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GREENHOUSE GAS EMISSIONS REPORT

NPD CLOSURE PROJECT

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Revision 1

Accepted by:

Brian Wilcox
Director, Reactor Decommissioning
(NPD & WR-1)

2020/03/28

Date

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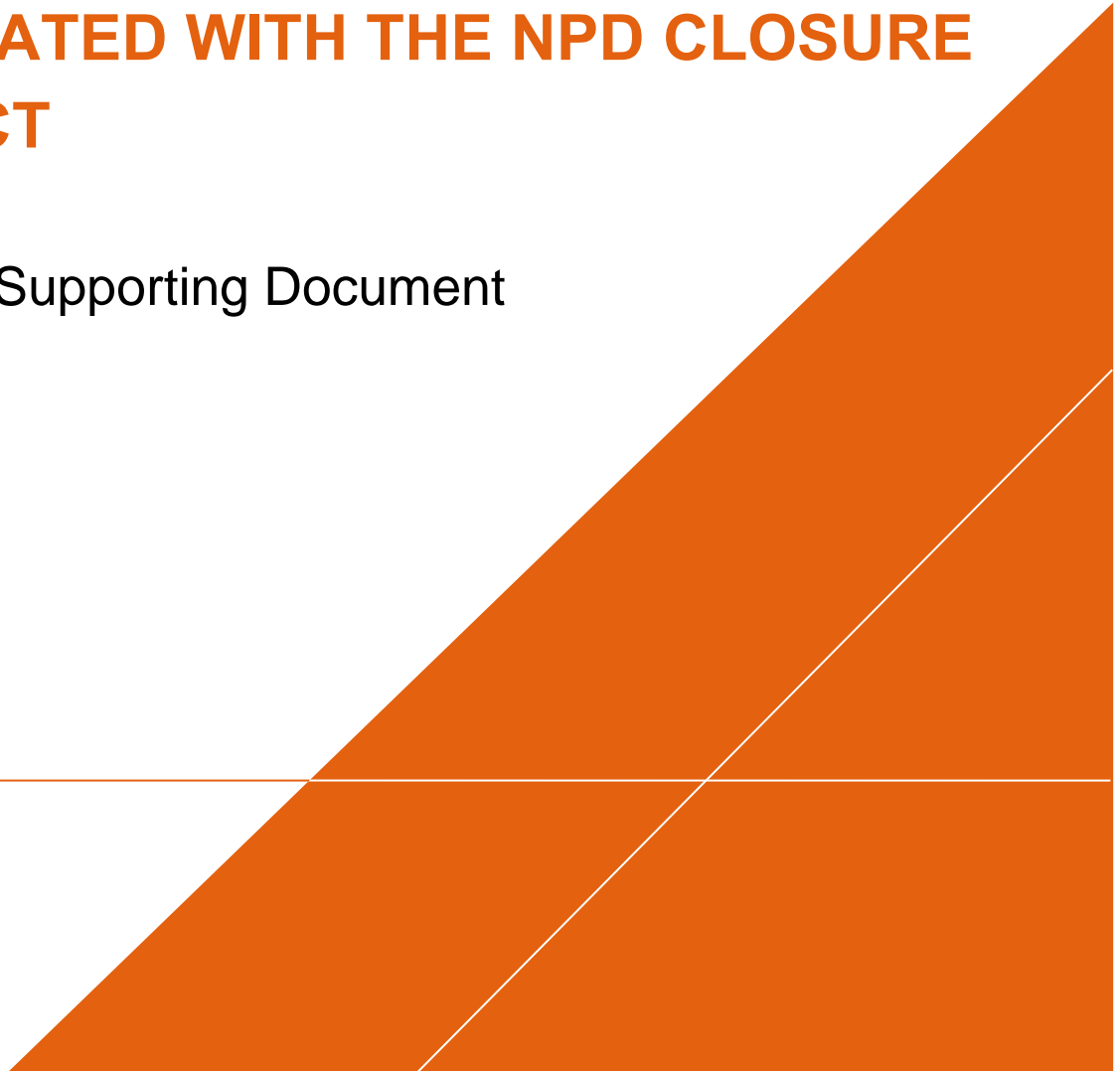
Canadian Nuclear Laboratories

FINAL

GREENHOUSE GAS EMISSIONS ASSOCIATED WITH THE NPD CLOSURE PROJECT

Technical Supporting Document

February 2020



Technical Supporting Document - Greenhouse Gas Emissions Associated with the NPD Closure Project

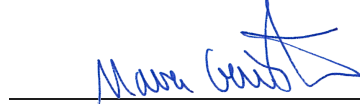
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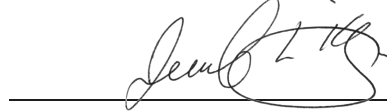
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GREENHOUSE GAS EMISSIONS ASSOCIATED WITH THE NPD CLOSURE PROJECT

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ACRONYMS AND ABBREVIATIONS

EA	Environmental Assessment
FPTCCCEA	Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment
GCL	Geosynthetic Clay Liner
GHG	Greenhouse Gas
CNSC	Canadian Nuclear Safety Commission
CEPA	Canadian Environmental Protection Act
IPCC	Intergovernmental Panel on Climate Change
LCA	Life-Cycle Assessment
LULUCF	Land Use, Land-Use Change and Forestry
NPD	Nuclear Power Demonstration
NPRI	National Pollutant Release Inventory
TSD	Technical Supporting Document

1 INTRODUCTION

In November 2003, the Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment (FPTCCCEA) released a document entitled *Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners*. That Guidance Document, which is the most current guidance document available, requires that an Environmental Assessment (EA) must assess whether a proposed project may contribute to Greenhouse Gas (GHG) emissions. This Technical Supporting Document (TSD) follows the general methodology described in the FPTCCCEA document for including GHG emissions in the Environmental Assessment.

According to the Canadian Nuclear Safety Commission (CNSC)'s *Generic Guidelines for the Preparation of an Environmental Impact Statement (CNSC 2016a)*, both the direct (company controlled) and indirect (controlled by another party) GHG emissions linked to a project need to be assessed. The indirect emissions are associated with upstream activities. The definition of upstream includes "all industrial activities from the point of resource extraction to the project under review", which will vary depending on the project. This generally includes extraction of natural resources, processing and handling as well as transportation. Emissions are to be presented for each individual pollutant and summarized in units of CO₂ equivalent units per year.

The CNSC issued a draft guidance document for assessment GHG emissions from nuclear facilities, titled *Proposed CNSC Path Forward for Assessing Total GHG Production from Nuclear Facilities (CNSC 2016b)*. This document covers activities such as mining, fuel conversion and fabrication, nuclear power plant operation and waste disposal. This CNSC guidance document refers to ISO 14040: 2006 Environmental Management Life Cycle Assessment: Principles and Framework and ISO 14044: 2006 Environmental Management Life Cycle Assessment Requirements and Guidelines. The general approach described in this guidance document was followed in the present assessment. However, life-cycle GHG emissions associated with the construction and operation of the original reactor are not included in this assessment. The Project Description (Titterington 2016) bounds the start of this project as the decommissioning activities, and as such excludes the full life-cycle of the nuclear reactor.

