to the above, during impact assessment, there are national differences in technology used, CO2 emissions from difference sources of electricity generation, and the type of waste management infrastructure in place (i.e., incineration, landfilling, recycling, and/or composting). All contribute to the difficulty in comparing results.

- Weighting, which can be done during the impact assessment phase, assigns a weighting factor to each impact category depending on the relative importance (ISO 14040 2006). However, the impact assessment and interpretation often depends on the environmental priorities of the industry segment or public agency sponsoring the analysis, and may affect the subjective ranking of impacts (Fridge, 2002).

- The age of the study is a complicating factor, as technologies and data are updated and improved, and environmental impact factors revised (Murphy, 2004). For example, some industries have cut emissions or energy use by substantial amounts during the last ten years. At the same time, manufacturing technologies have changed either in response to regulation or to industry’s efficiency gains (or are different according to geographical location). For example, the plastics industry has made consistent gains in “lightweighting” products, that is, using less material in product applications with no loss of quality or function. In both these cases, the use of obsolete data (or the unavailability of recent data) can cause distortions (Rosselot, 2004).

The ISO standards also discuss limitations inherent to LCA, including the assumptions made, restrictions of data accessibility, availability, and quality (ISO 2006).

Given this range of assumptions and limitations, LCAs often do not indicate clear winners and losers, but do highlight environmental implications and tradeoffs (Europen, 1999). Several researchers highlight the challenge of using LCAs to show that one product is environmentally preferable to another (Patel 2001) [2]. Despite the level of uncertainty, most industry and public professionals agree that life-cycle assessments are an important and useful tool for informing environmental management systems and public policy (ACC 2007; Rosselot, 2004)

Life Cycle Impact Review Results

This section summarizes the results of our review of available LCAs relevant to the City of Seattle's goals. The reports reviewed represent the most recent and relevant results regarding disposable shopping bags and food service items found during the literature search. The reports contain a wealth of information, in far too much to detail to present fully in this report. Review of the reports in their original context would prove a useful supplement to the information presented here, and a glimpse into the complexity of the analysis behind these summaries.

Disposable Shopping Bags

Several reports made direct comparisons of "one-way" disposable plastic bags, one-way disposable paper bags, one-way biodegradable/compostable bags, and reusable bags. "One-way" refers to the bags' primary use as one-time use bags. The reports do reflect the reuse of disposable bags of all types for other purposes, which is consistent with a sampling of Seattle residents that indicates 46 percent of people in Seattle reused bags for other purposes (SPU 2007). As would be expected and as shown in the results that follow, this can have a positive effect on environmental impacts. Definitions for all environmental indicators used, including units, are contained in Appendix E. All individual inventory results are contained in Appendix F.

1. *Environmental Assessment of Bio-Based Polymers and Natural Fibres. Dr. Martin Patel, Dr. Catia Bastioli, Dr. Luigi Marini Dipl.Geoökol. Eduard Würdinger*

This report was prepared in 2003 and reviewed twenty life cycle assessments. Seven of the studies reviewed deal with starch polymers, five with polyhydroxyalkanoates (PHA), two with polylactides (PLA), three with other bio-based polymers (lignin-epoxy resins, epoxidised linseed oil) and three with composites based on flax, hemp, and china reed (miscanthus). These reports are a mixture of full and partial (mostly) LCAs, and include data about both petrochemical plastic pellets and biobased and biodegradable plastic pellets. The results represent the state of the art technologies at the time of the studies.

[2] Patel summarized several researchers regarding the limitations of LCA as a tool for decision support. "… Finnveden (2000) points out that it is - strictly spoken – impossible to show by means of an LCA that one product is environmentally preferable to another. This has to do with the fact that universal statements are logically impossible to prove. Let us, for example, assume that a product A is (objectively) preferable to product B in environmental terms. Even if there is an LCA showing this, it is likely to contain some methodological and empirical choices that are uncertain to some extent. (Finnveden, 2000)."

Type of Bags: Petrochemical plastic pellets (high density polyethylene (HDPE), low density polyethylene (LDPE), linear low density polyethylene (LLDPE), general purpose polystyrene (GPPS), expanded polystyrene (EPS) and bio-based and biodegradable plastic pellets (thermoplastic starch (TPS), TPS + polyvinyle alchohol (PVOH), TPS + polycaprolactone (PCL), PLA, (PHA).

Full or Partial LCA: Partial

Functional Unit: 1 kg of material

Environmental Indicators Used: Non-renewable energy; greenhouse gas (GHG) emissions; Ozone precursors; Acidification; and Eutrophication.

Assessment Results: See Table F-1 in Appendix F.

Assessment Conclusions: The authors conclude that in spite of some uncertainties and information gaps (see below), the LCAs indicate that biodegradable polymers can "make significant contributions to reducing environmental impacts and contribute to sustainability compared to their petrochemical alternatives" (Patel 2001). This is particularly true when composting is chosen as the waste management alternative. The same is true for biobased materials that are not biodegradable. The authors go on to say that of all the materials studies, starch polymers performed best among environmental indicators under the current technology being used, though some differences were seen between starch polymers (Patel 2001).

Limitations: However, given uncertainties due to limited data at the time, it was not possible to conclude whether bio-based plastics should be preferred to petrochemical plastics environmentally. Many of the environmental analyses choose a cradle-to-factory gate perspective (i.e., the analysis ends with the product under consideration). According to the authors, the most important uncertainties in the LCA studies they reviewed related to the waste management phase, "particularly regarding methane emissions from landfills, energy recovery yields in waste-to-energy facilities and carbon sequestration due to composting[3]. Compared to starch polymers the environmental benefits seem to be smaller for PLA (LCA results only available for energy and CO2). For PHA, the achievable environmental advantage currently seems to be very small compared to conventional polymers (LCA results only available for

[3] The report states, "If a biobased material is recycled through composting, and the compost applied to land, then significant emission and energy credits can accrue, because of the value of the compost to sustainable agriculture. On the other hand a biobased material dumped in a landfill could produce negative effects by an uncontrolled evolution of methane as pointed out by Kurdikar et al. (2001) and BIFA/IFEU/Flo-Pak (2001)." In fact, some studies account for methane (CH4) emissions due to anaerobic emissions when compostable products are landfilled, while others do not. This can have a considerable impact on the results due to the strong greenhouse gas effect of CH4 (Patel 2001), and may even mean that overall GHG emissions from biodegradable polymers manufactured from renewable raw materials may be higher than for petrochemical plastics depending on the waste management system chosen (Würdinger et al., 2001 in Patel 2001)

energy use). For both PLA and PHA, the production method, the scale of production and the type of waste management treatment can influence decisively the ultimate conclusion about the overall environmental balance." (Patel 2001). Finally, the reviewers indicate that the characteristics of the starch polymer considered in the studies reviewed, and the type of composting technology used, may influence the amount of carbon sequestered in compost versus that which is emitted during degradation[4].

2. Environmental Impact Assessment of Carrefour Bags

This report was completed by Ecobilan in 2004 for Carrefour, a French grocery chain seeking to evaluate areas of potential environmental improvement in its own systems. This analysis is taken from the document.

<u>Type of Bags:</u> Disposable polyethylene (PE) shopping bags (14 liter capacity), disposable paper shopping bags (20 liter capacity), and disposable biodegradable (Mater-Bi) bag (25 liter capacity), and a reusable PE bag (37 liter capacity).

<u>Full or Partial LCA:</u> Full, according to ISO Standards

<u>Functional Unit:</u> Packaging of 9000 liters of goods (a typical annual purchase volume in France)

<u>Environmental Indicators Used:</u> Non-renewable energy consumption, water consumption, greenhouse gas emissions, air acidification, photochemical oxidants, eutrophication, residual, solid waste, and littering probability.

<u>Assessment Results:</u> See Table F-2 in Appendix F.

<u>Assessment Conclusions</u>: The report (as cited in EuroCommerce 2004) concludes that "for all indicators, reusable PE bags are always better than one-way bags, when reused at least 4 times. In addition, one-way PE bags perform better than the other bags, except for littering probability "particularly in costal areas," and represent the next preferable option, if reused (e.g. as bin liner) and sent to energy recovery (not applicable in Seattle). Paper bags are also shown to be the least environmentally preferable option. This was due to the greater amount of resources (materials and fuels for transport from greater weight per bag) that they require. The report indicated that compared with lightweight plastic bags, paper bags: consume about the same amount of energy; create about the same amount of photochemical oxidants; consume three times the amount of water; create 90% more greenhouse gas emissions; create 80% nitrogen oxide (NOx)/sulphur dioxide emissions; create 12 times the level of eutrophication (nitrate and

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[4] It is generally assumed that the carbon dioxide originating from biomass is equivalent to the amount which was previously withdrawn from the atmosphere during growth, and that it therefore does not contribute to global warming (fossil fuels required for transportation processing the crops and producing fertilizers are accounted for separately).

phosphate pollution to water) and 80% more solid waste. Paper bags performed better in the litter category.

The report also concludes that materials production is the dominant source of environmental impact for all types of bags and for most of the indicators. Also, bag manufacture generates lower (but still significant) impacts than materials production, while use impacts are relatively minor. Waste management contributes mainly to litter probability, residual solid waste, and greenhouse gas emissions. As a result, weight minimization and reuse contribute to reducing all of these impacts.

Limitations: Because of it's orientation toward the French store's operations, this LCA's applicability to the Seattle situation may be affected due to the potential for different technology use, regulatory regimes, and waste management options. For example:

- Energy sources are different (coal, oil, natural gas versus hydroelectric)
- The French mix of waste management options includes 49% incineration and 51% land filling, with 45% paper recycling.
- However, when sensitivity analyses is applied, the results cited above do not change with the following changes:
- Reuse -up to 65%- of one-way PE bags as kitchen bin liners
- Paper bags reused once
- 100% land filled or 100% incinerated at the end of life
- 30% recycling of PE reusable bag.

Finally, the report concludes that reusing one-way PE bags improves its environmental performance, as does reuse of a paper bags reusable PE bags remain better for all indicators when reused over 4 times.

3. Environment Australia – Plastic Shopping Bags-Analysis of Levies and Environmental Impacts

This report was completed by Nolan-ITU Pty. Ltd for Environment Australia, Department of the Environment and Heritage in 2002. This report comes close to the combination of policy analysis and LCA report parameters that best match the needs of Seattle. The report compares the environmental, economic, and social outcomes of several different policy options aimed at reducing litter from disposable shopping bags.

Type of Bags: Disposable HDPE shopping bags, disposable 50% recycled HDPE shopping bags, boutique LDPE shopping bags, Coles Calico shopping bags, woven HDPE reusable shopping bag, reusable polypropylene (PP) fiber shopping bag, disposable kraft paper shopping bag, reusable solid PP smart box, reusable LDPE shopping bag, biodegradable starch-based shopping bag, and biodegradable PE shopping bag with prodegradant additives.

Full or Partial LCA: Full but "Streamlined" (data is the result of a streamlined study using existing data, rather than data from the actual processes used for each specific bag)

Functional Unit: Bags necessary for a household to carry approximately 70 grocery items home from a supermarket each week for 52 weeks

Environmental Indicators Used: Material consumption, litter, greenhouse gas emission, primary energy use

Assessment Results: See Table F-3 in Appendix F.

Assessment Conclusions: The report concludes that available policy options do have the potential to significantly reduce environmental impacts in resource and energy consumption, and littering (Nolan-ITU 2002). Overall, the report indicates that a shift from single use disposable plastic bags to reusable bags would provide the best environmental gains over the full life cycle of the packaging. In addition, "less significant and consistent gains are made by switching from HDPE to other single use bags, such as paper and biodegradable bags, with potential gains in litter being offset by negative resource use outcomes. There were no significant differences [between different] reusable bag environmental outcomes. Reusable heavy duty plastic bags which can combine low resource use, longevity, and recycling came out on top. The use of biodegradable bags would offer some benefits in litter persistence but would not deliver significant resource use gains and would not be compatible with plastic bag recycling (Nolan-ITU 2002)."

Limitations: The main issue addressed by the report is litter caused by disposable plastic bags. No data is presented to address other environmental issues such as acidification, eutrophication, ozone, or human toxicity.

The report states that the results are highly dependent on assumptions made about reuse of HDPE bags and LDPE boutique bags; use patterns for reusable bags; purchase of alternative products (e.g. bin liners); and the percentage of bags entering the litter stream. Correspondingly, environmental gains from reusable bags are closely linked to the life expectancy of the bags, their weight-to-capacity ratio and their final destination – low litter, high recycled.

The study found it difficult to develop quantitative indicators on litter potential, but they used a methodology in their model (expanded in a subsequent study to address marine litter) that provides useful guidelines. The three indicators they use include:

- Mass of material finding its way into the litter stream – representing mass of resources lost from recovery options

- The area of ground covered by litter – measured in square meters (m^2) and based on the maximum area which a bag could cover if it became litter
- The persistence of litter measured in meters squared per year to represent the area covered by litter over time. (Nolan-ITU 2002).

4. *The Impacts of Degradable Plastic Bags in Australia – Final Report to Department of the Environment and Heritage*

This report was completed by Nolan-ITU, ExcelPlas Australia, and the Centre for Design at RMIT in 2003-2004 for Environment Australia, Department of the Environment and Heritage. This report builds on the earlier report cited above by adding the environmental analysis for biodegradable bags largely missing from the other report. This report also expands the environmental categories considered, placing some emphasis on marine litter impacts. Finally, this report makes assumptions about waste management options that are consistent with the general waste management options provided in Seattle, including composting. In combination with the previous report, this report comes the closest to the combination of policy analysis and LCA report parameters that best match the needs of Seattle for informing its own policy analysis.

