Blue Source Canada

TECHNICAL PROTOCOL PLAN FOR FLY ASH USE IN CONCRETE AND OTHER CEMENT BASED PRODUCTS

NOVEMBER 2008

Version 1

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Part B Technical Protocol Plan

B.1 Description of the Project Type and How Real Reductions Will be Achieved

Introduction

The production of cement has long been recognized as a greenhouse gas intensive industry internationally by the Intergovernmental Panel on Climate Change (IPCC) and domestically by Environment Canada (EC) in the National GHG Inventory. The EC National Inventory reports industrial process emissions from cement production in Section 4.2 under Mineral Products and reports energy related emissions from cement production in Section 3.2.2 under Manufacturing Industries. In 2005, industrial process emissions from cement production in Canada totalled 7.2 Mt CO2e (an increase of 33% since 1990), while energy related GHG emissions were 4.58 Mt CO2e (an increase of 24% since 1990)[1]. In Canada, cement is produced at 16 plants located in the provinces of Alberta, British Columbia, Ontario, Quebec and Nova Scotia. In Alberta, industrial process emissions from the two cement plants were 990 kt CO2e in 2005[2].

The majority of GHG emissions from cement production occur during the production of clinker, an intermediate product from which cement is made. CO_2 is generated during the production of clinker when calcium carbonate ($CaCO_3$) from limestone, chalk, or other calcium-rich materials and other raw ingredients such as silicates are heated in a high-temperature kiln, forming lime (CaO) and CO_2 in a process called calcination, represented by the following equation[3]:

$$CaCO_3 + \text{heat} \rightarrow CaO + CO_2$$

The lime is then combined with silica-containing materials in the higher-temperature section of the kiln (1350-1450°C) to produce clinker. The clinker is removed from the kiln, cooled, and pulverized, while gypsum is added to produce Portland Cements. Direct and indirect sources of GHG emissions from fossil fuel combustion at cement plants may result from the operation of quarry trucks and other equipment , raw material processing equipment such as grinders, mixers, dehydrators and pre-calcinators, cement kilns, cement grinding and blending equipment, fuel and product transport, and electricity/steam/heat consumption facilities[4].

One approach to reduce the GHG emissions from cement production is to decrease the required quantity of clinker used in cement through the addition of other supplementary

[1] National Inventory Report, 1990-2005: Greenhouse Gas Sources and Sinks in Canada (Environment Canada 2005)
[2] Ibid.
[3] Ibid.
[4] California Climate Action Registry Cement Reporting Protocol.

cementing materials (SCMs), such as fly ash, slag, gypsum and other materials[5]. By decreasing the clinker content in blended cement products through the addition of SCMs, either at the cement plant or further down the supply chain, the GHG emissions from energy consumption and calcination are indirectly decreased.

This Technical Protocol Plan is limited to the use of fly ash as a partial substitute for cement in concrete and other cement based products. Fly ash is generated during the combustion of ground or powdered coal (primarily at power generation facilities) and is collected from the exhaust gas stream in air pollution control equipment. There are numerous coal combustion facilities in Canada, that generate fly ash, and the 7 coal-fired generating stations in Alberta generate approximately 2.7 million tonnes of fly ash per year[6].

Overview of GHG Reduction Activity

The GHG reduction activity discussed in this Technical Protocol Plan is the use of fly ash, a coal combustion product recovered from air pollution control devices at coal combustion facilities, as a partial substitute for cement (e.g. Portland Cements) used to produce concrete and other cement based products (e.g. pre-cast pipe, oil well slurries, paving stones, soil cement, etc.). The use of fly ash can reduce GHG emissions through two mechanisms: the avoidance of process emissions associated with the production of clinker from carbonate materials such as limestone; and the avoidance of fossil fuel combustion normally required to process raw materials and to operate cement kilns and other equipment during the production of clinker and other cement products. For every unit of cement replaced by fly ash a corresponding greenhouse gas emission reduction can be achieved. The quantity of GHG emissions reduced through the use of fly ash depends primarily on the GHG intensity of cement production in Alberta and the ratio in which fly ash replaces cement.

In order to ensure that the use of fly ash has resulted in real GHG reductions the project proponent must demonstrate that his/her activities (e.g. the implementation or expansion of a marketing/ distribution system for fly ash, change in mixing facility operating practices or increased use of fly ash in place of cement products) have resulted in the incremental use of fly ash in place of conventional cement products and that the fly ash would normally have been managed differently. The project proponent may be from one of many positions in the fly ash supply chain (e.g. fly ash producer, marketer, blender, user etc.).

Alberta Offset System Eligibility Criteria

In order for a GHG emission reduction activity to create eligible offsets in the Alberta Offset System, a number of eligibility criteria must be met under the Specified Gas

[5] Consolidated Baseline Methodology for Increasing the Blend in Cement Production" (CDM Methodology AM0005)
[6] Sustainability in Construction, Use of Fly Ash as a Cement Replacement (Seabrook, P.T. and Campbell K. Levelton Engineering Ltd.)

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Emitters Regulation (SGER), as outlined in the February 2008 Offset Credit Project Guidance Document. A summary of how the proposed protocol will address each of the relevant eligibility criteria is given in the following table.

TABLE B.1 Alberta Offset System Eligibility Criteria

Principle	Analysis
Start Date	The proposed protocol is applicable to projects that initiate or increase the use of fly ash in concrete and other cement based products after January 1, 2002. The project activities could be implemented at existing mixing facilities that handle fly ash or at new facilities built for the purpose of handling fly ash. In cases where the project proponent used fly ash prior to January 1, 2002, a project specific baseline fly ash usage rate is to be defined by the project proponent based on their average fly ash usage during the 3 years from 1999-2001. This historical fly ash usage prior to January 1, 2002, is discounted from the total fly ash used in the crediting year and therefore only the incremental quantity of fly ash used in the project condition would be considered eligible for offset crediting.
Crediting Period	Projects applying this protocol will have a credit duration period of 8 years, consistent with Alberta Offset system guidelines.
Real	The use of fly ash as a partial substitute for cement in concrete and other cement based products decreases the overall requirement for cement, a material that requires large amounts of fossil-fuel derived energy to produce and releases large volumes of carbonate-bound CO_2 during the calcination process. Therefore, the displacement of a functionally equivalent quantity of cement with fly ash constitutes a real GHG reduction based on the avoidance of the GHG emissions associated with the production of cement at Alberta's two cement plants. The proposed protocol requires the project proponent to establish a historical baseline 3-year average fly ash usage rate in order to ensure that only the incremental quantity of fly ash is credited. Therefore, fly ash usage considered to be 'business as usual' prior to the January 2002 release of Alberta's first climate change plan is not credited under the proposed quantification approach to ensure that only real and incremental GHG reductions are credited.
Demonstrable, Quantifiable	GHG reductions from the use of fly ash can be quantified following scientifically acceptable methods based on actual measurement and monitoring. The quantification approaches discussed in this document and the proposed protocol are derived from consensus-based good practice guidance documents developed internationally (refer to section B.2) that give a high degree of certainty with regard to the sources and sinks of GHG emissions associated with fly ash usage and cement production.

