ENHANCED RECOVERY OF ROOFING MATERIALS

Prepared for:

CANADIAN CONSTRUCTION INNOVATION COUNCIL

By:

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January, 2007

Executive Summary

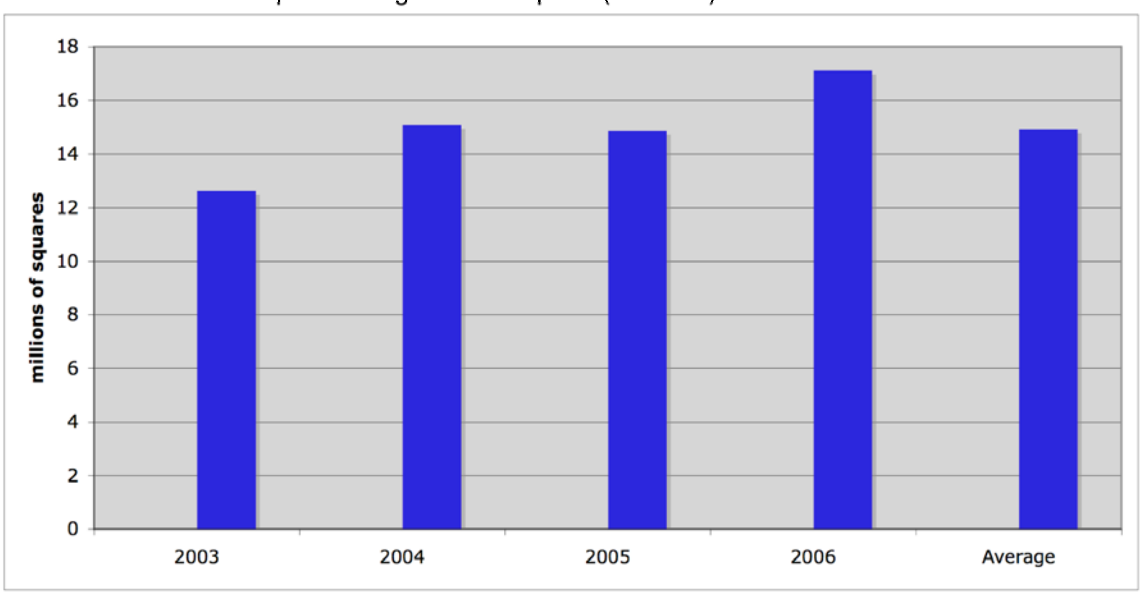
This briefing paper has been prepared to support the development of an implementation plan for increasing the recovery of end-of-life roofing materials. The paper is intended as an introductory status update on the quantity of roofing scrap available in Canada, potential end-uses for this scrap, and the various economic and environmental drivers that may influence future recycling and reuse. A workshop, to be held in Toronto in February, 2007, will focus on the various barriers to be overcome (e.g., regulation, legislation, technological, economic and environmental) to make roofing scrap recycling a market reality.

This paper concentrates on asphalt based roofing products, which make up 90% of the residential market and as much as 80% of the low slope (ICI) roofing market in Canada.

Canadian Residential Asphalt Roofing Market & Scrap Production

Between 2003 and 2006, Canadian asphalt shingle consumption increased steadily and mirrored the growth in new housing starts. On average, approximately 15 million squares[1] of asphalt shingle roofing are installed in Canada annually (see Chart ES1 below). Regionally, Central Canada (Ontario and Quebec), Alberta plus British Columbia, and the combined Prairie and Maritime provinces have accounted for 65%, 20% and 15% of asphalt shingle consumption over the last four years, respectively. IKO and BP-EMCO are the two Canadian manufacturers of asphalt shingles, but there is considerable Canadian and U.S. trade, with almost equal quantities of asphalt shingles flowing in both directions.

Chart ES1 Canadian Asphalt Shingle Consumption (2003-06)



Re-roofing accounts for the largest share of the annual asphalt shingle market in both Canada and the U.S., estimated at 80% by the Canadian Asphalt Shingles Manufacturers'

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[1] One square is equivalent to 100 square feet of roof area.

Association (CASMA) and at 80 to 85% in the U.S. by the Asphalt Roofing Manufacturers' Association (ARMA). Re-roofing generates a corresponding large volume of scrap material, estimated at 7 to 10 million tons (6 to 9 million metric tonnes) of shingle tear-off waste and installation scrap in the U.S.

Table ES1 below summarizes our estimate of annual Canadian residential asphalt shingle tear-off (re-roofing), new construction scrap, and related organic felt scrap quantities. The annual total comes to 1.25 million tonnes of scrap asphalt shingles and saturated felt.

Table ES1 – Annual Generation of Asphalt Shingle and Organic Felt Waste in Canada

	Units	Quantities	Notes
Total An. Roof Squares (mill. of squares)	MMsq	15	
new construction (@ 20% of market)	MMsq	3	
tear-offs (@ 80% of market	MMsq	12	
Mass of shingles per square	m t	0.102	(225 lbs installed)
Mass of felt per square	m t	0.0035	(15 lbs installed)
Total scrap - asphalt shingles			
from new construction	m t	4,590	est. @1% of mass
from tear-offs	m t	1,224,000	
Total scrap - organic felt			
from new construction	m t	7,350	est. @14% of mass
from tear-offs	m t	21,000	Est. based on 50% of roofs use felt
Grand Total asphalt shingle/felt scrap	m t	1,256,940	

Notes: MMsq- millions of squares, m t – metric tonnes
New construction asphalt shingle scrap estimated by the Athena Institute
New construction organic felt scrap estimated by the Athena Institute

Canadian Industrial, Commercial and Institutional (ICI) Asphalt Roofing Market & Scrap Production

The Canadian industrial, commercial and institutional (ICI) roofing market, typically categorized as a low-slope roofing market, uses a vast array of roofing products and systems. There are conventional roofs and protected membrane roofs, single and multiple ply roofs, and numerous types of membranes and built-up roof (BUR) systems. Roofing asphalt is prominent in three types of systems – traditional 4-ply built-up roofs, 2-ply modified bitumen roofs, and rubberized asphalt roof. Modified bitumen and asphalt built-up roofs combined account for as much as 80% of the annual Canadian ICI low-slope roofing market. The Canadian Roofing Contractors' Association (CRCA), the primary national industry association for the ICI sector, estimates that Canadian commercial roofing sector sales approach $1.6 billion on an annual basis. They also estimate that roof replacement accounts for approximately 60% of all activity in the sector, with new roof installations accounting for the remaining 40% of the market. A small portion of the roof replacement segment includes roof repairs.

Table ES2 below, which provides the Institute's estimate of annual asphalt roofing scrap for the ICI sector, shows that new asphalt roofing activity contributes a very small portion to the overall waste stream. Overall, we estimate that a total of 330,000 tonnes of asphalt related roofing scrap is produced by the sector annually, with re-roofing responsible for 99% of the total waste stream.

Table ES2 ICI Sector Calculated Annual Asphalt Roofing Related Wastes

	Units	Quantities	Source
Total ICI Sector Sales Value	$ millions	1600	P. Kalinger
new construction (@ 40% of market)	$ millions	320	P. Kalinger
replacement (@ 60% of market	$ millions	1280	P. Kalinger
Average cost of BUR/Mod.Bit. Roofs	$/ square	380	P. Kalinger
New construction no. of squares basis	squares	842,105	
Replacement no. of squares basis	squares	3,368,421	
Total Scrap in New Construction			Waste factor
unsaturated organic felt use	tonnes	1,117	at 14%
asphalt saturant use in felt	tonnes	1,391	at 14%
asphalt interply and flood coat use	tonnes	547	at 1%
asphaltic primer	tonnes	63	at 5%
aggregate ballast	tonnes	-	
Total	**tonnes**	**3,119**	
Total Scrap from Replacement			**%**
unsaturated organic felt	tonnes	28,724	9%
asphalt saturant in felt	tonnes	35,773	11%
asphalt interply and flood coat	tonnes	197,053	59%
asphaltic primer	tonnes	4,547	1%
aggregate ballast	tonnes	62,585	19%
Total	**tonnes**	**328,682**	99%
Total ICI Sector Asphalt Roofing Scrap	**tonnes**	**331,801**	

Notes: Average cost of BUR ($3.50/sq.ft.), Mod.Bit ($4.25/sq.ft.) at equal market share = $3.80/ sq.ft.x100=$380/roofing square, Used a replacement quantity of 90% to account for repair activity

Total Asphalt Roofing Scrap Production by Component

Table ES3, below, summarizes the total annual asphalt based roofing scrap available in Canada by primary component. Although the ICI sector's roofing scrap output is only about 25% of that estimated to be produced by the residential sector on a mass basis, the amount of asphalt in the ICI roofing scrap is almost 75% that of the residential market on a percentage of asphalt basis, making it a significant consideration for recycling. Overall, an estimated 1.5 million tonnes of asphalt related roofing waste is generated in Canada, with aggregate, asphalt and organic felts representing 57%, 35% and 9% by mass, respectively.

Table ES3 Annual Residential & ICI Asphalt Based Roofing Scrap by Component

Component	Residential		ICI		Total	
	m tonnes		m tonnes		m tonnes	
Unsaturated org. felt	109,627	9%	29,841	9%	139,468	9%
Asphalt	311,872	25%	239,384	72%	551,256	35%
Aggregate/Granules	835,441	66%	62,585	19%	898,026	57%
Total	1,256,940	100%	331,810	100%	1,588,750	100%

End-uses for Asphalt Roofing Scrap

Eight potential end-use markets were identified for Residential and ICI asphalt roofing scrap: hot-mix asphalt (HMA); cold patch; dust control on rural roads; temporary roads; driveways and parking lots; aggregate base; fuel; and new roofing shingles. The benefits of recycling asphalt based roofing products include conservation of landfill space and resources, reduced costs of disposal, and lower costs of production as compared to new roofing products made from virgin materials. Some of the obvious risks associated with establishing an asphalt recycling facility are uncertain capital costs, permitting problems or delays, highly variable material supply and sources, and undeveloped and/or under-developed markets.

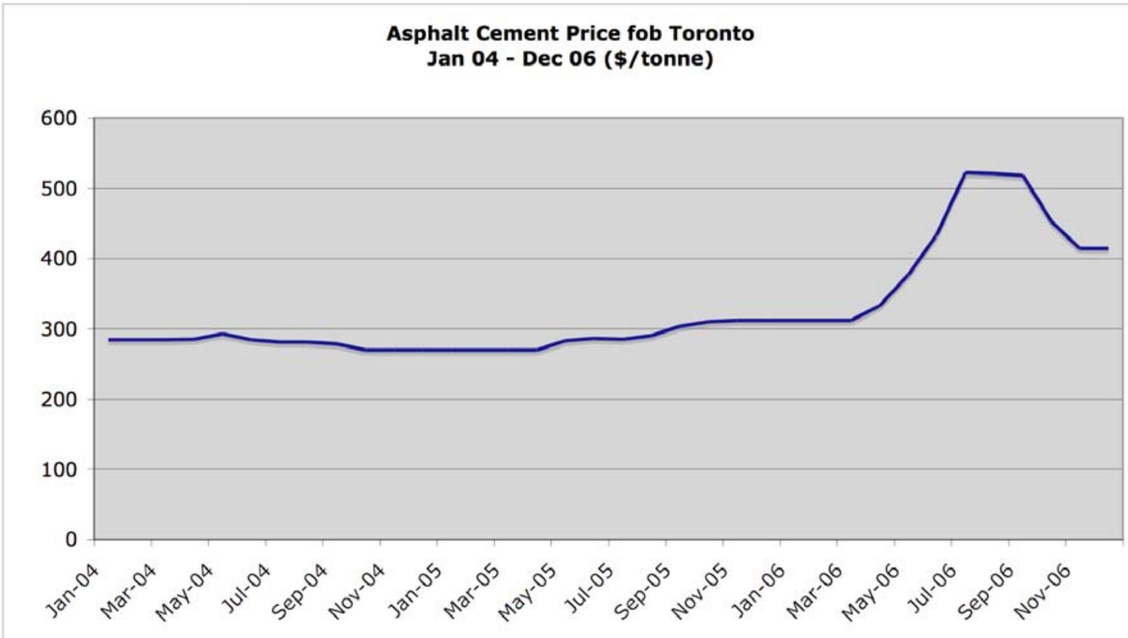
In Canada, asphalt based roofing scrap has been incorporated in HMA, trail construction and as a fuel in cement kilns. By far the largest end-use market for scrap asphalt roofing products in North America is the hot-mix asphalt industry and road construction. Numerous states and some provinces (Ontario and Nova Scotia) have provisions for using recycled asphalt shingles in HMA. Although HMA specifications have typically allowed for the use of only uncontaminated manufacturers' scrap shingles (cut outs and off spec shingles) at up to 5% of the HMA mix, more state and provincial transportation authorities are accepting tear-off scrap in their HMA specifications. It is estimated that there are over 500 hot-mix asphalt plants across Canada producing in the order of 30 to 31 million tonnes annually. Substitution of 5% of the virgin material in hot-mix asphalt could consume in the order of 1.5 million tonnes of asphalt roofing scrap; in other words, the total asphalt roofing scrap generated in Canada annually. Further, it is estimated that substituting 5% roofing scrap for virgin asphalt concrete would eliminate 90,000 tonnes of greenhouse gases produced by the HMA industry. Obviously, the HMA sector is a potentially large, and therefore a key market to focus on when assessing asphalt based roofing scrap recycling.

Economic and Environmental Drivers

The HMA industry has experienced a considerable increase in asphalt cement prices in recent months (see Chart ES2). Perhaps the most significant reason for this increase is the relatively large increase in gasoline, diesel fuel (see Chart ES3) and home heating oil prices, which makes it economical for refiners to invest in facilities to further refine the heavy end of the crude oil barrel from which asphalt cement is derived. U.S. and Canadian refineries have invested hundreds of millions of dollars in the last few years in cokers for this type of conversion. As a result, long-term supply of asphalt cement may become an issue, driving up those prices and creating more incentive for recycling.