This TSD presents the GHG emissions estimates prepared for the NPD Closure Project (also referred to as 'the project' in this report), based on information provided by CNL on project activities. The main direct and indirect source of GHG emissions (methane (CH₄), carbon dioxide (CO₂) or nitrous oxide (N₂O)) related to this project is expected to be the use of fossil fuels. There are no emissions of HFCs, PFCs or SF₆ associated with this project. GHGs will be emitted as a result of fuel combustion associated with the project-related construction equipment, construction-related traffic and grout and concrete manufacturing during the Decommissioning Execution phase of the project. During the Institutional Control phase, GHG emissions will be primarily a result of minor site-related vehicle traffic associated with site maintenance activities, which are considered negligible and not included in this assessment. The Decommissioning Execution phase activities are the focus of this assessment.

In the time since this TSD was prepared in 2016, the NPD closure project has refined the technical approach and engineering design for the project. The following changes affect GHG emissions.

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The first is a change in grout formulation. The NPD closure project will no longer be using fly ash as part of the grout recipe. Instead blast furnace slag will be used, which reduces the amount of Portland cement required in the grout. The use of blast furnace slag instead of fly ash would result in a decrease in GHG emissions because the energy required to produce Portland cement, and the amount of CO₂ released from the raw materials during its production, is significantly more than the energy needed to produce ground granulated blast furnace slag ^[1]. In addition, the source location for blast furnace slag is in the Kingston area, which is much closer to the NPD site than the source locations for fly ash (Minnesota or Nova Scotia).

Secondly, the volume of clay is reduced. Instead of trucking in clay separately to be used in the cover system, a Geosynthetic Clay Liner (GCL) (which is two layers of geotextile material with clay sandwiched between the layers) will be used. This change also results in considerably less GHG emissions than the original estimate. This TSD was prepared in the early stages of engineering design and accordingly used very cautious estimates for material and transport. Namely, the amount of clay was assumed to be equal to the amount of grout needed, resulting in an estimate of 4 trucks per hour * 12 h/d * 70 days of work = 3,360 truckloads. The GHG emissions even for this amount resulted in no residual effects. The current estimate is 15 truckloads to deliver the GCL, much lower than the amount assessed in this TSD. It follows that the GHG calculations in this TSD bound the current design plans for clay.

Finally, instead of the original assumption of four grout/concrete trucks per hour travelling from the batch mixing plant to the nuclear area, the grout will be delivered either through a pipeline from the batch plant to the facility, or through one Reimer truck (which allows for concrete mixing directly in the truck). Using a Reimer truck or pumping grout through a pipeline to the facility would reduce GHG emissions as the number of trucks needed for this task would be reduced from four to not more than one.

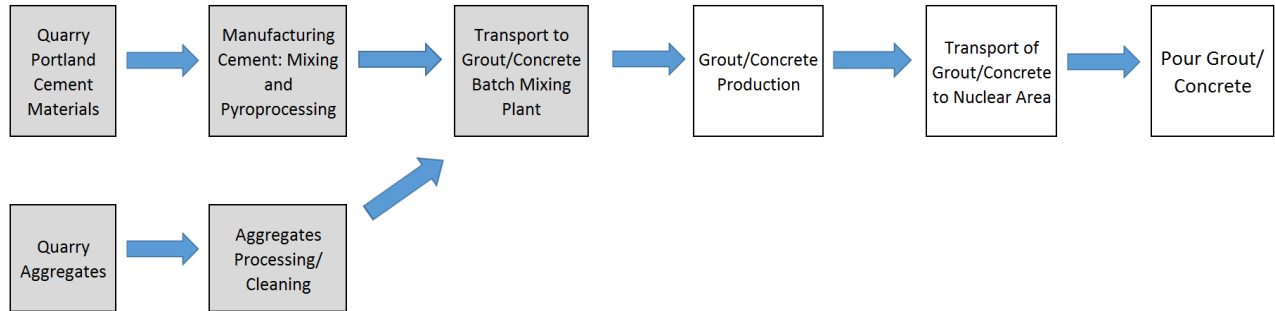
The conclusion of this TSD is that the project's GHG emissions (direct and life-cycle combined) are negligible in comparison to Ontario's total GHG emissions (i.e., less than 0.005%) and are approximately 0.3% of the Ontario total for cement production. The changes in engineering design described above would result in further reductions in GHG emissions. Therefore, CNL has determined that this TSD bounds the changes in engineering design.

Figure 1-1 illustrates the grout and concrete batch mixing plant process at a high level, which includes quarrying the raw materials, processing, transport, production and delivery. There are no GHG models available for grout. While the final composition of concrete and grout may be different, the processes of obtaining raw materials, mixing and pouring the final product are very similar. Consequently, cement / concrete production has been used as a surrogate. Figures 1-2 (cement manufacturing) and 1-3 (concrete (grout) manufacturing) illustrate in more detail the processes considered in the indirect and direct GHG emissions considered in this study.

¹ The energy to produce a tonne of cement is about 0.28 kilocalories per kilogram and one tonne of cement releases about 0.8 tonnes of CO₂. The manufacture of cement is responsible for about 5% of all global carbon dioxide emissions. In comparison, the production of ground granulated blast furnace slag (GBFS) requires less than a fifth of that energy and produces less than one tenth of the carbon dioxide emissions. Therefore, while well within the boundary scenario, reducing the Portland content of the grout further reduces the CO₂ impact. (From Divsholi, Lim and Teng, "Durability Properties and Microstructure of Ground Granulated Blast Furnace Cement Concrete", International Journal of Concrete Structures and Materials, vol. 8, No. 2 pp. 157-164, 2014 June.)

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Figure 1-1. Diagram of the Grout / Concrete Production Process



Note: Grey shading indicates activities for which emissions are considered indirect (i.e., controlled by another party, happening mostly off-site).

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Figure 1-2. Cement Production Processes and Associated Life-cycle Impacts