Principle	Analysis
	The quantification methodologies outlined in the proposed protocol provide a high a level of accuracy and reliability through the use of emission factors derived from 3 years worth of third party verified SGER reporting data and 3 years of fly ash usage data prior to 2002. The data management requirements discussed in the proposed protocol are rigorous with regard to tracking the distribution of fly ash up to the point of mixing or end use to ensure that real GHG reductions are occurring and to avoid double counting of fly ash used at Large Final Emitter (LFE) Sites. Collectively, these steps ensure that the GHG reductions are demonstrable and quantifiable.
Not Required by Law	Under current Alberta legislation, there are no requirements to use fly ash as a partial substitute for cement in concrete or other cement applications. Therefore, the use of fly ash is surplus to regulation.
Ownership	For consistency with other Alberta Offset System protocols the proposed protocol does not explicitly assign ownership, but instead states the minimum data collection requirements in order to adequately quantify the net GHG benefit of the project activity. It is therefore up to each project proponent to provide proof of ownership of all offsets claimed at the time of third party verification or upon request by Alberta Environment (e.g. through contracts with other participants in the fly ash distribution chain).
Counted Once	In Alberta, some fly ash may be used at LFE sites (cement plants) and included in the total production output from those facilities such that the GHG intensity reported under SGER is lower than it would have been had fly ash not been included in the production totals. To avoid the potential of double counting, the proposed protocol is NOT applicable to fly ash that is directly used at cement plants subject to the SGER (or other applicable provincial or federal climate change regulations), where the GHG intensity (tonnes of CO_2 equivalent from direct emissions per unit of cement product output from the plant) of the cement plant includes the tonnes of fly ash used in the denominator. The project proponent would be responsible for tracking fly ash distribution to ensure that fly ash used at regulated cement plants is not included, to ensure that double counting of GHG emission reductions does not occur.
Verifiable	In general, data quality management must include sufficient data capture such that the mass and energy balances may be easily performed with little or no need for assumptions and contingency procedures. The data should be of sufficient quality to fulfill quantification requirements and be substantiated by company records for the purpose of verification. The primary data would be the tonnes of fly ash mixed with cement and therefore the proposed approach would be for the project proponent to make use of commercial weigh scale

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Principle	Analysis
	records (e.g. truck scales) or to establish the quantity of fly ash received at the project site.
Occurred in Alberta	Only projects in Alberta are eligible for offsets. The proposed protocol applies to projects located in Alberta that initiate or increase the use of fly ash in concrete and other cement based products. The proposed protocol requires the project proponent to track the fly ash from the point of production (coal combustion facility) to the point at which it is mixed or used. This ensures that only the fly ash used in Alberta is eligible for offsets.

B.2 Description of Background Information / Best Practice Guidance Used

During the development of the proposed protocol a significant amount of background information on fly ash usage, cement production and the GHG emissions associated with each was gathered from Canadian and international sources. This information provided the foundation to identify relevant sources and sinks of GHG emissions, to identify potential project and baseline scenarios, to develop the GHG quantification approaches for relevant sources and sinks and to account for relevant policies. A list of the guidance documents used is provided in TABLE B.2.

TABLE B.2 Good Practice Guidance

1. Document Title	2. Publishing Body / Date	3. Description
General Protocol Guidance		
ISO 14064-2: 2006: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements	International Standards Organization, 2006	ISO 14064-2:2006 specifies principles and requirements and provides guidance at the project level for quantification, monitoring and reporting of activities intended to cause greenhouse gas (GHG) emission reductions or removal enhancements. It includes requirements for planning a GHG project, identifying and selecting GHG sources, sinks and reservoirs relevant to the project and baseline scenario, monitoring, quantifying, documenting and reporting GHG project performance and managing data quality.

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1. Document Title	2. Publishing Body / Date	3. Description
National Inventory Report, 1990-2005: Greenhouse Gas Sources and Sinks in Canada	Environment Canada, April 2007	On behalf of the Government of Canada, Environment Canada develops and publishes annually Canada's GHG inventory. The inventory reporting format is based on international reporting methods agreed to by the Parties to the UNFCCC, using the procedures of the Intergovernmental Panel on Climate Change (IPCC).
Alberta Offset System Offset Credit Project Guidance Document	Alberta Environment, February 2008	This Offset Credit Project Guidance Document is one of a series of guidance documents prepared for the Specified Gas Emitters Regulatory Framework. The purpose of this Guide is to outline the process and requirements for undertaking offset projects in Alberta.
A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H2S) Emissions by the Upstream Oil and Gas Industry	Clearstone Engineering Ltd. on behalf of the Canadian Association of Petroleum Producers (CAPP), September 2004	This document was used for emission factors to calculate GHG emissions from fuel combustion as well as the upstream emissions from extraction and production of those fuels.
Quantification Protocols		
Cement Reporting Protocol	California Climate Action Registry (CCAR), December 2005	This document provides guidance for reporting entity-wide greenhouse gas emissions produced by cement companies and was used for evaluating quantification approaches.
The Cement CO_2 Protocol: CO_2 Emissions Monitoring and Reporting Protocol for the Cement Industry (Guide to the Protocol, Version 1.6)	World Business Council for Sustainable Development (WBCSD) Cement Working Group, October 19 , 2001	This document was used for evaluating quantification approaches and developing flexibility mechanisms.

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1. Document Title	2. Publishing Body / Date	3. Description
ACM0015: Consolidated baseline and Monitoring Methodology for Project Activities Using Alternative Raw Materials that do not Contain Carbonates for Clinker Manufacturing in Cement Kilns (Version 1)	United Nations Framework Convention on Climate Change (UNFCCC), valid from November 30 2007 onwards	This document was used for evaluating baseline approaches.
ACM0005: Consolidated Baseline Methodology for Increasing the Blend in Cement Production (Version 4)	UNFCCC, valid from November 2 2007 onwards	This document was used for evaluating baseline approaches.
Technical Resources		
Estimating GHG Savings from Use of Fly Ash	NRCan, Materials Technology Laboratory, October 2006	This document provides the background scientific data required to determine an appropriate ratio in which fly ash would typically be used to replace cement. This ratio ensures functional equivalence.
Background Document for Life-Cycle Greenhouse Gas Emission Factors for Fly Ash Used as a Cement Replacement in Concrete (EPA 530-R-03-016)	United States Environmental Protection Agency (US EPA), November 7, 2003	This document presents a complete lifecycle GHG analysis on the recycling of fly ash for use as a substitute for cement. This document was used to assess the materiality of GHG emissions from transportation in the baseline and project conditions.
Cement Production Guidance Manual for Estimating Greenhouse Gas Emissions	Greenhouse Gas Division of Environment Canada (EC), March 2004	This document was used to evaluate quantification approaches.
Use of Fly Ash and Slag in Concrete: A Best Practice Guide (MTL 2004-16)	NRCan's International Centre for Sustainable Development of Cement and Concrete (ICON), January 2005	This document was used for general background information.