Type of Bags: Disposable Shopping Bags made from thermoplastic starch (TPS) with a variety of co-polymers (Poly (butylene succinate-co-adipate) (PBSA), Polybutyrate adipate terephthalate (PBAT), Polycaprolactone (PCL), PE), PLA, disposable HDPE shopping bag, Kraft paper shopping bag, reusable PP fiber shopping bag, reusable woven HDPE shopping bag, reusable Calico shopping bag, and reusable LDPE shopping bag

Full or Partial LCA: Full but "Streamlined" (data is the result of a streamlined study using existing data, rather than data from the actual processes used for each specific bag)

Functional Unit: Bags necessary for a household to carry approximately 70 grocery items home from a supermarket each week for 52 weeks

Environmental Indicators Used: Material consumption, greenhouse gas emissions, abiotic depletion, eutrophication, litter aesthetics, and litter marine biodiversity

Assessment Results: See Table F-4 in Appendix F.

Assessment Conclusions: The report concludes that "reusable bags have lower environmental impacts than all of the single-use bags. Degradable bags have similar greenhouse impacts to conventional HDPE bags (apart from Mater-Bi, which is higher), and depending on the source of the raw material may have much higher nutrient impacts (eutrophication) from farming activity. On the other hand, the conventional polymers have higher resource impacts (abiotic depletion). If the degradable material can be kept out of landfill, and managed through composting, the impacts will be reduced, but not eliminated." In addition, "the benefits of degradable bags are in lower consumption of non-renewable resources and faster rates of degradation in the litter stream (with potential benefits for wildlife is less plastics are ingested by fish and marine mammals)."

The report went on to say that degradable polymers could help to reduce the impacts of plastic bags in litter if exposed to heat, ultraviolet (UV) light, mechanical stress and/or water, though actual rates of degradation are unclear.

The report also pays some attention to the effects of the introduction of biodegradable bags on plastic bag manufacturers and distributors, and recyclers. Like Australia, Washington State does not have a large amount of grocery bag manufacturing, with most competition coming from other states, or Asian Pacific countries. The loss in manufacturing and distribution economics was judged low. However, for recyclers, the report cites the lack of compatibility between Australia's current plastic bag recycling infrastructure, and biodegradable plastics.

<u>Limitations:</u> Like the previous Australian report, key assumptions for all of the results presented in this report involve bag weight, relative capacity, and expected life. In addition, the relative standard limitations regarding technology, energy sources, and geographic differences also apply to the Seattle circumstances. In addition:

- The levels of separation of organic material (food, paper etc) for organics treatment modeled in this report are lower than those in Seattle. The assumptions about the percentage of bags disposed to landfill and compost made by the research underestimate any increase or decrease in impacts associated with this waste management option.

- There is limited data available on degradation rates in litter. Estimated degradation times depend on both the resin and the environment, and range from 2 months to more than a year.

Finally, this study does not, nor do many LCAs prepared for bio-based products, take land use into consideration. A growing number of researchers consider the inclusion of land use in LCAs desirable because it would capture the potential scarce land conflict between growing biobased feedstock for non-food and energy production and the need for increased food production as population grows (EPOBIO 2006)[5].

[5] Emerging research is being done on the comparison of environmental impacts of biobased feedstock production and bioenergy. Patel states "By comparing the use of biomass for the manufacture of materials (polymers and fibers) on the one hand and for energy purposes (bioenergy) on the other, insight can be gained about the most effective options for land use and cultivation. Important findings of Dinkel et al. (1996) and the LCA prepared by Corbière-Nicollier et al. (2001) are hence that materials based on starch, kenaf and china reed offer larger opportunities for energy saving and GHG mitigation than bioenergy (Dinkel et al., 1996; Wolfensberger and Dinkel, 1997). In contrast, Kurdikar et al. (2001) argue that bioenergy contributes more to GHG emission reduction than biomass-derived feedstocks. The main reason for this contrasting finding seems to be that the product and process Kurdikar et al. (2001) studied – i.e., the production of polyhydroxyalkanoates [PHA] in plants – currently cannot compete with conventional products in energy terms. Wherever the opposite applies – and this is the case for most of the other products analyzed – the available results indicate that biomaterials offer higher environmental gains than bioenergy. …Comparative assessments will continue to be needed in order to keep track of the aspects of

5. *Resource and Environmental Profile Analysis of Polyethylene and Unbleached Paper Grocery Sacks*

This report was completed by Franklin Associates in 1990, and as such is subject to the obsolescence limitations described earlier. However, the report is one of the original sources of domestic information regarding the environmental impacts of plastic disposable shopping bags versus paper disposable shopping bags.

Type of Bags: 1/6 barrel polyethylene (HDPE and LDPE) vest type grocery shopping bags; and 1/6 barrel 70 pound base weight single ply unbleached paper grocery shopping bags.

Full or Partial LCA: Full (ISO standards for LCA were yet to be developed)

Functional Unit: 10,000 bags

Environmental Indicators Used: Energy, solid waste emissions, atmospheric emissions, waterborne wastes,

Assessment Results: See Table F-5 in Appendix F.

Assessment Conclusions: The authors of a recent review of this LCA conclude:

- "[T]he energy requirements for the plastic polyethylene shopping bags were found to be 20 to 40% less than for paper shopping at zero percent recycling for both bags. As recycling increases, the energy requirements became equivalent at approximately a 90% recycling rate (for a 2:1 plastic to paper use ratio) (Fridge, 2002).

- Polyethylene sacks were found to contribute 74 to 80 percent less solid waste than paper shopping bags at zero percent recycling. Polyethylene shopping bags continued to contribute less solid waste than paper sacks at all recycling rates. For the purposes of this study solid wastes included ash from energy generation and incineration and post consumer solid wastes. The landfill volume occupied by the polyethylene sack is 70 to 80 percent less than the volume occupied by paper sacks given equivalent uses.

- Atmospheric emissions for the polyethylene shopping bag were found to range from 63 to 73 percent less than for paper shopping bags at zero percent recycling. These lower impacts for polyethylene shopping bags

competition and complementarities between bioenergy and biomaterials. This is also necessary in order to account for innovations in both areas. It would ease such comparisons and the useful-ness for decision-makers if future studies dealing with bioenergy and biomaterials always also studied the land use requirements of the various options. (Patel 2003)" continued throughout all recycling rates. Six components were analyzed and aggregated for this category, including particulates, nitrogen oxides, (NOx), hydrocarbons, sulphur oxides (SOx), carbon monoxide, and odorous sulphur.

- At zero percent recycling rate, the polyethylene shopping bag contributed over 90 percent less waterborne wastes than the paper shopping bags. As the rates of recycling increased, the difference was found to increase as well. Four components were analyzed and aggregated for this category, including dissolved solids, biological oxygen demand (BOD), suspended solids and acids (Fridge, 2002)."

<u>Limitations:</u> In addition to the technology improvement and environmental data changes that affect the applicability of the 1990 Franklin Study to local circumstances (mentioned earlier), a number of other issues affect any comparison of this report to local circumstances, for example:

- Raw material source (e.g. coal vs. oil)
- Sources of energy (nuclear, coal, hydroelectric)
- Production processes (cracking, extrusion technologies, emission controls)
- Conversion processes (new technology and regulatory requirements)
- Consumer practices (reuse, availability of and propensity to recycle)
- Waste management processes (landfill gas captured or not, used for energy generation or not) (Fridge, 2002).

Additional insight is provided by another reviewer of the 1990 Franklin report. That reviewer pointed out that while paper shopping bags have higher total air emissions than plastic shopping bags, paper had higher emissions of particulates, nitrogen oxides, and sulfur dioxides, but lower emissions of hydrocarbons.

Disposable Shopping Bag Key Findings

- The potential exists to reduce life cycle environmental impacts of disposable plastic bag use in Seattle, given the alternatives available. The benefits are most likely in the form of resource consumption, greenhouse gas emissions, and litter reduction. Despite the difficulty in comparing reports with different goals, methodologies, assumptions, functional units, product sizes, and locations among others, clear trends have emerged from our review.

- Disposable plastic bags are a significant source of litter around the world, in the U.S., and in the City of Seattle. Disposable plastic bag litter affects both terrestrial and marine wildlife.

- Plastic shopping bags entering the marine environment represent a threat (not quantified) to marine life along with other packaging and other littered items.

- In most instances, a switch to reusable bags provides the greatest environmental benefits if reused a minimum number of times (e.g., 4 is cited in (Ecobilan 2004). The environmental benefits of the reusable bag relative to those of disposable plastic bags depend on the number of times it is reused. Policies developed to discourage disposable shopping bags should focus on consumer behavior to maximize this approach.

- Increased use of reusable bags would result in fewer plastic bags littering neighborhoods and being ingested by marine animals.

- There were no significant differences in environmental impacts among reusable bags. Reusable heavy duty plastic bags, which can combine low resource use, longevity and recycling, seem to be the best. (Nolan-ITU 2004).

- A shift from disposable plastic bags to biodegradable bags and paper bags would benefit litter persistence impacts (due to an anticipated faster degradation rate in both land and marine settings)

- Both biodegradable bags and disposable plastic bags offer environmental benefits over paper bags in resource and energy use, even with higher levels of paper bag recycling, though litter persistence is a major drawback.

- Biodegradable bags may offer some other environmental benefits, particularly if the waste management option is a commercial-scale composting system. However, it is unclear if biodegradable bags offer environmental benefits to a clear enough degree that they are better than disposable plastic bags. The litter persistence benefits offered by a shift from disposable plastic bags to biodegradable bags and paper bags may come with an increase in resource use, energy use, and greenhouse gas emissions. (EuroCommerce 2004). In addition, biodegradable bags are not compatible with the existing plastic bag recycling infrastructure.

- Most disposable plastic bags end up in a landfill, where their volume and environmental impacts are minimized (assuming no degradation). The total weight of disposable shopping bags as a percentage of the waste stream, is minor as a solid waste handling issue – usually less than 0.4%

Disposable Food Service Items

Several reports made direct comparisons of various type of disposable food service items, including clamshells, cups, plates, and cutlery. The analyses focused on mostly polystyrene and other existing petrochemical plastics versus biodegradable polymers, paper, and in some cases reusable alternatives. Far fewer LCAs were found during the literature search than were found focusing on disposable plastic bags, with much of the research focused on polystyrene. Definitions for all environmental indicators used for food service items, including units, are contained in Appendix E. All individual inventory results are contained in Appendix G.

1. *Environmental Assessment of Bio-Based Polymers and Natural Fibres. Dr. Martin Patel, Dr. Catia Bastioli, Dr. Luigi Marini Dipl.Geoökol. Eduard Würdinger*

The cradle-to-factory gate LCAs that focused on both petrochemical plastic pellets and biobased and biodegradable plastic pellets are also relevant to the food service items discussion. Please refer to that discussion in the disposable bag LCA results section.

2. *Life Cycle Inventory of Polystyrene Foam, Bleached Paperboard, and Corrugated Paperboard Food service Products.*

This report was completed by Franklin Associates in 2006 for the Polystyrene Packaging Council, a part of the American Chemistry Council's Non-Durables Plastics Panel.

<u>Type of Food service items:</u>

- 16-oz cups used for hot beverages from expanded polystyrene (EPS) foam, polyethylene (PE)-coated bleached paperboard (used alone and with corrugated unbleached paperboard cup sleeves)
- 32-oz cups used for cold beverages from EPS foam, PE-coated bleached paperboard, wax-coated bleached paperboard
- 9-inch high-grade (heavy-duty) plates from general purpose polystyrene (GPPS) foam [EPS], PE-coated bleached paperboard, molded pulp
- 5-inch sandwich-size clamshells from GPPS foam, insulated (corrugated) paperboard

<u>Full or Partial LCA:</u> Partial, in that it is a life cycle inventory and does not contain an impact assessment. The report covers a cradle-to-grave scope and is compliant with ISO standards in most respects. (See Limitations)

<u>Functional Unit:</u> 10,000 product units

<u>Environmental Indicators Used:</u> Energy, solid waste (weight), solid waste (volume), atmospheric and waterborne emissions, greenhouse gas emissions

Assessment Results: See Table G-2 in Appendix G.

Assessment Conclusions: The study authors reach the following conclusions regarding the full range of product weights analyzed in each product category.

- For energy, "the difference between system energy totals is not meaningful for comparisons of polystyrene foam systems with PE-coated paperboard hot cups and cold cups, molded pulp plates, and fluted paperboard clamshells. Energy differences between systems are meaningful in favor of polystyrene foam products in some comparisons, including PE-coated paperboard hot cups with sleeves and wax-coated paperboard cold cups. The energy comparison of GPPS foam plates and PE coated paperboard plates is meaningful in favor of paperboard (Franklin 2006)."

- For solid waste, "total solid waste weight comparisons of polystyrene foam products and alternative products all are meaningful in favor of polystyrene. By volume, the solid waste totals for polystyrene and paper-based products are comparable (or, in the case of plates, polystyrene is higher) (Franklin 2006)."

- For atmospheric and waterborne emissions, no overall conclusions were made since no system produced the lowest emissions in every category (Franklin 2006).

- For greenhouse gas emissions, the comparison of EPS cups with alternative cups was inconclusive (Franklin 2006). For plates, PE-coated paperboard plates compared favorably with all other alternatives, including GPPS. For clamshells, comparisons are inconclusive.

- The study also provided a brief assessment of the contribution of secondary packaging. In general, the report concludes that the weight of secondary packaging and the corresponding environmental impacts tend to be higher for foamed products. Specifically, "on average, secondary packaging increases the environmental burdens for average weight paperboard products by 4 to 12 percent, while packaging adds 14 to 46 percent to the environmental burdens for average weight foam products (EPS, GPPS).

- The study also provided a brief assessment of the effects of low levels of recycling. In general, the report concludes that for all food service materials "two percent recycling or composting reduces total environmental burdens by two percent or less. The percent reduction for recycling is less than one percent, since some of the savings in virgin material production burdens are offset by the burdens for collection and reprocessing of post-consumer material."

Limitations: The authors cite the following study limitations:

- "Participation by some industry stakeholders in this study was limited despite extensive and repeated efforts to secure participation of all stakeholder industries. In particular, the paperboard industry, which is represented in every food service product category studied, declined to participate in any way. Thus, the data quality goals of the study could not be realized as originally intended. However, the environmental profiles presented in this report for non-participating industries were developed using the best and most current data available from Franklin Associates' U.S. life cycle database, updated to the extent possible to represent current technology.

