

By-Product Synergy Greenhouse Gases Accounting Tool

**Préparé par
Hatch**

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Pour

Canada 

Action Plan 2000 on Climate Change
Enhanced Recycling Program

Project Report

PR64982.002
FL64982.201
Page 2

**Natural Resources Canada
GHG Accounting Tool**

May 31, 2002
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DISTRIBUTION

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By-Product Synergy Greenhouse Gases Accounting Tool

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List of Appendices:

N.B. Appendix A1 is new to this report (Rev.1) and the appendices numbering has been changed accordingly throughout the document.

- Appendix A1:** BPS-GHG Tool – Flow Sheet
- Appendix A2:** Request for Information
- Appendix A3:** Boundaries of GHG Analysis
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1. Introduction

Natural Resources Canada is seeking to encourage Canadian industry to identify innovative approaches to resource recovery and move towards a 100% product operation. One of the potential benefits of implementing eco-industrial resource recovery and reuse opportunities is a reduction in greenhouse gas emissions associated with the extraction and processing of raw materials, as well as production of the final product. This project uses life cycle analysis (LCA) concepts and applies them in a limited manner focusing only the greenhouse gas emission factors. The result is a tool that can be used to assess the potential for Canadian industry to use innovative approaches such as By-Product Synergy¹ to reduce greenhouse gas emissions (GHGs).

This report is supporting documentation for the GHG Accounting Tool, which has been provided to Natural Resources Canada. The report describes the tool and how it is applied and then demonstrates the results of a preliminary testing of the tool on two real life examples of By-Product Synergy projects currently being implemented. The report also makes recommendations for future testing and development of this approach to GHG accounting.

1.1 Project Objectives

The main objective of this project was to develop a life cycle analysis approach for estimating the greenhouse gas savings potential of by-product synergies or industrial eco-efficiency projects. The tool that has been developed to present this approach identifies the key issues and factors that should be considered when evaluating the potential GHG impacts of eco-efficiency efforts. Use of this approach, and further development of the tool, could represent a significant opportunity for the gaining an understanding of the impact of eco-efficiency efforts across the Canadian economy.

2. The GHG Accounting Tool

2.1 Structure of the BPS-GHG Tool

This tool is designed and runs in Excel using Visual Basic code (MS Office 2000). It is composed of 5 worksheets:

- Worksheet 1 – Instructions: this sheet gives the user an introduction to the tool, followed by basic instructions on how to follow through the programme. Most cells are colour coded to define the purpose, i.e. required information, calculated by the worksheet and etc.
- Worksheet 2 – BASE - Generator: this is the input page for the GHG emissions associated with the handling of the by-product. The company who is generating the by-product should fill this sheet in.
- Worksheet 3 – BASE - User: this is the input page for the GHG emissions associated with the potential user's processing routine. The user is asked for the GHG emissions associated

¹ Golden Horseshoe By-Product Synergy, Phase I – Project Report (Hatch, Canada, 2002)

with their entire processing routine. As well, if the by-product could replace a raw material input, this sheet will guide the user through assessing the GHG emissions associated with just those raw materials (going upstream, i.e. extraction, manufacturing and transportation).

- Worksheet 4 – The SYNERGY: information on by-product generation and use would be input into this page. This page will summarize the GHG emissions associated with the handling the by-product for transporting to the potential user, the GHG emission associated with using that by-product as an additional raw material input or as a material replacement in the user's production process.
- Worksheet 5 – GHG Difference: this sheet will summarize the GHG emissions values from the previous three sheets, conduct a unit conversion and calculate the potential GHG emissions savings (increases) that would result from implementing the by-product synergy.

To understand the different steps of the GHG Accounting Tool and how it can be used, please refer to Appendix A1 for a graphical presentation.

2.2 Complexities and Benefits of this GHG Accounting Tool

Throughout the development of this GHG accounting methodology, opportunities were identified to enhance the value of the tool to make it more widely applicable and user friendly. These enhancements were incorporated into the tool, which can be used to assess the GHG implications of eco-efficiency initiatives that may be far more complex than the two examples assessed in this project. For example, both our selected synergies involve a material replacement on a one-to-one mass ratio. However, the tool has been developed to accommodate situations where a by-product may replace a current raw material input at an uneven ratio. For example, provisions have been made to assess a situation where a by-product may replace more than one raw material inputs (each at different ratios), or may be added to a current process as an additional material.