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1. Document Title	2. Publishing Body / Date	3. Description
Revised General Guidelines and Draft Technical Guideline for EPACT Section 1605(b) Voluntary GHG Reporting (Vol. 70, No. 56)	United States Department of Energy (US DOE), June 22, 2005	This document was used to evaluate the functional equivalence of using fly ash in place of cement and to double-check the magnitude of the cement to fly ash replacement ratio.
A3000: Cementitious Materials Compendium (consists of A3001, A3002, A3003, A3004, A3005)	Canadian Standards Association (CSA), 2008	This document was used to obtain the definition of fly ash.
The Cement Sustainability Initiative	WBCSD, March 2007	This document was used for background information.
Canadian Cement Industry 2008 Sustainability Report	Cement Association of Canada (CAC), 2008	This document was used for background information.
A Review of Energy Consumption and Related Data: Canadian Cement Manufacturing Industry 1990 to 2004	Canadian Industrial Energy End-use Data and Analysis Centre (CIEEDAC)	This document was used for background information.
Calculation Tool for Direct Emissions from Stationary Combustion (Version 3.1)	World Resources Institute (WRI) and WBCSD, December 2007	This document was used for evaluating stationary combustion emission factors.
The Regulatory and Standards Landscape of Canada's Public Infrastructure	CSA, March 2005	This document was used to verify that fly ash was not a required component of concrete under any Canadian legislation or municipal bylaws.
Sustainability in Construction, Use of Fly Ash as a Cement Replacement	Levelton Engineering Ltd. Seabrook, P.T. and Campbell K.	This document was used for background information on business as usual fly ash usage in Alberta and BC.
Fly Ash: Its Origin, Applications and the Environment	Canadian Industries Recycling Coal Ash (CIRCA), March 2006	This document was used to reference some statistics on fly ash use in Canada.

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B.3 Regulatory, Legal Requirements and/or Government Incentive/Grant Programs

Relevant Climate Change Regulations

In Alberta, the Specified Gas Emitters Regulation applies to facilities with GHG emissions of greater than 100,000 tonnes CO_2e per year, which are referred to as Large Final Emitters (LFEs). All facilities exceeding this threshold are required to reduce GHG emissions by 12% on an intensity basis beginning July 1, 2007. Because of these requirements, any facilities classified as LFEs are not eligible for offset generation as any emission reduction activity that occurs within the boundary of an LFE site will be subject to the SGER. In Alberta, there are two cement plants and seven coal-fired electricity generating stations, all of which are subject to the SGER.

In Alberta, the supply chain for fly ash involves a number of participants, including the cement companies that operate LFE sites, and some fly ash is blended at the two cement plant sites and included in their total product output. As a result, there is the potential for double counting of emission reductions from any quantities of fly ash that are included in the cement plant's production output such that the facility's GHG intensity decreases per unit output (as reported under SGER) and later distributed to another user and claimed for offset creation. To mitigate this issue the proposed protocol has included an applicability criterion to require that the project proponent does not include any fly ash that has already been included in the SGER reporting at the regulated cement plants.

In April 2007, the Federal Government released the Regulatory Framework for Air Emissions, which outlined the broad design for regulations of industrial emissions of air pollutants and greenhouse gases. In March 2008, the Federal Government then provided further details on the proposed regulation of GHGs through the "Turning the Corner" document titled "Regulatory Framework for Industrial Greenhouse Gas Emissions." This framework provided more detailed sector specific regulations for large emitting facilities and included mention of the planned use of a sector-wide approach that would require an 18% reduction threshold from the sector's average 2006 intensity level for the cement industry among others, starting in 2010. It is not clear at this time how Environment Canada will define cement plant operations and how this might differ from Alberta Environment's approach or not. There is however, the potential that the boundary defined for the cement plants could include some operations or facilities that handle, mix or use fly ash. Any fly ash mixed or used within the boundary of a regulated site/entity would not be expected to be eligible for offsets under the federal offset system for the same reasons as under the Alberta SGER. It is expected that some level of harmonization will be needed in 2010 between the federal and provincial regulations.

Other potentially relevant regulations / requirements

Cement plants and coal-fired generating facilities must comply with the requirements of several Canada-wide regulations such as the Canadian Environmental Protection Act (CEPA 1999), National Pollutant Release Inventory (NPRI) and National Ambient Air

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Quality Objectives (NAAQO's). Additionally, air emissions from coal-fired power plants will also be subject to the Canada Wide Standards (CWS) for Mercury Emissions from Coal Fired Electric Power Generation Plants published by the Canadian Council of Ministers of the Environment (CCME). The CWS set a target of provincial caps representing a 60% national capture of mercury by 2010. These regulations are not expected to impact the use of fly ash as a partial substitute for cement.

Under the current Alberta waste classification, "fly ash waste, bottom ash waste, slag waste or flue gas emission control waste generated from the combustion of domestic waste, coal, wood, or other fossil fuels" are not considered hazardous wastes. Disposal options in Alberta include on-site disposal within mined out areas, disposal at Class I and Class II landfills (operator permission obtained), or co-disposal with sulphur containing wastes at Class I or Class II landfills. If the ash is used instead of disposed the proper handling procedures and documentation must be completed[7].

The transportation of fly ash may be subject to the requirements of the Transportation of Dangerous Goods Act, depending on its classification which is currently under review to change from a "waste" to a "recyclable" material.

The Canadian Standards Association (CSA) identifies different types of fly ash based on chemical composition and permits a maximum of 5% SO_3 for all types for use in cement. As of March 31, 2004 this CSA standard was not required by any Canadian legislation, regulation or municipal bylaw. The CSA also gives guidance on the materials and mix proportions required to achieve the desired physical properties in the finished concrete.

Based on these requirements, there do not appear to be any regulations that would require the use of fly in certain applications and therefore no requirements that would preclude the use of fly ash from being surplus to legal requirements.

Potentially relevant climate change incentives

At the time of writing, there were no known climate change incentives for the use of fly ash as a partial substitute for cement in concrete or other cement based products.

There are various organizations and standards that encourage the use of fly ash as a replacement for cement and in some cases acknowledge the GHG benefit of using fly ash, such as the Association of Canadian Industries Recycling Fly Ash (CIRCA), Leadership in Energy and Environmental Design (LEED), BuiltGreen™, EcoSmart™ and Natural Resources Canada (NRCan). NRCan established the International Centre for Sustainable Development in the Cement and Concrete Industry in 1998 and aims to increase Canada's annual use of fly ash and other supplementary cementing materials from 9 percent to 25 percent by 2008-2010[8]. A field project was funded by NRCan

[7] Management of Coal Ash (Alberta Environment, August 2005)
[8] Fly Ash Technology in Canada (NRCan). http://www.nrcan-rncan.gc.ca/com/elements/issues/05/ghgges-eng.php

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(CANMET) in British Columbia to demonstrate the use of high volumes of fly ash in construction[9].

B.4 Barriers to Implementation

There are a variety of barriers that may impact the use of fly ash as a partial substitute for cement. These may include economic barriers, infrastructure barriers, supply and demand constraints, institutional barriers and technological barriers.