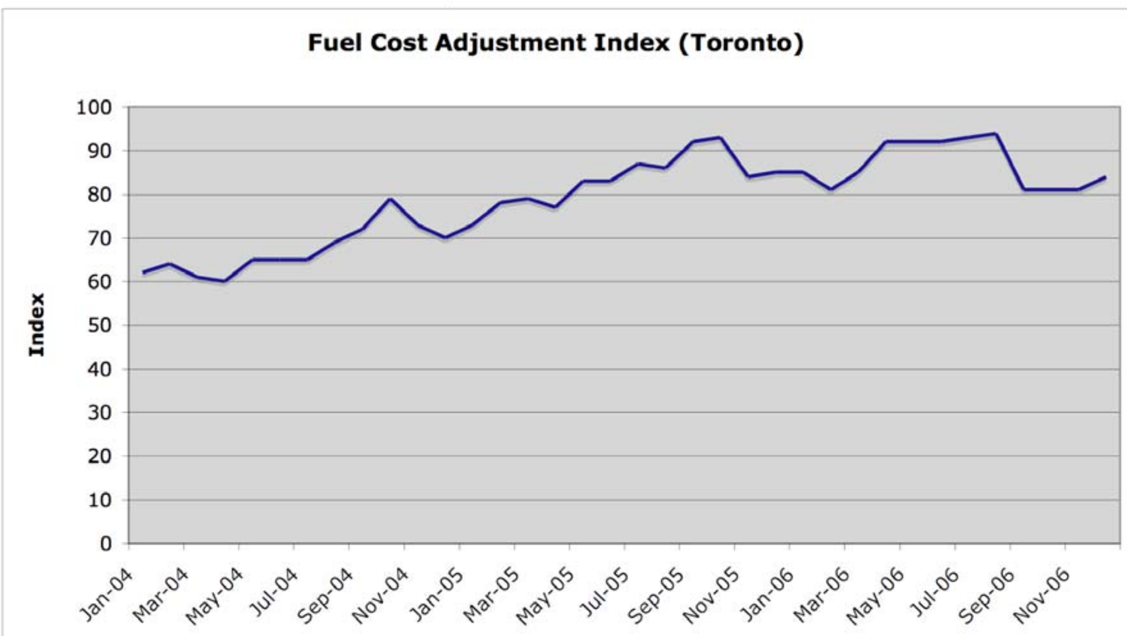
Other significant drivers toward more recycling of roofing materials include diminishing landfill capacity and increasing tipping fees for construction and demolition waste. On the negative side, there is the difficulty obtaining operating permits for recycling facilities and a lack of diversion incentives.

Chart ES2 Recent Asphalt Cement Prices, FOB Toronto



Source: Ministry of Transportation Ontario (PG Grade 58-28 or equivalent)

Chart ES3 – MTO Diesel Fuel Cost Adjustment Index[2] for Toronto



Source: Ministry of Transportation Ontario

[2] The Fuel Cost Adjustment Index is based on the price, including taxes, FOB Toronto area terminals for low sulphur diesel – MTO.

GLOSSARY OF ACROYNMS AND TERMS

AASHTO - The American Association of State Highway and Transportation Officials
An organization of highway engineers from 50 U.S. states that develops guides and standards, including specifications for utilizing manufacturer and tear-off asphalt shingle scrap in HMA

Aggregate
Hard, inert mineral material, such as gravel, crushed rock, sand, or crushed stone, used in pavement applications either by itself or for mixing with asphalt

Aggregate Base
Well-graded aggregate suitable for compacting to such a degree that it provides a firm, stable base

APP – atactic polypropylene
Modifier used in modified bitumen roofing membranes

ARMA - Asphalt Roofing Manufacturers' Association

ASRAP - Asphalt Shingles Research Assessment Project

Bitumen
A class of black or dark-coloured (solid, semisolid, or viscous) cementitious substances, natural or manufactured, typically composed of asphalts, tars, pitches, and asphaltites

BTU - British Thermal Unit
A unit of energy

BUR - Built-Up Roofing Membrane
Four layers of either fibreglass mat or organic felt, with asphalt applied between plies and a flood coat over top

CASMA - Canadian Asphalt Shingles Manufacturers' Association

CCME - Canadian Council of Ministers of the Environment

CMRA - Construction Materials Recycling Association

Cold Patch
Aggregates and liquid bitumen vulcanized at room temperature, activated by chemical agents without the application of heat from an outside source and stockpiled for patching or maintenance

Conventional Roofing System
A roofing system on which the membrane is located above the insulation

CRCA - Canadian Roofing Contractors' Association

DOT - Department of Transportation

Elastomer
A material that, after being stretched, will return to its original shape

EPDM – ethylene propylene diene monomer
A family of resins based upon olefinic monomers. Used in single ply roofing membranes

EPR - Extended Producer Responsibility

Fibreglass Mat
Fibres condensed into strong, resilient mats for use in roofing materials

Fibreglass Shingle
A shingle with a woven fibreglass mat as the base material. The fibreglass mat is coated with asphalt on both sides then covered with ceramic granules

Hammermill
A high-speed size reduction mill for pulverizing an array of raw and waste materials for process or recovery. Utilizes a series of swinging hammers for cutting material

HMA – Hot-Mix Asphalt
A high-quality, thoroughly controlled, engineered mixture made by heating asphalt cement and mixing it with aggregates and mineral fillers. Hot-mix pavement design formulas usually contain between 5 and 7% bitumen

Hot Applied Rubberized Asphalt Membranes
A flexible, site applied membrane for use in waterproofing and roofing applications. It consists of proprietary blends of asphalt, mineral fillers, elastomers (natural, synthetic, or a blend of both), virgin or reclaimed oil, and a thermoplastic resin.

ICI - Industrial, Commercial and Institutional

Manufacturers' Scrap Shingle
Trimmings, overruns generated from manufacturing processes

Modified Bitumen
Rolled roofing membrane with polymer modified asphalt and either polyester or fibreglass reinforcement

NAPA - National Asphalt Pavement Association

NRCA - National Roofing Contractors' Association

Organic Shingle
A shingle that uses paper as the base material. The paper is saturated in asphalt and coated with ceramic granules on the top surface. The asphalt waterproofs the shingles

PMRA - Protected Membrane Roofing System
A protected membrane roof assembly, or inverted roofing system, is defined as a roof on which the membrane is located below the insulation

RAP - Reclaimed Asphalt Pavement
Pulverized excavated asphalt that is used as an aggregate in the recycling of asphalt pavements. Factory-rejected roofing shingles can be added to RAP

RAS - Recycled Asphalt Shingle
Shingle from post-consumer tear-offs; see TOSS

SBS Membranes
Modified bitumen membranes using styrene butadiene as modifier. Can be applied by torch or asphalt

Tipping Fee
A per-ton fee charged to haulers and citizens for waste delivered to a waste management facility such as a landfill or recycling depot

TOSS - Tear Off Shingle Scrap
Also known as post-consumer scrap shingle or RAS; shingle generated during the demolition or replacement of existing roofs; scraps of trimmed shingles

TPO
A chemical industry accepted designation for a family of thermoplastic resins created from basic olefinic monomers. Used in single ply TPO roofing membranes

Underlayment
Asphalt based rolled material designed to be installed under main roofing material, to serve as added protection

Acknowledgements

This report was made possible through the support of Natural Resources Canada and the Canadian Council of Ministers of the Environment. The Institute would like to thank Peter Kalinger of the Canadian Roofing Contractors' Association and Mr. Mike Vandenbusshe of the Canadian Asphalt Shingle Manufacturers' Association for their timely assistance with this report. We also would like to acknowledge the fine work done by the U.S. Construction Materials Research Association and their invaluable web resource <www.ShingleRecycling.org> without which we would not have been able to complete this project in the short time allotted.

Disclaimer

Although the Athena Sustainable Materials Institute has done its best to ensure accurate and reliable information in this report, the Institute does not warrant the accuracy thereof. If notified of any errors or omissions, the Institute will take reasonable steps to correct such errors or omissions. This report, while characterizing roofing industry scrap generation, its composition and avenues for roofing scrap recycling, does not claim to have investigated the environmental hazards associated with any described activities.

Contents

1 Introduction

This briefing paper has been prepared to support the development of an implementation plan for increasing the recovery of end-of-life roofing materials. This briefing paper will serve as an introductory status update for a workshop to be held in Toronto in February 2007. Due to the prevalence of asphalt based roofing materials in both residential and industrial, commercial and institutional markets, the primary focus of this report is asphalt based roofing materials.

1.1 Objectives

The Canadian Construction Innovation Council engaged the Athena Institute to prepare this briefing paper with the intent of finding answers to the following questions:

- What potential quantities of asphalt based roofing materials can be deemed recoverable in Canada?
- Who in North America is recovering roofing materials and to what end-uses are these recovered materials put?
- What collection and sorting systems are typically used to divert roofing materials from landfills?
- To what extent are these collection and sorting systems specific to the eventual material end-use?
- What municipal ordinances are in place governing roofing material recovery?
- What, if any, are the environmental (e.g., regulations) or economic (e.g., landfill tipping fees, energy costs) determinants driving the recovery of roofing materials?

1.2 Literature Review and Gap Analysis

Over a two-week period in January 2007, the Institute conducted a web search for literature related to the recycling of asphalt based roofing products in North America. We also contacted relevant associations (Canadian Asphalt Shingles Manufacturers' Association and Canadian Roofing Contractors' Association), as well as others with involvement in the recycling of roofing materials (e.g., Canadian municipalities regarding ordinances concerning asphalt roofing product recycling). In some instances we found considerable information (e.g., recycling of asphalt shingles in hot-mix asphalt), while in other instances there was a dearth of information. At various points in the report, gaps in the data or information concerning asphalt roofing product quantities or recycling end-uses are acknowledged as a way to identify future research efforts in this field.

1.3 Report Structure

The remainder of this report is structured as follows.

Sections 2 and 3, respectively, describe the residential and ICI asphalt roofing sectors in Canada, including applicable sector asphalt products and estimates of the roofing scrap from these sectors.

Section 4 describes various end-uses for asphalt roofing scrap.

Section 5 describes some of the major economic and environmental drivers affecting asphalt roofing scrap recycling.

2 The Residential Asphalt Roofing Industry

2.1 Residential Roofing Products

2.1.1 Asphalt Shingles

The residential asphalt roofing industry started in the 1890s with bitumen and coal tar pitch impregnated roofing felts[1]. Two weights of roofing felts, #15 and #30, are still used today in residential and industrial, commercial and institutional (ICI) applications. The popular 3-tab asphalt shingle had been invented by 1915. From these modest beginnings, asphalt roofing became the most readily used and accepted roof covering material in North America. According to the Asphalt Roofing Manufacturers' Association (ARMA), more than 80% of all residential roofs in the United States are covered with asphalt roofing industry products. In Canada, this number is even higher – estimated at 90% of all residential roofing applications.

In the early 1950s, there were 11 manufacturers of asphalt roofing products in Canada. Over the years, the industry underwent considerable consolidation, and by the early 1980s there were four producers left. Today only two remain: Building Products, a division of EMCO Limited; and IKO Industries Ltd.

Building Products (BP) operates two plants – one in LaSalle, QC, the other in Edmonton, AB. Since the late 1980s, BP has been a part of EMCO Limited, Canada's largest plumbing and HVAC wholesaler. BP also operates a paper felt mill in Pont Rouge, QC. IKO Industries, a family-owned manufacturer of residential and commercial roofing products, has grown from modest beginnings in the early 1950s to become the largest roofing manufacturer in Canada. It supplies the market from its plants in Calgary, AB, Brampton, ON and Hawkesbury, ON. Its newest roofing plant in Sumac, WA, is just south of the Canadian border, supplying not only the US Pacific Northwest, but also the British Columbia market. In 1993, IKO also purchased former CGC roofing plants in Toronto, ON and Winnipeg, MB. IKO is a vertically integrated company, producing its own felts in Brampton, ON, Calgary, AB, and Monroe, MI, its roofing granules in Madoc, ON and controlling its source of asphalt. IKO also operates a number of roofing plants in the U.S. (recently forming a joint venture with Owens Corning) and Europe.

In British Columbia, there is also a felt producer, HAL Industries Inc., with factories in Surrey and Burnaby (HAL does not manufacture asphalt shingles or mineral roll roofing). The company produces saturated felts for built-up roofing (BUR) applications, SBS (styrene butadiene) modified torch-on roofing and waterproofing sheets; in addition, some of the #15 felt HAL Industries produces is undoubtedly used as asphalt shingle underlayment.

Canadian roofing manufacturers are members of CASMA, the Canadian Asphalt Shingles Manufacturers' Association, and associate members of CRCA, Canadian Roofing

[1] Much of this section comes from the Athena Institute's report entitled, "Life Cycle Analysis of Residential Roofing Products," prepared by Venta, Glazer Associates in 2000.

Contractors' Association. Due to their manufacturing and export interest in the U.S., they also participate in equivalent organizations there: ARMA (Asphalt Roofing Manufacturers' Association) and NRCA (National Roofing Contractors' Association).

2.1.2 Types of Asphalt Shingles

Asphalt roofing shingles come in many different types, weights and shapes. The weight of asphalt shingles can vary between 125 lbs. (57 kg) and 380 lbs. (173 kg) per square of roof covered [2]. The principal reason for the difference is the number of plies of roofing felt with asphalt saturant, coating and granules in the completed roof.

The most common form of asphalt shingles is strip or 3-tab shingles. They are rectangular in shape, the most prevalent sizes being 1000mm by 336mm (39 3/8" by 13 1/4") metric shingles and 12" by 36" shingles. They generally have three tabs that are exposed along the length of the shingle for visual effect. Shingles may also be embossed to give a more upscale, heavier appearance (referred to as architectural shingles). Shingles may be produced in single thickness or with more than one thickness; these are generally known as laminated shingles. Such shingles provide a more three-dimensional appearance. The term self-sealing refers to the addition of a strip of factory applied adhesive on the back of the shingle; the adhesive is activated by the sun's heat after installation and "seals" each shingle to the one below it. This provides the roofing system with greater wind resistance. Another way to achieve wind resistance is through the use of interlocking shingles, which rely on the locking mechanism of the tabs instead of a sealant for their wind resistance.

Back in 2000, at least 65% of the shingles produced in Canada were of the basic 3-tab self sealing variety, with about 15% each of the laminated and architectural shingles being produced, and 5% of the specialty interlocking shingles. Many in the industry believe that laminated and architectural shingles have increased their share of total shingle production, but production by shingle type is not reported by either IKO or BP. This is significant as the range of weights vary by type, with the laminated and architectural shingles being of the heavier variety. CASMA estimates that the average asphalt shingle bundle weighs 75 lbs. (34 kg), but the range can be from 60 lbs. (27 kg) to 85 lbs. (39 kg) per bundle[3]. Using CASMA's average weight per bundle and assuming three bundles per square of roofing (100 sq. ft.), a typical square of installed asphalt shingle roof will weigh 225 lbs. (102kg). BP produces eight asphalt shingle types (with varying warranties) ranging between 215 lbs. (98 kg) and 310 lbs. (141 kg) per square of roof; IKO produces over 16 different types, ranging between 213 lbs. (97 kg) and 300 lbs. (136 kg) per square of roof. As a result, the type of shingle used will have a significant bearing on the installed weight of the roof and the amount of asphalt shingle waste calculated when it is eventually removed and replaced. CASMA's average weight per square of roof would indicate the use of a shingle with a 20 to 25-year warranty.

[2] One roofing square is equal to 100 square feet.

[3] Personal correspondence, Mike Vandenbusshe, CASMA.

Lastly, asphalt shingles may be produced using either organic felts or glass mats. Traditionally, asphalt shingles incorporating organic felts have dominated the Canadian residential roofing market due to their greater flexibility in cold weather (90% of the Canadian market). However, glass mat based asphalt shingles are the product of choice in the U.S. and are making inroads into the Canadian market. In the foreseeable future, however, the majority of roof tear-off waste shingles will primarily be organic based shingles.