Hatch also added additional value to the tool by making it as user-friendly as possible. To help achieve this objective, cells that require data input are either already highlighted yellow or become highlighted yellow as the user moves through the tool. Radio buttons and pull-down bars were used wherever possible. If the tool is to become part of a standard resource recovery evaluation package then it should be field tested on a wide range of potential projects. Linking to an available database of emission factors (such as Environment Canada's) may represent an opportunity to enhance the tool and start to raise the profile of resource recovery efforts in terms of its GHG reduction potential.

3. Application of the Tool

The methodology we used in constructing the template for estimating the greenhouse gas savings potential of by-product synergies was applied to two case examples of by-product synergies using the following approach:

- Evaluating the potential greenhouse gas impacts associated with the current disposal methods of the by-products.

- Compiling an inventory of the relevant inputs and outputs of the product system for which the by-product will be used as an alternative material.
- Evaluating the potential greenhouse gas impacts associated with the inputs, outputs processing and handling methods for that product system.
- Evaluating the potential greenhouse gas savings or impacts associated with the use of those by-products in the product system as replacement material.

For both synergies, we reviewed the greenhouse gas emissions for each of the life cycle steps that are involved in getting the by-product to the user for replacement of an original material input, and comparing that with the greenhouse gas emissions associated with the original steps involved in handling or disposing the by-product, and with the greenhouse gases emissions associated with the production of the material that the by-product is replacing.

We compared two systems for each by-product synergy. They are the base-case and the synergy-case. The equivalence of the systems being compared was evaluated before interpreting the results. The systems were compared using the same functional unit and equivalent methodological considerations, i.e. boundaries.

In addition to the data solicited through the Golden Horseshoe BPS project, detailed questionnaires were sent to participating companies to collect further data (Appendix A2). We have been talking regularly with the steel company and the oil refinery. We used public/documented data for cement production and will be making assumptions where necessary.

We have sourced general production information for steel, carbon black, asphalt and cement, including emissions information and data from participating companies, as well as available literature (due to the proprietary nature of these processes).

3.1 By-Product Synergies Selected for Testing the Tool

The following two synergies were selected from the Golden Horseshoe By-Product Synergy Project.

1. By-product carbon black fines from activated carbon process to be used as a substitute fuel in a cement kiln.
2. By-product steel slag from the steel making process to be used as a raw material in producing asphalt.

The analysis boundaries are graphically in Appendix A3.

3.2 Boundaries and Level of Detail

The focus of this study is on greenhouse gas emissions and a life cycle approach is used. The GHG accounting tool considers greenhouse gas emissions associated with each life cycle step involved in getting the by-product to the user for addition to the process or replacement of an original raw material input, the original steps involved in handling the by-product, and the production of the material that the by-product might be replacing.

The level of detail of this life cycle analysis includes all greenhouse gas emissions that are within the scope of the boundaries outlined in Appendix A3.

Information was respected and we have substituted confidential data with assumptions that will reflect typical processes and activities.

3.3 Results

- Example 1: By-product carbon black fines from activated carbon process to be used as a substitute fuel in a cement kiln. Implementation of this synergy would result in a reduction in GHG (CO₂ equivalent basis) emissions of 14 kg/tonne of carbon black used. The results of the analysis are presented in Appendix A4.
- Example 2: By-product steel slag from the steel making process to be used as a raw material in producing asphalt. Implementation of this synergy would result in a reduction in GHG (CO₂ equivalent basis) emissions of 7 kg/tonne of steel slag used. The results of the analysis are presented in Appendix A4.

4. Recommendations

- The Golden Horseshoe By-Product Synergy Project companies participated directly in the development of this tool. It is recommended that those companies be approached to field test the tool and possibly apply it in various eco-efficiency scenarios.
- The potential for linking the tool to various existing GHG databases (i.e. Environment Canada) should be investigated.
- Consideration could be given to using the tool in a standard resource recovery project implementation.

5. Acknowledgements

Hatch would like to thank representatives from Golden Horseshoe By-Product Synergy member companies Columbian Chemicals, Dofasco and Petro-Canada for their input to the project. Hatch would also like to recognize the efforts of Natural Resources Canada for providing direction and input to the development of the tool.