- Although the methodology for this study is compliant with ISO standards, it was not possible to meet some of the ISO data quality requirements due to the limited participation by some industries. In particular, this study does not meet all the stringent data quality requirements set out in the ISO 14040 standards for life cycle studies used to make general comparative assertions regarding the overall environmental superiority or preferability of one system relative to a competing system or systems. The authors discourage the use of this study to make general comparative assertions about overall environmental performance of the systems studied. The use of this study to make public comparative assertions is limited to specific statements that are supported by the study results." (Franklin 2006)

The authors also caution against making comparisons between the results in the report and different material products in different product categories (Franklin 2006). Conclusions regarding the relative performance of the range of competing products cannot be drawn from the report because results for the full range of product weights for each material are not included.

In addition, Franklin studies are the only reports reviewed that used the following convention around "meaningfulness" of the data, which third-party reviewers did not take issue with. Summarized from the report:

- If the energy or post consumer solid waste of one system is 10 percent or more different from another, it can be concluded that the difference is significant.

- If solid waste (weight and volume), atmospheric emissions or waterborne emissions of a system is 25 percent different from another, it can be concluded that the difference is significant.

- Percent difference is defined as the difference between two values divided by the average of the two values.

Finally, a third-party peer review of the report points out many items that may affect any overall conclusions that can be drawn from the report. Again, both the report and the peer-review contain a wealth of information, in far too much to detail to present fully in this report. Review of these reports in their original context would prove a useful supplement to the information presented here, and a glimpse into the complexity of the analysis behind these summaries.

3. Life Cycle Inventory of Five Products Produced From Polylactide (PLA) and Petroleum-Based Resins

This report was completed by Franklin Associates in 2006 for the Athena Sustainable Materials Institute. The report evaluates the life cycle inventories of five products from PLA and petroleum-based resins. The Athena Institute is a Canadian-based non-profit that undertakes and directs research and development activities that allow architects, engineers, and others to factor environmental considerations into the design process from the conceptual stage onward (Athena 2007).

<u>Type of Food service items:</u>

- 16-oz cups used for cold beverages from high impact polystyrene (HIPS), polyethylene terephthalate (PET), and polypropylene (PP).
- 16 oz 2-piece deli containers: light weight from PLA and general purpose polystyrene (GPPS); and heavy weight from PET.
- #2 Foam meat trays from PLA (not commercial as of 2006) and GPPS foam[6]

<u>Full or Partial LCA:</u> Partial, in that it is a life cycle inventory and does not contain an impact assessment. The report covers a cradle-to-grave scope and is compliant with ISO standards

<u>Functional Unit:</u> 10,000 product units

<u>Environmental Indicators Used:</u> Energy consumption, solid waste generation, environmental emissions to air and water, and greenhouse gas emissions

<u>Assessment Results:</u> See Table G-3 in Appendix G.

[6] According to the California Integrated Waste Management Board, "PS comes in many types and forms and is used in a variety of applications. However, the two major types are "general-purpose" (also known as "crystal") PS and "high-impact" (also known as "rubber-modified") PS. When a blowing agent (usually pentane) is added to general purpose PS, the material is referred to as "expandable (or "expanded") polystyrene" (EPS). (CIWMB 2004)"

<u>Assessment Conclusions:</u> For the 16-ounce cold cups, the report concludes

- For energy requirements,"the PET cup requires the most total energy, while the PP cup requires the least total energy. This correlates with the fact that the PET cup is the heaviest, while the PP cup is the lightest. The PLA 2005 cup requires significantly more energy than the PP cup and less than the PET cup; however, it is not significantly different from the HIPS cup (Franklin 2006B)."

- For solid waste generation (by weight), "the PET cup is the heaviest and so produces the most post consumer solid waste; however, the PLA cup post consumer solid waste is not considered significantly different from that of the PET cup. The PLA and PET cups produce significantly more post consumer solid waste than the PP and HIPS cups (Franklin 2006B)."

- According to the report, "the predominant atmospheric emissions from the product systems include greenhouse gases (particularly carbon dioxide, methane, and nitrous oxide), nitrogen oxides, sulfur oxides, particles of 10 micrometers or less (PM10), and hydrocarbons" among others. However, the report did not reach any differentiating conclusions about the cold cups (Franklin 2006B).

- Also according to the report, "the predominant waterborne emissions from the container systems include dissolved solids, suspended solids, chemical oxygen demand (COD), biological oxygen demand (BOD), chlorides, and various metals. However, the report did not reach any differentiating conclusions with cold cups (Franklin 2006B).

- For greenhouse gas emissions, "the PP cup produces the lowest amount of CO2 equivalents. This is due to the fact that much of the fossil fuel used in the PP drink cup is from feedstock energy, which is bound within the product and therefore does not produce greenhouse gases. The PLA 2005 drink cup produces a greater amount of CO2 equivalents than the PP drink cup. There is no significant difference in the amount of carbon dioxide equivalents between the PLA 2005 cup system and the HIPS cup system. The PLA 2005 cup system creates significantly less carbon dioxide equivalents than the PET cup system (Franklin 2006B)."

For the 16-ounce 2-piece deli containers, the report concludes:

- For energy requirements, the lightweight GPPS deli container energy is not considered significantly different from the PLA 2005 deli container. The heavyweight PET deli container "requires significantly more energy than the PLA deli container (Franklin 2006B)."

- For solid waste generation (by weight), the lightweight PLA deli container is the heaviest and so produces the most post consumer solid waste. Also, the PET deli container is the heaviest among heavyweight containers, and produces the most post consumer solid waste (Franklin 2006B).

- As with the cold cups, the report did not reach any differentiating conclusions concerning atmospheric or waterborne emissions with the deli containers (Franklin 2006B).

- For greenhouse gas emissions, "the carbon dioxide equivalents for the lightweight PLA 2005 deli container are not significantly different than for the GPPS deli container. The carbon dioxide equivalents for the heavyweight PET deli container system are significantly greater than for the heavy-weight PLA deli container system (Franklin 2006B)."

For the #2 foam meat trays, the report concludes:

- For energy requirements, "the PLA 2005 foam meat tray total energy is not significantly different from the GPPS foam meat tray (Franklin 2006B)."

- For solid waste generation (by weight), the PLA 2005 foam meat tray total is "not significantly different from the GPPS foam meat tray (approximately 5 percent) (Franklin 2006B)."

- As with the cold cups and the deli containers, the report did not reach any differentiating conclusions concerning atmospheric or waterborne emissions with the foam meat trays (Franklin 2006B).

- For greenhouse gas emissions, "CO2 equivalents for the PLA 2005 foam meat tray is not significantly different from the amount of CO2 equivalents for the GPPS foam meat tray. This is due to the fact that much of the fossil fuel used in the GPPS foam meat tray is from feedstock energy, which is bound within the product and therefore does not produce greenhouse gases (Franklin 2006B)."

<u>Limitations:</u> The authors cite the following study limitations:

- Environmental emissions associated with end-of-life management of the products are not part of the scope of the report. Only landfilling and combustion of the products are analyzed for end-of-life management. (This represents a different infrastructure than that existing in Seattle.)

- Like the previous study, this study used the following convention around "meaningfulness" of the data. Cited from the report:

- "If the energy or post consumer solid waste of one system is 10 percent or more different from another, it can be concluded that the difference is significant.
- If solid waste (weight and volume), atmospheric emissions or waterborne emissions of a system is 25 percent different from another, it can be concluded that the difference is significant.
- Percent difference is defined as the difference between two values divided by the average of the two values (Franklin 2006B)."

4. Life Cycle Assessment of Polylactide (PLA). A Comparison of Food Packaging Made From Natureworks® PLA and Alternative Materials. Final Report.

This report was completed by IFEU Heidelberg in 2006 for NatureWorks LLC. The report evaluates the life cycle inventories of 500 ml clamshell retail take-out containers from PLA and petroleum-based resins. NatureWorks LLC is an independent company formed by a joint venture of Cargill and Dow and now wholly owned by Cargill (NatureWorks 2007).

Type of Food service items: 500 ml clamshell containers from polylactic acid (PLA), PLA-5 (Natureworks LLC 5th generation production resin, general purpose polystyrene (GPPS), polypropylene (PP), and polyethylene terephthalate (PET)

Full or Partial LCA: Full (compliant with ISO standards)

Functional Unit: 1,000 product units

Environmental Indicators Used: Fossil Resource Consumption (weighted with a scarcity factor of fossil fuel); greenhouse gas emissions, acidification, terrestrial eutrophication (i.e. eutrophication of soils by atmospheric emissions), aquatic eutrophication (i.e. eutrophication of aquatic ecosystems by effluents), summer smog (photo-oxidant formation), and human toxicity as PM10-equivalents

Assessment Results: See Table G-4 in Appendix G.

Assessment Conclusions: The report concludes that:

- "…[T]he PLA system shows advantages compared to all three packaging systems using conventional polymers, in the categories Fossil Resource Consumption, Global Warming and Summer Smog. Similar results regarding Human Toxicity (Carcinogenic Risk) are of limited reliability due to existing data quality issues.
- "For the remaining impact categories, comparisons of the PLA system with the alternative systems do not show a clear trend. The LCA results

for Acidification, Terrestrial Eutrophication and Human Toxicity (PM10) show disadvantages of PLA when compared to PS and PP systems.

- "Comparing PLA with PET, PLA only shows disadvantages for terrestrial and aquatic Eutrophication. However, the latter observation has been found to depend on the choice of PET inventory dataset. For Aquatic Eutrophication PLA shows environmental advantages if compared to PP and disadvantages in comparison with PS and PET. These conclusions proved to be quite robust. Similar patterns were found in the various sensitivity analyses performed…

- "Altogether, the comparative results show a pattern of environmental advantages and disadvantages of PLA according to the individual environmental category considered. The fundamental message here is that there is a trade-off which does not allow for a clear overall preference of any particular system in the first place." (IFEU 2006)

<u>Limitations:</u> The authors point out in numerous locations in the report that the results are reliable within the framework conditions set by the goal and scope of the assessment; however, "the results should not be used for general comparisons of plastics packaging from different polymer materials." (IFEU 2006) Despite this statement, the report goes on to present some results for different polymer systems side by side.

In general, the authors also point out that each of the packaging systems evaluated in the report, and those elsewhere on the market, are unique combinations of production systems, energy sources, and product weights and volumes among other standard differences. All have the potential to change the environmental profile. (IFEU 2006)

In addition, this report used a set of data for PET that, when compared with an alternative data set from a different source, altered some of the relative environmental outcomes with PLA. The report also states that the results are only valid for NatureWorks PLA, and not representative of other PLA producers.

The report also states that the LCA study is "designed to reflect German conditions. Inventory data and material flow settings which are specific for the German market are:

- Grid electricity data (relevant for electricity requirements for polymer conversion into clam shells and credits for electricity output from MSWI);

- End-of-life settings; and

- Process data for recovery and recycling operations (IFEU 2006)."

In addition, the authors suggest that the LCA should be considered as a case study since the packaging weights and conversion data used are only valid for the clam shells of the French packaging producer Vitembal. Also, the report makes some assumptions about the recovery of in-process PLA scrap that are not yet standard at converters using PLA (IFEU 2006).

Finally, the authors contend that the overall quality of the data used is satisfactory, despite ongoing concerns about the quality of the inventory data behind the indicator results for human toxicity (carcinogenic risk) (IFEU 2006).

5. *Comparative LCA of 4 Types of Drinking Cups Used At Events*

This report was completed in 2006 by OVAM, the Public Waste Agency for the Flemish Region of Belgium. It looks at the life cycle environmental impacts of four types of drinking cups used at both small (2000-5000 visitors) and large (>30 000 visitors) events.

Type of Food service items: Re-usable cup in polycarbonate (PC); one-way cup in polypropylene (PP); one-way cup in PE-coated cardboard; and one-way cup in polylactide (PLA).

Full or Partial LCA: Full (compliant with ISO Standards)

Functional Unit: The cups needed for serving 100 liters of beer or soft drinks at a small-scale indoor (2000-5000 visitors) and a large-scale outdoor event (>30 000 visitors)

Environmental Indicators Used: Fossil fuels, minerals, acidification/eutrophication, ecotoxicity, ozone layer, climate change, respiratory effects caused by inorganics, respiratory effects caused by organics, and carcinogens

Assessment Results: See Table G-5 in Appendix G.

Assessment Conclusions: The authors conclude that for small-scale events, the reusable PC cup had a lower environmental profile in fossil fuels, ecotoxicity, greenhouse gas emissions, respiratory organics and carcinogens than all other cups. PP cups had the lowest environmental profile in minerals, ozone layer, acidification/eutrophication, and respiratory inorganics; both reusable PC cups and PP cups were far lower in acidification/eutrophication than cardboard and PLA cups. Cardboard cups are notable for their negative environmental profiles, compared to the other cups, in minerals, ozone layer, ecotoxicity, carcinogens, and respiratory inorganics. Despite the differences, the authors do not make a straightforward conclusion for the selection of the most favorable cup system with regard to the environment since none was clearly favorable in all categories. (OVAM 2006)

The authors conclude that for large-scale events, the reusable PC cup had a lower environmental profile in only respiratory organics. PP cups had the lowest environmental profile in minerals, acidification/eutrophication, ecotoxicity, ozone layer, and carcinogens. PLA cups did not have the lowest environmental profile in any category. Cardboard cups are notable for their lowest environmental profile in fossil fuels, and their highest environmental profiles in minerals, ecotoxicity, respiratory inorganics, and carcinogens. Reusable PC cups are notable for their highest environmental profile in ozone layer depletion. Again, despite the differences, the authors do not reach a straightforward conclusion for the selection of the most favorable cup system with regard to the environment since none was clearly favorable in all categories (OVAM 2006).