2.1.3 Other Residential Asphalt Roofing

Saturated organic felt

An asphalt saturated felt is used as underlayment for asphalt shingle roofs as well as other roof types (e.g., metal roofing). Rolls have markings to guide overlapping. The most common grades are #15 and #30 asphalt felts. The grade numbers indicate the weight of saturated felt per square of roof covered (e.g., #15 felt when applied to one square of roof would weigh 15lbs. (6.8 kg) per square of roof.

Roll roofing

Mineral surfaced roofing roll is comprised of a heavy duty felt base with asphalt, covered with mineral granules. It can be used as a roof covering membrane, for valley flashing or as a starter strip at the eaves of asphalt shingle roofs.

2.1.4 Residential Asphalt Roofing Product Components

All asphalt roofing incorporates at least two of the following three primary materials.

1. **Carrier sheet**, which can be either organic paper felt or fibreglass mat, provides a base and reinforcement for the bituminous weatherproofing, and gives the finished product appropriate strength and handling and application properties (rigidity and flexibility). Organic paper felt consists of both virgin and recycled cellulosic (wood, cardboard, paper) fibres. Asbestos based roofing felts were once used by the roofing industry, but were completely eliminated from the industry once the health problems related to asbestos fibres became known. Glass mats were introduced over the last couple of decades. The bonding of glass fibre filaments with phenol formaldehyde or urea formaldehyde resin produces the glass mat used in the roofing industry. All three asphalt based residential roofing products incorporate felts or mats.

2. **Bituminous materials**, primarily petroleum asphalts, are used for weatherproofing the felts because of the outstanding combination of waterproofing, preservative and cementing qualities. Asphalt is a co-product of petroleum refining, which produces a large number of chemicals through a complex set of physical and chemical processes. In North America, the dominant products of refineries are fuels. In recent years, the category of "asphalt and roofing oils" has accounted for less than 3% annually of the output of the U.S. petroleum refineries (due to data confidentiality, no comparable data is available on Canadian refinery operations). Asphalt is the bottom fraction remaining after all lighter fractions of fuels and oils have been distilled off. This heavier fraction

of the crude petroleum is further processed into a number of products, including asphalt, via a combination of distillation, solvent extraction and solvent de-asphalting. Practically, refineries will produce a number of asphalt grades. To attain the saturant and coating grades of proper softening point consistencies, air is blown at elevated temperatures through the asphalt, usually by the roofing operations themselves.

Asphalt impregnates and coats the carrying sheet of felt, providing the long term weatherproofing and performance desired in roofing products. Organic felts are first saturated using asphalt that fully impregnates the cellulosic fibres and the spaces between them, then coated with harder, more viscous coating asphalt. Glass mats are rather thin and non-absorbent, requiring no saturant. The mat sheet is usually perforated, allowing the complete encapsulation by the coating asphalt only. Coating asphalt, in addition to providing the weathering medium, may also provide the embedment layer for mineral granule surfacing.

3. **Mineral surfacing materials** include roofing granules, fine stone chips, or natural and baked on ceramic coatings on the exposed side of the asphalt product. Surfacing has a number of different functions: it protects the asphalt coating against the effects of solar radiation, extending the lifespan of the roof; it increases the fire resistance of the shingles; and lastly, it provides visually attractive surfaces through the selection and combination of various granule types and colours. Talc or mica is applied to the back side of asphalt shingles and mineral roll roofing to prevent sticking in the bundle or roll during storage and transport prior to application – after which, the self adhesive mastic cements the shingles together.

   There are other raw materials used in the production of residential asphalt roofing products. Mineral stabilizers and fillers, usually finely ground limestone or mineral dust from the production of roofing granules, are used in the coating asphalt.

2.1.5 Residential Asphalt Roofing Product Material Composition

The following Table sets out the raw material composition for three typical residential roofing products. It should be noted that the organic asphalt roofing shingle formulation was adjusted to agree with CASMA's average product usage per roofing square (100 sq. ft.).

Table 1 Residential Asphalt Roofing Product Formulations

lbs or kg/square	Organic Asphalt Shingles			#15 Organic Felt			Mineral Surface Roll		
	lbs/sq	kg/sq	%	lbs/sq	kg/sq	%	lbs/sq	kg/sq	%
Organic felt	17	8	8	6	3	40	9	4	8
Asphalt	54	24	24	9	4	60	26	12	23
Granules/filler	154	70	68	0	0	0	76	34	68
Total	225	102	100	15	7	100	111	50	100

Note: sq= one roofing square (100 sq. ft.)

2.2 Canadian Residential Roofing Market

This section describes the salient aspects of the Canadian residential roofing market. Overall, organic felt based asphalt shingles dominate the market. It is estimated that asphalt shingles represent close to 90% of the market, with wood shakes, metal roofing and a minor amount of asphalt roll roofing comprising the remaining 10% of the market. Statistics Canada tracks Canadian production, shipments and exports for the asphalt roofing sector (cat. No. 45-001-XIB). Statistics Canada and the CASMA are the primary sources used in this section of the report.

Table 2 below summarizes the production, shipments and exports of asphalt roofing products in Canada as reported by Statistics Canada for the four years 2003 through 2006.

Table 2 Canadian Asphalt Roofing Industry Production, Shipments and Exports

Production	**2003**	**2004**	**2005**	**2006**
Asphalt shingles	41,579,089	43,638,986	40,284,660	48,917,868
Smooth surfaced organic felt roll roofings	66,468	73,815	56,297	26,390
Mineral surfaced organic roll roofings	157,975	280,644	605,308	239,129
Asphalt saturated organic felts	96,401	98,480	88,106	84,809
Total shipments				
Asphalt shingles	42,096,229	47,693,282	44,299,711	51,350,951
Smooth surfaced organic felt roll roofings	76,357	67,512	62,009	54,571
Mineral surfaced organic roll roofings	338,518	402,842	377,720	385,367
Asphalt saturated organic felts	109,463	119,359	114,999	122,019
Exports				
Asphalt shingles	8,877,320	9,090,399	8,552,113	9,273,820
Smooth surfaced organic felt roll roofings	14,127	13,468	10,872	8,277
Mineral surfaced organic roll roofings	134,410	206,073	208,391	211,389
Asphalt saturated organic felts	55,353	58,513	60,182	62,188
Apparent Domestic Consumption				
Asphalt shingles	33,218,909	38,602,883	35,747,598	42,077,131
Smooth surfaced organic felt roll roofings	62,230	54,044	51,137	46,294
Mineral surfaced organic roll roofings	204,108	196,769	169,329	173,979
Asphalt saturated organic felts	54,110	60,846	54,817	59,831

Notes: Asphalt shingle reported on metric bundle basis (one metric bundle =3m^2 of roof coverage
Roll products reported on a metric roll basis (one metric roll = 10m^2 of roof coverage
Apparent consumption = Total Shipments – Exports (Dec 06 values estimated by CASMA)

Not all of the products in Statistics Canada's table above are used by the residential roofing sector. Smooth surfaced organic felt roll roofing can describe a number of products, including modified bitumen cap sheets and base sheets, which are used almost exclusively in the ICI roofing sector. Mineral surfaced roll roofing, while often used in the residential sector, may also be used in built-up roofing applications as a cap sheet. Saturated felts are used in both residential and ICI roofing applications. Table 3 presents the four-year average apparent Canadian consumption for these various products and converts them to a roof square (100 sq. ft.) basis. The table clearly shows that asphalt shingles comprise an overwhelming majority of the products used by the asphalt roofing industry. It should be noted that roofing asphalt as used in the ICI sector as a component in asphalt built-up roofs, in rubberized asphalt roofs, and as an adhesive in modified bitumen roofing is not reported by Statistics Canada for confidentiality reasons (see Section 3 for further information concerning the ICI market). In addition, these tables do not include imports of roofing materials, and it is known that a considerable amount of modified bitumen roofing and felts (organic and glass mat) as well as asphalt shingles are imported from the U.S. These data, as developed up to this point, should therefore be viewed as conservative.

Table 3 Average Apparent Consumption on a Roof Square Basis

Apparent Domestic Consumption	4-yr Average	Roof Square Basis	% Contribution
Asphalt shingles	37,411,630	12,068,268	97.42%
Smooth surfaced organic felt roll roofings	53,426	57,509	0.46%
Mineral surfaced organic roll roofings	186,046	200,265	1.62%
Asphalt saturated organic felts	57,401	61,788	0.50%
Total		12,387,830	100%

2.2.1 Asphalt Shingle Roofing Market

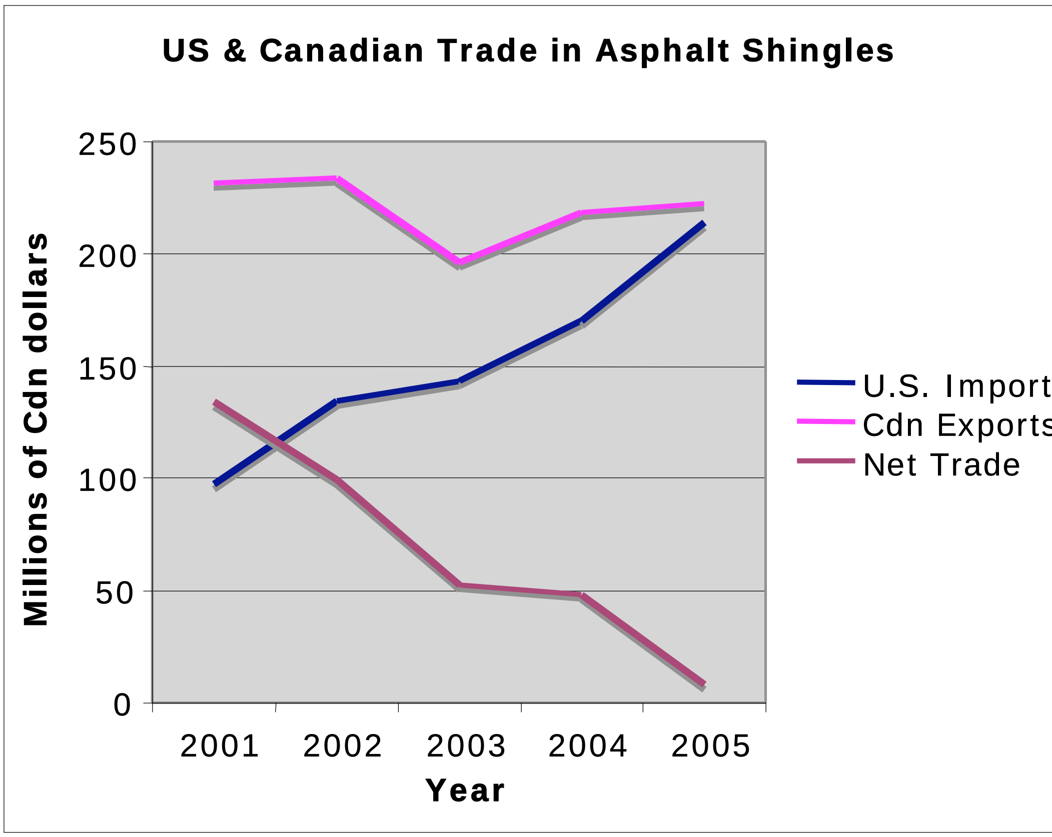
This section focuses on the Canadian residential asphalt shingle exclusively as it is the largest segment of the asphalt roofing industry. Again, much of this section is based on Statistics Canada data augmented with data from CASMA.

In the previous section we noted that asphalt shingles represented the largest segment of the roofing market; imports, however, were not included in the analysis. Table 4 again shows Canadian production, domestic shipments and exports, but also includes U.S. imports into Canada, thus providing a more complete picture of overall Canadian consumption of asphalt shingles. Canadian exports have remained relatively constant, while U.S. imports of asphalt shingles have steadily increased on a volume basis. Prior to the signing of the North American Free Trade Agreement, the U.S. didn't ship shingles to Canada. And while Canada is now a net importer of asphalt shingles in terms of volume, Canada still enjoys a small trade surplus in asphalt shingles with the U.S. on a monetary basis (Figure 1). CASMA has interpreted this volume/value difference to mean that Canada is importing lower value (i.e., lower durability) asphalt shingles from the U.S. This may have implications for the industry in the longer-term as these U.S. lower durability shingles will need to be replaced sooner.

Table 4 Canadian Asphalt Shingle Production, Shipments, Exports/Imports & Apparent Consumption

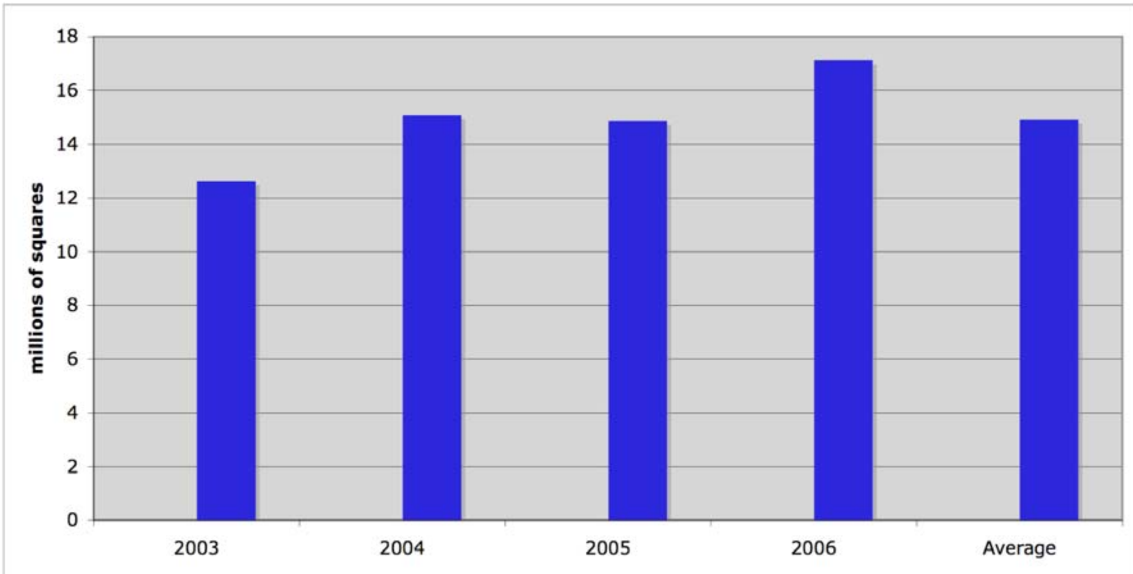
millions of metric bundles	**2003**	**2004**	**2005**	**2006**	**4-yr Average**
Cdn Production	42	44	40	49	44
Domestic Shipments	33	39	36	42	37
Cdn Exports	9	9	9	9	9
Cdn (US) Imports	6	8	10	11	9
Cdn Consumption	39	47	46	53	46

Figure 1 U.S. & Canadian Trade in Asphalt Shingle



Over the last four years, Canadian asphalt shingle consumption has increased steadily and mirrored the growth in new housing starts. On average, 46 million metric bundles, or approximately 15 million squares of asphalt shingle roofing, have been installed in Canada (see Figure 2). Regionally, Central Canada (Ontario and Quebec), Alberta plus British Columbia, and the combined Prairie and Maritime provinces have accounted for 65%, 20% and 15%, respectively, of asphalt shingle consumption in Canada over the last four years.