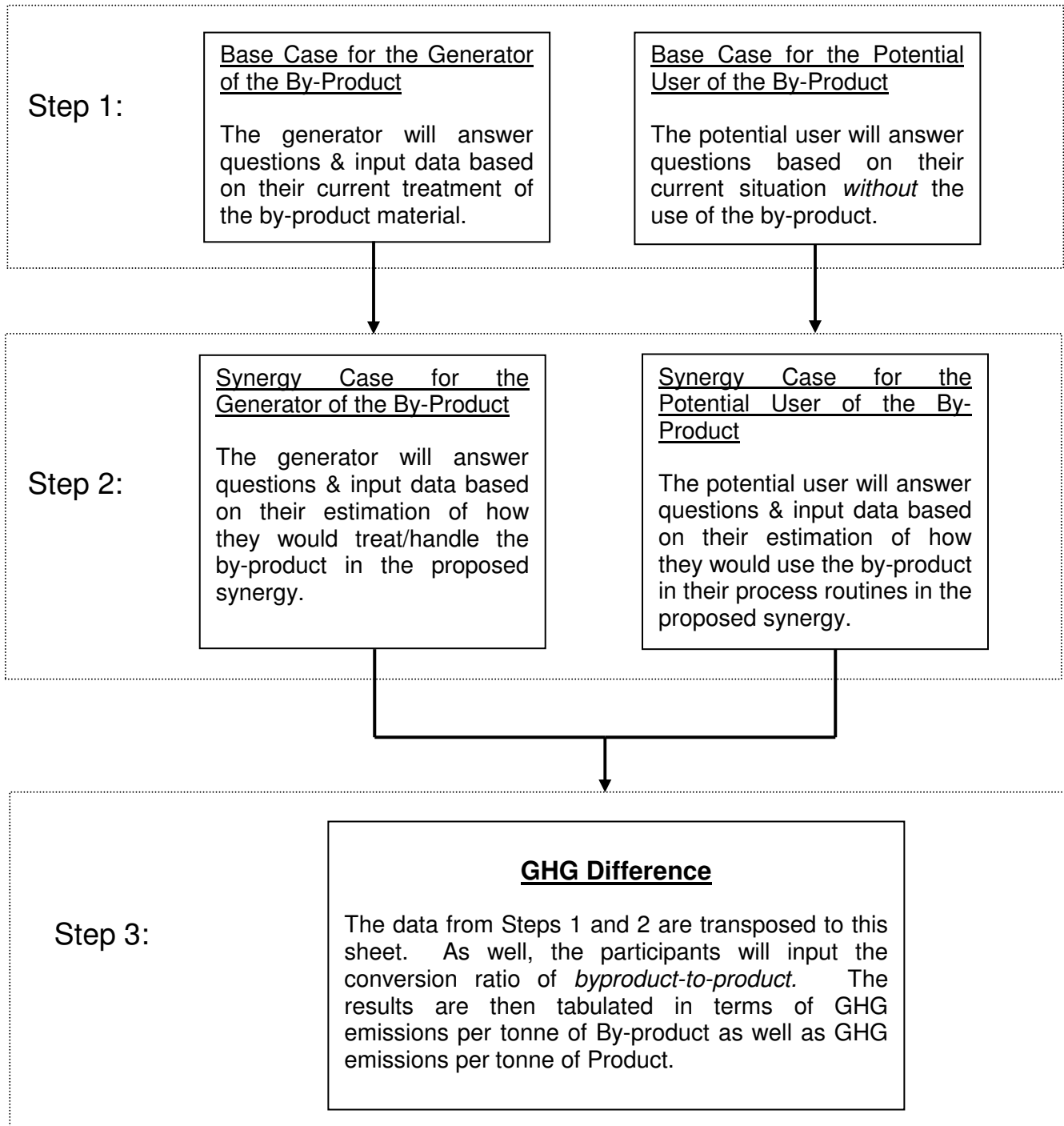
Sabrina Dias
Jim Farrell

SB/JF:aa
Attachments

Appendix A1

BPS-GHG Tool – Flow Sheet

BPS-GHG Tool – Flow Sheet



Appendix A2

Request for Information

Project Memo

PM64982.002
FL64982.101.03
Page 11

April 15, 2002

TO: Howard Holt - Dofasco
Brian Young - Columbian Chemicals

FROM: Sabrina Dias

cc: Jim Farrell

**Natural Resources Canada
Life Cycle Analysis**

Life Cycle Analysis - Request for Information By-product Carbon Black

1. Introduction

Hatch is conducting a life cycle analysis project for Natural Resources Canada to assess the potential for greenhouse gas emissions through two synergy ideas from the Golden Horseshoe By-Product Synergy Project. Dofasco and Columbian Chemicals are involved in the carbon black synergy that involves the transportation and storage of by-product carbon black fines from Columbian Chemicals by Dofasco until it is used as a substitute fuel in a cement kiln. The synergy's base case and alternative case are described in more detail in the attached project report.