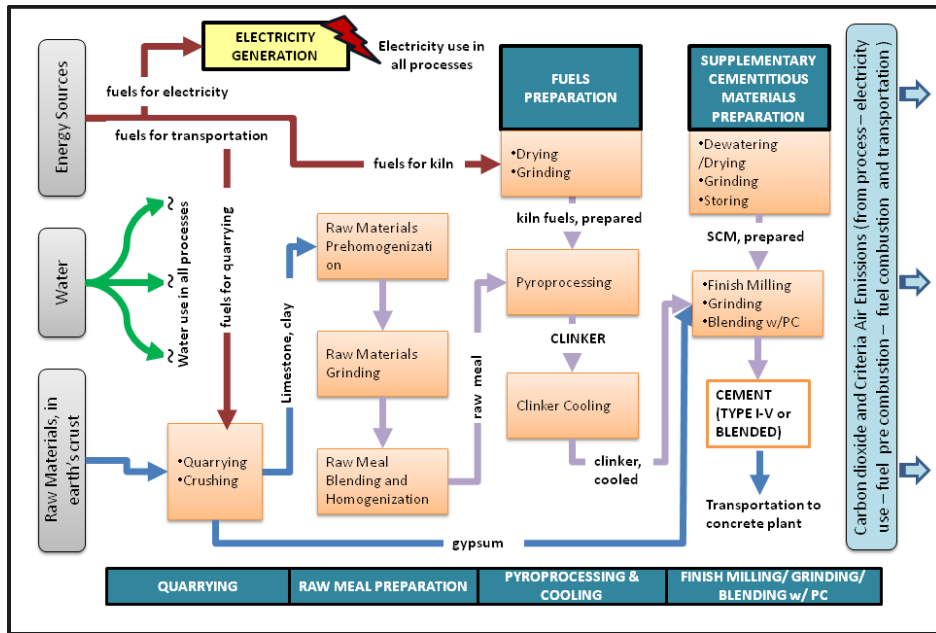
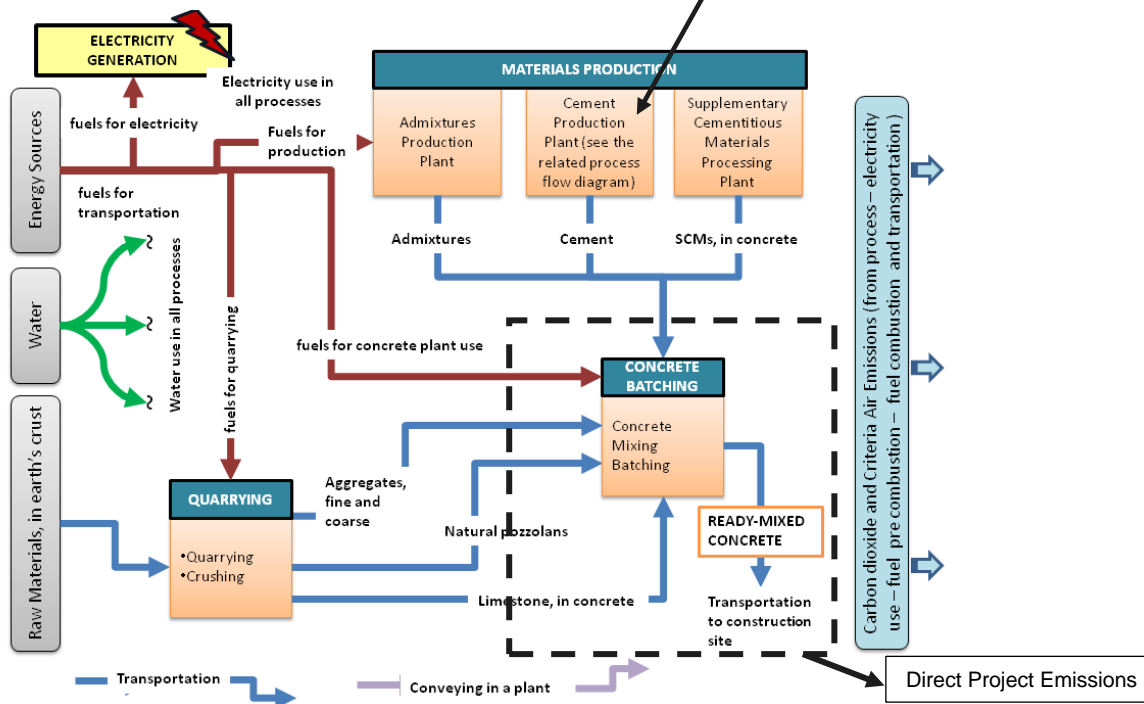


Figure 1-3. Concrete Production Processes and Associated Life-cycle Impacts



Source: Green Concrete LCA Web Tool (<http://greenconcrete.berkeley.edu/concretewebtool.html>)

2 ESTIMATED GREENHOUSE GAS EMISSIONS

GHG emissions during the Decommissioning Execution phase of the project consist of both direct emissions (company controlled) and indirect (controlled by another party) emissions. The indirect GHG emission estimates are described in Section 2.2 and direct GHG emission estimates are described in Section 2.3. GHG emissions associated with all of the processes illustrated in Figures 1-2 and 1-3 are considered in this analysis.

2.1 Scope of Activities Considered in the Analysis

Table 2-1 presents a list of activities included and excluded in the life-cycle assessment. As shown in the table, life-cycle GHG emissions associated with the construction and operation of the original reactor are not included in this assessment. The Project Description (Titterington 2016) bounds the start of this project as the decommissioning activities, and as such excludes the full life-cycle of the nuclear reactor.

Table 2-1 Activities Included and Excluded in Life-cycle Greenhouse Gas Emissions Estimate

Included	Excluded
<ul style="list-style-type: none"> • Raw material extraction and transport (indirect emission) • Cement production, which includes pyroprocessing (indirect emissions) • Transport of cement (indirect emissions) • Transport of fine and coarse aggregates to the batch mixing plant (indirect emissions) • Batch mixing plant operation (direct emissions). • Demolition activities involving heavy construction equipment (direct emissions). 	<ul style="list-style-type: none"> • Uranium mining, refining and conversion • Nuclear Reactor construction • Nuclear Reactor operation

The indirect GHG emissions, which occur mostly off the NPD site, are described in Section 2.2. The direct GHG emissions, which occur mostly within the NPD site, are described in Section 2.3.

2.2 Indirect GHG Emissions

Indirect GHG emissions associated with grout and concrete manufacturing are considered in this assessment, and include emissions associated with raw material extraction and transport, cement production (including pyroprocessing), transport of cement, fine and coarse aggregates to the batch mixing plant. Figures 1-2 and 1-3 illustrate the processes included in the calculation of GHG emissions from grout and concrete production and transport.

The indirect GHG emissions were estimated using the Green Concrete LCA Web Tool (<http://greenconcrete.berkeley.edu/concretewebtool.html>), developed at the University at Berkeley. This is an online tool which considers the life-cycle emissions of concrete production from raw material extraction to the end concrete product. In using this tool, the default values for life-cycle emissions were accepted, with the exception of the electricity grid mix for cement production and mixing and batching during concrete production. The Ontario electricity grid mix for 2014 (Ontario Energy Board, 2015) was used as input to the tool for other concrete production activities.

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Summary of default assumptions used in the LCA Web Tool is provided in Table 2-2. These default values are based on U.S. average values.