The cost of transporting fly ash to distribution centers and end users may be significant compared to relatively low costs associated with disposal of the fly ash in a mine near the coal-fired generating station. The cost of building silos and other infrastructure to store the fly ash at distribution facilities and mixing/ blending facilities can be a major impediment for smaller operators lacking capital resources. In jurisdictions with a large number of coal-fired generating stations there may be a surplus of fly ash as compared to the demand in nearby regions. This is particularly relevant in Canada, where the majority of coal-fired generating stations are located in Alberta, Saskatchewan and Ontario. The variability in fly ash production by region impacts the breadth of marketing and distribution and the cost of transporting fly ash. The main institutional barriers are the resistance to changing operational practices and the perception of fly ash as a waste material. The development or expansion of a marketing and distribution program for fly ash would also represent a barrier that would need to be overcome through increased spending on programs, office space, staffing, training and education of potential fly ash users in addition to the physical costs of distributing the fly ash.

Specific technological barriers include the setting time of concrete containing fly ash and the impact of air pollution control systems on fly ash quality. The type and amount of fly ash used in concrete will affect the properties of the concrete important to the user. Concrete setting time may be increased by the use of fly ash due to lower heat of hydration and slow pozzoloanic reaction. Many construction projects are driven by short turnaround times and a long setting time could be a deterrent to using fly ash. Additionally, longer setting times are more of a concern with horizontal elements, such as suspended slabs, and the potential use of fly ash could be limited for these purposes[10]. Historically, concrete strength acceptance in Canada has been based on a 28 day test. This does not allow for the long-term strength gain potential of fly ash mixes to be realized. Generally concrete strength is required either earlier or later depending on the structural element and construction schedule, making the 28 day acceptance an outdated method[11]. There is also a misconception that high-strength concrete will become high-durability concrete, leading to less fly ash usage to obtain early strength[12].

[9] Sustainability in Construction: Use of Fly Ash as a Cement Replacement (Levelton Consultants)
[10] EcoSmartTM website.
[11] Sustainability in Construction: Use of Fly Ash as a Cement Replacement (Levelton Consultants)
[12] High-Performance, High-Volume Fly Ash Concrete for Sustainable Development (University of California)

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The operation of air pollution control systems can impact the composition of fly ash. Mercury emissions from coal-fired generating stations in Alberta represent 44% of the national total[13]. In response to concerns about the levels of mercury in the natural environment, CCME has released Canadian Wide Standards (CWSs) for mercury emissions from coal-fired generating stations. The effects of mercury emission control systems on fly ash quality have been identified by industry. CIRCA has issued the following statement:

"Efforts to prepare for more stringent regulation of Mercury and other emissions suggest a range of technology retro-fit mitigation options. However, these are not equal in terms of their effects on the characteristics of coal combustion products (CCPs); while some will safeguard valued properties of CCPs, others will render them unusable for significant markets."

B.5 Review of Technology / Scientific Knowledge

As discussed, this technical protocol plan is applicable to the practice of using fly ash as a partial substitute for cement in concrete and other cement based products. While, the proposed protocol centers around the quantities of fly ash used, it is necessary to discuss the properties of fly ash that make it a suitable material to replace a portion of cement in concrete or other cement based products. Current scientific knowledge and technologies relating to fly ash and cement were reviewed and summarized below.

Fly Ash

Fly Ash is defined as the "finely divided residue that results from the combustion of pulverized coal and which is carried from the combustion chamber of a furnace by exhaust gases[14]". It consists mostly of silicon dioxide, aluminium oxide, calcium oxide, and iron oxide. In its standard A-3000 (Cementitious Materials Compendium) the Canadian Standards Association (CSA) identifies three types (or classes) of fly ash on the basis of calcium oxide (CaO) content. The three types are Type F (<8% CaO), Type CI (8-20% CaO), and Type CH (>20%CaO). Type F and Type CI are produced in Canada.

A pozzolan is a material which, when combined with calcium hydroxide, exhibits cementitious properties. Fly ash is known to have pozzolanic properties and can be used as a substitute for a portion of the cement required to make concrete or other cement based products. The type and amount of fly ash used in concrete will affect the properties of the concrete that are important to the user. One of the more strongly affected, as well as key properties affected by the use of fly ash, is the strength development. In general, the use of low-calcium fly ash will decrease the early compressive strength (up to 28 days) and increase the strength at later ages[15].

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[13] Canada Wide Standards for Mercury Emissions from Coal-Fired Electric Power Generation Plants (CCME, October 2006)
[14] Cementitious Materials Compendium (CSA A3000)
[15] Use of Fly Ash and Slag: A Best Practice Guide (NRCan, January 2005)

Cement

Cement is a basic ingredient of many building materials including concrete, mortar, stucco, and grout. Cement can be characterized as hydraulic or non-hydraulic and can be used on its own or as a binder to bond aggregate materials together. All cements are made by grinding clinker with calcium sulphate and other minor constituents. The most common type of cement used in construction around the world is called Portland Cement, however other types of blended cement exist.

Technology

Fly ash is typically used to replace up to 25% of cement. A product called high-volume fly ash (HVFA) concrete was developed during the late 1980s. This product is defined as containing 50% or more fly ash by mass of the total cementitious material. It has been suggested that HVFA concrete can show high workability, high ultimate strength, and high durability[16].

No project specific technologies related to fly ash handling and processing were identified as the storage and mixing of fly ash requires similar infrastructure as the handling of conventional cement.

B.6 Review of Existing Projects

In Canada, fly ash has been used for its pozzolanic properties for decades. However, it has not been as widely adopted as a supplementary cementing material (SCM) as in other jurisdictions. For example, the European Coal Combustion Products Association (ECOBA) statistics from 1999 relate that 31% of the fly ash in Canada was recycled for use in various applications, with the remainder being landfilled, while 88% of fly ash produced in Europe was recycled[17]. Specifically, in 2001, 3.8 of the 4.8 million tonnes of fly ash produced in Canada were disposed or stored. Of the fly ash used in all sectors 78% (828 000 tonnes) was used as a substitute for cement in concrete[18]. A report by Levelton Engineering Ltd. titled "Sustainability in Construction, Use of Fly Ash as a Cement Replacement" estimated that of the 2.7 million tonnes of fly produced annually in Alberta, approximately 25% was being used for different applications, with the majority being used as a substitute for cement[19]. Additionally, British Columbia's Ready Mix concrete industry was estimated to have replaced 15-18% of cement with fly ash imported from Alberta or Washington State.

Although the use of fly ash as a substitute for cement occurs in Alberta and in Canada, there is a significant margin for the industry to increase its usage, particularly in high

[16] High-Performance, High-Volume Fly Ash Concrete for Sustainable Development (University of California)

[17] Fly Ash: Its Origin, Applications and the Environment (CIRCA Fact Sheet 1, March 2006)

[18] Policy Making for Greening the Concrete Industry in Canada (NRC Canada, 2005)

[19] Sustainability in Construction, Use of Fly Ash as a Cement Replacement (Seabrook, P.T. and Campbell K. Levelton Engineering Ltd.)

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strength applications that can use fly ash for up to 70% of the weight of all cementitious materials. Additionally, there remains a large amount of unutilized fly ash as evidenced by an Alberta Environment statement that "Given the volumes produced and the likelihood for creating airborne particles, most coal ash is managed on-site within mined-out areas adjacent to the mine or the coal power plant.[20]" The various producers of fly ash also confirmed that the disposal of fly ash in mined-out areas of coal mines or landfill was common place.