For both type of events, it was concluded that none of the cups systems has the highest or the lowest environmental score for all environmental categories considered, and so the authors did not select the most favorable cup system with regard to the environment (OVAM 2006). In addition, the results show that the cups evaluated do not hold their relative ranking for environmental profiles between small and large events. For example, at small events the reusable PC cup never has the highest environmental profile, but at large events, it has the highest environmental profile for ozone layer depletion and a very close second highest in greenhouse gas emissions. (OVAM 2006)

Sensitivity analysis performed indicates that the number of trips associated with the cups is a significant factor in determining the relative ranking environmental profiles between cups for both small and large events. Sensitivity analysis also showed that the additional use of water and soap to wash reusable PC cups did not have much influence on the relative ranking of environmental profiles among cups. The study also showed that the PLA cup weight, which may have the potential to drop as production processes are optimized, could proportionally decrease the environmental profile, depending on the category, from 10-60%. (OVAM 2006)

<u>Limitations:</u> The report's authors do not specifically call out limitations to the study. However, a review of the document highlights standard limitations associated with complex studies such as this, and with making direct comparisons to Seattle's situation, including for example:

- Raw material source (e.g. coal vs. oil)
- Sources of energy (nuclear, coal, hydroelectric)
- Production processes (cracking, extrusion technologies, emission controls)
- Conversion processes (new technology and regulatory requirements)
- Consumer practices (reuse, availability of and propensity to recycle)
- Waste management processes (landfill gas captured or not, used for energy generation or not) (Fridge, 2002).

In addition, the authors point out that the data reflects only the specific actual situation in Flanders. Data on representative cups, on average number of trips, etc. are specifically directed at the Flemish (Belgian) situation. They also state that the study "addresses only those environmental issues that are identified in the goal and scope (OVAM 2006)."

Disposable Food service items Key Findings

- In contrast to the findings for disposable shopping bags, the potential to reduce life cycle environmental impacts of disposable food service items in Seattle is less clear. If they are to occur, given the alternatives available, the benefits are most likely in the form of litter persistence reduction. Because of the relatively few LCA reports available for these products, and the inconsistent environmental data for all product alternatives, few clear trends emerged during this study's review.

- Expanded polystyrene entering the marine environment represents a threat (not quantified) to marine life along with other packaging and other littered items.

- A shift from disposable food service items to biodegradable food service items would benefit litter impacts on marine ecosystems due to the faster rate of degradation.

- Two reports showed PP performing better in some categories (i.e., acidification, terrestrial eutrophication, human toxicity, and in the formation of ozone precursors), and for only the products and circumstances reviewed, compared to PLA, OPS, paper, or reusable PC.

- One report suggested that biodegradable food service items (e.g., plates, cutlery) makes it possible to increase the fraction of waste handled through composting or anaerobic digestion by allowing the capture of food wastes that would other wise go to the landfill (Innocentia 2002).

- When evaluating PS among similar products, and depending on product applications among other factors, sometimes EPS, GPPS, HIPS, PE-paperboard, reusable PC, or PLA performed best on energy consumption; therefore, the results were inconclusive.

- When evaluating PS among similar products, and depending on product applications among other factors, sometimes PE-paperboard, reusable PC, PP, or PLA performed best on greenhouse gas emissions; therefore, the results were inconclusive.

Relevant Conclusions for Strategies to Be Evaluated

Disposable Shopping Bags

Based on this review of available disposable bag LCAs, four policy options aimed at reducing disposable bag use will be evaluated in the next chapter of this report. The policy options address both paper and plastic disposable bags, and emphasize the use of reusable bags in their place. While the use of biodegradable bags shows some potential for environmental benefit, Seattle's existing plastic bag recycling and composting systems cannot support the levels of contamination that would be expected if a mixture of plastic and biodegradable shopping bags were used throughout the City. The absence of a comprehensive labeling system for compostable and biodegradable plastics that is easily presentable and understood by the wide range of residents that use bags is also a contributing factor. However, future development of such a system may allow the City to revisit its options to emphasize a wider range of alternatives to disposable bags.

The studies prepared in 2002 and 2004 for the Australian Department of the Environment and Heritage are the most comparable to the City of Seattle circumstances. This conclusion is due to the similarity between the assumptions and data used to develop life cycle inventory and assessment conclusions, including manufacturing processes, energy sources, bag sources, types, weights/capacities, bag uses, and waste management options. The life cycle assessment results for these reports will be used to develop and model environmental impacts for all policy options evaluated. Coupled with the economic costs and benefits to be described in the next chapter, a full evaluation of the life cycle impacts of each policy option will be presented.

Disposable Food Service Items

Based on this review of available food service items LCAs, four policy options aimed at reducing disposable food service items use will be evaluated in the next chapter of this report. The policy options address both EPS and other disposable food service items, and emphasize the reduction of litter and environmental impacts from disposable food service items through the use of biodegradable products. The absence of a comprehensive labeling system for compostable and biodegradable plastics is less of a problem related to these products, since the target is much narrower and aimed at commercial establishments using "take-away" packaging.

A combination of the Franklin studies and the OVAM studies prepared in 2006 and 2004 are the only studies to look at the range of products the City is interested in addressing through this study. The life cycle assessment results for these reports will be used to develop and model environmental impacts for all policy options evaluated. Coupled with the economic costs and benefits to be described in the next chapter, a full evaluation of the life cycle impacts of each policy option will be presented.

Finally, it is likely that manufacturing technologies for biodegradable products will advance significantly relative to petrochemical plastics, which have already been optimized for over 50 years, and benefit from large economies of scale. As a result, these advances will likely improve the environmental performance of biodegradable plastic products across many categories. Newer LCAs should be used to update this existing report for specific cases on an ongoing basis.

6 Evaluation of Alternative Waste Reduction Program Strategies for Seattle

To reduce the impacts associated with the use of disposable shopping bags and disposable food service items, the range of strategies reviewed in Chapter 2 is available to the City of Seattle:

- Keeping the status quo
- Education
- Curbside recycling
- Private recycling
- Extended producer responsibility mechanisms
- Voluntary product bans or restrictions
- Reusable bag credits/giveaway
- Environmental preferable packaging requirements
- Mandatory advanced recovery fees (ARF)
- Mandatory product restrictions
- Mandatory product bans

One or more of these strategies could also be combined to create a hybrid or multifaceted approach to reducing use of disposable plastics. Whether alone or in combination, the strategy(ies) adopted by the City of Seattle should be suited to the unique conditions set by Seattle's businesses, residents, programs, and regulatory setting.

Research and Stakeholder Input

A literature review was conducted to evaluate the applicability of these strategies to the City of Seattle (see References). Perspective was also sought from other similarly-sized cities that had, or might, enact one or more of the strategies listed above. Both the literature review and communications with other municipalities were used to assess relevant advantages and disadvantages if applied to the City of Seattle.

Stakeholder input came from several sources. First, a survey of approximately 400 heads of households was conducted by Elway Research, Inc. to assess:

- Current behavior with regard to plastic bags and food service products
- Potential for changing behavior, particularly with regard to more recycling and composting
- Levels of potential support and opposition to various policy options, including fees and bans on certain products (SPU 2007).

The full draft report detailing the results of the survey is included in Appendix H. Figure 6-1 is an excerpt from the SPU report, and summarizes the key findings of the survey.

Not surprisingly, many Seattleites already walking the walk

- 1 in 3 claimed to bring their own bags to carry their groceries
- Well over half re-used or recycled most of their plastic bags

In order of priority, the general finding is support for

- Encouragement, Education and Persuasion of both merchants and consumers
- Ban on plastic foam
- Ban on reusable plastic bags
- Fees on consumers

Seattle residents generally favor a ban on plastic foam, and [a slight majority] are ready for City Government to act now

- 2 in 3 favored a ban
- 52% said city should act now
- 42% favored waiting until convenient replacements are available

"Encouragement" favored over bans or fees

- 9 in 10 supported encouraging restaurants to use recyclables voluntarily
- 2 in 3 supported banning disposable plastic food service items
- 5 in 10 supported consumer fee on disposable plastic food service items

Citizens willing to "pitch in" but less willing to pay

- 9 in 10 would "gladly separate my garbage" at a fast food restaurant, but
- 5 in 10 opposed consumer fee on disposable plastic food service items

Opinion about plastic bags less insistent than opinion on foam

- 9 in 10 agreed that stores should be encouraged to reduce usage of disposable bags
- 9 in 10 agreed that stores should be required to provide recycling bins for plastic bags
- 7 in 10 agreed that public funds should be spent for promoting reusable bags
- 6 in 10 opposed to prohibition on plastic shopping bags

Fees for paper bags even less popular

- 6 in 10 disagreed that the City should charge a fee to shoppers for every plastic bag
- 6 in 10 disagreed that a fee should be charged for any type of disposable bag, including paper

Any fees or bans assessed on merchants should be applied to all types and sizes of stores. "Mom and Pop" stores should not get a pass.

Persuasion and education preferred means to desired end

- As noted, 7 in 10 agreed that public funds should be spent for promoting reusable bags
- 9 in 10 agreed that stores should be encouraged to reduce usage of disposable bags
- Half said revenue from any fees should be spent on public education and promotion rather than keeping garbage rates down or subsidizing stores for reusable bags

Opinions were relatively uniform across sectors of the sample. There were some differences among demographic categories of respondents, but they were not pronounced.

Source: SPU/Elway 2007

Figure 6-1. Summary results from public opinion poll on disposable plastic.

Second, a series of focus groups and meetings were assembled to assess the potential level of support and opposition to various policy options from local businesses, non-profits, and private sector interests that may be affected by strategy implementation. A list of meeting or focus group attendees is listed in Appendix I. In addition, the Seattle Solid Waste Advisory Committee (SWAC) was informed of the study parameters and input sought from its members.

Figure 6-2 presents summaries of stakeholder views related to selection of strategies for Seattle.

Local Businesses [(1)]

Retailers, both food service and "general," are open and receptive to cooperating with the City in finding mutually acceptable ways to reduce the amounts of hard-to-recycle items entering our landfills. They are aware of the negative impacts these items do have on the environment, but are often confused as to which items are "green," which go in recycle bins, which can be composted and so forth. It appears that one challenge for the City of Seattle would be to continue its marketing and communication efforts for the public, both businesses and consumers, to increase their confidence and knowledge in proper, preferred disposal methods. In fact, retailers are also the consumer and recipient of many hard-to recycle items such as those used by their vendors in packing and are unsure of how to dispose of these materials as well.

There appears to be a greater consensus among these retailers as it pertains to bans on "Styrofoam" disposable products. There was some support for a ban on plastic shopping bags, but certain needs, however, dictate that some exceptions might be considered when/if imposing these bans, at least until acceptable alternative products are available and cost effective for the business. The need to protect a product that could be damaged by rain, for instance, would be one example. It was also noted by food service businesses that a need to keep something hot for an extended period of time might dictate the use of a polystyrene product until an acceptable alternative is available.

These retailers also seem to be amenable to measures as long as they do not impose onerous new requirements in fees, record keeping or other time-consuming activities. Smaller retailers on whom this burden would impact a greater share of their time and total profits especially note this concern. Measures that require them to charge their customers are also viewed with concern because this is perceived to increase the amount of revenue upon which they would owe taxes.

Over all, these retailers are more in favor of measures that would educate, promote and provide incentives rather than on measures that would require fees. They also believe these efforts should target the consumer as well as the retailer. Managers and owners of take out and fast food establishments are especially in favor of these kinds of efforts as they are applicable to landlords who must be encouraged to supply bins for recycling and composting.

It is also crucial that any bans or Advance [Recovery] Fees apply to ALL retail establishments in the City so the "playing field remains even." In fact, any measure adopted by the City should be unilaterally applied. Businesses would rather their customer attribute these measures and regulations on the City rather than on them. It is also important that the City allow enough time for businesses to phase out current practices in their efforts to meet new City guidelines. If there were a ban on plastic shopping bags, for instance, a retailer might need a year to use up his current inventory. In fact, one to two years seems to be the amount of time desired by a majority of participants.

(1) Source: Gilmore 2007. *Qualitative Investigation: Hard-To-Recycle Disposable Products*

Figure 6-2. Summary results from meetings with local businesses, non-profits, and private sector interests.

Non-Profit

- Disposable plastic presence in, and impacts on, the marine environment are unacceptable and action should be taken immediately to mitigate or eliminate impacts through a ban on EPS container packaging. (2)
- Disposable shopping bag consumption wastes resources, increases greenhouse gas emissions, costs consumers and municipalities, and creates unwanted litter. Their consumption should be reduced through a consumer fee on bags (3)

Private Sector (4)

- Banning disposable plastics will not solve the litter problem. It is a behavioral issue, not a product issue
- Best solution is education, a strong focus on recycling and enforcement of penalties for littering
- Biodegradable products are not the solution:
  - Would send wrong message to those who litter
  - Will contaminate the existing and emerging plastics recycling industry
  - The process of degradation gives off greenhouse gases
- All plastic waste to landfill represents around 7 per cent of waste stream(by weight)
- Existing disposable plastic product applications are efficient, waterproof, sanitary, non-toxic, and insulate better (i.e., EPS) than any alternative.

(2) Source: Trim 2007
(3) Source: Lundquist 2007
(4) Source: ACC 2007

Figure 6-2 (continued). Summary results from meetings with local businesses, non-profits, and private sector interests.

Disposable Shopping Bag Strategies

Based on the combined input described, and in consultation with Seattle Public Utilities' staff, the overall range of strategies to reduce the use of disposable plastics was narrowed for each product category (disposable shopping bags and disposable food service items).

The strategies to address disposable shopping bags were narrowed to the following four for further life cycle cost/benefit and environmental assessment. Given the City's policy goals for reducing greenhouse gas emissions, reducing the use of disposable products and increasing recycling and sustainability, keeping the status quo is not an alternative on its own. All other options are evaluated in comparison to the expected results if the status quo were continued without further intervention by the City.

- <u>Keeping the status quo:</u> General education focused on ongoing reduce-reuse-recycle messaging; plus city-provided residential curbside recycling opportunities for plastic bags and paper bags. Voluntary recycling facilities made available by some retail outlets (most grocery stores) for plastic bags with no support from the City.