The following sections contain questions designed to gather pertinent information that will allow Hatch to properly estimate the greenhouse gas emissions from these synergies.

2. Columbian Chemicals

2.1 Base Case: spent carbon black to landfill

- 1) Do you transport the spent carbon-black to the landfill? - Yes/No.
- 2) Do you use mechanical means to *collect* the spent carbon black? – Yes/No.
- 3) Do you use mechanical means to *package* the spent carbon black? – Yes/No.

- 4) Do you use mechanical means to *load* the spent carbon black onto the truck? – Yes/No.
- 5) How far is the landfill from your site? – km.
- 6) What is the name of the landfill? (if possible).
- 7) What type of truck do you use to transport the spent carbon black?
- 8) Does your by-product carbon black need processing before landfilling? – Yes/No.
- 9) If Yes to number 7, please elaborate.

2.2 Alternative Case: spent carbon black to Dofasco

- 10) Do you transport the spent carbon-black to Dofasco? - Yes/No.
- 11) Do you use mechanical means to *collect* the spent carbon black? – Yes/No.
- 12) Do you use mechanical means to *package* the spent carbon black? – Yes/No.
- 13) Do you use mechanical means to *load* the spent carbon black onto the truck? – Yes/No.
- 14) How far is Dofasco from your site? – km.
- 15) What type of truck do you use to transport the spent carbon black?
- 16) Does your by-product carbon black need processing before transporting it to Dofasco? – Yes/No.
- 17) If Yes to number 16, do your process your by-product carbon black using mechanical methods? – Yes/No.

3. Dofasco

3.1 Alternative Case: accepting spent carbon black

- 1) Do you use mechanical means to unload the spent carbon black from the truck onto on your site? – Yes/No.
- 2) Do you need to process the spent carbon black before depositing it into your coal pile? – Yes/No.
- 3) Do you need to process the spent carbon black to meet the cement company's raw material requirements? – Yes/No.
- 4) If yes to number 3, what type of processing is required and what type of equipment do you use?

- 5) Does the spent carbon black change the GHG emissions from your client's (cement company) operations? – Yes/No.
- 6) Does the spent carbon black replace your client's (cement company) raw material on a 1:1 mass basis? – Yes/No.
- 7) If No to number 6, what is the replacement ratio?
- 8) Do you transport the spent carbon-black to the cement company? - Yes/No.
- 9) Do you use mechanical means to *collect* the spent carbon black? – Yes/No.
- 10) Do you use mechanical means to *load* the spent carbon black onto the truck? – Yes/No.
- 11) What type of truck do you use?
- 12) How far is the cement company from your site? – km.