Organizations such as the Association of Canadian Industries Recycling Coal Ash (CIRCA), which was incorporated in December 2002, advocate the responsible use of fly ash and other coal combustion products (CCPs) as mineral resources. In January 2005, Natural Resources Canada's (NRCan) International Centre for Sustainable Development of Cement and Concrete (ICON) released a "Best Practices Guidelines on the Use of SCMs in Concrete" with the aim of promoting the use of supplementary cementing materials (SCMs) as a partial replacement for cement. The Guideline also recognized the environmental benefits of this practice.

Many projects and programs in Canada have been undertaken to demonstrate fly ash as a desirable and effective substitution for cement. The Confederation Bridge to Prince Edward Island was built with a significant amount of fly ash used in place of cement, which resulted in an indirect GHG reduction of approximately 30,000 tonnes of CO2 equivalent, according to NRCan[21]. Two other examples of major initiatives are:

- The voluntary Leadership in Energy and Environmental Design (LEED) program assigns points for the use of recycled content in building materials under Materials and Resources credits 4.1 and 4.2. The use of fly ash in concrete counts towards meeting the requirements laid out in this credit.

- The EcoSmart™ Foundation in Vancouver, BC markets the use of SCMs in concrete (including fly ash) by promoting what they've termed "EcoSmart™ Concrete". The Foundation provides technical support to project teams and supports the development of standards, guidelines and specifications around the use of SCMs, often by networking suppliers, designers, and contractors to one another.

B.7 Summary of Quantification Approaches

<u>Identification of Sources and Sinks of GHG Emissions</u>

In order to develop quantification approaches for the use of fly ash as a partial substitute for cement, it was necessary to examine the different lifecycles for both cement and fly ash to identify all potential sources of GHG emissions from material production through

[20] Management of Coal Ash. Alberta Environment. June 2000, updated August 2005.
[21] Research, Technology and Innovation June 2005. NRCan. http://www.strategis.ic.gc.ca/epic/site/rti-rti.nsf/en/te01459e.html

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to end use. The identification of sources and sinks was completed using the best practice guidance documents listed in Table B.2 and by examining typical project configurations. This life cycle analysis was done following the ISO-14064-2 standard where the different sources and sinks (SS's) of GHG emissions were classified as upstream, on-site, downstream, controlled, related and affected. A brief summary of this analysis is presented in this section for context along with a typical process flow diagram incorporating the identified sources and sinks of emissions.

For cement production these lifecycle SS's included upstream elements related to material and fuel extraction, processing and transportation; cement plant operations related to fossil fuel consumption and industrial process emissions; and downstream operations related to cement transportation and end use. For fly ash these life cycle elements included upstream elements related to fly ash production at coal combustion facilities and transportation to other uses or disposal; on-site elements related to further fly ash distribution and mixing or blending with cement; and downstream elements related to transportation and use of the cement products containing fly ash and the disposal of any unutilized fly ash. The handling and use of both fly ash and cement would also require a variety of infrastructure at different stages of their respective lifecycles and the development (and later decommissioning) of this infrastructure would have some associated GHG emissions that are not directly tied to the upstream, downstream or on-site elements.

A process flow diagram was developed for the proposed protocol based on the life cycle analysis of the project activities and the review of the various best practice guidance documents and quantification approaches referenced in section B.2. Figure 1, below, summarizes the different SS's identified for the relevant lifecycles of fly ash and cement. The most material SSs recommended for quantification, as discussed in the following section are shaded in grey in Figure 1. The two dashed lines in Figure 1 represent the boundaries of the cement plant operations and the main points within the fly ash supply chain at which information may need to be collected by the project proponent.

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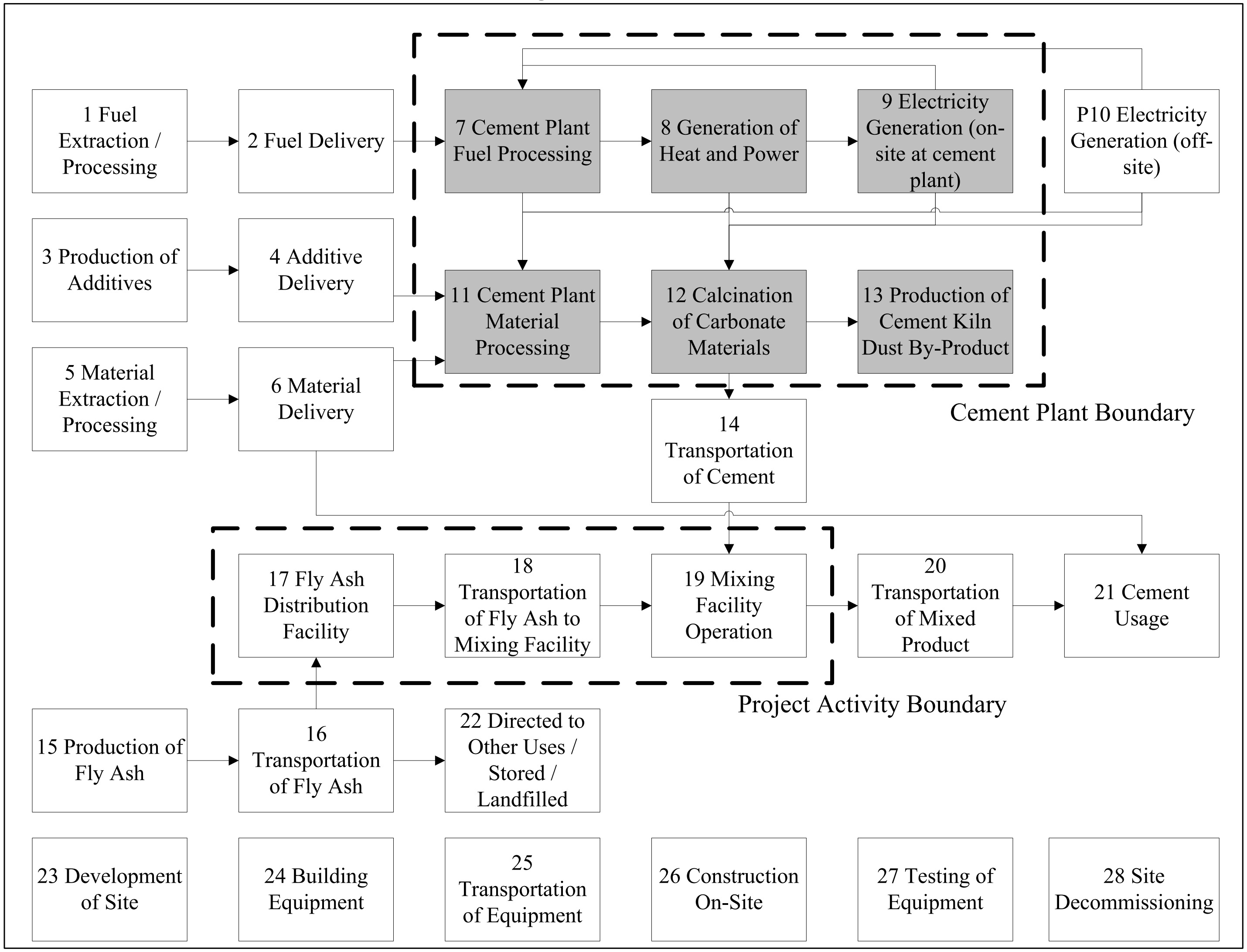
FIGURE 2: Recommended Process Flow Diagram



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Determination of Material Sources and Sinks of GHG Emissions

Following the lifecycle analysis that facilitated the identification of relevant sources and sinks of GHG emissions, a preliminary analysis of these SSs was performed to identify the most material sources of GHG emissions in the project and baseline conditions. These 'material' SSs were then the focal point for the development of quantification approaches. The evaluation of these SS's was completed based on a review of the best practice guidance documents discussed in Section B.2. These Technical Seed Documents (TSDs) formed the basis of the scientific consensus behind the quantification of GHG emissions from cement production and fly ash usage.