- Enhanced education: Begin a public education and promotional campaign specifically focused on encouraging consumers to use reusable bags in place of disposable bags. This would become part of Seattle Public Utilities' ongoing reduce-reuse-recycle messaging. Activity may include varying degrees of technical assistance.

- Enhanced education plus ban on disposable plastic shopping bags only at all stores in Seattle.

- Enhanced education plus a mandatory advanced recovery fee (ARF) (likely range, 10 to 25 cents) on disposable plastic shopping bags only. The ARF could be remitted entirely to the City, split by the City and merchants who would use their share to promote reusable alternatives and recycling, or retained entirely by merchants for promotion and administrative costs.

- Enhanced education plus advanced recovery fee (ARF) (likely range, 10 to 25 cents) on all disposable shopping bags. The ARF could be remitted entirely to the City, split by the City and merchants who would use their share to promote reusable alternatives and recycling, or retained entirely by merchants for promotion and administrative costs.

The primary reasons for focusing further evaluation on only the above options are as follows:.

- There are currently high levels of community concern about the environmental impacts of disposable plastic shopping bags in Seattle. (SPU 2007) An estimated 290 million plastic shopping bags are used annually in Seattle (see Consumption Estimate in this chapter), and their light weight is a cause for high levels of inadvertent littering. Persistence of plastic bags in the environment and documented impacts on marine ecosystems dictates that their use be minimized.

- Reusable bags offer the greatest potential for improving the environmental performance of shopping bags, followed by increased reuse and recycling of existing bags through existing infrastructure.

- Biodegradable bags are not emphasized due to insufficiently clear environmental benefits given reusable alternatives, and because Seattle's existing plastic bag recycling and composting systems cannot support the levels of contamination that would be expected if a mixture of plastic and biodegradable shopping bags were utilized throughout the City. (CG 2007)

- Voluntary measures have often been shown to be insufficiently effective in changing consumer behavior when environmental costs are externalized from the market.

Table 6-1, following page, summarizes the perceived advantages and disadvantages associated with each of the strategies evaluated.

Economic Costs and Benefits

In order to create additional decision support for the analysis of program strategies, this report uses a simple model of anticipated net present value (NPV) economic costs and benefits over a 30-year time frame. SPU and the City of Seattle often use the 30-year time horizon to evaluate costs and benefits; going out farther loses significance due to the effects of discounting and uncertainty (SPU 2007c). Marginal costs and benefits are estimated based on a combination of:

- Consumer and retailer behavior (see below)
- Consumption estimates (see below)
- Available demographic data
- Published product price averages or estimates (see Alternative Products)
- SPU estimates for collection, processing, transfer and disposal contract expenditures; and market revenues
- Estimated administrative, personnel, and program costs
- Fiscal impacts of strategy implementation (e.g., ARF costs and revenues)

The model is primarily a narrow assessment of costs and benefits. The following analysis and Tables 6-2 through 6-11 assume an ARF of $0.15 per bag, split evenly between the retailer and the City of Seattle for recycling and alternative bag promotion and education. Sensitivity analyses assessing the impacts of different ARF levels is included in Appendix N. Assumptions, calculations, and full results of the model are contained in Appendix J. Summary results for all affected sectors and in total are presented in Table 6-2, below.

Consumer and Retailer Behavior

Consumer and retailer behavior in response to implementation of each of the strategies is estimated based on stakeholder input (See Research and Stakeholder Input; Appendix J), published studies (See Nolan-ITU 2004, GHK 2007, Scottish Executive 2005, and ACG 2006) and best professional estimates of participation in, and efficiency of, Seattle's programs. The assumptions and estimates used to approximate consumer behavior are intended to reflect the choices that consumers and retailers might make when confronted by any of the strategies outlined above (Nolan-ITU 2004). Consumer behavior in turn directly affects alternative

Table 6-1. Perceived advantages and disadvantages of evaluated shopping bag strategies.

#	Option	Advantages	Disadvantages
1	Enhanced education	▪ Voluntary ▪ Least intrusive ▪ Public supports (See survey.) ▪ Fits with existing curbside recycling of plastic bags ▪ Would not require enforcement	▪ Lacks urgency ▪ Most environmental impacts of bags continue ▪ Limited behavior change occurs. ▪ No clear targets, results uncertain
2	Enhanced education, and Ban on Disposable Plastic Shopping Bags	▪ Environmental impacts from disposable plastic bags significantly reduced ▪ If universally applied, treats all retail outlets equally ▪ If applied to subset of retailers, may reduce resources required to administer program ▪ May be easier to administer than ARF ▪ Implements a mandatory behavior change that could lead to more responsible attitudes towards waste and packaging generally	▪ Majority opposed (Elway poll Q4-3. See Appendix H.) ▪ Makes non-plastic more acceptable, despite potentially higher environmental and GHG impacts even when recycled. ▪ If universally applied, may increase bureaucracy required to introduce across all retailers ▪ If applied to subset of retailers, creates perception of “uneven playing field” ▪ Eliminates store and customer option for waterproofed bag ▪ Adds administrative and enforcement responsibilities to the City ▪ Does little to change the culture around the use of disposable shopping bags
3	Enhanced education, and Advanced Recovery Fee (ARF) on Disposable Plastic Shopping Bags	▪ Environmental impacts from disposable plastic bags substantially (< #2) reduced ▪ If universally applied, treats all retail outlets equally ▪ If applied to subset of retailers, may reduce resources required to administer program ▪ Fits with curbside recycling of plastic bags and paper ▪ Implements an incentive (less onerous) that could lead to more responsible attitudes towards consumption and disposability ▪ Could provide a revenue stream to fund projects related to packaging reduction.	▪ Makes non-plastic more acceptable, despite potentially higher environmental and GHG impacts even when recycled, and creates perception of “uneven playing field” ▪ Majority opposed (Elway poll Q4-5) ▪ If universally applied, may increase bureaucracy required to introduce across all retailers ▪ If applied to subset of retailers, creates perception of “uneven playing field” and applies uneven encouragement for behavior change ▪ Adds administrative and enforcement responsibilities and costs to the City ▪ Fee may be difficult for City to administer ▪ Adds administrative responsibilities and costs to retailer. May pose administrative difficulties for retailers regarding bag use reporting and fee reconciliation

Table 6-1 (continued). Perceived advantages and disadvantages of evaluated shopping bag strategies.

#	Option	Advantages	Disadvantages
4	Enhanced education, and Advanced Recovery Fee (ARF) on All Disposable Shopping Bags	▪ Environmental impacts from all disposable bags substantially reduced ▪ If universally applied treats all disposable items and retail outlets equally ▪ If applied to subset of retailers, may reduce resources required to administer program ▪ Puts pressure on the consumer – the decision-maker – to change to reusable bags ▪ Maximizes waste prevention – materials not generated, therefore not landfilled and not downcycled. ▪ Implements an incentive that could lead to more responsible attitudes towards consumption and disposability ▪ Preserves store and customer options at point of purchase ▪ Fee could support public education on packaging reduction and recycling	▪ If universally applied, may increase bureaucracy required to introduce across all retailers ▪ If applied to subset of retailers, creates perception of "uneven playing field" and applies uneven encouragement for behavior change ▪ Majority opposed (Elway poll Q4-6) ▪ Adds administrative and enforcement responsibilities and costs to the City. ▪ Fee may be difficult for City to administer ▪ Adds administrative responsibilities and costs to retailer. May pose administrative difficulties for retailers regarding bag use reporting and fee reconciliation ▪ Merchants prefer voluntary, say many already promoting reusable bags (focus group)

Notes:
Lifecycle Cost Analysis found that paper bags consistently showed a higher environmental impact than plastic bags.
Other jurisdictions have either banned or taxed plastic bags. Research has shown both to be effective. The degree to which consumer use is suppressed will be determined by the option chosen, the fee imposed and other factors.
An Advance Recovery Fee is not a tax. The City does not have the authority to tax this activity. The City has the authority to impose an Advance Recovery fee.
There will be an ongoing public outreach cost in all cases.
Chosen program would be phased in.

product use, recycling and composting rates (and hence, disposal rates), and environmental impacts. As such, the accuracy of the analysis is subject to a degree of uncertainty. Assumptions are summarized in Appendix J.

Table 6-2. NPV of economic (costs) and benefits ($000).

	Status Quo	Education	Ban Plastic	ARF on Plastic	ARF on Both Paper and Plastic
SPU/City of Seattle	($39,553)	($41,677)	($30,877)	$190,117	$228,237
Consumer	($416,854)	($399,958)	($346,383)	($778,253)	($744,640)
Retailer	$4,066	$3,455	$3,266	$231,386	$268,210
Regional	$92,001	$88,188	$102,773	$84,120	$42,433
Total	($360,812)	($349,993)	($271,221)	($272,630)	($205,759)

NPV economic costs and benefits are calculated over a 30-year time frame.
ARF equal to $0.15 per bag; revenue split 50/50 between retailers and City of Seattle.
An ARF at this rate yields overall estimated reduction of 65% in disposable plastic and/or paper bag use.
Figures are based on a discount rate of 3 percent.

Like a similar analysis done by GHK for Hong Kong, this study expresses consumer and retailer choices as a percentage of affected transactions that adopt different bag types (or stay with their existing one) and ancillary purchases (e.g. bin liners) due to each strategy. A similar methodology was used in studies for Australia, South Africa, and Scotland (See Nolan-ITU 2004; Fridge 2006; AEA 2005).

Table 6-3 shows estimated total percentages of alternative bag use and ancillary bin liner purchases for all options. Appendix J shows the estimated percentages of alternative bag use and ancillary bin liner purchases for all options, for each of five retailer types (See Nolan-ITU 2004). The model allows for five retailer categories in order to model for different application of the strategies to each of the retailer categories, if desired. For this analysis, it is assumed that all retailers are covered by each strategy and consumer responses are consistent across retailer categories.

Consumption Estimate

Table 6-4 shows status quo plastic bag consumption as estimated from 2004 Seattle waste composition data and anecdotal estimates of individual component proportions (SVA Seattle 2007). Future consumption is based on estimated waste generation growth, consumer behavior regarding alternative products, consumer behavior regarding composting and recycling rates[7], and average bag weights and capacities (See Appendix J; Seattle 2007, LA County 2007).

[7] See Seattle Solid Waste Recycling, Waste Reduction, and Facilities Opportunities. May 2007.

Table 6-3. Percentage switching to alternative bag use and garbage bag purchases.

	Status Quo	Education	Ban Plastic	ARF on Plastic	ARF on Both Paper and Plastic
Switch from Plastic To:					
Continue Plastic Bag	100%	95%	10%	35%	35%
Paper Bag	0%	0%	40%	21%	0%
Long Term Reusable Bag	0%	5%	40%	37%	52%
Compostable Bag	0%	0%	0%	0%	0%
No Bag	0%	0%	10%	7%	13%
Increase in Garbage Bags	0%	0%	10%	5%	7%
Switch from Paper To:					
Continue Paper Bag	100%	95%	90%	90%	35%
Plastic Bag	0%	0%	0%	0%	0%
Long Term Reusable Bag	0%	5%	10%	10%	52%
Compostable Bag	0%	0%	0%	0%	0%
No Bag	0%	0%	0%	0%	13%
Increase in Garbage Bags	0%	0%	10%	0%	3%

Table 6-4. Estimated baseline shopping bag consumption.

	Percent of Res. Waste Disposed (2004 Composition) [a]	2008 Estimate	Percent of Waste Comp. Category
Est. 2008 Residential Waste Generated (Tons) [b]		291,578	
Grocery/Bread Bags	0.82%	2,377	80%
Plastic Grocery Bags (Tons)		1,901	
Avg. Plastic Grocery Bag Weight (lbs.)		0.013	
Plastic Grocery Bags Consumed (#) [c]		292,525,673	
2004 Seattle Population		572,600	
Annual Per Capita Plastic Bag Use		511	
Old corrugated cardboard (OCC)/Kraft Paper	6.03%	17,592	15%
Mixed Low Grade	9.59%	27,950	2%
Paper Grocery Bags (Tons)		3,198	
Avg. Paper Grocery Bag Weight (lbs.)		0.094	
Paper Grocery Bags Consumed (#) [c]		68,038,177	
2004 Seattle Population		572,600	
Annual Per Capita Paper Bag Use		119	

[a]. See (SPU 2006) *"Copy of Revised 60% projections March 24_ 2006 Update"* prepared by SPU Staff, March 2006.

[b]. See (SPU 2007) Seattle Solid Waste Recycling, Waste Reduction, and Facilities Opportunities. May 2007

[c]. Consumption figures based on one year. A variety of methodologies to estimate bag consumption are available. Some jurisdictions have used a survey of retail outlets offering disposable bags, and extrapolate utilizing business counts to determine aggregate estimates. Other jurisdictions have used national or state estimates of disposable bag production and imports per capita, and then extrapolate to the population for which management strategies may be directed. Other jurisdictions have used landfill surveys similar to Seattle's waste characterization program. It was determined that because Seattle's waste characterization program quantifies waste in a category that nearly mimics the products under consideration, it would provide the closest estimation. Discussions with the City of San Francisco, which used a survey technique, confirmed a similar per capita consumption rate (Haley 2008).
The direct cost to the City and ratepayers of collecting, transferring and disposing of waste is approximately $121 per ton (not including applicable revenue from City fees and taxes). The net direct cost to the City and ratepayers of collecting, processing and shipping to market recyclables is approximately $75 per ton (including market revenue). For plastic in 2008, the cost is estimated at $217,000 for the amounts disposed and recycled; for paper in 2008, the cost is estimated at $268,000 for the amounts disposed and recycled.

Stakeholder Implications

Manufacturers

This report measures broad impacts on manufacturers by looking at the affect of strategies on production of bag units. Estimated percentage of bag production by type is used to assign economic effects to the region. For these calculations, it is assumed that approximately 10 percent of disposable plastic shopping bags are produced in the region, and 40 percent of paper shopping bags.