SD:aa

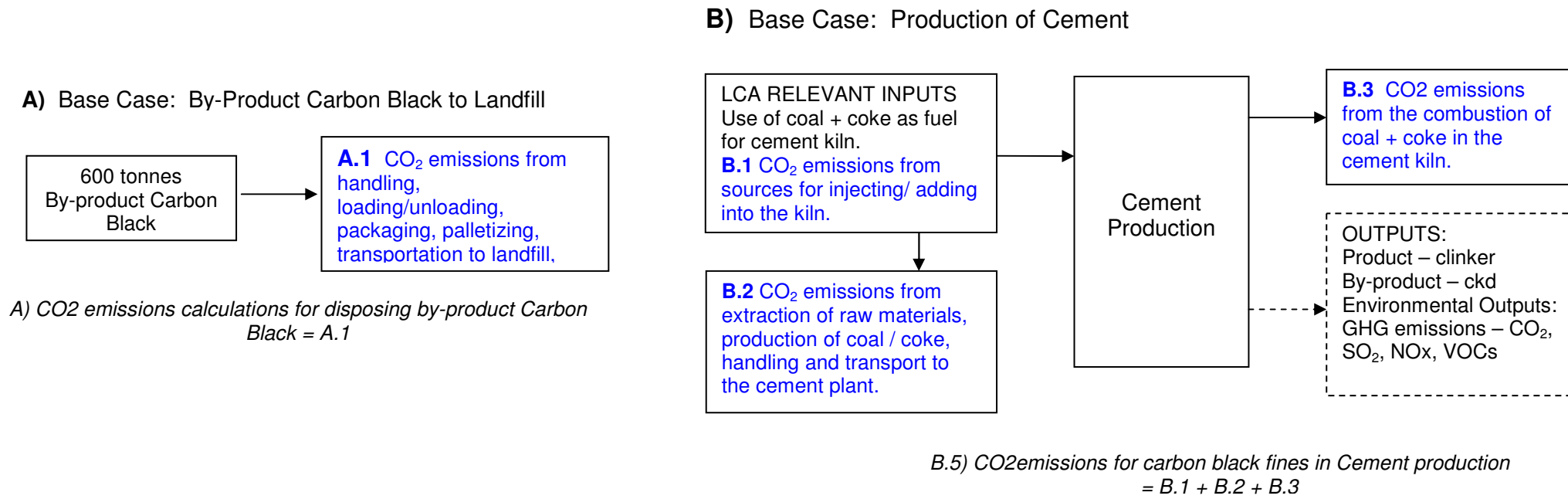
Appendix A3

Boundaries of GHG Analysis

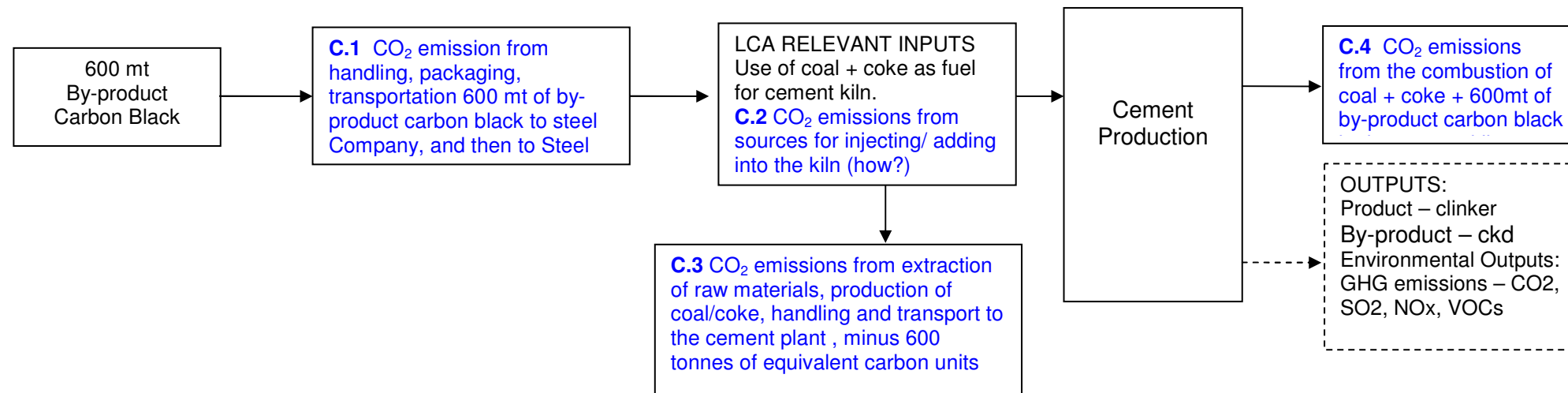
(Two pages to be printed on 11 X 17 paper)

3.1.1 Schematic of By-product Carbon Black Synergy

Please note that only the blue steps are included in this LCA approach to assess the greenhouse gas implications of this synergy.



C) Alternative Case: By-Product Carbon Black to Cement Company via Steel Company



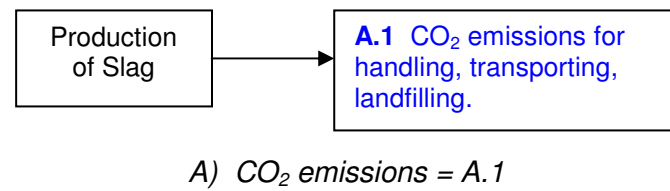
Greenhouse Gas Emissions

- A)** The greenhouse gas emissions associated with the original steps (base case) for disposal of the by-product carbon black.
- B)** The greenhouse emissions associated with the original steps (base case) for the production of cement for which the by-product is going to be used through this synergy.
- C)** The greenhouse gas emissions associated with each life cycle step involved in the synergy – getting the by-product carbon black to the steel plant and then to the cement plant for substitution of coke as fuel in the cement kiln. And then the greenhouse gas emissions associated with the production of cement using 600 tonnes of by-product carbon black as a substitute for an equivalent amount of coke.