Figure 2 Canadian Asphalt Shingle Consumption (in million of roofing squares)



2.3 Estimated Canadian Asphalt Shingle Waste

CASMA estimates that over the long term, re-roofing accounts for 80% of Canadian asphalt shingle demand annually. This estimate is similar to those of other literature sources. ARMA estimates that re-roofing accounts for 80 to 85% of annual asphalt shingle use in the U.S. Annually, roof installation generates an estimated seven to 10 million tons (six to nine million metric tonnes) of shingle tear-off waste and installation scrap in the U.S. Table 5 below derives an estimate of annual residential asphalt shingle (re-roofing) tear-off and new construction scrap and related organic felt scrap quantities generated in Canada.

Overall, our analysis of the residential asphalt shingle market suggests that 1.25 million metric tonnes of scrap asphalt shingles and saturated felt are generated in Canada annually.

Table 5 – Annual Generation of Asphalt Shingle and Organic Felt Waste in Canada

	Units	Quantities	Notes
Total An. Roof Squares (mill. of squares)	MMsq	15	
new construction (@ 20% of market)	MMsq	3	
tear-offs (@ 80% of market	MMsq	12	
Mass of shingles per square	m t	0.102	(225 lbs installed)
Mass of felt per square	m t	0.0035	(15 lbs installed)
Total scrap asphalt shingles			
from new construction	m t	4,590	est. @1% of mass
from tear-offs	m t	1,224,000	
Total scrap organic felt			
from new construction	m t	7,350	est. @14% of mass
from tear-offs	m t	21,000	Est. based on 50% of roofs use felt
Grand Total asphalt shingle/felt scrap	m t	1,256,940	

Notes: MMsq - millions of squares, m t – metric tonnes
New construction asphalt shingle scrap estimated by the Athena Institute
New construction organic felt scrap estimated by the Athena Institute

3 The Canadian Industrial, Commercial and Institutional Asphalt Roofing Market

The Canadian industrial, commercial and institutional (ICI) roofing market is typically categorized as a low-slope roofing market. A vast array of roofing products and systems is employed in the low-slope roofing market. There are conventional roofs and protected membrane roofs; there are single and multiple ply roofs; and there are numerous types of membranes and built-up roof systems. The use of roofing asphalt is prominent in three types of roof membranes or systems: traditional 4-ply built-up roofs, 2-ply modified bitumen roofs, and rubberized asphalt roof. Rubberized asphalt garners a small portion of the Canadian ICI roofing market (less than 5%); however, modified bitumen and asphalt built-up roofs combined account for as much as 80% of the ICI low-slope roofing market[4]. The primary national industry association for the ICI sector is the Canadian Roofing Contractors' Association (CRCA) with 320 members representing about 75% of the roofing contractor industry in the country. There are also provincial roofing contractor associations in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick and Nova Scotia.

The CRCA estimates that the Canadian commercial roofing sector sales approach $1.6 billion on an annual basis. They also estimate that roof replacement accounts for

[4] Personal correspondence, Mr. Peter Kalinger, Canadian Roofing Contractors' Association, January, 2007. Mr. Kalinger and the CRCA are the primary sources for the information in this section.

approximately 60% of all activity in the sector, with new roof installations accounting for the remaining 40% of the industry's activities. A small portion of the roof replacement segment denotes roof repairs.

3.1.1 ICI Roofing Systems and Asphalt Use[5]

Conventional Roofing Systems

A conventional roofing system is defined as a roof on which the membrane is located above the insulation. In Canada, conventional roofing systems typically require vapour barriers, and can be installed on any type of roof deck. Advantages of conventional systems include reduced loads and protection of the insulation. Disadvantages include the exposure of the membrane to temperature extremes, and the possibility of water or moisture being trapped beneath the membrane. Conventional roofing systems are generally more popular in Canada than protected membrane roof assemblies.

Protected Membrane Roofing Systems

A protected membrane roof assembly (PMRA), or inverted roofing system, is defined as a roof on which the membrane is located below the insulation. In Canada, PMRAs are most often installed on concrete decks, although they are occasionally installed on steel decks. PMRAs typically require a great deal of ballast to reduce the likelihood of flotation or blow-off of the insulation, which is loose-laid above the membrane. In PMRAs, the membrane normally also acts as the vapour barrier. Advantages of PMRAs include protection of the membrane from mechanical damage, traffic, UV light and temperature extremes. Disadvantages of PMRAs include increased cost, increased loads due to ballast, difficulties in performing maintenance, and increased exposure of the membrane and insulation to moisture and water.

PMRAs always utilize extruded polystyrene insulation. Typically, a woven polyethylene filter fabric is utilized above the insulation to provide UV protection for the insulation and to prevent migration of the ballast (commonly aggregate stone). Re-roofing of PMRAs typically involves reuse of a large portion of the insulation and ballast materials.

Asphalt Use

Either roofing grade asphalt or bitumen can be used in built-up roofing (BUR), modified bitumen and rubberized asphalt roofing systems, both as an adhesive and as an integral part of the waterproofing system. Asphalt is typically purchased directly from a refinery and shipped to a processing plant, where it is oxidized. Following oxidation, it is either cooled into cake form at the plant and subsequently delivered to distributors, or delivered while still hot in heated tanker trucks.

The majority of roofing projects in Canada utilize cakes of asphalt, which are delivered to a site on a flatbed truck and re-heated in propane-fired kettles. Heated tanker trucks are utilized on large jobs for both modified bitumen and BUR systems. Currently, tanker trucks serve approximately 15 to 30% of the asphalt market in Toronto, Calgary,

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[5] Much of the material in this section describing roofing/membrane systems and component details comes from an Athena Institute report entitled "Life Cycle Inventory of ICI Roofing Systems: Onsite Construction Effects". Prepared by Morrison Hershfield Ltd., 2001.

Montreal, and Winnipeg. Some energy savings are achieved through the use of tanker trucks due to the delivery of hot (rather than cold) asphalt from the plant.

3.1.2 ICI Roofing Membrane Types

This section briefly describes the various roofing membranes employed in the Canadian ICI market. As previously discussed, single ply (non-asphalt based) membranes, while growing in application in Canada, make up less than 10% of the market; as a result, less effort has been devoted to characterizing these systems in this report.

Single Ply Membranes

PVC Roofing Membranes - PVC (polyvinyl chloride) roof membranes are members of a thermoplastic group of materials. PVC polymers are produced by polymerization of vinyl chloride monomer, a gaseous substance resulting from the reaction of ethylene with oxygen and hydrochloric acid. Additives including plasticizers and stabilizers are utilized to provide a product suitable for roofing applications. Seams in PVC membranes can be welded together with heat or solvent to achieve bonds stronger than the original material.

PVC membranes can be installed as PMRAs or conventional assemblies, and currently make up less than 3% of the Canadian roofing market. The largest distributor in the country is Sarnafil Canada, which supplies the majority of PVC membrane in North America from its plant in the U.S.

TPO Roofing Membranes - The acronym TPO is a chemical industry accepted designation for a family of thermoplastic resins that are created from basic olefinic monomers. The TPO acronym is a true representation of the chemistry in the resin used to make a particular roofing membrane, much as 'PVC' represents a family of chlorinated vinyl resins and 'EPDM' represents a family of resins also based upon olefinic monomers.

Typically, and for the roofing industry, TPO polymers are blends or alloys of polypropylene plastic or polypropylene and ethylene propylene rubber (EPR) or ethylene propylene diene terpolymer rubber (EPDM). These alloys can be made either by mechanical mixing or by reactor blending using proprietary polymer manufacturing processes. After further mixing with other additives, these polymer alloys are then formed into roofing membranes with a variety of properties.

TPO membranes can be installed as PMRAs or conventional assemblies and currently make up less than 5% of the Canadian roofing market, although increased use is expected in the future. The largest TPO membrane manufacturers serving Canada are Carlisle SynTec and Lexcan/JP Stevens in the U.S.

EPDM Roofing Membranes - EPDM (ethylene-propylene-diene monomer) roof membranes are members of an elastomeric group of materials. EPDM membranes are compounded with polymers and ingredients such as fillers, anti-degradants, processing oils, and processing aids. EPDM contains 30-50% polymer (ethylene-propylene-diene monomer), 20-30% carbon black and 30-50% extender oil, sulfur, accelerator, and anti-oxidant. Sheets are produced by laminating two plies with or without reinforcement. Most EPDM sheets are vulcanized or cured in the factory by heating the compound with sulfur or another cross-linking agent. EPDM membranes can be provided in very long, relatively narrow rolls (2-3m) when they are to be mechanically fastened or fully adhered, or in very large sheets to be used in ballasted or fully adhered systems. Seams in EPDM roofs are created using adhesives either in the field or the factory.

EPDM roofing membranes are typically installed as PMRA or conventional assemblies. EPDM membrane systems in Canada are fully adhered with adhesives, ballasted with smooth stones or concrete pavers, or mechanically fastened with screw and plate systems. Adhered EPDM membranes are usually mechanically fastened with bars at the perimeter and large roof penetrations, and adhered at the remainder of the roof surfaces. Conventional and PMRA loose laid, fully adhered, and mechanically fastened systems are common in Canada.

The largest EPDM membrane manufacturers serving Canada are Carlisle SynTec and Firestone in the U.S.

Multiply Membrane Systems

<u>Built-Up Roofing Membranes</u> - A BUR membrane typically consists of four layers of felt and asphalt and a flood coat of asphalt over the top layer. The felts can be constructed using fiberglass or organic materials. Asphalt is available in several different types which vary by viscosity, although not significantly by composition. Coal tar pitch was once a common component in BUR roofing assemblies, but is now rarely used in Canada. Asphalt is either mopped or poured over the felt layers to provide uniform and complete asphalt coverage of each layer.

BUR membranes currently make up approximately 40% of the Canadian roofing market and are particularly popular in Ontario, Alberta and the Prairies. BUR membranes are typically installed as PMRA or conventional assemblies. All BUR membranes are fully adhered to their substrate, although the insulation above the membrane in PMRAs is ballasted.

Specific components utilized in built-up roofing membrane systems include the following.

- ***Organic Felts:*** no. 15 perforated asphalt felt.
  Unsaturated felt weight = 1.020 kg/m^2 total for four felts.
  Asphalt saturant weight in felts = 1.275 kg/m^2 total for four felts.
  Asphalt (interply and flood coat): 7.0 kg/m^2 total for four felts.

- ***Fiberglass Felts:*** type 4 asphalt saturated glass ply sheet.
  Unsaturated felt weight = 0.372 kg/m^2 total for four felts.
  Asphalt saturant weight in felts = 1.153 kg/m^2 total for four felts.
  Asphalt (interply and flood coat): 7.8 kg/m^2 total for four felts.

- ***Vapour barrier:*** vapour barriers in built-up roofs typically consist of either a 2-ply mopped on felts, or kraft paper. Kraft paper vapour barriers are normally composed of two layers of 30 lb. kraft paper laminated with asphalt and reinforced with glass fiber. Kraft paper weighs about 1.5kg/square. Vapour barriers are typically adhered with asphalt or adhesive.

- ***Vapour barrier adhesive***: if vapour barriers are applied directly to a steel deck, then adhesives are commonly utilized. Typical adhesives are comprised of an engineered cutback asphalt modified to improve elasticity and adhesion. The primary ingredients are asphalt and a solvent base. Other ingredients are proprietary and vary by manufacturer. Approximately 1.8 kg/square of adhesive are used in applications directly over a steel deck, with no appreciable waste.

- ***Primer:*** solvent based asphaltic primer.

In addition to the above, there is typically a gravel cover of 20 kg/m^2 applied for UV protection on conventional roofs. Both IKO and EMCO, Canadian manufacturers of roofing felts (see Section 2.1.1), supply this market.

Modified Bitumen Roofing Membranes are composite sheets consisting of bitumen, modifiers and reinforcements. The term “modified bitumen” encompasses a broad range of materials, with each specific material differing from the others with respect to the modifiers and reinforcements used. Modified bitumen membranes exhibit the thermoplastic quality of being softened by heat. They are typically bonded to substrates by torch application or asphalt.

Reinforcing materials consist of plastic films, polyester mats, glass fibers, felts, or fabrics. The modified bitumen membranes utilized most commonly in Canadian roofing applications, however, include polyester reinforcement mats integral to the material.

Modified bitumen membranes can be separated into two general categories: those utilizing atactic polypropylene (APP) as modifiers, and those utilizing styrene butadiene (SBS) as modifiers. SBS membranes can be applied by torch or asphalt, and are far more typical in Canada. APP membranes are always applied with a propane torch and represent a small portion of the roofing market in Canada.

Modified bitumen membranes currently make up approximately 40% of the Canadian roofing market and are particularly popular in British Columbia and Quebec, but are also used in significant quantities in Ontario. The two largest Canadian manufacturers of modified bitumen membranes are IKO and Soprema.

Modified bitumen roofing membranes typically consist of two layers — a base ply and a finishing (or cap) ply — and are commonly installed as PMRA or conventional assemblies. In PMRAs, modified bitumen membranes are fully adhered to the substrate. In conventional assemblies, modified bitumen membranes are either mechanically fastened with screws and plates, or fully bonded to the substrate. Both types of conventional assemblies, as well as PMRAs, are common in Canada.

Specific components utilized in modified bitumen membrane systems include the following.

- ***Primer:*** solvent based asphaltic primer.
- ***Vapour barrier:*** vapour barriers in modified bitumen membrane roofs typically consist of either a 2-ply mopped on felts, or kraft paper.
- ***Modified bitumen base sheet membrane adhered with* asphalt:** 2.2 mm, fiberglass reinforcement.
- ***Modified bitumen base sheet, torch applied:*** 3 to 4 mm, polyester reinforcement.
- ***Modified bitumen cap sheet, torch applied:*** 4 mm, polyester reinforcement, granule surfaced.

Overall, the total quantity of roofing asphalt used in modified bitumen membranes and their application is similar to that of BUR roof membranes and assemblies.

<u>Hot Applied Rubberized Asphalt Membranes</u> Rubberized asphalt is a flexible, site-applied membrane for use in waterproofing and roofing applications. It consists of proprietary blends of asphalt, mineral fillers, elastomers (natural, synthetic, or a blend of both), virgin or reclaimed oil, and a thermoplastic resin.

Rubberized asphalt is delivered to sites in keg form via truck. It is typically heated on site in large, propane fired kettles and applied by squeegee or trowel. Rubberized asphalt is considered a relatively low cost membrane system, but currently makes up less than 5% of the Canadian roofing market. However, it is gaining popularity in the green roof market place as a PMRA.

The largest manufacturer in Canada is Hydrotech Canada, supplying the majority of rubberized asphalt membrane used in the country.