Table B.3 summarizes the relevant TSDs that were used in the development of GHG quantification approaches:

TABLE B.3: Quantification Approaches

Technical Seed Document	Scope of Methodology	Emission Sources Identified and Quantified
CCAR Cement Reporting Protocol	Cement production only. Includes an efficiency metric for determining GHG intensity per unit of product as defined by the WBCSD.	• Mobile fuel combustion; • Stationary combustion; • Process emissions; • Fugitive emissions.
WBCSD Cement CO_2 Protocol	Cement production only. Includes an efficiency metric for determining GHG intensity per unit of product which includes additives such as fly ash.	• Fossil fuel combustion; • Alternative fuel combustion (fossil and biomass wastes); • Process emissions; • Non-kiln fuel combustion.
Environment Canada Cement Production Guidance Manual for Estimating GHG Emissions (March 2004)	Cement production only.	• Stationary fuel combustion; • Mobile fuel combustion; • Process emissions. • Fugitive emissions.
CDM Consolidated Baseline Methodology for Increasing the Blend in Cement Production (ACM0005 v4.)	Includes cement production and the use of alternative materials such as fly ash to displace some clinker to decrease GHG intensity of cement production.	• Fossil fuel combustion for kiln operation • Fossil fuel combustion for material/fuel preparation • Indirect emissions from use of electricity • Process emissions

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Technical Seed Document	Scope of Methodology	Emission Sources Identified and Quantified
CDM Consolidated Baseline Methodology for Project Activities Using Alternative Raw Materials that do not Contain Carbonates for Clinker Manufacturing in Cement Kilns (ACM0015 v1.)	Includes cement production and the use of alternative materials such as fly ash to displace some clinker to decrease GHG intensity of cement production.	• Fossil fuel combustion for kiln operation • Fossil fuel combustion for material/fuel preparation • Indirect emissions from use of electricity • Process emissions
US EPA Background Document for Life-Cycle Greenhouse Gas Emission Factors for Fly Ash Used as a Cement Replacement in Concrete (November 2003)	Includes cement production and transportation, fly ash transportation, disposal and usage in place of cement. GHG emissions for each aspect are quantified per tonne of cement. A sensitivity analysis on transportation emissions was completed.	• Fossil fuel combustion for process energy • Process emissions • Transportation of fly ash and cement • Fly ash disposal in landfill

Based on the above TSDs, it was determined that the primary sources of GHG emissions were related to the operations at the cement plant, which included process emissions and emissions from fossil fuel combustion. Other less material sources of GHG emissions included the operation of a distribution facility to handle and store fly ash and the transportation of fly ash from producer through the supply chain to the user.

The US EPA life cycle analysis of fly ash usage clearly indicated that the most material source of GHG emissions from the use of fly ash were the baseline emissions from the production of cement. The avoided GHG emissions from the production of cement from raw materials contributed to approximately 96% of the net GHG reduction emissions from fly ash usage, while the disposal of fly ash in landfill contributed the remainder. Cement and fly ash were assumed to be transported equivalent distances such that the net GHG balance was null. To check the significance of this assumption the study then did a sensitivity analysis to assess how the net GHG reduction would be impacted by different transportation distances. According to the sensitivity analysis in the US EPA study, a baseline condition in which cement is transported approximately 95 km compared to a project condition in which fly ash transported approximately 320 km would affect the net GHG reductions from fly ash by only 2%[22].

Based on this analysis it was assumed that in the majority of project configurations any increase in the distance required to transport fly ash to markets versus the equivalent

[22] US EPA Background Document for Life-Cycle Greenhouse Gas Emission Factors for Fly Ash Used as a Cement Replacement in Concrete (November 2003)

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distance to transport cement to those same markets would not materially impact the net GHG balance.

Development of a Quantification Approach

Based on the review of the above best practices guidance documents, it was deemed necessary to develop the quantification approach in the proposed protocol around two main parameters: the emissions intensity of cement production in Alberta and the ratio in which fly ash can be used to displace cement.

The quantification of the first parameter requires the calculation of an emissions intensity factor for cement production in Alberta. The data for this factor will be derived from the annual GHG reports that the cement plants have submitted annually under the SGER on a per unit of production basis since 2003. Additionally, this data has to be audited by a third party each year and then later submitted to Alberta Environment for review, which ensures its accuracy and completeness. The cement production GHG intensity factor will be developed using aggregated GHG emissions data from fossil fuel consumption and industrial process emissions at the two cement production plants operating in Alberta. The data used will consist of three years of historical GHG emissions data collected after the Alberta Offset System project eligibility start date of January 1, 2002 and thus will provide reasonable certainty as to the actual GHG emissions avoided by projects initiated post 2002.

The second parameter requires the determination of a ratio that reflects the normal mass to mass displacement of cement when fly ash is used. Research conducted by Natural Resources Canada (NRCan) yielded a cement to fly ash replacement ratio of 0.88[23] as discussed in Section B.12 under functional equivalence.

The use of these two factors enables the GHG quantification approach to be developed in a fairly simple way by tracking the mass of fly ash used by the project proponent and discounting for historical fly ash use under business as usual conditions. The incremental tonnes of fly ash used after 2002, as compared to the business as usual use of fly ash during the reference period of 1999-2001, can then be converted to an equivalent amount of cement displaced and then into an equivalent quantity of GHG emissions avoided using these two factors.

Further quantification methods that enable project flexibility are discussed in section B.13.

[23] Estimating GHG Savings from Use of Fly Ash (NRCan, October 2006)

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B.8 Other Impacts (optional)

Although difficult to measure, the use of fly ash in building materials can have positive effects on the durability of the concrete or other cement based products and the structures they form. Over the long term this could mean fewer GHG emissions from repairs and maintenance and potentially reduced cement usage through longer lasting concrete. Additional indirect environmental benefits are derived through decreased fossil fuel combustion at the cement plant due to decreased production. Decreasing fossil fuel combustion leads to reduced emissions of criteria air contaminants and reduced cooling water requirements. The productive use of fly ash also reduces the quantity sent for disposal in landfill, which increases the life of the landfill.