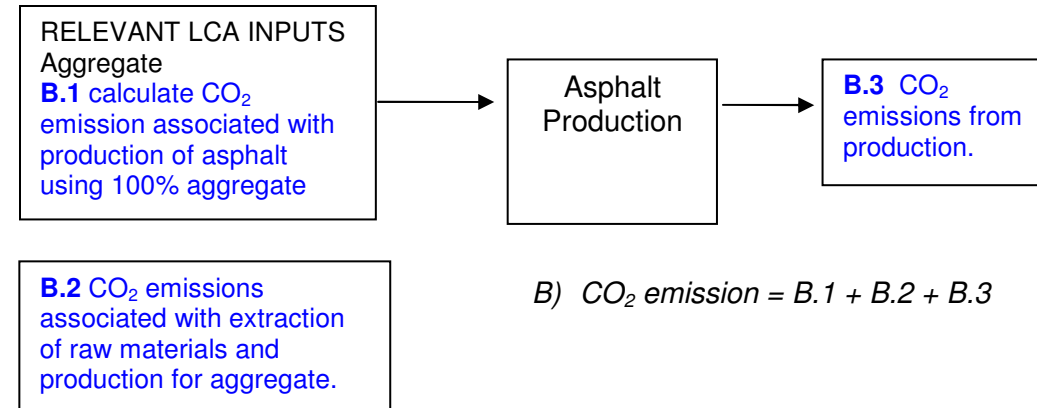
3.2.2 Schematic of By-product Steel Slag Synergy

Please note that only the blue steps are included in this LCA approach to assess the greenhouse gas implications of this synergy.

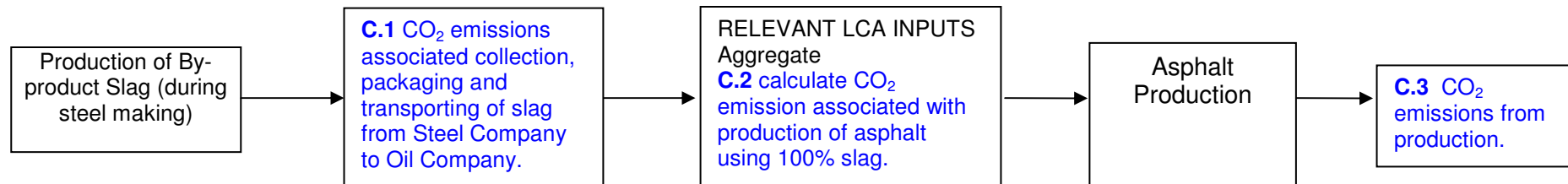
A) Base Case – slag production



B) Base Case – asphalt production



C) Alternative: Use of By-product Slag from Steel Making in Production of Asphalt.



Greenhouse Gas Emissions

- A)** The greenhouse gas emissions associated with the original steps (base case) for disposal of the by-product slag.
- B)** The greenhouse emissions associated with the original steps (base case) for the production of asphalt, using 100% gravel for which the by-product slag is going to be used through this synergy.
- C)** The greenhouse gas emissions associated with each life cycle step involved in the synergy – getting the by-product slag to the oil refinery plant (or site of asphalt production) for substitution of gravel in making asphalt. And then the greenhouse gas emissions associated with the production of asphalt using 100% of by-product slag as a substitute for an equivalent amount of gravel.

Appendix A4

BPS-GHG Tool

See spreadsheet models in the following two files:

Appendix A4 BPS-GHG Tool_slag.xls

Appendix A4 BPS-GHG Tool_carbon black.xls

By-Product Carbon Black

The denominator

GHG emissions value			
BASE CASE		per tonne of by-product	per tonne of product
GHG emissions associated with generator		2.04	2.29
GHG emission associated with the user		474.12	532.72

What is your conversion ratio of by-product:product?

0.89

The SYNERGY			
		per tonne of by-product	per tonne of product
GHG emissions associated with generator		2.88	3.24
GHG emission associated with the user		458.99	515.72

What is your conversion ratio of by-product:product?

0.89

Change in GHG emissions value:

Units:	delta(GHG)	=	[GHG(base-generator) + GHG(base-user)]	-	[GHG(alternative-generator) + GHG(alternative-user)]				
GHG emissions per tonne of By-product	14.29		2.04		474.12		2.88		458.99

By-Product Steel Slag

The denominator

GHG emissions value			
BASE CASE		per tonne of by-product	per tonne of product
GHG emissions associated with generator		3.97	12.24
GHG emission associated with the user		14.58	45.00

What is your conversion ratio of by-product:product?

0.324

The SYNERGY			
		per tonne of by-product	per tonne of product
GHG emissions associated with generator		10.77	33.24
GHG emission associated with the user		0.81	2.50

What is your conversion ratio of by-product:product?