Table 2-2 Summary of LCA Web Tool Default Assumptions

Transportation Inputs	Distance (km)
Gypsum to Cement Plant	200
Fly Ash to Cement Plant (if Blended cement)	500
Granulated Blast Furnace Slag to Cement Plant (if Blended cement)	1000
Cement to Concrete Plant	500
Fine Aggregates to Concrete Plant	200
Coarse Aggregates to Concrete Plant	300
Admixture to Concrete Plant	1000
Fly Ash to Concrete Plant	500
Granulated Blast Furnace Slag to Concrete Plant	1000
Natural Pozzolan to Concrete Plant	1000
Limestone to Concrete Plant	500
Fuel Options for Pyroprocessing	% by Energy Source
Bituminous coal	64.1
Distillate (Diesel or Light) fuel oil	0.8
Petroleum Coke	21.2
Residual Fuel (Heavy) oil	0.2
Natural gas	3.7
Waste Oil	0.3
Waste Solvent	4
Waste Tire (whole)	1.8
Waste Tire (shredded)	1.8
Waste (Other) (non-hazardous)	2.3

The emission estimates for this tool were generated using the following U.S.EPA AP-42 Sections:

- Section 1.1 Bituminous and Subbituminous Coal Combustion
- Section 1.2 Anthracite Coal Combustion
- Section 1.3 Fuel Oil Combustion
- Section 1.4 Natural Gas Combustion
- Section 3.3: Gasoline and Diesel Industrial Engines
- Section 11.6. Portland Cement Manufacturing
- Section 11.12. Concrete Batching
- Section 11.19.1. Sand & Gravel Processing

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Table 2-3 presents the resulting CO₂ equivalent emissions for the assumed production of 19,000 m³ of grout/concrete. Appendix A.1 presents the output from the model, from which the values below were derived, as well as the input information supplied to the model.

Table 2-3 Estimated Annual Greenhouse Gas Emissions – Decommissioning Execution Phase - Indirect Emissions

Activity	Total kg CO₂(eq)
Cement Production	
Quarrying	29,556
Cement Pyroprocessing	6,495,433
Concrete Production	
Fine Aggregate Extraction	45,856
Coarse Aggregate Extraction	77,509
Transport to Batch Mixing Plant	1,599,769
Total kg CO₂(eq)	8,202,313
Total tonnes CO₂(eq)	8,202

2.2.1 Indirect GHG Sensitivity Cases

In order to assess the level of uncertainty that may be introduced by using default parameters within the Green Concrete LCA Web Tool, an analysis was completed to test the sensitivity of the GHG emissions estimates to different inputs

Table 2-4 presents the results for five (5) different scenarios to test the sensitivity of the Green Concrete LCA Web Tool to different inputs. The scenarios are as follows:

1. Scenario 1: US Electricity Grid; all other parameters are the U.S. default values provided in the tool
2. Scenario 2: Ontario Electricity Grid; all other parameters are the U.S. default values provided in the tool
3. Scenario 3: Ontario Grid; Pyroprocessing Fuels assumed 50% Bituminous Coal and 50% Petroleum Coke¹; 50% Bit Coal / 50% Pet Coke - US Default Transportation Distances
4. Scenario 4: Ontario Grid; Pyroprocessing Fuels assumed 50% Bituminous Coal and 50% Petroleum Coke¹; 50% Bit Coal / 50% Pet Coke – Double US Default Transportation Distances
5. Scenario 5: Ontario Grid; Pyroprocessing Fuels assumed 50% Bituminous Coal and 50% Petroleum Coke¹; 50% Bit Coal / 50% Pet Coke – Half US Default Transportation Distances

¹Note: - Approximately 98% of the fuel used in Ontario's cement industry comes from coal and petcoke (<https://www.newswire.ca/news-releases/canadas-cement-industry-welcomes-ontarios-climate-action-plan-582222671.html> - accessed 2018-02-21).

This sensitivity analysis illustrates that cement pyroprocessing is the largest contributor to the indirect GHG emissions for the NPD Closure Project. Changing the pyroprocessing fuel to 100% coal and petcoke can

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increase the total emissions by approximately 5%. Doubling all of the assumed transportation distances travelled would increase the total GHG emissions by up to 26%.

Regardless of the assumptions used to estimate the indirect GHG emissions, the project's GHG emissions (direct and life-cycle combined) are negligible in comparison to Ontario's total GHG emissions (i.e., less than 0.01%) and less than 0.4% of the Ontario total for cement production, thus no further consideration is required. Further, even if the actual material quantities or activity hours were to increase substantially, e.g., by 50-100 percent, the GHG emissions associated with the project are not expected to contribute a substantial fraction of the provincial emissions.

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Table 2-4 Green Concrete LCA Web Tool - Annual Greenhouse Gas Emissions –Indirect Emissions for Different Default Values

	Results of this Assessment (Table 2-3 above)	Scenario 1: US Grid US Default	Scenario 2 Ontario Grid US default	Scenario 3 Ontario Grid 50% Bit Coal / 50% Petcoke US Default Distance	Scenario 4 Ontario Grid 50% Bit Coal / 50% Petcoke Double distance Travelled	Scenario 5 Ontario Grid 50% Bit Coal / 50% Petcoke Half distance Travelled
Activity	Total kg CO ₂ (eq)	Total kg CO ₂ (eq)	Total kg CO ₂ (eq)	Total kg CO ₂ (eq)	Total kg CO ₂ (eq)	Total kg CO ₂ (eq)
Cement Production						
Quarrying	29,556	58,472	29,556	29,556	29,556	29,556
Raw materials Grinding	0	103,455	0	0	0	0
Cement Pyroprocessing	6,495,433	6,495,433	6,237,896	6,736,607	6,736,607	6,736,607
Concrete Production						
Fine Aggregate Extraction	45,856	45,856	18,987	18,987	18,987	18,987
Coarse Aggregate Extraction	77,509	77,509	35,227	35,227	35,227	35,227
Mixing and Batching	0	54,663	0	0	0	0
Transport to Concrete Plant	1,599,769	1,599,769	1,599,769	1,599,769	3,199,539	799,885
Total kg CO₂-(eq)	8,202,331	8,435,157	7,921,435	8,420,146	10,019,916	7,620,262
Total tonnes CO₂-(eq)	8,202	8,435	7,921	8,420	10,020	7,620

The model inputs and outputs for all scenarios are provided in Appendix A.2.

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2.3 Direct GHG Emissions

The potential impact of GHG emissions from the project was assessed through estimation of the GHG emissions during the Decommissioning Execution phase of the project. These emissions consider only the activities which are directly controlled by CNL, including the operation of the batch mixing plant, the demolition activities, and the acquisition of material for site restoration. Most of these activities occur on the NPD site. For the batch mixing plant related activities, direct emissions are illustrated in Figure 1-3 as the items within the dashed line, and are assumed to start after material delivery to the NPD site.

These emissions were estimated based on U.S. EPA AP-42 emission factors (U.S. EPA 1995), and source information provided by CNL. The methodology used to estimate GHGs is consistent with the GHG Protocol. The results are considered over-estimates because they assume conservative operating time frames for all equipment. The following U.S.EPA AP-42 sections and emission sources were used in developing the emission estimates:

- Section 3.3 Gasoline and Diesel Industrial Engines
- Section 11.19.2 Crushed Stone Processing and Pulverized Mineral Processing
- Section 13.2.2 Unpaved Roads
- Section 13.2.4 Aggregate Handling and Storage Piles
- U.S.EPA Non-Road
- U.S.EPA Mobile 6C

The estimated GHG emissions emitted from the project during the Decommissioning Execution phase are provided in Table 2-5 below. Details are provided in Appendix A.3. Direct GHG emissions expected during this phase include emissions from on-site combustion equipment, on-site roads, delivering clay to the site and operating the batch mixing plant.