B.9 Assessment of Baseline Scenarios

An assessment of potential baseline scenarios was conducted based on the recommended methodology from best practice guidance in the Alberta Offset Credit Project Guidance Document. Potential baseline options were assessed based on their capacity to incorporate two aspects of the baseline: the GHG emissions from cement production and the project proponent's historical usage of fly ash (e.g. the 'business as usual' fly ash usage). Each baseline scenario also contemplated the selection of a static or dynamic approach. Table B.4 provides a summary of the different baselines considered.

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TABLE B.4 Assessment of Possible Baseline Scenarios

1. Baseline Options	2. Description	3. Static/ Dynamic	4. Accept or Reject and Justify
1.Historic Benchmark	A) Assessment of the baseline emissions from cement production based on site specific fossil fuel consumption and process emissions data from one or more years of cement plant operation.	Static.	Accept. The use of site specific historic data from the 2 cement plants in Alberta provides a high level of accuracy. 3 years of GHG reporting data is available under the SGER that has been 3rd party verified. This ensures that data is of high enough quality to warrant using a historic benchmark type baseline. Additionally, the SGER data was collected from 2003-2006, which makes it especially relevant for offset projects starting after January 1, 2002. Note that this approach is similar to the performance standard approach since there are only 2 cement plants in Alberta.
	B) Assessment of one or more years of historic fly ash usage by the project proponent prior to the Alberta Offset System start date eligibility criterion of Jan 1, 2002.	Static.	Accept. This approach uses 3 years of project specific data from pre-2002 to establish business as usual (non-eligible) fly ash usage a ensures that the exact amount of fly ash is quantified as 'eligible' for each project proponent. This is similar to an adjusted baseline, but is done at the project level rather than the regional or provincial level.
2.Performance Standard	A) Assessment of the typical GHG emissions from cement production as a proxy to estimate the avoided GHG emissions from fly ash usage.	Dynamic or Static	Reject. This approach uses typical industry GHG emissions data per tonne of cement produced as a proxy for the avoided emissions, which is less representative than the historic benchmark approach that uses multiple years of site-specific cement plant GHG reporting data.

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1. Baseline Options	2. Description	3. Static/ Dynamic	4. Accept or Reject and Justify
	B) Assessment of the baseline scenario based on the typical industry use of fly ash as a substitute for cement in concrete or cement based products.	Dynamic or static.	Reject. Detailed data on the use of fly ash is not readily available and in many cases may be sensitive commercial information. There are many participants in the fly ash supply chain, so characterizing typical usage rates may lead to an over simplification that creates a disincentive for individual project proponents to increase usage.
3.Comparison-based	A) Assessment of the baseline GHG emissions from cement production based on the performance of a control group.	Dynamic	Reject. This approach would create an unnecessary burden for project proponents as these GHG emissions can already be characterized using existing GHG reporting data available under SGER.
	B) Assessment of baseline fly ash usage based on the performance of a control group. This would likely involve examining one or more control groups that use limited amounts of fly ash (e.g. no fly ash use, the industry average amount in 2001 etc.)	Dynamic.	Reject. This approach is not practical for an 'activity-based' emission reduction activity where it would be necessary to characterize the average industry uptake for an activity to represent the 'control' group. Project configurations can vary greatly as some projects will have no baseline usage of fly ash and others will have significant business as usual fly ash usage. Generalizing fly ash usage by defining control groups would be challenging given the diversity of the fly ash supply chain and this could cause the protocol to be overly prescriptive and potentially limiting to new applications for fly ash.

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1. Baseline Options	2. Description	3. Static/ Dynamic	4. Accept or Reject and Justify
4. Projection-Based	A) Assessment of the baseline GHG emissions from cement production using a model to project an increase or decrease in the GHG intensity of cement production into the future. This could include a linear projection of the GHG intensity of cement production based on past trends or expected future trends.	Dynamic	Reject. There are no models available to accurately predict changes in the emission intensity of cement plants. This approach does not provide any increase in accuracy over the historic benchmark approach, which uses recent data (post 2002).
	B) Assessment of the baseline fly ash usage based on a projection of the future use of fly ash. This approach would likely involve establishing a dynamic rate of fly ash usage based on past trends.	Dynamic.	Reject. There are no models currently available to predict future use of fly ash in Alberta. Fly ash usage is driven by many market factors.
5.Adjusted Baseline	A) Assessment of the baseline GHG emissions intensity from cement production using regional or plant specific data and adjusting for the mandated 12% reduction in GHG intensity imposed on LFEs under the SGER. This could be similar to a linear projection based approach.	Static or Dynamic.	Reject. The industrial process GHG emissions that make up over half of GHGs emitted during cement production cannot be reduced at the cement plant due to the chemical properties of the materials (which is why these industrial process emissions were not subject to the 12% reduction requirement under the SGER). Adjusting the baseline GHG intensity based on the SGER, which came into force in July 2007 (as compared to the possible offset project start date of January 1, 2002), would not reflect actual GHG emissions prior to 2007. There is also no assurance that GHG intensity will decrease by 12% per year since companies can opt to pay into the Climate Change and Emissions Management Fund or purchase offsets rather than implement potentially more costly GHG reductions at their own facilities.

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1. Baseline Options	2. Description	3. Static/ Dynamic	4. Accept or Reject and Justify
	B) Assessment of the baseline scenario based on the average level of fly ash usage in the province. This would likely be applied as a discount factor applied to all projects based on the tonnes of fly ash used as a substitute for cement versus the total tonnes of fly ash produced in the province.	Static.	Reject. The use of fly ash per project varies greatly across Alberta and it may not be feasible to generalize the typical fly ash usage per project. Given the large number of different participants in the sector, commercial interests could also hinder the ability to gather commercially sensitive data. The use of historic practices may unduly penalize certain projects that previously did not use fly ash or those that increased fly ash usage significantly post 2002.

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B.10 Selection of Baseline Scenario

The development of quantification approaches for the use of fly ash as a substitute for cement in concrete and other cement based products required the examination of a variety of baseline scenarios as described in Section B.9. The main criteria used to evaluate each scenario included data availability, environmental integrity, accuracy, consistency with Alberta project configurations and ease of application (e.g. through monitoring requirements). These approaches include site-specific scenarios and more generalized scenarios that included regional average factors.

The recommended baseline option for the proposed protocol is the historical benchmark approach for both the baseline avoided emissions from cement production and the baseline fly ash usage. Under this scenario the GHG emissions from cement production would be calculated based on the average GHG intensity per unit of production for the two operating cement plants in Alberta. The business as usual use of fly ash would be established for each project proponent using three years of historical fly ash usage. This project specific value for the business as usual rate use of fly ash would then be subtracted from the total tonnes of fly ash used in the project condition.

The historic benchmark approach was selected for the baseline emissions from cement production based on the robustness of the SGER data which consisted of three years of GHG intensity reporting at the relevant cement plants that had already been audited by a third party and reviewed by Alberta Environment. The high quality of data from both Alberta cement plants ensures environmental integrity. Additionally this data was collected from 2003-2006, making it relevant to the offset crediting period under the Alberta Offset System. Since the GHG emissions intensity factor for cement production was derived from three years of data reported during the relevant timeframe a static emission factor was selected to represent the baseline emissions from cement production in the proposed protocol. The use of a static baseline emission intensity factor was also practical given the challenges related to the transfer of potentially sensitive information between proponents in the cement industry and the project proponent(s) distributing and using the fly ash. However, it is expected that as additional data are collected under SGER and equivalent Federal GHG reporting requirements, there will be opportunities to refine the baseline emission intensity factor for cement production with more up to date data at that time.