3.2 Estimated Canadian ICI Sector Asphalt Waste

This section describes the Institute's calculated asphalt and related roofing scrap for new and replacement BUR and modified bitumen roofing. The process used to estimate the asphalt scrap from this sector is markedly different than that used to derive the asphalt shingle and related scrap for the residential sector. Specifically, the methodology used is as follows:

1. The sector's total gross sales activity ($1.6 billion) is apportioned between re-roofing and new roofing on the basis of percent activity (60% re-roofing and repairs and 40% new roof construction).
2. Next we apportion the membrane types across the two activities, concentrating on BUR and modified bitumen applications (combined, these two systems are estimated to represent 80% of the overall ICI market).

3. Then, using the average installed cost of BUR and modified bitumen roofing on an area basis, we determine the number of roofing squares for these asphalt products in each segment of the market – re-roofing and new construction.
4. Finally, using the component material breakdown for BUR, we determine the asphalt related scrap flows for the ICI industry sector.

Table 6 below provides the Institute's calculated annual asphalt roofing scrap for the ICI sector as determined using the methodology described above. New asphalt roofing activity contributes a very small portion of the overall calculated waste stream. In total, we have calculated in the order of 330,000 tonnes of asphalt related roofing waste for the sector, with replacement roofing (re-roofing) responsible for 99% of the total waste stream. As calculated, asphalt accounts for 70% of the total waste stream, with felts accounting for another 9%. Aggregate ballast waste at 20% is a considerable portion of the estimated waste stream and is likely on the high side as we did not adjust for the division between conventional and PMRA roofs in the ICI market.

Table 6 ICI Sector Calculated Annual Asphalt Roofing Related Wastes

	Units	Quantities	Source
Total ICI Sector Sales Value	$ millions	1600	P. Kalinger
new construction (@ 40% of market)	$ millions	320	P. Kalinger
replacement (@ 60% of market	$ millions	1280	P. Kalinger
Average cost of BUR/Mod.Bit. Roofs	$/ square	380	P. Kalinger
New construction no. of squares basis	squares	842,105	
Replacement no. of squares basis	squares	3,368,421	
New Construction	m tonnes	0.0035	A. Inst.
unsaturated organic felt use	kg/ square	9.5	A. Inst.
asphalt saturant use in felt	kg/ square	11.8	A. Inst.
asphalt interply and flood coat use	kg/ square	65.0	A. Inst.
asphaltic primer	kg/ square	1.5	A. Inst.
aggregate ballast	kg/ square	185.8	
Replacement (at 90% of new constn)			
unsaturated organic felt lifted	kg/ square	8.5	A. Inst.
asphalt saturant use in felt lifted	kg/ square	10.6	A. Inst.
asphalt interply and flood coat lifted	kg/ square	58.5	A. Inst.
asphaltic primer lifted	kg/ square	1.4	A. Inst.
aggregate ballast (80% reused)	kg/ square	37.16	A. Inst.
Total Scrap in New Construction			Waste factor
unsaturated organic felt use	tonnes	1,117	at 14%
asphalt saturant use in felt	tonnes	1,391	at 14%
asphalt interply and flood coat use	tonnes	547	at 1%
asphaltic primer	tonnes	63	at 5%
aggregate ballast	tonnes	-	
Total	**tonnes**	**3,119**	
Total Scrap from Replacement			**%**
unsaturated organic felt	tonnes	28,724	9%
asphalt saturant in felt	tonnes	35,773	11%
asphalt interply and flood coat	tonnes	197,053	59%
asphaltic primer	tonnes	4,547	1%
aggregate ballast	tonnes	62,585	19%
Total	**tonnes**	**328,682**	99%
Total ICI Sector Asphalt Roofing Scrap	**tonnes**	**331,801**	

Notes:
Average cost of BUR ($3.50/sq.ft.), Mod.Bit ($4.25/sq.ft.) at equal market share = $3.80/ sq.ft.x100=$380/ roofing square

Used a replacement quantity of 90% to account for repair activity

3.3 Total Annual Asphalt Roofing Scrap Production by Component

Table 7 below summarizes the total annual asphalt based roofing scrap available in Canada by primary component. The ICI sector's roofing scrap output is about 25% of that estimated to be produced by the residential sector on a mass basis; however, on a percentage of asphalt basis, the amount of asphalt in the ICI roofing scrap is almost 75% that of the residential market – making it a significant consideration for recycling. Overall, it is estimated that 1.5 million tonnes of asphalt related roofing waste is generated in Canada with the primary components - aggregate, asphalt, and organic felts representing 57%, 35% and 9% by mass, respectively.

Table 7 Annual Residential & ICI Asphalt Based Roofing Scrap by Component

Component	Residential		ICI		Total	
	m tonnes		m tonnes		m tonnes	
Unsaturated org. felt	109,627	9%	29,841	9%	139,468	9%
Asphalt	311,872	25%	239,384	72%	551,256	35%
Aggregate/Granules	835,441	66%	62,585	19%	898,026	57%
Total	1,256,940	100%	331,810	100%	1,588,750	100%

4 Enhanced Asphalt Roofing Recovery

This section describes the various end-uses, processing steps and regulations covering the recovery and recycling of asphalt roofing in North America. Much of this section arose from an extensive web and literature review and discussions with various parties familiar with asphalt material recovery and use. Considerably more information was found regarding asphalt shingle recycling (www.ShingleRecycling.org) than ICI asphalt roofing, but given their similarities, much of what is applicable to asphalt shingles is also applicable to ICI asphalt wastes.

4.1 End-uses for Asphalt Roofing Waste

Several potential reuse and recycling markets exist for Residential and ICI asphalt scrap. The benefits of recycling asphalt roofing products include conservation of landfill space and resources, and reduced costs of disposal and product production as compared to typical landfilling or virgin product production costs. Some of the obvious negatives associated with establishing an asphalt recycling facility are uncertain capital costs, potential difficulty obtaining various permit licenses, a highly variable material supply and sources, and undeveloped and/or under-developed markets.

4.1.1 Hot-Mix Asphalt (HMA)

This is the largest current market for recycled asphalt shingles (RAS) in the U.S. 16 states allow asphalt shingles to be incorporated into hot-mix asphalt (HMA) (see Figure 3 below), with other states likely to follow. A number of laboratory and field experiments in North America have been performed regarding the feasibility of recycling asphalt shingles. Many of these studies have been carried out by US state transportation or environmental departments, and most of these projects have culminated in specifications from state Departments of Transportation (DOT) allowing manufacturer or tear-off asphalt shingle scrap use in HMA mix designs.

Most specifications for RAS use in HMA require that the mix only include manufacturers' scrap (pre-consumer) or tear-off (post-consumer) material. Most specifications will not allow a mixture of the two. Many specifications only specify the use of manufacturers' scrap, as it does not contain the deleterious material (metal, glass, paper, etc.) found in tear-off loads. Pre-consumer asphalt shingle manufacturers' scrap is currently being used in hot-mix asphalt in Ontario. Lafarge is the leader in this area.

Hot-mix pavement design formulas usually contain between 5 and 7% bitumen. These formulations are based on two factors: climate, i.e., precipitation and hot/cold temperature extremes; and traffic conditions, including types of vehicles and volume/types of traffic, e.g., rush hour, stop and go, or highway. Because climate and pavement specifications vary from state to state, state DOTs have needed to independently test the effect that adding recycled shingles has on a pavement's performance. Test pavements with batches containing a maximum of 5% shingles by weight of mixture have performed at least as well as traditional pavement (both manufacturers' scrap and tear-off were tested); however, with current technology, if shingles are added at a higher percentage, performance may begin to suffer due to the harder asphalt found in shingles. Employing a softer grade of asphalt cement in the HMA mix design may allow greater quantities of asphalt shingles to be used. This is the subject of a number of pending research projects in this field.

In 2005, the American Association of State Highway and Transportation Officials (AASHTO) adopted a standard materials specification (MP 15) for utilizing both manufacturers' and tear-off asphalt shingle scrap in HMA. This national specification enables HMA producers to design the appropriate mix of RAS in asphalt to meet the specifications of state and local transportation agencies. Some of the specifications detailed requirements include the following:

- the final RAS product must be sized and screened such that 100% passes the ½ inch sieve screen;
- gradation must meet the requirements of the mix design;
- deleterious material must not exceed a maximum of 0.50% by weight, cumulative total (i.e., combination of all metal, glass, paper, rubber, wood, nails, plastic, soil, brick, tars and other contaminating substances); and
- the final RAS product must meet the asbestos level established by the state or U.S. EPA.

AASHTO also adopted a recommended practice (PP 53) as a companion to the standard specification.

Figure 3. U.S. States Allowing (RAS) in HMA

STATES WITH SHINGLE RECYCLING OPERATIONS AND/OR STATE DOT SPECS ALLOWING RECYCLED SHINGLES

State	State DOT Specs/Rules On Recycled Shingle Usage*	Material Recycled
FL	under development	T
GA	5% manufacturer scrap	M
IL		T
IN	5% manufacturer scrap	M
IA		T
ME		T
MD	5% manufacturer scrap	M, T
MA		T
MI	50% recycled content[1]	
MN	5% manufacturer scrap	M
NH		T
NJ	5% manufacturer scrap	
NC	5% manufacturer scrap	M
OH	"certain percentage of recycled material"	T
PA	5% manufacturer scrap	M, T
WA		T

*: "%" represents percent by weight allowed as an additive to hot mix asphalt
M: manufacturer scrap is recycled T: tear-off waste is recycled
[1]: shingles not specifically mentioned in the spec, but in practice both M & T are routinely allowed in certain hot mixes

Source: U.S. Environmental Protection Agency (EPA)
www.epa.gov/epaoswer/non-hw/debris-new/pubs/roof_br.pdf

4.1.2 Cold Patch

The use of RAS as cold patch is a practice that has been employed for years. It has been used in New Jersey, Washington state, and California, as well as in the city of Chicago. Presently, Gardner Asphalt Corporation of Tampa, FL supplies Home Depot with an RAS cold patch product.

According to field tests, RAS cold patch behaves like a "high-performance" patch, outlasting HMA and traditional cold mixes. The fiberglass and/or cellulose fibers in the shingles apparently add to the structural integrity of the patch.

Although the initial cost of RAS cold patch is usually higher than HMA and traditional cold patch, the overall cost may be lower due to longer life and decreased maintenance costs. When compared to other high performance patches, the RAS cold patch usually costs less.

RAS cold patch is easier to use than traditional patches for the following reasons:

- lighter weight — it has a lower weight-to-volume ratio, so it is easier to handle;
- no equipment needed — just fill the crack or pothole and tamp down with a shovel or drive over it; and
- time flexibility – RAS cold patch doesn't harden as quickly as HMA, so there's no hurry to use it; after applying, traffic can be allowed over the area immediately.

4.1.3 Dust Control on Rural Roads

Recycled asphalt shingles may be ground and mixed into the gravel used to cover rural, unpaved roads.

4.1.4 Temporary Roads or Driveways

RAS has been used in temporary roads, driveways, and parking lot surfaces. RAS is typically ground to ¼-inch and passed under a magnetic separator in order to remove all nails. The processed shingles are spread and compacted for an easily installed surface. In Altus, OK, RAS was mixed with reclaimed asphalt pavement (RAP) to create a parking lot surface.

4.1.5 Aggregate Base

Little research has been conducted into this market, but recycled shingles have been used as part of the sub-base in road construction. Processed shingles may be blended with RAP and concrete. It is suspected that the addition of RAS may improve the compaction of the sub-base.

4.1.6 New Roofing Shingles

A report prepared for the U.S. Department of Energy in 1984 indicated that the addition of up to 20% of recycled shingles did not affect the production of new shingles. Significant energy savings were achieved by using RAS. Others have also looked into closed loop recycling of asphalt shingles and found problems persisted in reprocessing shingles to conform to feedstock requirements or locating/devising technologies that could maintain product performance specifications. The majority of asphalt shingle manufacturers' scrap is finding a use in paving products, rather than the plant. We are unaware of any facility producing new shingles for either manufacturer's scrap or tear-off material on a commercial basis.

4.1.7 Fuel

Energy recovered from waste shingle feedstocks is an established market in Europe. Only recently has the concept been applied in the U.S. to produce No. 6 fuel oil. It is very limited, however, because of concerns over air pollution. The Lafarge cement plant in

Brookfield, NS is using a “flaked” asphalt shingle scrap as a fuel source in its cement kiln (see case study section 4.3.4).

4.2 Asphalt Roofing Scrap Processing

Because scrap from shingle manufacturers comes from a known source and is not contaminated with other materials, it is usually preferred. But, as discussed above, post-consumer scrap shingles (tear-offs) can also be recycled, provided that materials such as paper and nails are removed. Some markets allow a greater amount of manufacturers' scrap to be used as compared to post-consumer material.

When processing tear-off shingles for recycling, the shingles must be separated from other components such as wood, metal and paper. This can be performed at the source (job-site) or at a processing location. Debris must be removed to prevent equipment damage during size reduction. There is no standard processing equipment to accomplish this task; as a result, it is very labour intensive. Possible contaminants may include the following.

- Metals, which can be removed by a rotating magnet.
- Wood, which sometimes accompanies shingles when the plywood is also replaced in a re-roof job, and is the biggest problem: unlike nails, wood cannot be extracted by magnets, and unlike plastic, it doesn't melt during the asphalt mixing process. Wood can be removed by hand, or floated off in a water flotation unit.

Waste shingles are typically ground using a horizontal mill, although tub grinders have been used in some applications. The ground shingles are usually screened to achieve a uniform product size (depending on the market). The ground shingles are passed under a magnet or magnets to remove nails. Below, each step in the processing of asphalt shingles for inclusion in HMA is briefly described. Similar processing steps would be conducted for a number of the other possible end-uses discussed previously.

Shredding

Roofing shingle scrap used in asphalt paving mixes is typically shredded into pieces approximately 13 mm (½-inch) in size and smaller, using a shingle shredding machine that consists of a rotary shredder and/or a high-speed hammermill.

Screening

Shredded shingles are typically discharged from the shredder or hammermill, screened to the desired gradation, and stockpiled. Experience indicates that the size of the processed pieces should be no larger than approximately 13 mm (½-inch) to ensure uniform incorporation of the roofing shingle scrap into the hot-mix asphalt. Scrap shingle greater than 13 mm (½-inch) in size does not readily disperse, functioning much like aggregate. Particles sized too small can release the fibres, which may act as a filler substitute.

Blending
Processed roofing shingle material can re-solidify during stockpiling, necessitating reprocessing and re-screening prior to introduction to the hot-mix plant. To mitigate this problem, processed roofing shingle scrap may be blended with a carrier material such as sand or recycled asphalt to prevent the particles from sticking together.

Watering
To keep the roofing shingle material from agglomerating during processing, it is usually passed through the shredding equipment only once, or kept cool by watering at the hammermill. Watering of the processed shingle scrap may also be required to conform to environmental regulations concerning dust generation. However, the application of water is not desirable, since the processed material naturally becomes quite wet and must be dried prior to introduction into hot-mix asphalt.

Grinding
To prepare shingles for use in new products, the shingles must be ground to a specified size. Grinding may be easier in the winter when the asphalt is more brittle. If the shingles begin to stick together in hot weather, or from the heat of the equipment, the material may be sprayed with water or have sand or gravel blended into the mix to reduce agglomeration of the material.