The following assumptions were used to estimate the direct greenhouse gas emissions associated with the project:

- Demolition and concrete batching activities occur for approximately 70 days/year;
- Power for the batch mixing plant is supplied by a 40 hp diesel generator;
- The demolition site maintains a 100 hp standby generator;
- One 100 tonne crane; two 10 tonne excavators, two backhoes and a concrete saw are used for demolition activities;
- An upper bound estimate of 19,000 m³ of concrete (grout) will be required;
- emissions associated with concrete batching are related to the diesel generator and the delivery of concrete from the batch mixing plant to the nuclear area where the grout is being placed;
- Assuming 70 working days (12 hours per day), approximately four grout/concrete trucks (each carrying 6 m³) per hour will travel from the batch mixing plant to the nuclear area, to deliver approximately 24 m³ grout/concrete per hour;
- Four haul trucks per hour to deliver clay for cover material; and
- An estimated five size G acetylene cylinders are used for torch cutting. All acetylene is assumed to convert completely to CO₂.

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The Intergovernmental Panel on Climate Change (IPCC) Global Warming Potential 100 year time horizon from the Fourth Assessment Report (Government of Canada, 2016) was used to calculate the Total CO₂ (eq) for the Direct Emissions.

Table 2-5 Estimated Annual Greenhouse Gas Emissions – Decommissioning Execution Phase -

	Source	Emission Rate (kg/y)
CO₂	Stationary Equipment Tailpipe (Electrical Generators)	4.4
	Haul Truck Tailpipe – clay delivery (100 km along Hwy. 17 to active site)*	177
	Non-Road Tailpipe (heavy construction equipment for demolition)	42.8
	Acetylene Torch Cutting	121.7
	Total	345.9
CH₄	Stationary Equipment Tailpipe (Electrical Generators)	0.0002
	Haul Truck Tailpipe – clay delivery (100 km along Hwy. 17 to active site)*	0.0037
	Non-Road Tailpipe (heavy construction equipment for demolition)	0.0134
	Acetylene Torch Cutting	0
	Total	0.0173
N₂O**	Stationary Equipment Tailpipe (Electrical Generators)	3.5e-05
	Haul Truck Tailpipe – clay delivery (100 km along Hwy. 17 to active site)*	0.0014
	Non-Road Tailpipe (heavy construction equipment for demolition)	0.0067
	Acetylene Torch Cutting	0
	Total	0.0081
Total CO₂ kg (eq)		345.9
Total CO₂ tonnes (eq)		0.35

Notes:

* Delivery of clay material to the site (i.e., for covering the concrete cap, as part of site restoration activities), has been attributed as a direct emission for this assessment.

** Emission factors for N₂O are not typically available in AP-42, therefore the IPCC Volume 2, Chapter 2 Stationary Combustion was used to estimate a ratio between CO₂ emissions and N₂O emissions for application to AP-42 emission factors.

3 DISCUSSION AND CONCLUSIONS

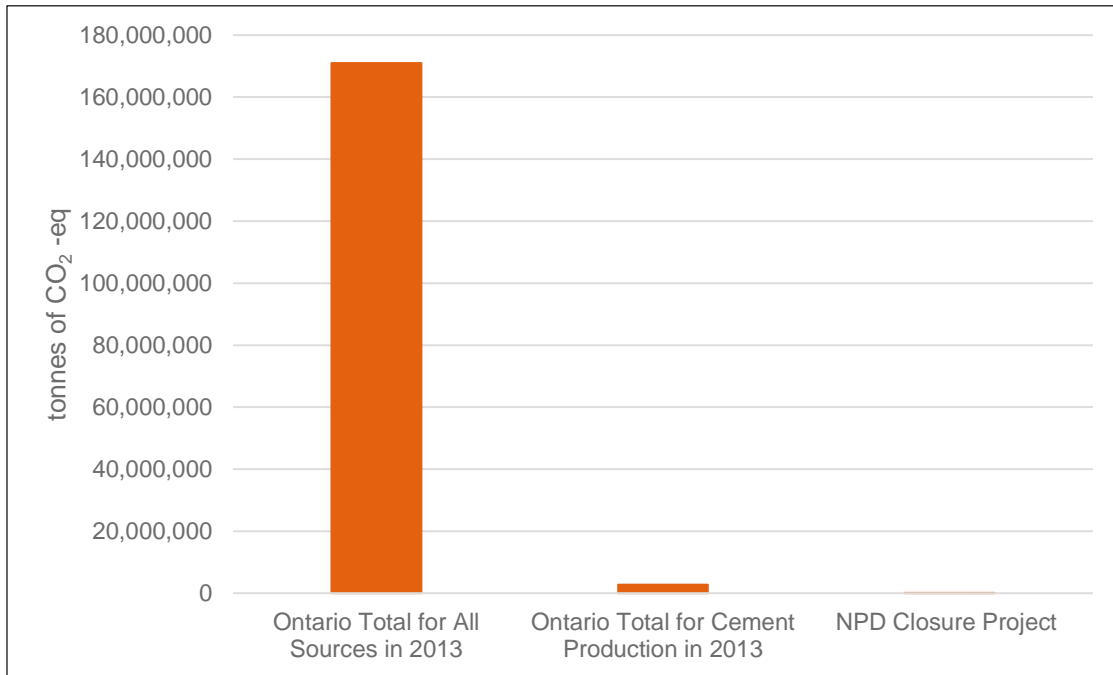
Environment Canada (2015) reported approximately 171,000,000 tonnes CO₂-eq from Ontario sources in 2013. The inventory estimates include emissions from the following five sectors defined by the IPCC: Energy, Industrial Processes and Product Use, Agriculture, Waste, and Land Use, Land-Use Change and Forestry (LULUCF). The GHG emission and removal estimates contained in Canada's GHG inventory are developed using methodologies consistent with the inventory guidelines prepared by the IPCC. Greenhouse gas emissions from Ontario's cement production in 2013 were estimated to be approximately 2,700,000 tonnes CO₂-eq. In comparison, the direct emissions (for the Decommissioning Execution Phase) of the project are estimated to be 0.35 tons of CO₂-eq. The indirect emissions from the project are estimated at 8,202 tonnes CO₂-eq.

Figure 3-1 provides a visual comparison between the reported 2013 Ontario sources and the project's lifetime CO₂-eq emissions. The project's GHG emissions (direct and life-cycle combined) are negligible in comparison to Ontario's total GHG emissions (i.e., less than 0.005%) and are approximately 0.3% of the Ontario total for cement production, thus no further consideration is required.

As outlined in Sections 2.2 and 2.3 above, several assumptions were made with respect to the required material quantities as well as the associated processing and transportation. Wherever possible, conservative assumptions were made; for example, it was assumed that the standby diesel generator at the batch mixing plant will operate for 12 hours per day. Despite these conservative assumptions, the emissions from the project are a small fraction of the provincial totals. Even if the actual material quantities or activity hours were to increase substantially, e.g., by 50-100 percent, the GHG emissions associated with the project are not expected to contribute a substantial fraction of the provincial emissions.