The plastic film and sheet manufacturing industry in the Pacific Northwest is much more limited than in the rest of the country. Primary manufacturers include Mohawk Northern Plastics in Auburn, WA, Shields Bags in Yakima, WA, Redi-Bag in Tukwila, WA, and Norplex, Inc. in Auburn. None of these firms produce grocery bags. American Plastics Manufacturing in Seattle produces patch handle bags and T-shirt bags. National firms such as Sonoco Products, AEP, Vanguard Plastics, API, Formosa Plastics Corp, Superbag Co., Tyco, and Pliant together have at least 60-70 percent of the domestic grocery bag market. The remainder of the market is occupied by a growing competition from Asia. Imports, particularly from China, Indonesia, Thailand, and Canada, have grown at an aggressive rate - tripling in the last five years, according to some manufacturers.. Imports of PE bags jumped from $268 million in 1996 to $700 million in 2004 (Plastics Technology 2005).

Any policy strategies that focus on reducing the use of disposable plastic shopping bags will have a negative effect on the regional economy through a reduction in manufacturing and distribution services. The estimates in this report reflect a reduction in revenue from loss of sales, manufacturing, and ancillary services and supplies.

The paperboard and bag manufacturing industry in the Pacific Northwest is dominated by Weyerhaeuser, particularly after their merger with Willamette Industries in 2004. Nationally, three major U.S. companies are the primary manufacturers of grocery bags — Weyerhaeuser and two other companies based in the Southeast (PCC 2007).

Table 6-5 shows the estimated net present value (NPV) of economic costs and benefits anticipated for the region in each strategy evaluated.

Retailers

This report measures broad impacts on retailers by looking at the effect of strategies on “give-away” bag costs and revenues (assuming the cost of “give-away bags is passed on to consumers in general store prices), garbage and reusable bag sales; and implementation, equipment, administration, promotion and education, and staff training costs. Some analyses take into account estimated impacts related to increased theft, revenue changes due to increased or decreased transaction times, but these are not considered in this report. In addition, no account is taken for any losses in revenue due to sales leaving the City of Seattle for jurisdictions with no bag restrictions.

Table 6-5. Summary of Estimated Strategy NPV Economic Costs and Benefits for the Region ($000)

Cost / Revenue Category	Status Quo	Education	Ban Plastic	ARF on Plastic	ARF on Both Paper and Plastic
Plastic Production	$8,929	$8,559	$2,727	$4,359	$4,118
Paper Production	$83,072	$79,629	$100,046	$79,761	$38,315
Reusable Production	$0	$0	$0	$0	$0
Compostable Production	$0	$0	$0	$0	$0
Total	$92,001	$88,188	$102,773	$84,120	$42,433

NPV economic costs and benefits are calculated over a 30-year time frame.
Figures are based on a discount rate of 3 percent.

Any of the ARF strategies would represent a greater burden to all retailers in administration and training. If it is assumed that smaller retailers are less likely to have the available systems, they may be more impacted. If that is the case, the City could choose to exempt small retailers from reporting and may be able to allow them to keep the ARF to cover administrative costs. Any ARF will require an auditable system that will record bag sales, account for bags in stock, reconcile sold versus stock remaining, and allow for submittal of records and payment. (AEA 2005) This analysis also assumes that the retailer will keep 50 percent of the ARF in order to promote reusable bags and recycling. This is shown as a benefit.

Table 6-6 shows the estimated net economic costs and benefits anticipated for retailers in each strategy evaluated.

Table 6-6. Summary of Estimated Strategy NPV Economic Costs and Benefits for Retailers ($000)

Cost / Revenue Category	Status Quo	Education	Ban Plastic	ARF on Plastic	ARF on Both Paper and Plastic
Bag Revenue	$406,589	$389,738	$320,690	$301,672	$187,529
Bag Costs	($402,523)	($385,841)	($317,483)	($298,655)	($185,653)
Consumer ARF	$0	$0	$0	$229,436	$267,166
Alternative Product Sales	$0	$376	$17,106	$9,831	$17,697
Alternative Product Costs	$0	($365)	($16,593)	($9,536)	($17,166)
Administration	$0	($41)	($41)	($413)	($413)
Training and Staff	$0	($413)	($413)	($949)	($949)
Amortized Capital	$0	$0	$0	$0	$0
Total	$4,066	$3,455	$3,266	$231,386	$268,210

NPV economic costs and benefits are calculated over a 30-year time frame.
Figures are based on a discount rate of 3 percent.

Consumers

This report measures broad impacts on consumers by considering the effect of strategies on "give-away" bag costs (assuming the cost of "give-away" bags is passed on to consumers in general store prices), garbage and reusable bag purchases; advanced recovery fees under strategies 3 and 4, and implementation, and solid waste management fees paid to the City of Seattle.

Table 6-7 shows the estimated net economic costs and benefits anticipated for consumers in each strategy evaluated.

Table 6-7. Summary of Estimated Strategy NPV Economic Costs and Benefits for Consumers ($000)

Cost / Revenue Category	Status Quo	Education	Ban Plastic	ARF on Plastic	ARF on Both Paper and Plastic
Bag Costs	($406,589)	($389,738)	($320,690)	($301,672)	($187,529)
Consumer ARF	$0	$0	$0	($458,872)	($534,331)
Household Expenditure	$0	($376)	($17,106)	($9,831)	($17,697)
Hauling	($7,746)	($7,331)	($6,842)	($6,100)	($3,723)
Recycling & Composting	($321)	($307)	($352)	($290)	($147)
Transfer and Disposal	($2,299)	($2,206)	($1,393)	($1,489)	($1,213)
Total	($416,854)	($399,958)	($346,383)	($778,253)	($744,640)

NPV economic costs and benefits calculated over a 30-year time frame.
Figures based on a discount rate of 3 percent.

City of Seattle

This report measures broad impacts on the City of Seattle by considering the effect of strategies on fee revenue (under strategies 3 and 4), solid waste management fees and taxes paid to the City of Seattle, the incremental costs of implementing and managing the plastic bag program, enforcement and inspection, ancillary costs associated with plastic bags in the recycle, compost, and disposal streams (e.g., maintenance, litter control at disposal facilities, additional costs for recycled commodity quality control, etc.), and the costs of litter and marine litter abatement.

Table 6-8 shows the estimated incremental net economic costs and benefits anticipated for the City of Seattle in each strategy evaluated.

Environmental Impacts

Environmental impacts are based on estimated consumption data and life cycle inventory data from Nolan-ITU 2004 (See Review of Existing LCA Studies section in this report). As discussed in that section, the results presented here have a great deal of uncertainty due to errors and differences in the assumptions in the inventory data. Results are presented for the environmental categories with applicable data. As is typical of most impact assessments, assumptions and uncertainty of the data have to be taken into account when interpreting the results presented (Rosselot, 2004). For that reason, and to get a better sense of the broader level environmental implications, Table 6-9 compares data for each environmental category under each strategy, normalized as a percentage of the status quo condition. Raw results for environmental burdens over the 30 year period are shown in Appendix J.

Table 6-8. Summary of estimated strategy NPV economic costs and benefits for the City of Seattle ($000).

Cost / Revenue Category	Status Quo	Education	Ban Plastic	ARF on Plastic	ARF on Both Paper and Plastic
Administration	($7,938)	($9,624)	($9,624)	($11,309)	($11,309)
Inspection and Enforcement	($1,686)	($1,686)	($2,783)	($4,979)	($4,979)
Program Marketing, Monitoring, Education, and Research	($1,960)	($3,136)	($3,136)	($4,312)	($4,312)
Hauling, Transfer, Recycling, and Disposal	$958	$919	$580	$620	$505
Other Costs Due to Bags	($18,735)	($17,959)	($5,722)	($9,147)	($8,641)
Terrestrial Litter Control	($9,800)	($9,800)	($9,800)	($9,800)	($9,800)
Marine Litter Abatement	($392)	($392)	($392)	($392)	($392)
Consumer ARF	$0	$0	$0	$229,436	$267,166
Total	($39,553)	($41,677)	($30,877)	$190,117	$228,237

NPV economic costs and benefits calculated over a 30-year time frame.
Figures based on a discount rate of 3 percent.

Table 6-9. Environmental impacts normalized to status quo.

	Units	Status Quo	Education	Ban Plastic	ARF on Plastic	ARF on Both Paper and Plastic
Non-Renewable Energy	Megajoules (MJ)	100%	96%	73%	70%	47%
GHG Emissions	kg CO2 eq.	100%	96%	82%	75%	47%
Resource Depletion (Abiotic)	kg Sb eq.	100%	96%	69%	68%	47%
Eutrophication	kg PO4 eq.	100%	96%	101%	85%	46%
Litter Marine Diversity	kg	100%	96%	33%	49%	49%
Litter Aesthetics	Square meters	100%	96%	34%	50%	49%
Shopping Bag Waste Generated	Tons	100%	96%	89%	78%	45%

Units produced in each environmental category are summed over a 30-year time frame.

This report does not attempt to estimate the monetary value of environmental impacts. Though it leaves the comparison of environmental and economic impacts to subjective analysis, assigning a monetary value to the environmental impacts of the various policy strategies is inherently difficult (ACG 2006)[8]. There are a number of advancing methodologies for monetizing ecosystem functions and services, and environmental impacts (EVG 2007), but they are outside the scope of this report.

The results for each of the strategies on estimated tonnage of shopping bag waste over a 30-year time frame are presented in Table 6-10.

Table 6-10. Estimated shopping bag tonnage changes compared to status quo as the result of strategy implementation (tons).

	Status Quo	Education	Ban Plastic	ARF on Plastic	ARF on Both Paper and Plastic
Generated	169,791	162,366	150,583	133,233	77,082
Increase / (Reduction %)		(4%)	(11%)	(22%)	(55%)
Disposed	69,731	66,724	40,290	43,482	34,451
Increase / (Reduction %)		(4%)	(42%)	(38%)	(51%)
Recycled	100,060	95,643	110,293	89,751	42,630
Recycle Rate	59%	59%	73%	67%	55%

Total tons summed over a 30-year time frame
Increase/(Reduction) % compared to status quo

Economic and Environmental Costs and Benefits Conclusions

Cost benefit analysis of these policy options provides an insight to the likely impacts of the measures — if implementation and consumer behavior proceeds as expected. According to research, the intent of LCAs is to show the relative importance of the different environmental categories for improvement analysis (Rosselot, 2004), in our case, for each of the strategies evaluated. In this section, Table 6-11 shows a comparison between all environmental categories and the NPV economic costs and benefits calculated earlier.

The shaded fields in Table 6-11 show those strategies with highest reductions in each of the economic cost and environmental burden categories, compared to the status quo. The assumptions discussed earlier and listed in Appendix J give a sense for the range of interpretation and results possible within the confines of this analysis. The quantitative results can help foster an understanding of the implicit trade-offs that will result if any of these strategies are adopted.

[8] For example, according to the ACG report, when the "willingness to pay" methodology is used "individual households are often unable to indicate a *reliable* 'willingness to pay' for a better environment, because one person's expenditure on clearing up litter in the neighborhood benefits the entire neighborhood. The service provided is a public good. What's more, an expectation that government (not the householder) will pay for the provision of a benefit can lead to an exaggeration of willingness to pay, while an expectation that a payment may be required can result in an under-statement (particularly if there is an expectation by individuals that they may be able to 'free ride' on the contributions of others)." (ACG 2006)

Table 6-11. Economic and environmental costs and benefits normalized to status quo.

	Units	Status Quo	Education	Ban Plastic	ARF on Plastic	ARF on Both Paper and Plastic
NPV	$	100%	97%	75%	76%	57%
Non-Renewable Energy	Megajoules (MJ)	100%	96%	73%	70%	47%
GHG Emissions	kg CO2 eq.	100%	96%	82%	75%	47%
Resource Depletion (Abiotic)	kg Sb eq.	100%	96%	69%	68%	47%
Eutrophication	kg PO4 eq.	100%	96%	101%	85%	46%
Litter Marine Diversity	kg	100%	96%	33%	49%	49%
Litter Aesthetics	Square meters	100%	96%	34%	50%	49%
Waste Generated	Tons	100%	96%	89%	78%	45%

Units produced in each environmental category are summed over a 30-year time frame.
NPV economic costs and benefits calculated over a 30-year time frame.
Figures based on a discount rate of 3 percent.

The combined economic and environmental lifecycle assessment offers a number of relevant observations, given the above caveats:

- All strategies offer both environmental and economic benefits, despite some environmental trade-offs and uneven economic gains by sector.

- Education provides the least environmental gains, and the least overall economic gains, though consumers are better off economically than with other strategies due to the absence of an ARF.

- A ban on plastic bags provides similar environmental benefits to a plastic only ARF, though improvement in litter with a ban is significantly better than with all strategies. A ban provides overall economic gains similar to a plastic only ARF. However, with a plastic ban, consumers and the region benefit (due to fewer bag "purchases" and more paper production respectively) and the City and retailers add costs. With a plastic only ARF, consumers and the region experience additional cost, while the City and retailers experience gains (with additional ARF revenue).

- An ARF on all disposable shopping bags provides the most environmental gains (except for litter), and provides for much higher overall economic gains when compared to all strategies. With an ARF on all bags, consumers experience slightly less costs than with a plastic only ARF (due to an anticipated increase in reusable bags), and the region experiences much more economic cost (due to decreased paper production). Again, the City and retailers both benefit from revenue under either a plastic only or an all-bag ARF.

- These quantified results apply only to types of bags evaluated, and may not be applicable to all product types.