The historic benchmark approach was selected to establish the baseline or business as usual use of fly ash on a project specific level. Given the diversity of participants in the fly ash supply chain, a project-specific approach using three years of historic fly ash usage data from 1999-2001 was the most appropriate approach to characterize each project proponent’s baseline use of fly ash. An average provincial discount factor based on the total tonnes of fly ash used versus produced from 1999-2001 would be easier to apply, but might create a disincentive for new users of fly ash. The historic benchmark approach would also have a higher level of environmental integrity as it would quantify the incremental amount of fly ash used by an individual project proponent rather than the

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change in use as compared to a regional average that might not reflect all applications of fly ash. A dynamic approach to determining the baseline use of fly ash was not selected as it was not practical to develop a model to predict the business as usual use of fly ash. The fly ash supply chain is already or likely will be subject to a variety of market supply and demand factors, air pollution control requirements at coal-fired generating facilities (e.g. scrubbers, mercury control equipment), non-hazardous waste handling requirements, activities to promote green building practices, and further climate change regulations that may impact the operations of cement plants and coal-fired electricity generating facilities. Therefore a static factor based on three years of historical data was reasonable to characterize the business as usual rate of fly ash usage on a project specific basis.

The recommended baseline condition for the proposed protocol is the GHG emissions associate with the production of a functionally equivalent mass of cement that has been displaced by the incremental fly ash used by the project proponent. The baseline GHG emissions will be quantified based on the baseline GHG intensity of cement production in Alberta and the incremental quantity of fly ash used in the project crediting year relative to historic levels during 1999-2001.

B.11 Definition of the Project Condition

The proposed protocol is applicable to projects that involve the mixing of fly ash with cement to decrease the quantity of cement required in concrete or other cement based products and therefore reduce GHG emissions associated with the production of cement from raw materials. In the project condition the fly ash may enter the cement product supply chain at a variety of points, which may include transportation to cement production plants, product mixing facilities, intermediate distribution centres or transported directly to the site of concrete pouring or other end use. The fly ash may ultimately be used in many different applications as a replacement for cement and therefore the quantification of GHG emissions is focussed on the tonnes of cement displaced by fly ash.

To demonstrate that a project is covered by the scope of the proposed protocol, the project proponent must show that certain activities (e.g. the implementation or expansion of a marketing/ distribution system for fly ash, changes in mixing facility operating practices, construction of a fly ash storage silo or increased purchase or use of fly ash in place of cement products) have resulted in the incremental use of fly ash in place of conventional cement products and/or that the fly ash would normally have been managed differently. This justification combined with the baseline definition of business as usual use of fly ash will provide the project proponent with the mechanisms to demonstrate the incremental GHG benefit of increasing the use of fly ash and how barriers to project implementation were overcome.

B.12 Functional Equivalence

The project and the baseline should provide the same function and quality of products or services. This type of comparison requires a common metric or unit of measurement for comparison between the project and baseline activities. In order for the use of fly ash as a partial substitute for cement to be functionally equivalent to the conventional use of cement (without fly ash), the cement based product containing fly ash must provide the same function as the conventional product. This form of functional equivalence is achieved by using an appropriate cement to fly ash replacement ratio. Research conducted by Natural Resources Canada (NRCan) yielded a cement to fly ash replacement ratio of 0.88[24]. This cement to fly ash replacement ratio factor (tonnes of cement displaced per tonne of fly ash used) is based on the assumption that concretes containing some fly ash and those that only contain cement have similar 28 day compressive strengths and workability. It is based on laboratory data on concrete using fly ashes from eastern and mid-western Canada, and validated by field data provided by ready mixed concrete companies from western Canada. This factor represents a conservative approach to determining the quantity of cement displaced by fly ash for the majority of applications.

Additional research from the US Department of Energy, through the Utility Solid Waste Activities Group, confirms the magnitude of the value presented by the NRCan report. An average cement to fly ash replacement ratio of 0.91 was assumed in this research for most construction, manufacturing and grout applications[25].

The use of the cement to fly ash replacement factor will ensure that functional equivalence is met provided that the project proponent tracks the use of fly ash in the project condition on a mass basis.

B.13 Flexibility Mechanisms

The inclusion of flexibility mechanisms is recommended in the proposed protocol to allow project proponents to address project specific issues that may require contingent methods of data collection or alternative quantification approaches. The project proponent will have to justify their application of any flexibility mechanisms within the proposed protocol such that the quantification approaches and data quality meet the minimum standards specified in the proposed protocol. The following flexibility mechanisms are recommended:

Project specific cement to fly ash replacement ratio. The project proponent may define and justify a project specific cement to fly ash replacement ratio (tonnes of cement displaced per tonne of fly ash used) based on measured fly ash and cement usage data from at least one year of operations for their specific application of fly ash. This factor may be substituted for the conservative replacement ratio discussed in Section B.12 in this document. The methodology for generation of this factor must ensure accuracy and be robust enough to provide an uncertainty range.

Project specific baseline emissions intensity factor. The project proponent may choose to develop a baseline GHG emissions intensity factor for cement production using project specific fuel consumption and process emissions data from one or more cement production plants in place of the aggregated values recommended in this document. The

[24] Estimating GHG Savings from Use of Fly Ash (NRCan, October 2006)
[25] Revised General Guidelines and Draft Technical Guideline for EPACT Section 1605(b) Voluntary GHG Reporting (US DOE, June 2005)

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development of the baseline GHG intensity should reference Good Practice Guidance and account for all direct GHG emissions at the facility per unit of cement product output consistent with the quantification approaches outlined in the Alberta SGER Technical Guidance Document for Baseline Emission Intensity Applications. There exists a wide range of other good practice guidance related to the quantification of GHG emissions from cement production including, but not limited to, Environment Canada's Cement Production: Guidance Manual for Estimating Greenhouse Gas Emissions, the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) GHG Protocol Initiative, California Climate Action Registry (CCAR) Cement Reporting Protocol and the Clean Development Mechanism (CDM) Methodology ACM0005.

Project specific emission factors. Site specific emission factors may be substituted for the generic emission factors recommended by the proposed protocol. Some cement plants may employ Continuous Emissions Monitoring Systems (CEMS) or conduct frequent fuel analyses (e.g. fuel heating value and carbon content) which can effectively be used to determine site-specific emission factors that may be more appropriate than the default emission factors. The methodology for generation of these emission factors must ensure accuracy and be robust enough to provide uncertainty ranges in the factors;

Adapting measurement and data management procedures. Measurement and data management procedures may be modified by the project developer to account for the available equipment as long as the specified minimum standards for data quantity, frequency and quality are met. Where these standards cannot be met, the project developer must justify why the method used represents a reasonable deviation from the proposed protocol methodology.

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