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Figure 3-1. Ontario vs. NPD Closure Project Estimated Lifetime GHG Emissions (tonnes CO₂-equivalent)



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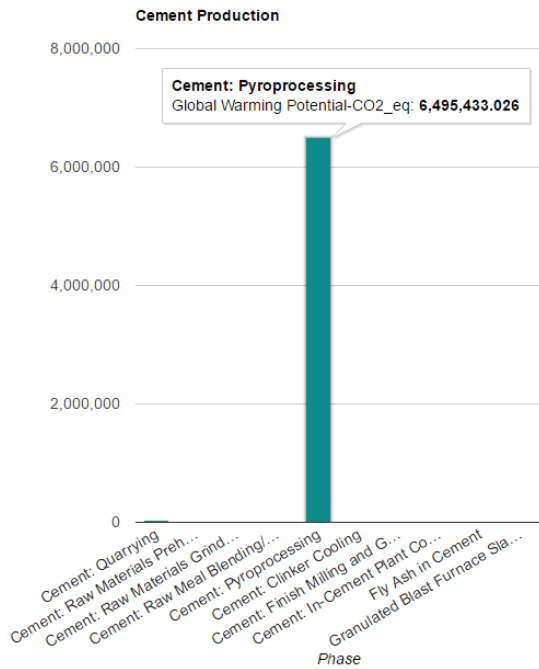
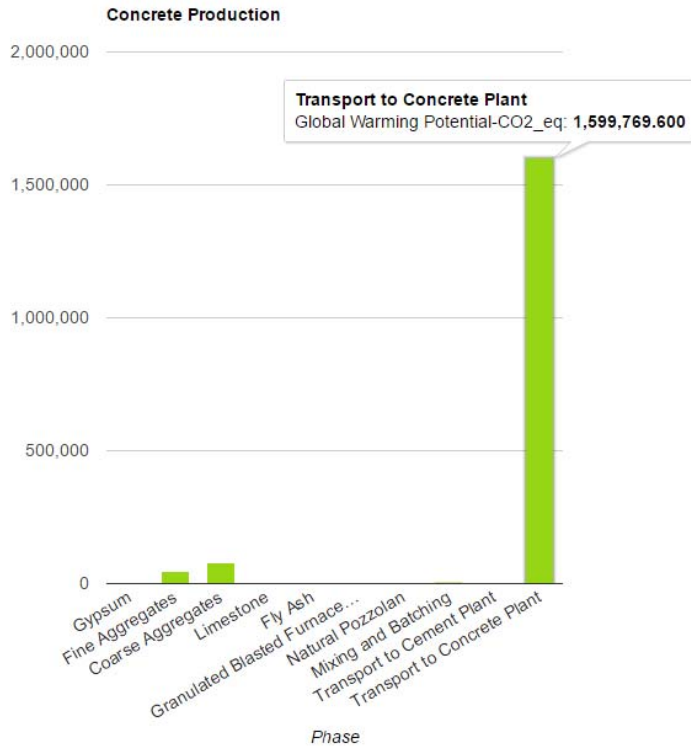
APPENDIX A

GHG Emission Calculations

A.1 – Output and Input of Indirect GHG Emission Calculation Model



GWP CO2-eq



Green Concrete LCA Web Tool

Home Structure Webtool Results References

READY-MIXED CONCRETE EXITING THE CONCRETE PLANT GATE

1. Modeling Parameters

Functional Unit
Unit Type
Unit
Unit Volume of Concrete Production
Volume
m³

Enter Amount of Concrete Produced: 19000

2. Concrete Mix Proportions for Unit Volume (kg/m³)

Calculated based on the user input for material quantities

Enter Concrete Mix Design Name
 Enter Cement Type
 Portland cement Normal, Type I

Portland cement Low heat of hydration, Type IV is no longer made in the US because of low demand. (Mehta and Monteiro 2006)

Total Weight of Concrete (kg/m³): 2416
 Total Cementitious Materials (Sum of PC and SCMs) (kg/m³): 356
 Water/Binder Ratio: 0.5

Please enter material quantities (per m³ of concrete)

Supplementary Cementitious Materials (also known as Mineral Admixtures).

Material Quantities	Value (per m ³ of concrete)	Total Amount Required	Unit Type	Unit
Cement	356	6764000	Mass	kg
Water	178	3382000	Mass	kg
Fine Aggregates	848	16112000	Mass	kg
Coarse Aggregates	1034	19646000	Mass	kg
Fly Ash		0	Mass	kg
Granulated Blast Furnace Slag		0	Mass	kg
Natural Pozzolan		0	Mass	kg
Limestone		0	Mass	kg
Total Cementitious Materials		6764000	Mass	kg
Admixtures (Chemical)				
Plasticiser	356	0	Mass	kg
Superplasticiser		0	Mass	kg

Retarder			Mass	kg
Accelerating admixture	0		Mass	kg
Air entraining admixture	0		Mass	kg
Waterproofing	0		Mass	kg

CEMENT TYPE AND AMOUNTS OF RAW MATERIALS (DEFINED BY ASTM)

Cement Raw Materials	Average Values	Unit Type	Unit
Cement clinker	6425800	Mass	kg
Cement Gypsum	338200	Mass	kg
Cement Kiln Dust (CKD)	0	Mass	kg
Fly ash, blended in cement	0	Mass	kg
Granulated Blast Furnace Slag, blended in cement	0	Mass	kg
Limestone	0	Mass	kg

3. Quarry and Plant Location, Grid Mix Information

Please define the electricity grid mix if you know the fuel mix %. Otherwise use the pre-defined State or US-Average mix values

CEMENT RAW MATERIALS (EXCEPT GYPSUM) QUARRY AND PLANT

Electricity Mix for Raw Material Mining (Quarry)
Electricity Mix for Cement Plant

US Average ▾
 User Defined Grid ▾

GYPSUM QUARRYING AND PROCESSING PLANT

Electricity Mix for Gypsum Quarrying and Processing

US Average ▾

AGGREGATES QUARRY AND PROCESSING PLANT

Electricity Mix for Fine Aggregates Quarrying and Processing
Electricity Mix for Coarse Aggregates Quarrying and Processing

US Average ▾
 US Average ▾

LIMESTONE (SUPPLEMENTING CEMENT IN CONCRETE) QUARRY AND PROCESSING PLANT

Electricity Mix for Limestone Quarrying and Processing

US Average ▾

NATURAL POZZOLAN QUARRY AND PROCESSING PLANT

Electricity Mix for Natural Pozzolan Quarrying and Processing

US Average ▾

FLY ASH PROCESSING PLANT

Electricity Mix for Fly Ash Processing Plant

US Average ▾

GRANULATED BLAST FURNACE SLAG PROCESSING PLANT

Electricity Mix for Granulated Blast Furnace Slag Processing Plant

US Average ▾

CONCRETE BATCHING PLANT

Electricity Mix for Concrete Batching Plant

User Defined Grid ▾

4. Operation Electricity Mix

Enter custom grid mix when grid electricity source % details are available (optional). If not available, use default State grid mix