Disposable Food Service Ware Strategies

The strategies to address disposable food service items were narrowed to the following four for further life cycle cost/benefit and environmental assessment:

- Keeping the status quo: General education focused on ongoing reduce-reuse-recycle messaging; plus encouragement to use privately-provided recycling opportunities for food service items.
- Enhanced education: Begin a public outreach, education and promotional campaign specifically focused on owners/managers of restaurants, cafes, and coffee shops to encourage replacement of disposable food service items with recyclable or compostable alternatives managed through recycling and food waste composting programs. This would become part of SPU's ongoing reduce-reuse-recycle messaging. Expanded polystyrene (EPS) products would be especially discouraged.
- Enhanced education plus ban on expanded polystyrene (EPS) products: Implementation of mandatory ban on EPS food service items only at all food vendors in Seattle. Ban to be phased in plus a later deadline for all food service items to be compostable or recyclable with restaurants enrolled in composting or recycling programs.
- Enhanced education plus advanced recovery fee (ARF) on expanded polystyrene (EPS) products only. The ARF (possible range 10 to 25 cents) could be remitted entirely to the City, split by the City and merchants who would use their share to promote reusable alternatives and recycling, or retained entirely by merchants for promotion and administrative costs.
- Enhanced education plus advanced recovery fee (ARF) on all non-compostable and non-recyclable food service ware items. The ARF (possible range 10 to 25 cents) could be remitted entirely to the City, split by the City and merchants who would use their share to promote reusable alternatives and recycling, or retained entirely by merchants for promotion and administrative costs.

The primary reasons for focusing further evaluation on only the above options includes the items listed below. Given the City's policy goals for reducing greenhouse gas emissions, and increasing recycling and sustainability, keeping the status quo is not an alternative on its own.

However, all other options are evaluated in comparison to the expected results if the status quo were continued without further intervention by the City.

- There are currently high levels of community concern about the environmental impacts of disposable EPS in Seattle. (SPU 2007) An estimated 21 million EPS clamshells alone, and other plastic food service items are used annually in Seattle, and their light weight is a cause for high levels of inadvertent littering. Persistence of EPS food service items (and plastic food service items in general) in the environment, and documented impacts on marine ecosystems, dictates that their use be minimized.

- The City does not provide curbside recycling for EPS and other plastic food service items due to sanitation and contamination issues. However, the City is working closely with its composting contractor to establish the ability to process compostable products combined with food waste from commercial establishments, as long as the economic and product quality standards targeted by the contactor are considered. (SPU 2007b)

- Biodegradable/compostable and recyclable food service items are considered due to the nature of the product use and the anticipated difficulties associated with reusable take-out foodservice items.

- Product bans and ARFs have been shown to be effective when applied in other municipalities. Voluntary measures have often been shown to be insufficiently effective in changing consumer behavior when environmental costs are externalized from the market. (ACG 2006)

Table 6-12, following page, summarizes the perceived advantages and disadvantages associated with each of the strategies evaluated.

Economic Cost / Benefit Case Study of 16-ounce Clamshells

As in the disposable shopping bag section, this section uses a simple model of anticipated net present value (NPV) economic costs and benefits over a 30-year time frame in order to create additional decision support for the analysis of program strategies. A limited amount of life cycle inventory data was available for food service items. However, in order to present useful information, economic costs and benefits due to the four strategies are considered only for one type of food service products with inventory data (16-ounce – approx. 5-inch – clamshells). Marginal costs and benefits are estimated based on a combination of:

Table 6-12. Perceived advantages and disadvantages to evaluated food service items strategies.

#	Option	Advantages	Disadvantages
1	Enhanced education	▪ Voluntary ▪ Recognizes that alternative products are available, but an emerging technology ▪ Least intrusive ▪ Public supports (See survey.) ▪ Recognizes that there aren't recycling programs for many of these plastics ▪ Would not require enforcement	▪ Lacks urgency ▪ Most environmental impacts of food service items continue ▪ Limited behavior change occurs ▪ No clear targets, results uncertain ▪ Public favors a ban on use of expanded polystyrene in food service (Qs 10-1, 13, 14-2 in Elway poll)
2	Enhanced education plus ban on expanded polystyrene (EPS) products plus a future deadline for conversion of all disposable plastic food service items to compostable or recyclable substitutes	▪ Alternative products are available ▪ Environmental impacts from EPS, a unique and serious pollutant in the marine environment, significantly reduced ▪ Ensures that changeover to compostable and recyclable products will occur ▪ If universally applied, treats all food outlets equally ▪ If applied to subset of food outlets, may use fewer resources required to administer program ▪ May be easier to administer than ARF ▪ Implements a mandatory change that could lead to more responsible attitudes towards waste and packaging generally ▪ Public and business (focus group) favors a ban ▪ With deadline, captures all products, not just EPS	▪ Makes non-EPS more acceptable, despite potentially higher environmental and GHG impacts even when recycled. ▪ If universally applied, may increase bureaucracy required to introduce across all food vendors ▪ If applied to subset of food vendors, creates perception of "uneven playing field" ▪ Adds administrative and enforcement responsibilities to the City ▪ Does little to change the culture around the use of disposable food service items ▪ Alternative products not environmentally better in all categories, and while available, still an emerging technology ▪ Recycling programs for food service plastic not yet widely available

Table 6-12 (continued). Perceived advantages and disadvantages to evaluated food service items strategies.

#	Option	Advantages	Disadvantages
3	Enhanced education plus advanced recovery fee (ARF) on expanded polystyrene (EPS) products	▪ Environmental impacts from EPS, a unique and serious pollutant in the marine environment, significantly (< #2) reduced ▪ If universally applied, treats all retail outlets equally ▪ If applied to subset of food vendors, may reduce resources required to administer program ▪ Implements an incentive (less onerous) that could lead to more responsible attitudes towards consumption and disposability ▪ Could provide a revenue stream to fund projects related to packaging reduction.	▪ Makes non-EPS more acceptable, despite potentially higher environmental and GHG impacts even when recycled, and creates perception of “uneven playing field” ▪ If universally applied, may increase bureaucracy required to introduce across all food vendors ▪ If applied to subset of food vendors, creates perception of “uneven playing field” and applies uneven encouragement for behavior change ▪ Adds administrative and enforcement responsibilities and costs to the City ▪ Fee may be difficult for City to administer ▪ Adds administrative responsibilities and costs to food vendors. May pose administrative difficulties for food vendors regarding food service items use reporting and fee reconciliation ▪ ARF likely would be paid by retailers and suppliers – invisible to consumers ▪ Small majority of public polled oppose a charge ▪ Alternative products not environmentally better in all categories, and while available, still an emerging technology ▪ Recycling programs for food service plastic not yet widely available

Table 6-12 (continued). Perceived advantages and disadvantages to evaluated food service items strategies.

#	Option	Advantages	Disadvantages
4	Enhanced education plus advanced recovery fee (ARF) on all non-compostable and non-recyclable food service ware items	▪ Environmental impacts from all food service items substantially reduced ▪ Treats all disposable food service plastics equally ▪ If universally applied, recognizes that all types of food service items have environmental impact; treats all disposable items and food outlets equally ▪ If applied to subset of retailers, may reduce resources required to administer program ▪ Motivates businesses to change to compostable and recyclable products ▪ Allows time for businesses and suppliers to find alternative products. ▪ Implements an incentive that could lead to more responsible attitudes towards consumption and disposability ▪ Preserves store and customer options at point of purchase ▪ Fee could support public education on packaging reduction and recycling	▪ If universally applied, may increase bureaucracy required to introduce across all food vendors ▪ If applied to subset of food vendors, creates perception of “uneven playing field” and applies uneven encouragement for behavior change ▪ Adds administrative and enforcement responsibilities and costs to the City. ▪ Fee may be difficult for City to administer ▪ Adds administrative responsibilities and costs to retailer. May pose administrative difficulties for food vendors regarding food service items use reporting and fee reconciliation ▪ Likely paid by distributor-retailer, invisible to customer ▪ Does not assure changeover to compostable or recyclable products ▪ Does not set a deadline for changeover ▪ Alternative products not environmentally better in all categories, and while available, still an emerging technology ▪ Recycling programs for food service plastic not yet widely available

Notes:
1 Lifecycle Cost Assessment shows various impacts among the products in use. There is no product with a notably minimal impact compared to others.
2. A standard for compostability is required. This could be approval/certification by Cedar Grove. The City can establish a standard by ordinance or administrative rule.
3. The City does not have the authority to tax this activity. Thus, a tax option is not included.
4. Adding commercial food service plastics to curbside recyclables collection is not considered in these options, though SPU may choose to do this for some plastics.
5. These options assume that commercial food service items approved “compostable” would also be acceptable in residential YWFW collection for consistency of message to public.
6. Chosen program will be phased in.
7. There will be an ongoing public outreach cost in all cases.

- Consumer and retailer behavior (see below)
- Consumption estimates (see below)
- Available demographic data
- Published product price averages or estimates (see Alternative Products)
- SPU estimates for collection, processing, transfer and disposal contract expenditures; and market revenues
- Estimated administrative, personnel, and program costs
- Fiscal impacts of strategy implementation (e.g., ARF costs and revenues)

Again, this model is primarily a narrow assessment of costs and benefits applied only to clamshells. All costs and benefits have been apportioned to clamshells at approximately 20% of food service item use. Based on the best practices associated with life cycle analysis, care should be taken before general conclusions are made concerning costs and benefits of other food service products. Assumptions, calculations, and full results of the model are contained in Appendix K. Summary results for all affected sectors and in total are presented in Table 6-13, below.

Table 6-13. NPV of economic (costs) and benefits ($000).

	Status Quo	Education	Ban EPS	ARF on EPS	ARF on All Types
SPU/City of Seattle	($12,098)	($14,957)	($15,988)	$1,327	$3,166
Consumer	($8,237)	($12,686)	($42,936)	($77,557)	($95,027)
Food Vendors	$79	($4,533)	($4,235)	$8,753	$10,748
Regional	$0	$273	$273	$273	$273
Total	($20,255)	($31,903)	($62,885)	($67,204)	($80,840)

Notes: 1. (NPV) economic costs and benefits over a 30-year time frame
2. Discount rate: 3 percent

Consumer and Food Vendor Behavior

Consumer and food vendor behavior in response to implementation of each of the strategies is estimated based on stakeholder input (See Research and Stakeholder Input; Appendix K), published studies (See Nolan-ITU 2004, GHK 2007, Scottish Executive 2005, and ACG 2006) and best professional estimates of participation in, and efficiency of, Seattle's programs. The assumptions and estimates used to approximate consumer behavior are intended to reflect the choices that consumers and food vendors might make when confronted by any of the strategies outlined above (Nolan-ITU 2004). Consumer behavior in turn directly affects alternative product use, recycling and composting rates (and hence, disposal rates), and environmental impacts. As such, the accuracy of the analysis is subject to a degree of uncertainty. Assumptions are summarized in Appendix K.

As with the plastic bag section, this section expresses consumer and food vendor choices as a percentage of affected transactions that adopt different clamshell types (or stay with their existing one) due to each strategy.

Table 6-14 shows estimated total percentages of alternative clamshell use for all strategies. For this analysis, it is assumed that all food vendors are covered by each strategy and consumer responses are consistent across food vendor categories.

Table 6-14.Percentage switching to alternative clamshell items.

	Status Quo	Education	Ban EPS	ARF on EPS	ARF on All Types
Switch from EPS To:					
Continue EPS	100%	90%	10%	40%	0%
PET	0%	0%	70%	40%	5%
PP	0%	0%	5%	5%	5%
PLA	0%	5%	10%	10%	5%
Paper	0%	5%	5%	5%	5%

Consumption Estimate

Table 6-15 shows status quo EPS clamshell consumption as estimated from 2004 Seattle waste composition data and anecdotal estimates of individual component proportions (SVA Seattle 2007). Future consumption is based on estimated waste generation growth, consumer behavior regarding alternative products, consumer behavior regarding composting and recycling rates[9], and average clamshell product weights and capacities (See Alternative Products section).

Table 6-15. Estimated baseline EPS clamshell consumption.

	Percent of Res. Waste Disposed (2004 Composition) [a]	2008 Estimate	Percent of Waste Comp. Category
Est. 2008 Residential and Commercial Waste Generated (Tons) [b]		686,658	
Expanded Polystyrene (Tons)	0.32%	2,210	5%
PS Clamshells (Tons)		120	
Avg. PS Clamshell Weight (lbs.)		0.011	
PS Clamshells Consumed (#) [c)]		21,863,000	
2004 Seattle Population		572,600	
Annual Per Plastic Capita PS Clamshell Use		38	

Notes:
[a] See (SPU 2006) "Copy of Revised 60% projections March 24_ 2006 Update" prepared by SPU Staff, March 2006.
[b] See (SPU 2007) Seattle Solid Waste Recycling, Waste Reduction, and Facilities Opportunities. May 2007
[c] Consumption figures based on one year

[9] See Seattle Solid Waste Recycling, Waste Reduction, and Facilities Opportunities. May 2007.

Stakeholder Implications

Manufacturers

This report measures broad impacts on manufacturers by looking at the effect of strategies on production of product units. Estimated percentage of product production by type is used to assign economic effects to the region. For these calculations, it is assumed that approximately 5 percent of disposable plastic food service items, 10 percent of paper items, and no PLA items are produced in the region.

Table 6-16 shows the estimated net economic costs and benefits anticipated for the region in each strategy evaluated.

Table 6-16.Summary of estimated NPV economic costs and benefits for the region.

Cost / Revenue Category	Status Quo	Education	Ban EPS	ARF on EPS	ARF on All Types
(All) Plastic Production	$0	$0	$0	$0	$0
Paper Production	$0	$273	$273	$273	$273
PLA Production	$0	$0	$0	$0	$0
Total	$0	$0	$273	$273	$273

Notes: 1. (NPV) economic costs and benefits over a 30-year time frame
2. Discount rate: 3 percent

Food Vendors

This report measures broad impacts on food vendors by looking at the effect of strategies on "give-away" clamshell costs and revenues, and implementation, equipment, administration, promotion and education, and staff training costs. No account is taken for any losses in revenue due to sales leaving the City of Seattle for jurisdictions with no food service item restrictions.