Sizing
Depending on the equipment used, primary grinding may yield 2-inch- or 3-inch-minus size pieces. Secondary grinding may be required to make smaller pieces if required; for example, aggregate base may require ¾-inch-minus, and asphalt pavement may require ½-inch-minus or ¼-inch-minus.

Sieving/Screening
Depending on the use, the shingles may have to be sieved or screened after grinding, to conform to grading requirements. The process removes contaminants from the ground shingles.

Equipment
Recycling of shingles typically requires modification of standard grinding, screening, and dust control equipment in order to process shingle waste material for the desired end-use products. Most processors improvise by modifying simple equipment. A hammermill will grind shingles, though it works best with softer aggregates, such as limestone, as opposed to granite granules. Recent advances in equipment design have overcome previous problems with blade wear and dust control. Secondary grinders are being used to process a variety of materials, including asphalt shingles.

Some machines have even been designed to specifically process roofing and other construction wastes. A Canadian company, Hammel Canada, produces and sells shredders and screens designed to handle shingles.

4.2.1 Processing Plant Regulations

Neither the Canadian nor U.S. federal government has a specific regulation for asphalt shingle recycling. Therefore, facilities that recycle asphalt shingles must follow appropriate provincial/state and local municipal regulations and, in some cases, obtain the necessary permits or licenses. Each province/state inevitably has different requirements.

The types of requirements for recycling asphalt shingles vary. A permit to operate a processing facility may be required in some areas, and environmental testing may be required in other areas. In addition, depending on the particulate emissions from the recycling process, an air permit may be required at the facility. The single biggest issue that has been raised with respect to asphalt shingle recycling is asbestos. The asbestos content of asphalt shingles has fallen from 0.02% in 1963 to zero today. The vast majority of tests conducted on asphalt shingles to be recycled have found no asbestos. However, other asphalt roofing products, such as roll-roofing, adhesives, paints or water proofing compounds, may contain asbestos. To strike a balance between the protection of worker health and the encouragement of recycling, several states have worked with recyclers to conduct initial testing on their waste stream to demonstrate the safety of their operation. But ongoing testing remains a 'cost of doing business' for some asphalt shingle recycling facilities.

4.3 Asphalt Roofing Recycling Case Studies

This section summarizes four case studies on the use of scrap asphalt roofing products in Canada and the U.S. These studies speak to the various market forces, processes and the regulatory environment surrounding asphalt roof product recycling.

4.3.1 Recycled Asphalt Shingles Used in Lunenburg Trail Construction

A pilot project was initiated by the Municipality of the District of Lunenburg, NS, to investigate the use of discarded asphalt shingles as a potential nature trail surfacing material. The project aims at significantly reducing the quantity of shingles sent to landfill[6]. Project sponsors are a mix of federal, provincial, and municipal governments, as well as corporate entities.

In October 2006, three sections of rail-trail were covered (500 metres per section) with a recycled asphalt shingle aggregate mix, which creates a dense, stable surface resistant to wear and tear, yet easily graded and repaired if necessary. This project is the first of its kind for the municipality and will continue for a 12-month period. Careful monitoring and testing is being carried out by a private environmental monitoring company. The testing program was devised to confirm that there is no significant impact to surface water quality from runoff from the trail surfacing product. Testing will take place at

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[6] Current landfill fee in Nova Scotia for asphalt shingle waste is $0.75/20 lbs. ($83/tonne) after the first 1000 lbs., which is accepted free of charge. (Personal Correspondence, Laura Barkhouse, Municipality of the District of Lunenburg).

three-month intervals. Due to the project's newness, there is no confirmed data regarding environmental or economical costs/benefits as of yet, but positive results are anticipated.

Regulations/Requirements
Nova Scotia does not currently have any standards for the use of asphalt shingles in road surface construction. There are, however, regulations regarding solid waste management. Used asphalt shingles are considered waste under the Solid Waste Management Resources Regulations. In order to dispose of solid waste (i.e., by spreading shingles on the ground), a permit is necessary. However, if asphalt shingles are processed as a feedstock for another product, then their use is not considered disposal and is not subject to the Environment Act and Regulations. The challenge in the Lunenburg project came in determining whether the shingles were waste, or a product. The Nova Scotia Department of Environment and Labour (DOEL) concluded that if the trail surface were to be designed by a Professional Engineer, who would also supervise its construction, the asphalt shingles would be considered a feedstock for a new product, and the practice would not require approval from the DOEL.

Processing Procedure
Tear-off shingles are selected as they arrive at the recycling centre. In this way, the workers can ensure that the shingles used are not contaminated. The shingles are accumulated and put through a round tub grinder, producing a 2-inch-minus material, then pass over a magnet, which removes any nails or other metals. During this process, water may be added to reduce dust.

The shingles are then put through a trommel screen with ½-inch x ½-inch mesh openings. The finished product goes over a magnet again. The final product continues on to a clean stockpile and is set for mixing with gravel. Any oversized material is removed by visual inspection and then reground and screened again.

Shingles are sized to meet requirements, then loaders are used to mix and roll the material together with aggregate. Two different mixes for trail use areas are being tested in this project:

1. 50% ½-inch-minus shingles and 50% ¾-inch-minus gravel
2. 75% ½-inch-minus shingles and 25% ¾-inch minus gravel

The finished product is either stockpiled or trucked out immediately for use.

4.3.2 Roofing Shingles in Asphalt Based Paving Products

In 1988, a U.S. company, ReClaim, produced a number of asphalt based paving products at two New Jersey plants: one in Kearny, the other in Camden. The plants reclaimed and reused non-hazardous, non-toxic asphalt roofing scrap to produce paving material, pothole patch material and hot-mix asphalt modifier. For quite some time, ReClaim was the only state certified recycler of asphalt roofing material in the USA.

New Jersey's state recycling program required roofers and demolition waste haulers to deliver a portion of their demolition waste to certified recycling facilities. In September

1989, ReClaim's Kearny plant was the first facility to be certified as a "waste-diversion recipient" by the New Jersey Department of Environmental Protection. Local governments therefore awarded "diversion credit" to haulers who took recovered material to ReClaim as part of the State's mandatory recycling program. High tipping fees (at the time, $115 per ton at Kearny-area landfills) provided further incentive for haulers to take material to ReClaim.

ReClaim processed 300 tons per day of clean roofing scrap at its Kearny facility. The feedstock was a mixture of various roofing materials. ReClaim estimated that approximately 60% of the material arriving at the plant was post-consumer commercial built-up roofing, and 38% was post-consumer asphalt shingles. The remaining 2% was scrap asphalt shingles from a nearby shingle manufacturer. The plant accepted material on site, but also maintained 20 drop sites within New Jersey.

In August 1992, ReClaim began adding quarried aggregate to the reduced roofing material in production of its pothole patch. Because the asphalt roofing was processed before it was combined with the aggregate, the new product increased production capacity of the facility without altering the parameters of the plant.

The production process at ReClaim's Kearny facility was based on simple material reduction and was accomplished mainly with two mechanical volume reduction machines (MVRM) modified to withstand the extreme wear caused by abrasive roofing scrap. ReClaim succeeded with this process where other roofing asphalt processors failed because of the durable and cost-effective MVRMs which they developed in-house. As roofers unloaded material onto a receiving pile at the facility, workers inspected it for contaminants. A bucket loader mixed the pile and loaded it into a modified MVRM that reduced the material to a less than 6-inch size. This feedstock then ran through a second MVRM before it was screened to specified size, depending upon the end product. Oversized pieces were returned to the MVRM, and ferrous metals (i.e., nails and wire) were magnetically removed. At the time, accepting the materials to produce one ton of Econo-Pav® brought ReClaim $65 ($64 per ton tipping fee and $1 per ton) in revenue. A five gallon bucket of Repave® sold for $7.75 wholesale.

Both the Kearny and Camden plants, although seemingly quite successful in their initial phases, are no longer operational. The company's head office and facility located in Tampa, FL has also ceased operation.

Gardner Asphalt Project

Approximately 25 years ago, Gardner Asphalt Corporation began a project, working together with ReClaim, to recycle asphalt shingles for use as a cold patch product. At the time, Gardner purchased separated, ground up, used shingles (from BUR) from ReClaim's various collection sites (New York, Newark, and surrounding areas). Gardner now purchases separated, ground shingles from local processing plants for 10¢/lb. ($220/m tonne). Asphalt is extracted from the ground shingles using solvents, mixed with additives, then aggregate, creating a cold patch material for potholes, etc. Gardner currently has three plants where this takes place: Tampa, Chicago and Houston. Gardner sells the cold patch product through Home Depot in the U.S.

4.3.3 Asphalt Shingle Recycling in Massachusetts

GreenGoat, a non-profit efficiency consultant based in Somerville, MA, conducted a case study[7], sponsored by Home Depot, which examined the generation rates and markets for post-consumer asphalt shingles in Massachusetts. The project was undertaken as part of an ongoing effort to discover and develop markets for construction and demolition debris.

The study concluded that the most promising application of post-consumer shingles in Massachusetts is road surface and base. Massachusetts Highway resurfaces enough roads to potentially buy 27,551 tons of shingles per year, assuming it would change its regulations to allow post-consumer content. If municipal roadwork were added to this, it would bring the total potential market to 82,653 tons per year.

The study found several factors influencing the rate of recycling (particularly for pavement).

Performance. The binding attribute of shingles is not diminished with time, although the elasticity is (a factor which is important for pavement). “Recipe adjustments” have been made to accommodate the effects of aging. In order for Massachusetts Highways to accept shingle into pavement materials, additional testing of the “recipes” used for surface and base would need to be done. In addition, added brittleness, further loss of elasticity and lower stone dust content as a result of exposure to the Massachusetts weather are factors.

Purchasing practices. Specifications s allow for *post-industrial* content in pavement (although none is being used), and there is no provision for *post-consumer* content in Massachusetts highways.

Predictable supply of feedstock. Established shingle recyclers are able to adjust volume to supply their markets with what they need. Many aggregate companies also produce pavement and contract, which helps leverage cost savings on state paving jobs. Shingle recycling is increasing; as a result, shingle manufacturers will be more confident in investing money in the development of better recipes for post-consumer use of their shingles.

Method of de-installing material. Source separation is easy, but change will come slowly because the labour is traditional; labourers have to be convinced to tarp an area to minimize yard waste and to prevent recyclable materials from going into the load.

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[7] A. Bauman. “Asphalt Shingle Recycling in Massachusetts,” March 15, 2005. The above summarized paper is available at thegoat@greengoat.org.

Complexity of the material. Shingles are composed of asphalt, stone dust, organic felt or fibreglass backing, and adhesive. Sorting them into product types so that they can be used as feedstock for new shingles is not cost effective. This is significant for manufacturers accepting the material.

Purity of product. Shingle recycling is a “young” recycling group and in order to accept post-consumer material, a producer has to be confident that the load taken in meets market specifications. In the Massachusetts government, the perception remains that the use recycled material is riddled with quality issues.

Availability of markets. Recycling technology is ready, but demand is low. Markets for shingles in Massachusetts are hot-mix asphalt, aggregate road base, cold patch, and erosion control; however, shingles are currently only used in private paving jobs. Simple education and marketing are needed to create markets for recycled shingles.

Price of virgin materials. Shingles are petroleum-based, and transportation of heavy virgin materials burns gas. As petroleum prices rise, the value of post-consumer feedstock becomes more attractive.

Regulatory Incentives. Massachusetts is planning to ban asphalt shingles from landfills once markets can handle at least 75% of the current waste. At the same time, the State is encouraging markets for recyclable materials such as asphalt shingles with incentives such as grants.

4.3.4 C&D Recycling Ltd., Nova Scotia

In 1995, Nova Scotia passed the Nova Scotia Environment Act and the province formally adopted a target of 50% diversion of solid waste from disposal by the year 2000. The province succeeded in achieving that goal and continues in its efforts.

Halifax Regional Municipality has since passed a bylaw that requires 75% of waste to be diverted from landfill. A second bylaw was passed which does not allow movement of waste outside of the municipality. The Municipality also created an incentive to divert waste from landfills by paying between $18 and $22 per tonne for each tonne diverted.

Used asphalt shingles have been utilized for a number of years in Nova Scotia as landfill coverings. Used, ground shingles (ground onsite), have also been used for amendment to roads. With the new bylaws in place, Canadian recycler Halifax C& D Recycling Ltd. developed a process in 2005 to separate sand and asphalt from the paper portion of shingles. The resulting product, ‘Asphalt Grit’, is used by Ocean Contractors in Dartmouth, NS, in hot-mix asphalt paving.

The Asphalt Grit replaces 2 to 3% of the new liquids in hot-mix (asphalt cement sold for approximately $500/tonne last summer) used in paving product, and it also replaces some of the natural sand used in the asphalt mix. Lab tests of the Asphalt Grit show no difference in flow or bonding, or in stability of the final product, when compared to a virgin mix. This can be attributed to the fact that 75% of the paper in the shingle is removed. Field tests showed the same positive results: there was no difference between Asphalt Grit (replacing 1 and 2% of liquid in hot-mix), and regular asphalt cement.

Once the sand portion has been removed from the asphalt shingle, a second product, 'Asphalt Flake', is produced. This flake (fibre paper coated with asphalt) is being used as fuel in place of coal at Lafarge's cement plant in Brookfield, NS. The flake is replacing 10% coal fuel per hour. Approximately 20 to 30 tonnes of Asphalt Flake are being blown into the kiln per day. Tests have shown the use of flake has reduced emissions.

According to Halifax C&D, to their knowledge, neither process has been tried anywhere else in North America.

The Resource Recovery Fund Board (RRFB) of Nova Scotia — Nova Scotia's business development program — is a provincial initiative that provides funding for waste diversion. Eligible applicants include individuals, businesses and universities undertaking projects that support the goals of the Nova Scotia Waste Resource Management Strategy. Funding is divided into three categories: value-added manufacturing, which provides funding for the manufacture of products or services that recover materials from the waste stream; research and development funding, for research studies or pilot projects that divert waste materials or add value to materials diverted from the waste stream; and special projects funding, for initiatives that divert materials recovered from the waste stream. Halifax C&D received approximately $67,000 from the RRFB grant, to be used for equipment.

5 Enhanced Recovery Market Drivers

This section describes prevailing economic and environmental factors influencing current and future recycling of asphalt roofing products. The Greater Toronto Area (GTA) is highlighted as a location where various market and regulatory forces are aligning that may spur on asphalt roofing recycling.

5.1 Economic Drivers for Asphalt Roofing Recycling

This section highlights the price of bitumen, as used in hot-mix asphalt concrete, escalating fuel prices, and landfill tipping fees as the primary economic drivers influencing the development of an extensive asphalt roofing recycling industry.