0.324

Change in GHG emissions value:

Units:	delta(GHG)	=	[GHG(base-generator) + GHG(base-user)]	-	[GHG(alternative-generator) + GHG(alternative-user)]				
GHG emissions per tonne of By-product	6.97		3.97		14.58		10.77		0.81

Appendix A5

The BPS-GHG Tool is contained in the following file:

Appendix A5 BPS-GHG Tool.xls

Welcome to the BPS-GHG Tool !

The BPS-GHG Tool is meant to be used as a guide to assist you in organizing your process information and GHG emissions so that you can evaluate the potential GHG savings your company could experience by implementing a by-product synergy. It will not provide you with GHG emissions values for any relevant processes or materials.

It is recommended that the user of this tool read and become familiar with all parts of the tool.

Worksheet 1: Instructions
Worksheet 2: BASE - generator
Worksheet 3: BASE - user
Worksheet 4: The SYNERGY
Worksheet 5: GHG difference.

For those entering GHG emissions data into the "BASE - generator" worksheet, please be aware that the unit is "GHG emissions per tonne of By-product".

For those entering GHG emissions data into the "BASE - user" worksheet, please be aware that the unit is "GHG emissions per tonne of Product". In other words, we are aiming to calculate the GHG emissions associated with specific raw material(s) needed to produce one tonne of your product.

The final sheet contains conversions so that you may express the "GHG emissions value per tonne of By-product" or "GHG emissions value per tonne of Product", depending on your preference.

Required inputs - any block that is or becomes highlighted in YELLOW, must fill in details

Optional Inputs - any cell that is or becomes highlighted in GREEN, details are optional

Referenced to another cell - ORANGE

Calculated on this Worksheet - do not edit BLUE cells, they are protected.

Referenced to another Worksheet - do not edit FUSCIA cells, they are protected.

Automatically Input by spreadsheet - these details are provided in RED TEXT, do not edit.

PINK callouts & boxes
provide tips to the user
of this tool.

Base Case for the Generator of the By-Product

1) Current Use of Material (choose one):	Y or N	Fraction (%)
a) Left in Situ	<input type="checkbox"/> Yes <input type="checkbox"/> No	
b) Landfill or Disposal	<input type="checkbox"/> Yes <input type="checkbox"/> No	
c) Currently being used	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Total:		0%

1a) Left in Situ - Details:	Answer	GHG emissions Value per tonne of By-product
Organic?	<input type="checkbox"/> Yes <input type="checkbox"/> No	
Inorganic?	<input type="checkbox"/> Yes <input type="checkbox"/> No	0
TOTAL:		0

1b) Landfill or Disposal - Details:	Answer	GHG emissions Value per tonne of By-product
i) Is it transported?	<input type="checkbox"/> Yes <input type="checkbox"/> No	
ia) How is it transported?	None	
ib) Fuel	None	
ic) Distance (km)	0	
id) GHG emissions associated with transportation		
ii) Mechanical Loading/Unloading	<input type="checkbox"/> Yes <input type="checkbox"/> No	
iii) Is material processed first?	<input type="checkbox"/> Yes <input type="checkbox"/> No	
iv) Packaging - mechanical means?	<input type="checkbox"/> Yes <input type="checkbox"/> No	
TOTAL:		0
Fraction:		0

Be sure to consider all aspects, i.e. transport, processing, packaging, ...
OR
you may use questions iii) - vii) below as a guide to estimating the GHG emissions for your by-product.

1c) Current Use- Details:	Answer	GHG emissions Value per tonne of By-product
i) How is it currently being used?		
ii) What are the GHG emissions associated with its current use?		
iii) Is it transported?	<input type="checkbox"/> Yes <input type="checkbox"/> No	
iiia) How is it transported? (air, truck...)	None	
iiib) Fuel	None	
iiic) Distance (km)		
iiid) GHG emissions associated with transportation		
iv) Mechanical Loading/Unloading	<input type="checkbox"/> Yes <input type="checkbox"/> No	
v) Is material processed first?	<input type="checkbox"/> Yes <input type="checkbox"/> No	
vi) Packaging - mechanical means?	<input type="checkbox"/> Yes <input type="checkbox"/> No	
vii) ...n steps		
TOTAL:		0
Fraction:		0

TOTAL GHG emissions per tonne of By-product associated with the by-product from the Generator:	0
--	---

Base Case for the Potential User of the By-Product

2-1) Current Situation:	GHG emissions value per tonne of Product
What are the GHG emissions associated with your current production process?	