Contribution of Electricity Source %	User Defined	US Average (2009)
Bituminous Coal	0	44.4 %
Natural Gas	8.7	23.3 %
Residual (Heavy) Oil	0	0.5 %
Distillate (Diesel or Light) fuel oil	0.2	0.2 %
Petroleum Coke	0	0.4 %
Nuclear (Uranium)	60	20.2 %
Hydro	24.1	6.9 %
Biomass	1	1.4 %
Geothermal	0	0.4 %
Solar	1.1	0.02 %
Wind	4.9	1.9 %
Lignite coal	0.0	0.0 %
SUM	100	

5. Transportation Input

	Distance Traveled (km)	Mode of Transportation
Cement Raw Materials to Cement Plant	1	Truck Class 8b (Model 2005) ▾
Gypsum to Cement Plant	200	Truck Class 8b (Model 2005) ▾
Fly Ash to Cement Plant (if Blended cement)	500	Truck Class 8b (Model 2005) ▾
Granulated Blast Furnace Slag to Cement Plant (if Blended cement)	1000	Truck Class 8b (Model 2005) ▾
Cement to Concrete Plant	500	Truck Class 8b (Model 2005) ▾
Fine Aggregates to Concrete Plant	200	Truck Class 8b (Model 2005) ▾
Coarse Aggregates to Concrete Plant	300	Truck Class 8b (Model 2005) ▾
Admixture to Concrete Plant	1000	Truck Class 8b (Model 2005) ▾
Fly Ash to Concrete Plant	500	Truck Class 8b (Model 2005) ▾
Granulated Blast Furnace Slag to Concrete Plant	1000	Truck Class 8b (Model 2005) ▾
Natural Pozzolan to Concrete Plant	1000	Truck Class 8b (Model 2005) ▾

Limestone to Concrete Plant

Truck Class 8b (Model 2005) ▾

500

6. Cement Production Technology Options

TECHNOLOGY OPTIONS BY PHASE

Cement Production Phases

Raw Materials	Product of Each Phase	Technology
Raw Materials Prehomogenization	Raw Meal	Dry process Raw storing, non-preblending ▾
Raw Materials Grinding	Ground Meal	Dry raw grinding, ball mill ▾
Raw Meal Blending/ Homogenization	Blended Meal	Raw meal homogenization, blending, and storage ▾
Pyroprocessing	Clinker	Preheater/Precalciner kiln ▾
Clinker Cooling	Cooled Clinker	Reciprocating Grate Cooler (Modern) ▾
Finish Milling/Grinding/Blending w/ PC	Blended/Traditional Portland Cement	Ball Mill ▾

7. Fuel Use Options for Cement Pyroprocessing

For Pyroprocessing, Specify Fuel Inputs to Preheater kiln

Fuel Options	% by Energy Source	% by Energy Source
Bituminous coal	64.1	64.1%
Lignite coal	0.0	0.0%
Distillate (Diesel or Light) fuel oil	0.8	0.8%
Petroleum Coke	21.2	21.2%
Residual Fuel (Heavy) oil	0.2	0.2%
Natural gas	3.7	3.7%
Waste Oil	0.3	0.3%
Waste Solvent	4.0	4.0%
Waste Tire (whole)	1.8	1.8%
Waste Tire (shredded)	1.8	1.8%
Waste (Other) (non-hazardous)	2.3	2.3%
Waste Paper, cardboard	0.0	0.0%
Waste Plastics	0.0	0.0%
Waste Sewage sludge (dry)	0.0	0.0%
Waste (Other) (hazardous)	0.0	0.0%
SUM		

CLINKER COOLING PM CONTROL TECHNOLOGY OPTIONS

For Clinker Cooling PM Control, Specify Technology Option

Option: Electrostatic Precipitators (ESP) ▾

8. Conveying Technology Options

Product of Each Phase	Conveyance Distance [meters]	Conveyance Mode	Average Amount of Material Conveyed (kg)
Raw Meal	20	Screw Pumo ▾	10862984

Concrete LCA Webtool

Ground Meal	20	Screw Pump	10862984
Blended Meal	20	Screw Pump	10862984
Clinker	20	Screw Pump	6425800
Clinker Cooled	20	Screw Pump	6425800
Blended/Traditional Portland Cement	20	Screw Pump	6764000

9. Concrete Batching Plant Technology

BATCHING PLANT PM CONTROL TECHNOLOGY OPTIONS

For Process-related PM Control, Specify Technology Option (including material transfer, loading and unloading processes within the plant)

Option:

BATCHING PLANT LOADING/MIXING OPTIONS

For mixing/loading concrete materials into mixer trucks.

Option:

Energy (MJ)

GWP CO2-eq

GWP.
CO₂-eq.

Concrete Production

2,000,000

1,577,769.6

1,500,000

1,000,000

500,000

475,856.4166
775,913.17

- Gypsum
- Fine Aggregates
- Coarse Aggregates
- Limestone
- Fly Ash
- Natural Pozzolan
- Mixing and Batching
- Transport to Cement Plant
- Transport to Concrete Plant
- Granulated Basted Furnace