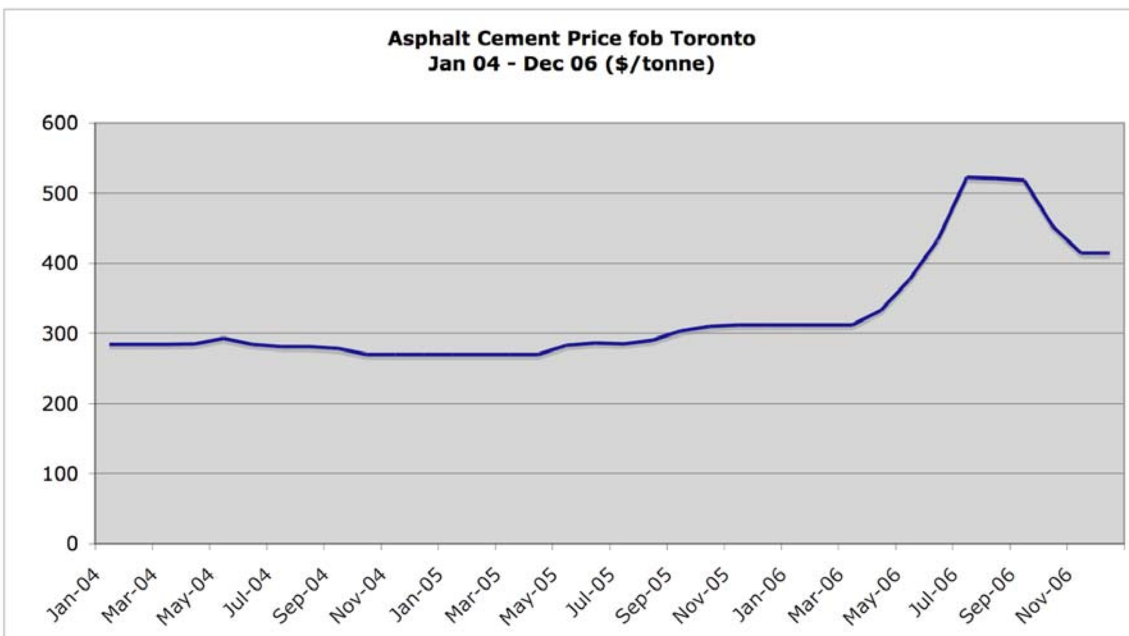
5.1.1 Hot-Mix Asphalt Production, Asphalt Cement & Fuel Prices

It is estimated that there are just over 500 hot-mix asphalt plants across the country producing in the order of 30 to 31 million tonnes annually. The province of Ontario has the greatest concentration of plants (28%) and produces about 40% of all hot-mix asphalt concrete in the country. In Canada, most asphalt production plants are over 30 years old and are predominately batch plants producing between180 and 240 tonnes per hour (tph)[8]. Typically, hot-mix asphalt concrete contains a mixture of 5% asphalt cement and 95% aggregate. It is therefore estimated that the Canadian hot-mix asphalt industry consumes in the order of 1.6 million tonnes of asphalt cement and 29.5 million tonnes of aggregate annually. The total combined scrap generated by the Canadian residential and ICI asphalt roofing industry is estimated at about 1.5 million tonnes in total, of which asphalt makes up about one-third of the total scrap, with the remaining components being aggregate and felts, which are also materials usable by the HMA industry.

Replacing 5% of the virgin raw materials in the Canadian HMA industry with asphalt roofing product scrap would result in the use of 1.6 million tonnes of asphalt roofing product scrap annually, i.e., all roofing asphalt scrap produced in Canada in a single year. Further, it is estimated that by making this substitution the HMA industry would avoid generating 90,000 tonnes[9] of greenhouse gases. Obviously, the HMA sector is a key potential market for asphalt based roofing scrap.

Due to supply constraints and growing demand for HMA, prices for asphalt cement have skyrocketed in recent months (see Figure 4 below).

Figure 4 Recent Asphalt Cement Prices, FOB Toronto



Source: Ministry of Transportation Ontario (PG Grade 58-28 or equivalent)

Although most petroleum and natural gas products have seen remarkable price increases, asphalt cement prices have been relatively stable. In March 2003, asphalt cement prices spiked to an all time high of $349.75/tonne (MTO Asphalt Price Index April 2003) when

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8 Source: "An Energy Use Benchmarking Study and Reduction Guide for Canadian Road Builders", prepared for The Canadian Construction Association (CCA) by the Athena Institute, 2004.

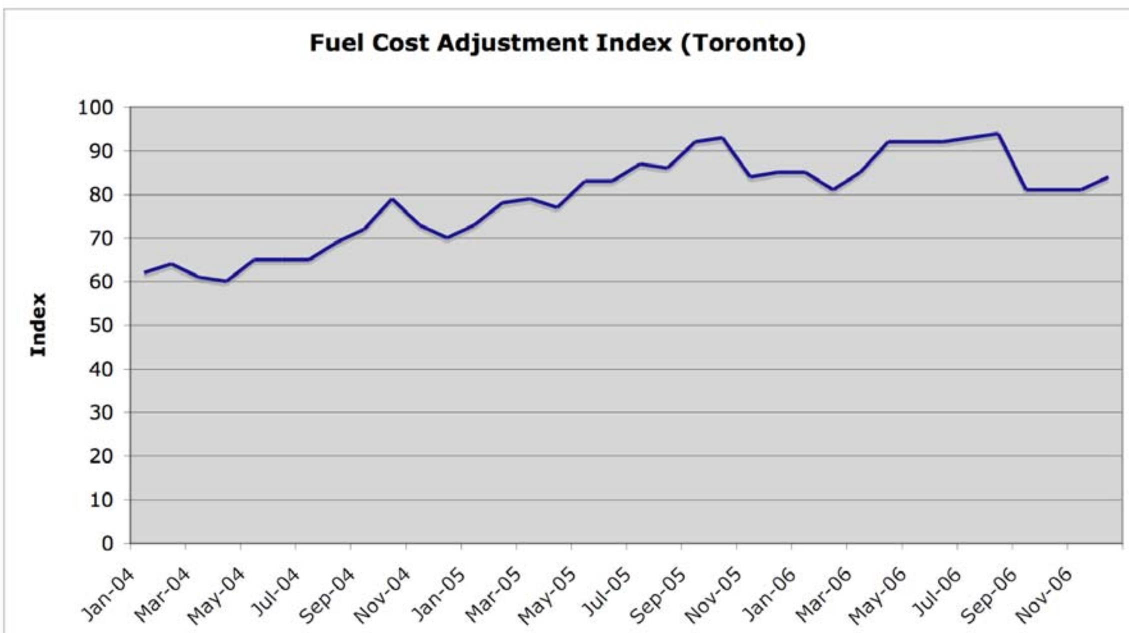
9 Athena Institute estimate calculated at 59 kg CO_2 equivalent per tonne of asphalt concrete

crude prices rose by 90% year over year to what seems now a very modest $37.83 per barrel. In the intervening three-year period, asphalt cement prices have fallen back to as low as $270/tonne in November 2004, finishing at the end of the last season at $312.20/tonne.

Perhaps the most significant reason for this increase is the relatively large increase in gasoline, diesel fuel (see Figure 5 below) and home heating oil prices, which makes conversion of the heavy bottom of the barrel feed stock, where asphalt cement resides, economically feasible. U.S and Canadian refineries have invested hundreds of millions of dollars in the last few years in cokers for this type of conversion. At the same time, the closure of Petro-Canada's Oakville refinery has left Imperial Oil's Nanticoke refinery as the only provincial producer and increased the province's reliance on outside suppliers.

The Ontario Hot Mix Asphalt Producers Association (OHMAPA) expects this recent increase in the asphalt cement price to remain in place. While asphalt cement prices will continue to fluctuate, it is unlikely in the long term that they will find their way back to $300/tonne. At a cost of $400/tonne for asphalt cement, the asphalt cement cost per tonne of HMA produced (at 5% asphalt cement content, about 50 kg) would be $20.00 per tonne. On the basis of a 5% displacement of asphalt cement with asphalt roofing scrap, the inferred value of roofing scrap is $125/tonne. With Toronto construction and demolition waste tipping fees at about $85/tonne[10], incorporating asphalt roofing scrap in HMA looks attractive and warrants more investigation.

Figure 5 – MTO Diesel Fuel Cost Adjustment Index[11] for Toronto



Source: Ministry of Transportation Ontario

[10] Personal correspondence – Avenue Road Roofing (January 2007)
[11] The Fuel Cost Adjustment Index is based on the price, including taxes, FOB Toronto area terminals for low sulphur diesel – MTO.

5.1.2 Tipping Fees

The current construction and demolition waste regulatory situation varies significantly across North America. The reasons for such different treatment of construction and demolition waste appear to be, among other things, interplay between landfill availability, economics of diversion/recycling/reuse, concentration of population, and local/regional attitudes about waste and recycling. Such differences are manifested in the types of programs that are promoted or enforced in a particular city or region.

Although many cities and regions do not have specific construction and demolition policies, the trend appears to be toward greater regulation. Increased landfill tipping fees, additional recycling options, and increased environmental awareness are helping to push the general movement for material diversion and recycling. Moreover, although there are a number of passive (i.e., voluntary) programs throughout North America, the more recent programs seem to be focused on active programs supported by laws and regulations.

The Institute contacted several Canadian cities/regions regarding existing regulations or ordinances concerning the diversion of asphalt based roofing waste from construction and demolition projects, as well as average landfill tipping fees.

Results are summarized in the table below.

LOCATION	REGULATION	C&D LANDFILL FEES/COSTS
Halifax Regional Municipality, Nova Scotia	Yes, asphalt scrap must be sent to licensed C&D waste facilities	Mixed C&D $80-$90 per tonne;
Montreal, Quebec	No	C&D waste from borough residents: C$40 per load for first 12 loads in single year, thereafter C$100 per load
Vancouver, British Columbia	No	C$430.00 per each tandem axle trailer; C$520.00 per each tridem axle trailer
Calgary, Alberta	No	For 2006: C$46 per tonne; for 2007: C$50 per tonne; for 2008: C$54 per tonne
Toronto, Ontario	No, asphalt waste is deemed private waste and must be handled by private C&D waste facilities, but ultimately disposed of in landfill	$85/tonne
Winnipeg, Manitoba	No	C$22.50 per tonne

Source Various (available upon request).

5.2 Environmental Drivers for Asphalt Roofing Recycling

5.2.1 Landfill Capacity and Regulations

Nowhere in the country is landfill capacity more of an issue than in Ontario, and specifically in the GTA. The Ontario Waste Management Association estimates that the total waste requiring disposal in Ontario is 9.3 million tonnes annually. More than one-third of this waste finds its way to Michigan. Of the 3.6 million tonnes of Ontario waste going to Michigan, two-thirds are private sector waste, a portion of which is construction and demolition waste. The disposal capacity of Ontario landfills has been in decline for many years as capacity expansion has not kept pace with capacity demand. In 1989, there were 730 landfills in operation in Ontario; today there are only 81. And the bulk of construction and demolition waste capacity, as opposed to capacity for municipal solid waste, resides in 11 major private landfills. In essence, Ontario is dependent on a foreign jurisdiction to handle its solid waste. This situation has arisen out of a set of circumstances brought on by poor municipal planning, a provincial government continuously changing landfill environmental assessment policies and expansion rules, and fierce environmental lobbying.

Recently, Michigan municipal and state governments have been trying to limit the importation of solid waste from Ontario through enacting laws to ban foreign waste; however, these laws would not likely receive the necessary NAFTA exemptions required to make them stick. Meanwhile U.S. Homeland Security has weighed in, suggesting that the 350 trucks entering Michigan from Ontario every day may be hauling contraband a suggestion which may necessitate cumbersome and costly inspections at the border. The enormity of this potential problem is beginning to be realized.

In the fall of 2006, the Ontario government proposed new regulations to encourage municipalities and industry to divert waste from landfill and to support new waste technologies. The proposed regulations focus on three key areas: recycling, alternative fuels, and emerging waste technologies.

Below is a summary of the proposed new regulations that may have a bearing on asphalt roofing recycling.

Recycling barriers removed

The environment ministry proposed amendments to Ontario's General Waste Regulation, Regulation 347, that would facilitate recycling by municipalities and remove regulatory barriers that prohibit or limit recycling activities by others. Currently, the regulatory framework that governs the recycling of waste imposes strict controls on the handling of recyclable materials, and requires that a waste approval be obtained. This has been a longstanding criticism of recycling policy as it is seen to discourage recycling activities.

Beneficial use of wastes

The ministry reviewed the placement of waste materials on land for beneficial purposes, identifying the construction of walkways, roads and parking areas that involve deposition of materials on land as beneficial uses, rather than disposal. As a result, Regulation 347 could be amended to exempt these beneficial uses of waste from approval requirements. This exemption is intended to apply to waste asphalt shingles, waste asphalt and waste glass.

Encouraging alternative fuels

The ministry has proposed removing specific approval requirements for converting certain wastes into alternative fuels in order to encourage diversion of these wastes and put them to beneficial use. All air emission approval requirements would still be applicable.

Further regulatory amendments are proposed to permit production of ethanol and biodiesel from biomass comprised of organic wastes and to permit their use as alternative fuels without the need for waste approvals (currently required). Production of energy from biomass is generally considered to have a neutral impact on greenhouse gas emissions.

Extended EPR

The ministry also intends to facilitate the development of more programs based on the principle of extended producer responsibility (EPR) to manage products when they become waste for reuse, recycling or proper disposal. Because these programs are a form of waste management, they currently require waste approvals. The ministry is proposing to exempt from the need for a waste approval any system based on extended producer responsibility that is designed and operated in accordance with the regulatory requirements. By providing a simpler regulatory mechanism for such systems, the ministry hopes to support the development of these programs, whether developed voluntarily or under the Waste Diversion Act.

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Asphalt Roofing Shingles in Asphalt Pavement
Date Published/Last Revised: Revised July 2006
3 page fact sheet: An overview of the use of ground asphalt roofing shingles in asphalt pavement, including potential markets and specifications.
CIWMB Publication Number: 431-97-033

Asphalt Roofing Shingles in Cold Patch
Date Published/Last Revised: Revised July 1999
3 page fact sheet: An overview of the use of ground asphalt roofing shingles in cold patch material for filling potholes and other uses. Includes a discussion of the technology and potential markets for recycled-shingle (R-S) cold patch.
CIWMB Publication Number: 431-98-013

Asphalt Roofing Shingles Recycling: Introduction
3 page fact sheet: An introduction to the recycling of asphalt roofing shingles (composition shingles). Includes information on quantities in the waste stream, composition, processing, and recycling issues.
CIWMB Publication Number: 431-97-031 July 2006

Appendix A

Annotated U.S. Asphalt Shingle Recycling

Project Summary

The following research project summary was provided by Mr. Dan Krivit, representing the Construction Materials Recycling Association, the developers of www.ShingleRecycling.org, a comprehensive clearinghouse of information on the subject.

A number of shingle recycling research and development projects are underway. This, along with the many other private development efforts, speaks to the need for continued communications and specification development at a national level.