GHG emissions associated with production process of your final product using all original raw materials (before synergy).

The by-product could be used as an additional material, added to your current input stream, or, it could be used to replace one or more existing raw materials. The questions in this section will help you to define the GHG emission associated with the material(s) that you could be replacing with the by-product.

2-2) Potential Situation:	Yes or No
A) Could the by-product be an <i>additional</i> material to the production process?	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No
B) Could the by-product be a <i>replacement</i> material in the production process?	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No

2-2A) Additional material - Details What are the GHG emission associated with the production process that uses this by-product as an additional material?		GHG emissions value per tonne of Product
TOTAL:		0

2-2B) Replacement Material - Details. How many materials could the by-product replace? (1, 2, 3)	▼
---	---

Material #1		
Please break down the GHG emissions per step associated with the material for which the by-product could <i>replace</i> . (upstream GHG emissions).		
		GHG emissions value per tonne of Product
i) Extraction of raw materials	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
ii) Transportation from mine to next point	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
iii) Processing	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
iv) Transportation from previous to next point	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
v) Manufacturing	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
vi) Packaging	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
vii) Transportation to production plant	<input type="checkbox"/> Yes <input checked="" type="checkbox"/> No	
... n		
TOTAL		0

Summary:	
GHG emissions associated with your current situation (1):	0
GHG emissions associated with the potential material to be replaced (2):	0
Difference between 1 and 2	0

The SYNERGY																																		
This Section will help you to assess the GHG emissions associated with the potential synergy.																																		
3-1) The Generator's new handling of the by-product: Your by-product will be sent to the potential user.																																		
	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;">Details:</th> <th style="width: 20%;">Response:</th> <th style="width: 30%;">GHG emissions value:</th> </tr> </thead> <tbody> <tr> <td>i) Mechanical means to <i>collect</i> the by-product?</td> <td><input type="checkbox"/> Yes <input type="checkbox"/> No</td> <td></td> </tr> <tr> <td>ii) Mechanical means to <i>package</i> the by-product?</td> <td><input type="checkbox"/> Yes <input type="checkbox"/> No</td> <td></td> </tr> <tr> <td>iii) Mechanical means to <i>load</i> the by-product?</td> <td><input type="checkbox"/> Yes <input type="checkbox"/> No</td> <td></td> </tr> <tr> <td>iv) Do you need to process/treat the by-product before sending it to the user?</td> <td><input type="checkbox"/> Yes <input type="checkbox"/> No</td> <td></td> </tr> <tr> <td>v) Do you transport the by-product to the user?</td> <td><input type="checkbox"/> Yes <input type="checkbox"/> No</td> <td></td> </tr> <tr> <td>v-a) How do you transport the by-product to the user?</td> <td><input type="text" value="Other"/></td> <td style="background-color: #cccccc;"></td> </tr> <tr> <td>v-b) Fuel</td> <td><input type="text" value="Choose One"/></td> <td style="background-color: #cccccc;"></td> </tr> <tr> <td>v-c) Distance to user? (km)</td> <td></td> <td style="background-color: #cccccc;"></td> </tr> <tr> <td>v-d) GHG emissions associated with transport.</td> <td></td> <td style="background-color: #ffff00;"></td> </tr> <tr> <td colspan="2" style="text-align: right;">TOTAL:</td> <td style="background-color: #00bfff; text-align: center;">0</td> </tr> </tbody> </table>	Details:	Response:	GHG emissions value:	i) Mechanical means to <i>collect</i> the by-product?	<input type="checkbox"/> Yes <input type="checkbox"/> No		ii) Mechanical means to <i>package</i> the by-product?	<input type="checkbox"/> Yes <input type="checkbox"/> No		iii) Mechanical means to <i>load</i> the by-product?	<input type="checkbox"/> Yes <input type="checkbox"/> No		iv) Do you need to process/treat the by-product before sending it to the user?	<input type="checkbox"/> Yes <input type="checkbox"/> No		v) Do you transport the by-product to the user?	<input type="checkbox"/> Yes <input type="checkbox"/> No		v-a) How do you transport the by-product to the user?	<input type="text" value="Other"/>		v-b) Fuel	<input type="text" value="Choose One"/>		v-c) Distance to user? (km)			v-d) GHG emissions associated with transport.			TOTAL:		0
Details:	Response:	GHG emissions value:																																
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v-b) Fuel	<input type="text" value="Choose One"/>																																	
v-c) Distance to user? (km)																																		
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