Any of the ARF strategies would represent a greater burden to all retailers in cost (assuming the cost of "give-away" clamshells is passed on to consumers in general food prices, but higher item costs require a larger percent of cash flow)[10], administration and training. If it is assumed that smaller retailers are less likely to have the available systems, they may be more impacted. If that is the case, the City could choose to exempt small retailers from reporting and may be able to allow them to keep the ARF to cover administrative costs. Any ARF will require an auditable system recording bags sales, account for bags in stock, reconcile sold versus stock remaining, and to submit records and payment. (AEA 2005) However, this report assumes that the food

[10] This may be a simplistic assumption for the treatment of these costs associated with switching to alternative food service items. A summary prepared for the state of California by Kahoe Associates indicates that for those food vendors that are limited in their ability to pass along the additional costs of alternative products (e.g., some state agencies, K-12 schools, social service institutions, etc.) the effects would be a direct impact on budgets with no offsetting revenue (Kahoe 2006).

vendor will keep 50 percent of the ARF in order to promote recyclable and compostable food service items, and recycling. This is shown as a benefit.

Table 6-17 shows the estimated net economic costs and benefits anticipated for retailers in each strategy evaluated.

Table 6-17.Summary of Estimated NPV Economic Costs and Benefits for Food Vendors

Cost / Revenue Category	Status Quo	Education	Ban EPS	ARF on EPS	ARF on All Types
Food service items Rev	$7,925	$12,360	$42,226	$32,201	$46,041
Food service items Costs	($7,846)	($12,236)	($41,804)	($31,879)	($45,580)
Consumer ARF	$0	$0	$0	$22,397	$24,254
Alternative Product Sales	$0	$0	$0	$0	$0
Alternative Product Costs	$0	$0	$0	$0	$0
Administration	$0	($423)	($423)	($4,234)	($4,234)
Training and Staff	$0	($4,234)	($4,234)	($9,733)	($9,733)
Amortized Capital	$0	$0	$0	$0	$0
Total	$79	($4,533)	($4,235)	$8,753	$10,748

Notes: 1. (NPV) economic costs and benefits over a 30-year time frame
2. Discount rate: 3 percent

Consumers

This report measures broad impacts on consumers by considering the affect of strategies on "give-away" clamshell costs (assuming the cost of "give-away" clamshells is passed on to consumers in general food prices), advanced recovery fees under strategies 3 and 4, and implementation, and solid waste management fees paid to the City of Seattle.

Table 6-18 shows the estimated net economic costs and benefits anticipated for consumers in each strategy evaluated.

Table 6-18.Summary of Estimated NPV Economic Costs and Benefits for Consumers

Cost / Revenue Category	Status Quo	Education	Ban EPS	ARF on EPS	ARF on All Types
Food service items Costs	($7,925)	($12,360)	($42,226)	($32,201)	($46,041)
Consumer ARF	$0	$0	$0	($44,795)	($48,508)
Household Expenditure	$0	$0	$0	$0	$0
Hauling	($180)	($189)	($411)	($325)	($278)
Recycling & Composting	$0	($1)	($2)	($2)	($8)
Transfer and Disposal	($131)	($136)	($297)	($235)	($192)
Total	($8,237)	($12,686)	($42,936)	($77,557)	($95,027)

Notes: 1. (NPV) economic costs and benefits over a 30-year time frame
2. Discount rate: 3 percent

City of Seattle

This report measures broad impacts on the City of Seattle by considering the effect of strategies on advanced recovery fees under strategies 3 and 4, solid waste management fees and taxes paid to the City of Seattle, the incremental costs of implementing and managing the food service program, enforcement and inspection, and the costs of litter and marine litter abatement.

Table 6-19 shows the estimated incremental net economic costs and benefits anticipated for the City of Seattle in each strategy evaluated.

Table 6-19. Summary of Estimated NPV Economic Costs and Benefits for the City of Seattle

Cost / Revenue Category	Status Quo	Education	Ban EPS	ARF on EPS	ARF on All Types
Administration	$0	($1,686)	($1,686)	($3,371)	($3,371)
Inspection and Enforcement	$0	$0	($1,098)	($3,293)	($3,293)
Program Marketing, Monitoring, Education, and Research	$0	($1,176)	($1,176)	($2,352)	($2,352)
Recycling	$0	$0	$0	$0	$0
Hauling, Transfer and Disposal	$55	$57	$124	$98	$80
Other Costs Due to Food Service Items	$0	$0	$0	$0	$0
Terrestrial Litter Control	($11,760)	($11,760)	($11,760)	($11,760)	($11,760)
Marine Litter Abatement	($392)	($392)	($392)	($392)	($392)
Consumer ARF	$0	$0	$0	$22,397	$24,254
Total	($12,098)	($14,957)	($15,988)	$1,327	$3,166

Notes: 1. (NPV) economic costs and benefits over a 30-year time frame
2. Discount rate: 3 percent

Environmental Impacts

Environmental impacts are based on estimated consumption data and life cycle inventory data from Franklin 2006, Franklin 2006B, and IFEU 2006 (See Review of Existing LCA Studies section in this report). As discussed in that section, the results presented here have a great deal of uncertainty due to errors and differences in the assumptions in the inventory data. Results are presented for the environmental categories with applicable data. As is typical of most impact assessments, assumptions and uncertainty of the data have to be taken into account when interpreting the results presented (Rosselot, 2004). Like the data presented for disposable bags, Table 6-20 compares data for each environmental category under each strategy for clamshells only, normalized as a percentage of the status quo condition. Care should be taken to avoid extrapolating these results to other food service products. Raw results for environmental burdens over the 30 year period are shown in Appendix K.

Table 6-20. Environmental impacts normalized to status quo.

	Units	Status Quo	Education	Ban EPS	ARF on EPS	ARF on All Types
Non-Renewable Energy	Megajoules (MJ)	100%	105%	214%	173%	156%
GHG Emissions	kg CO2 eq.	100%	105%	234%	185%	162%
Ozone	g ethylene eq.	100%	100%	134%	120%	105%
Acidification	kg SO2 eq.	100%	104%	179%	149%	142%
Eutrophication	kg PO4 eq.	100%	101%	104%	103%	108%

Notes: 1. Environmental category units produced summed over a 30-year time frame

The results for each of the strategies on estimated tonnage clamshell waste over a 30-year time frame are presented in Table 6-21.

Table 6-21. Estimated Clamshell Tonnage Changes Compared to Status Quo as the Result of Strategy Implementation

	Status Quo	Education	Ban Plastic	ARF on Plastic	ARF on Both Paper and Plastic
Generated	4,004	4,203	9,602	7,580	6,478
Increase / (Reduction %)		5%	140%	89%	62%
Disposed	4,004	4,168	9,503	7,481	6,099
Increase / (Reduction %)		4%	137%	87%	52%
Recycled	0	35	99	99	379
Recycle Rate	0%	1%	1%	1%	6%

Notes: 1. Total tons summed over a 30-year time frame
2. Increase/(Reduction) % compared to status quo

Environmental and Economic Costs and Benefits Conclusions

Table 6-22 shows a comparison between all environmental categories and the NPV economic costs and benefits calculated earlier. These results are only for the clamshell case study.

The shaded fields in Table 6-20 show that all strategies have increases in each of the economic cost and environmental burden categories, compared to the status quo. Again, the assumptions discussed earlier and listed in Appendix K give a sense for the range of interpretation and results possible within the confines of this analysis.

Table 6-22. Economic and environmental costs and benefits normalized to status quo.

	Units	Status Quo	Education	Ban EPS	ARF on EPS	ARF on All Types
NPV	$	100%	119%	169%	176%	199%
Non-Renewable Energy	Megajoules (MJ)	100%	105%	214%	173%	156%
GHG Emissions	kg CO2 eq.	100%	105%	234%	185%	162%
Ozone	g ethylene eq.	100%	100%	134%	120%	105%
Acidification	kg SO2 eq.	100%	104%	179%	149%	142%
Eutrophication	kg PO4 eq.	100%	101%	104%	103%	108%
Waste Generated	Tons	100%	105%	240%	189%	162%

Notes: 1. Environmental category units produced summed over a 30-year time frame
2. (NPV) economic costs and benefits over a 30-year time frame
3. Discount rate: 3 percent

The combined economic and environmental lifecycle assessment offers a number of relevant observations, given the above caveats:

- For the environmental categories for which data exists (which notably excludes litter aesthetics and litter marine diversity), all strategies result in environmental burdens higher than the status quo. However, the permanence of plastic in the environment dictates its use be minimized.

- A ban on EPS clamshells produces higher environmental impacts than other strategies, due to this assessment's assumed shift to PET and paper clamshells as substitutes (despite insulation and heat protection concerns).

- An ARF on all non-compostable, non-recyclable clamshells reflects the least environmental impacts among bans and ARFs. This is due primarily to the incentive toward compostables (e.g., PLA), which results in lower impacts than paper and PET in the environmental categories considered. The exception is in eutrophication potential, due to nitrogen and phosphorus runoff in agriculture.

- Despite lack of data quantifying the effects of these strategies on litter aesthetics and litter marine diversity, it is assumed by researchers that a reduction in the impacts from food service litter would be highest under a ban, followed by an ARF, and lastly through education only.

- Economically, the status quo represents the least costly strategy. This is likely due to the combined effects of higher costs associated with EPS clamshell alternatives and costs associated with implementation, enforcement, and administration. Unlike the disposable bag alternatives, no less costly clamshell alternative considered (like reusable bags) offsets these additional program costs.

- These quantified results apply only to the clamshells evaluated, and may not be applicable to all food service product categories.

As stated earlier, the type of waste management option modeled has significant impact on results. These results assume low (2 percent) recycling and composting rates (Franklin 2006; Franklin 2006b). Higher composting rates for compostable products, and the potential increase in organics composted with compostable food service products, would likely have additional energy and greenhouse gas benefits, and cost savings. In addition, studies indicate that composting for soil amendment results in the elimination of pathogenic microorganisms and the conversion of organic nitrogen and phosphorous compounds into inorganic compounds (Estermann, 1998).

7 Conclusions and Recommendations

This report provides information to help develop a disposable plastics policy for the City of Seattle. Actions taken within the spectrum of strategies presented here will likely reduce environmentally adverse and socially undesirable implications of disposable plastics. Regarding disposable shopping bags:

- Disposable plastic bags are a significant source of litter around the world, in the U.S., and in the City of Seattle. Disposable plastic bag litter affects both terrestrial and marine wildlife.

- The use of reusable bags instead of disposable shopping bags of all kinds provides substantial environmental benefits, and reduces unintended environmental impacts, including litter.

- All education on disposable shopping bag use should emphasize that no bag or an existing reusable bag is the preferred option, followed by a new reusable bag used for as long as possible, and finally recyclable plastic and paper bags reused often and then deposited in curbside or in-store recycling facilities.

- The use of biodegradable shopping bags may not lessen littering (i.e., lightweight, disposable), but may degrade faster in the marine environment, lessening impacts. Their shorter persistence in the environment still has the potential to harm the marine ecosystem.

- The presence of biodegradable bags in the recycling stream could potentially jeopardize Seattle's plastic bag recycling program through contamination. Furthermore, any additional presence of petroleum plastic bags in the Cedar Grove composting system could also harm Seattle's composting program.

- Experience and stakeholder input suggests that any strategy implemented for disposable shopping bags should address all disposable shopping bags (of all materials), at all retail outlets that provide them.

- The 'free' status of disposable shopping bags provides no incentive for consumers to reduce their use; experience has shown that consumption of disposable bags will be reduced substantially at modest prices paid by the consumer (ACG 2006).

- An ARF on all disposable shopping bags provides the most environmental gains (except for litter), and provides for much higher overall economic gains when compared to all strategies. With an ARF on all bags, consumers experience slightly less costs than with a plastic only ARF (due to an anticipated increase in the use of reusable bags), and the region experiences additional economic cost (due to decreased paper production). Again, the City and potentially retailers both benefit from revenue under either a plastic only or all-bag ARF.

These findings are reinforced by the comparison of modeled strategies, and suggest that an ARF, where prices are used to drive a reduction in bag use, and flexibility for consumers in deciding on efficient options for transporting purchases is preserved (ACG 2006), is likely to be considerably more cost-effective than a ban

For food service items, the results are less clear, based on the research conducted. Any strategy to be implemented could be heavily influenced by the relative weighting placed upon any of the environmental or economic factors discussed. Regarding food service items:

- Expanded polystyrene entering the marine environment represents a threat (not quantified) to marine life along with other packaging and other littered items.
- A shift from disposable food service items to biodegradable food service items may benefit litter persistence impacts on the marine environment due to the faster rate of degradation. Their shorter persistence in the environment still has the potential to harm the marine ecosystem.
- For clamshells and for the environmental categories for which data exists (which notably excludes litter aesthetics and litter marine diversity), all strategies result in environmental burdens higher than the status quo.
- All education on disposable food service item use when possible should emphasize minimization of packaging and avoidance of littering, then utilization of compostable products and depositing them with food waste in in-store commercial organics collection bins, or utilization of recyclable products deposited in curbside or in-store recycling bins. No environmental benefit will accrue from the use of compostable products if they end up in the landfill, the environment, or as a contaminant in the recycling stream (CIWMB 2007).
- As with bags, the presence of biodegradable food service items in the recycling stream could potentially harm Seattle’s plastics recycling program through contamination; the presence of petroleum plastic items in the composting system could also harm Seattle’s composting program.
- All strategies evaluated would likely provide for a reduction in litter impacts from disposable clamshells, but may be accompanied by other increased environmental burdens and costs. Available data limits the

extent to which this finding can be considered applicable to other food service items.

- An ARF on all non-compostable, non-recyclable clamshells reflects the least environmental impacts among bans and ARFs. This is due primarily to the incentive toward compostables (e.g., PLA), which results in lower impacts than paper and PET in the environmental categories considered. The exception is in eutrophication, due to nitrogen and phosphorus runoff in agriculture.

- Economically, the status quo represents the least costly strategy. This is likely due to the combined effects of higher costs associated with EPS clamshell alternatives and costs associated with implementation, enforcement, and administration. Unlike the disposable bag alternatives, no more cost effective alternative (like reusable bags) offsets these additional program costs.

- Widespread adoption of compostable products requires identification and labeling standards applicable to the systems in place in Seattle. In addition, additional research should consider impacts in other disposal environments including marine floating conditions, marine sinking conditions, anaerobic digestion, sewage treatment, and sewage sludge.

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