The following list (with hyperlinks) itemizes some of the past, current and future shingle recycling projects (in reverse chronological order):

- SWMCB Tear-Off Shingles
- CMRA Tear-Off Shingles Project funded by U.S. EPA (2006)
- AASHTO Shingles Recycling Specification
- *Construction & Demolition Recycling magazine* article
- Minnesota Lab Research on Tear-Off Shingle Scrap
- Missouri Lab Research on Tear-Off Shingle Scrap
- RMRC Project #22
- RMRC Project #13 / #14: Specification Development
- SWMCB Manufacturers' Shingles
- Previous Mn/DOT projects
- CMRA Original Project (1999) and web site: ShingleRecycling.org

SWMCB Tear-Off Shingles

The SWMCB Tear-Off Shingle Scrap Recycling Project is intended to accelerate the development of a new infrastructure for recycling post-consumer asphalt shingles. SWMCB is working to demonstrate adequate government sector demand for end products such as hot-mix asphalt (HMA) derived from recycled tear-off shingle scrap.

This Project will also help expand the market for this emerging recycling opportunity by improving information and technology exchange between key players in the private and government sectors.

The Tear-Off Shingle Scrap Recycling Project is building upon the past SWMCB Manufacturers' Shingle Scrap Recycling Project plus ongoing research and development efforts by the Minnesota Department of Transportation (Mn/DOT), together with the Office of Environmental Assistance (OEA). Some of the original research was funded by these two state agencies more than 12 years ago.

For more information on the first SWMCB Manufacturers' Shingle Scrap Recycling Project, visit the Green Guardian web page: SWMCB Shingle Recycling
URL: http://www.greenguardian.com/business/shinglerecycling.asp

CMRA Tear Off Shingles Project funded by the U.S. EPA

The primary goal of this new EPA project is to develop and demonstrate recommended best practices that provide for superior quality assurance/ quality control (QA/QC) that can be utilized by profitable shingle recycling operators throughout the nation. The project has three principal objectives, according to the Construction Materials Recycling Association (CMRA):

- demonstrate successful and appropriate environmental/worker health protection procedures;
- document materials engineering benefits and methods of QA /QC to optimize their pavement performance effects; and,
- develop operational guidelines that maximize cost-efficiency while attaining minimum environmental, worker health and safety, and engineering standards.

The project will be produced by CMRA with key partner support from a wide variety of public and private agencies and companies. "This project will build directly on the substantial efforts of other research and development efforts such as the recent RMRC project #22 in order to help bring tear-off shingle recycling technology to full-scale implementation," says (William) Turley (Executive Director of the CMRA).

For more information about the project, the CMRA can be contacted at (630) 585-7530 or at info@cdrecycling.org.

For more information, see:
EPA news release: "Tear-off asphalt shingles recycling project receives $74,625 innovation grant" (5-27-05).

And see attached sidebar news article in: ***Construction & Demolition Recycling*** magazine July / August 2005 article under the feature CMRA News: "CMRA Granted Shingle Recycling Funding" (Volume 7, Number 3; Pages 14 – 15.)

Or click here: CMRA News or type into your browser's address bar:
http://www.cdrecycler.com/articles/article.asp?MagID=2&ID=4817&IssueID=224

AASHTO Shingles Recycling Specification

The American Association of State and Highway Transportation Officials (AASHTO) and its Subcommittee on Materials (SOM), are in the final stages of adopting a materials specification that itemizes specific quality assurance/quality control requirements for utilizing manufacturer and tear-off shingle scrap in HMA.

Detailed requirements include the following:

- the final RAS product must be sized and screened such that 100% passes the ½-inch sieve screen;
- maximum addition rate contractor option;
- gradation must meet the requirements of the mix design;
- deleterious material must not exceed a maximum of 0.50% by weight cumulative total (i.e., combination of all metal, glass, paper, rubber, wood, nails, plastic, soil, brick, tars and other contaminating substances); and
- asbestos level established by the state or U.S. EPA.

AASHTO is a nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia and Puerto Rico. Its primary goal is to foster the development, operation and maintenance of an integrated national transportation system.

At its last meeting on August 10, 2005 in Santa Fe, NM, the AASHTO SOM, and its Technical Section 2c (Asphalt-Aggregate Mixtures), decided to recommend the proposed recycled asphalt shingle product specification for full committee balloting. It is expected that the full committee will approve the subcommittee recommendation and this will be published as a new AASHTO specification in 2006.

For more information on the results of this AASHTO SOM meeting, or a copy of the draft shingle recycling specification, contact:

Thomas E. Baker, P.E. (AASHTO Subcommittee, Tech Section Chair)
State Materials Engineer, Washington State Department of Transportation (WSDOT)
State Materials Laboratory, Environmental and Engineering Programs
PO Box 47365
Olympia WA 98504-7365
Phone: 360-709-5401
bakert@wsdot.wa.gov

For more information on the original white paper produced for the Recycled Materials Resource Center (RMRC) that led up to this AASHTO shingles recycling specification, see the section below "RMRC Project #13 / #14: Specification Development".

Construction & Demolition Recycling Magazine Article

Many of the projects in this summary are mentioned in a recent article in *Construction & Demolition Recycling* Magazine (www.cdrecycler.com):
Construction & Demolition Recycling magazine July / August 2005 article: "Shingle – Minded Purpose" by Dan Krivit (Volume 7, Number 3; Pages 24 – 31.)
(click here: Shingle-Minded Purpose or type into your browser's address bar: http://www.cdrecycler.com/backissues/issue.asp?MagID=2&ID=224)

Minnesota Lab Research on Tear-Off Shingle Scrap

The Minnesota Office of Environmental Assistance (OEA), via a time sensitive grant through Dan Krivit and Associates (DKA), is funding this Minnesota Lab Study Project. This OEA project directly complements a parallel study sponsored by the Missouri Department of Transportation (MoDOT). (See MoDOT project description below).

The goal of this OEA Project is to complete the testing of samples adequate to allow Minnesota Department of Transportation (Mn/DOT) to recommend changes to the State hot-mix asphalt (HMA) pavement specifications that will allow the use of tear-off shingles in HMA as a normal business practice. The Minnesota OEA project has the following objectives:

1. Develop a study methodology to compare the relative impacts of tear-off vs. manufacturer RAS on HMA quality and performance. This methodology should use standard practices and methods whenever possible such that the tests can be replicated by other research in the future.
2. Measure total asphalt cement (AC) content (percent) and PG binder grade variability in tear-off shingle scrap compared to manufacturer shingle scrap and other control samples (i.e., Mn/DOT lab extraction and PG grading).
3. Conduct a controlled set of HMA laboratory analysis to provide empirical data of tear-off vs. manufacturer shingles and other control samples on HMA strength (i.e., U of M indirect tensile tests).
4. Conduct a controlled set of recycled asphalt shingles (RAS) analyses to develop standard practices and methods to measure relative amounts of deleterious materials in the ground/screened RAS product (before incorporating into HMA).
5. Analyze the data results, and if these indicate that tear-offs are safe and feasible, recommend a new Mn/DOT specification allowing tear-off shingles in HMA. The Mn/DOT Bituminous Engineer will consider developing such a new recycled shingle specification if the results indicate the tear-off-derived HMA is equivalent to, or better than, manufacturer-derived HMA.

For more information, see:
"Revised MN methods DK2 4-27-02"

Missouri Lab Research on Tear-Off Shingle Scrap

The Missouri project will provide the necessary similar and additional lab data to further analyze the hot-mix asphalt (HMA) supplemented with recycled asphalt shingles (RAS) produced from tear-off shingle scrap. The RAS-derived HMA test samples will be compared to control samples of HMA produced from 20% RAP, 0% RAS mixes. The University of Minnesota, Department of Civil Engineering, is already scheduled to perform similar lab analysis using its equipment to measure indirect tensile strength for the Minnesota Department of Transportation.

The project will result in verification or modification of requirements within the new draft Missouri Department of Transportation (MoDOT) specification on tear-off shingle recycling into HMA. This project will conduct additional empirical lab tests needed by MoDOT engineers in order to confirm requirements within their new draft specification allowing recycled tear-off shingles in HMA.

This Missouri project directly complements the Minnesota lab project (see project description above).

For more information about the MoDOT specification, see:

Construction & Demolition Recycling magazine May/June 2005 article: by Dan Krivit (Volume 7, Number 3; Pages 6 – 8.)

Click here:
Missouri Takes Lead in Shingle Recycling

Or type into your browser's address bar:
http://www.cdrecycler.com/news/news.asp?ID=1959

RMRC Project #22

The Recycled Materials Resource Center (RMRC) funded a project produced principally by the Minnesota Department of Transportation (Mn/DOT). This RMRC Project, *Overcoming the Barriers to Asphalt Shingle Recycling* (RMRC Project 22), extends over 14 years of research and development in Minnesota and selected other states on recycling of shingle scrap. This RMRC Project focused on field-testing, market development, and technology transfer of tear-off shingle scrap recycling. The end-use road construction applications demonstrated included use of recycled asphalt shingles (RAS) as: (1) a dust control supplement; (2) an unbound aggregate supplement as base; and (3) a 5% blend into hot-mix asphalt (HMA). One of the first products was an "Environmental White Paper" documenting the results of a controlled personal air sampling of ambient dust generated from a shingle recycling operation. A major outreach strategy was the April 2003 Second Asphalt Shingles Recycling Forum held in Bloomington, MN.
In the past, the additional quality assurance / quality control (QA/QC) challenges of residential tear-off shingle scrap have been barriers to development of this type of asphalt

shingle scrap. In Minnesota, there is more demand for recycled manufacturer shingle scrap than available supply. Thus, there was a continued need to develop tear-off shingle recycling as addressed by this RMRC Project.

For more information, click here: *RMRC Project 22 Final Report*

Or type into your browser's address bar:
http://www.rmrc.unh.edu/Research/Rprojects/Project22/P22finalreport.asp

RMRC Project #13 / #14: Specification

There was substantial recycled shingles specification development work recently completed by the RMRC. This other related project sponsored by RMRC was the "Development and Preparation of Specifications for Using Recycled Materials in Transportation Applications" (RMRC Project #13 / #14). Conducted by Chesner Engineering, this related RMRC project resulted in the preparation of a draft shingle recycling specification submitted to the American Association of State Highway and Transportation Officials (AASHTO) for consideration and potential adoption. This RMRC Project #13 / #14 resulted in recommendations currently being acted upon by the AASHTO's Subcommittee on Materials (see AASHTO shingles recycling specification above for more information).

For more information, click here: RMRC Project #13 / #14 Shingles Recycling White Paper: **Reclaimed Asphalt Shingles in Asphalt Concrete**

Or type into your browser's address bar:
http://www.rmrc.unh.edu/Research/Rprojects/Project13/Specs/RASAC/p13RASAC.asp

SWMCB - Manufacturers' Shingles

In 2004, the Solid Waste Management Coordinating Board (SWMCB) completed a two-year study and developed recommendations on how to increase the recycling of manufacturer shingle scrap in the SWMCB region. County engineers were involved in discussions about the appropriate role of counties in encouraging hot-mixed asphalt (HMA) producers to use manufacturer shingle scrap in HMA used to pave county road construction projects. The project resulted in a web page on www.greenguardian.com to promote the recycling of manufacturer shingle scrap.

Since completing the project described above, the SWMCB has continued efforts to help expand the market for recyclable shingles. Ongoing SWMCB technical staff efforts include evaluation and promotion of proactive County procurement practices. Such practices recommended in the 2004 study include bid advisories and alternate bid language that indicates SWMCB Counties want to encourage highway paving bids that include hot-mix asphalt (HMA) with recycled shingle content. The SWMCB intends to continue with its market development efforts to promote use of tear-off (post-consumer) asphalt shingles and is a partnering organization in the new EPA funded project being produced by CMRA (see project description above).

For more information, click here:
SWMCB's Green Guardian – Shingle Recycling web page

Or type into your browser's address bar:
http://www.greenguardian.com/business/shinglerecycling.asp

Previous Mn/DOT projects

There is a substantial amount of previous research and feasibility work (informally referred to as "Phase One") conducted for Mn/DOT in the early 1990's. Within "Phase One", a series of three studies was sponsored and published by Mn/DOT:

- Turgeon, Curtis M., "Waste Tire & Shingle Scrap Bituminous Paving Test Sections On The Munger Recreational Trail Gateway Segment." Office of Materials and Research, Minnesota Department of Transportation, February, 1991.
- Newcomb, David E., Mary Stroup-Gardiner, Brian M. Weikle, and Andrew Drescher, "Properties of Dense-graded and Stone-mastic Asphalt Mixtures Containing Roofing Shingles." ASTM Special Publication 1193, ASTM, 1993.
- Newcomb, David, et al., "Influence of Roofing Shingles on Asphalt Concrete Mixture Properties." Report MN/RC-93/09, University of Minnesota, Minnesota, 1993.

Summary & Abstract
(http://www.moea.state.mn.us/lc/purchasing/newcomb-summary.pdf)
Full report
(http://www.mrr.dot.state.mn.us/research/MnROAD_Project/MnRoadOnlineReports/93-09.pdf)

- Janisch, D. W. and C.M. Turgeon, "Minnesota's experience using shingle scrap in bituminous pavements. Final report, 1991-1996." Minnesota Department of Transportation, Maplewood, MN. Report No. PB-97-132278/XAB MN/PR--96/34, October 1996.

These earlier research and development projects led to the first version of the Mn/DOT materials specification in 1996 to allow up to 5% manufacturer scrap shingles in certain asphalt hot-mixes.

The "Phase Two" Mn/DOT Project (approximately 1997 through 2002) was focused on outreach to expand implementation of manufacturer shingle scrap recycling. The top Phase Two priority was to increase utilization into HMA as per the current Mn/DOT specification.

A result of the Mn/DOT *"Phase Two" Project* was an information "tool kit". Mn/DOT published this as, A Guide to the Use of Roofing Shingles in Road Construction: It's All Part of the Mix and included the following fact sheets:

Project Overview

Minnesota Research

Case Studies

Economics

Vendors of Shingle-grinding Equipment (updated by the SWMCB, February 2004)

For more information

The Minnesota Office of Environmental Assistance (OEA) helped further disseminate this shingles recycling Guide via the OEA Environmentally Preferable Purchasing web page, www.moea.state.mn.us/lc/purchasing/shingles.cfm ,
with the subsequent links to view the individual fact sheets as listed (and hyperlinked) above.

This Guide packet was originally mailed out under signature of Patrick C. Hughes, Mn/DOT Office of Materials & Road Research, in September 2002 to local engineers, hot-mix asphalt producers, shingle manufacturers, solid waste / recycling officials, and other interested parties. It was subsequently used at related industry conferences, workshops and other forums.

CMRA Original Project: Shingle Recycling.org

The Construction Materials Recycling Association (CMRA) is the lead sponsor of the Asphalt Shingles Research Assessment Project (ASRAP), an ongoing, long-term development project to improve the market for asphalt shingles. Other co-sponsors include the University of Florida (Gainesville, FL), the National Roofing Contractors Association (NRCA), and U.S. EPA. (Region 5, Chicago, IL). The ASRAP project was initiated at the *First Asphalt Shingles Recycling Forum* held in Chicago in November 1999. The project began a survey of state agencies and private recyclers in 2001 and culminated in the publication of the web page www.ShingleRecycling.org, a comprehensive clearinghouse of information on the subject. The 2001 survey identified individual state regulations, asbestos sampling data, and other research and development projects being conducted around the country.