Phase

Concrete Production

1,600,000

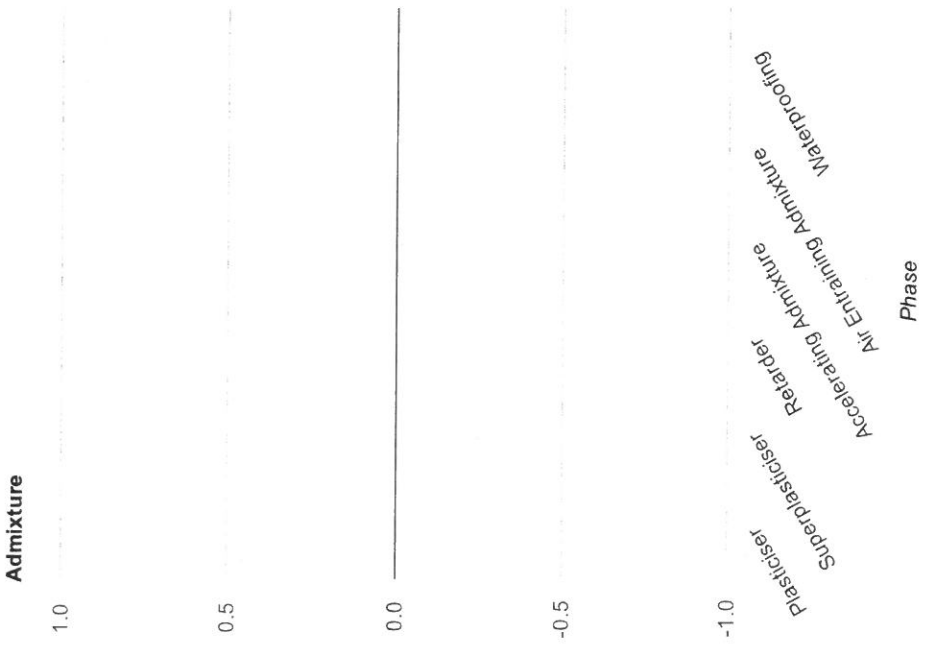
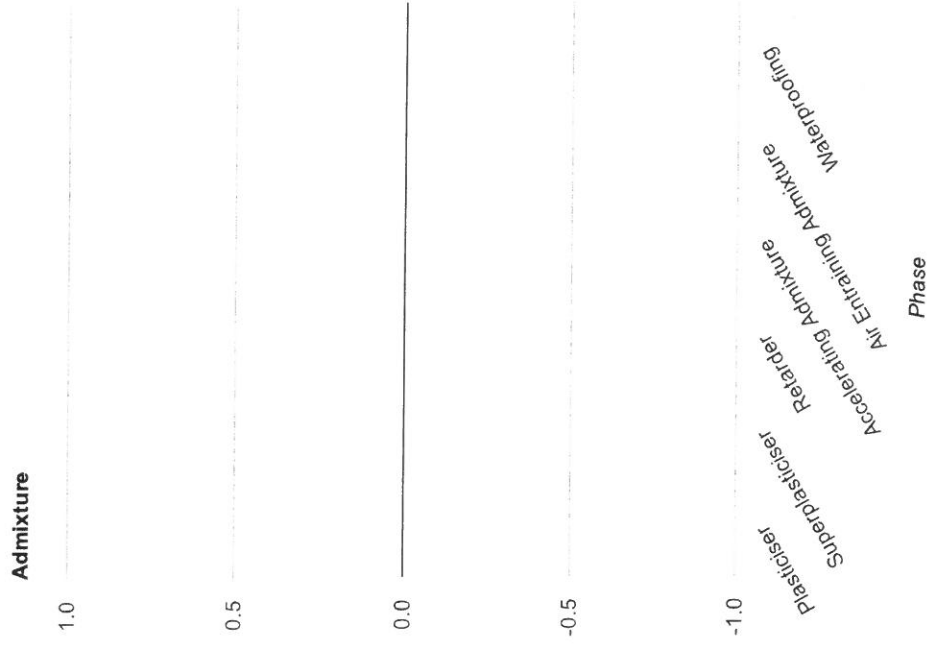
1,200,000

800,000

400,000

- Gypsum
- Fine Aggregates
- Coarse Aggregates
- Limestone
- Fly Ash
- Natural Pozzolan
- Mixing and Batching
- Transport to Cement Plant
- Transport to Concrete Plant
- Granulated Basted Furnace

Phase



9/6/2016

Concrete LCA Webtool

Phase	CO (kg)	Lead (kg)	NOx (kg)	PM10 (kg)	SO2 (kg)	VOC (kg)
Gypsum	2.494	0.000	0.807	37.899	1.166	0.023
Fine Aggregates	170.107	0.003	77.417	420.400	129.383	2.265
Coarse Aggregates	316.364	0.004	118.674	513.268	185.296	4.261
Cement: Quarying	226.301	0.003	100.338	10.266	143.926	4.089
Cement: Raw Materials Prehomogenization	2.040	0.000	1.639	0.041	2.811	0.019
Cement: Raw Materials Grinding	187.698	0.009	150.749	3.813	258.638	1.744
Cement: Raw Meal Blending/Homogenization	8.814	0.000	7.079	0.179	12.145	0.082
Cement: Pyroprocessing	1,402,575.386	295.431	15,577.916	383.829	12,812.352	772.778
Cement: Clinker Cooling	0.000	0.000	0.000	0.000	0.000	0.000
Cement: Finish Milling and Grinding and Blending with PC	0.001	0.000	0.002	0.000	0.001	0.000
Cement: In-Cement Plant Convey	0.079	0.000	0.169	0.000	0.098	0.000
Fly Ash in Cement	0.000	0.000	0.000	0.000	0.000	0.000
Granulated Blast Furnace Slag in Cement	0.000	0.000	0.000	0.000	0.000	0.000
Plasticiser	0.000	0.000	0.000	0.000	0.000	0.000
Superplasticiser	0.000	0.000	0.000	0.000	0.000	0.000
Retarder	0.000	0.000	0.000	0.000	0.000	0.000
Accelerating Admixture	0.000	0.000	0.000	0.000	0.000	0.000
Air Entraining Admixture	0.000	0.000	0.000	0.000	0.000	0.000
Waterproofing	0.000	0.000	0.000	0.000	0.000	0.000
Limestone	0.000	0.000	0.000	0.000	0.000	0.000
Fly Ash	0.000	0.000	0.000	0.000	0.000	0.000
Granulated Blast Furnace Slag	0.000	0.000	0.000	0.000	0.000	0.000
Natural Pozzolan	0.000	0.000	0.000	0.000	0.000	0.000
Mixing and Batching	4.898	0.000	10.529	0.000	6.123	0.007
Transport to Cement Plant	0.032	0.000	0.138	0.019	0.008	0.000
Transport to Concrete Plant	5,136.760	0.000	21,996.832	2,999.568	1,287.315	0.000

For further information contact Petek Gursel at pgursel@berkeley.edu
HTML and Javascript Coding by Claudine Custodio

This page was last modified: 08/02/2012 13:17:18

A.2 – Output and Input of Indirect GHG Sensitivity Case Emission Calculation Model

Green Concrete LCA Web Tool Scenario – Model input and Output

1. Scenario 1: US Electricity Grid; all other parameters are the U.S. default values provided in the tool
2. Scenario 2: Ontario Electricity Grid; all other parameters are the U.S. default values provided in the tool
3. Scenario 3: Ontario Grid; Pyroprocessing Fuels assumed 50% Bituminous Coal and 50% Petroleum Coke¹; US Default Transportation Distances
4. Scenario 4: Ontario Grid; Pyroprocessing Fuels assumed 50% Bituminous Coal and 50% Petroleum Coke¹; 50% Bit Coal / 50% Pet Coke – Double US Default Transportation Distances
5. Scenario 5: Ontario Grid; Pyroprocessing Fuels assumed 50% Bituminous Coal and 50% Petroleum Coke¹; 50% Bit Coal / 50% Pet Coke – Half US Default Transportation Distances

Green Concrete LCA Web Tool

[Home](#) [Structure](#) [Webtool](#) [Results](#) [References](#)

READY-MIXED CONCRETE EXITING THE CONCRETE PLANT GATE

1. Modeling Parameters

Functional Unit

Unit Type

Unit

Unit Volume of Concrete Production

Volume

m³

Enter Amount of Concrete Produced

19000

2. Concrete Mix Proportions for Unit Volume (kg/m³)

Calculated based on the user input for material quantities

Enter Concrete Mix Design Name

Enter Cement Type

Portland cement Normal, Type I ▼

Portland cement Low heat of hydration, Type IV is no longer made in the US because of low demand. (Mehta and Monteiro 2006)

Total Weight of Concrete (kg/m³)

2416

Total Cementitious Materials (Sum of PC and SCMs) (kg/m³)

356

Water/Binder Ratio

0.5

Please enter material quantities (per m³ of concrete)

Supplementary Cementitious Materials (also known as Mineral Admixtures).

Material Quantities	Value (per m ³ of concrete)	Total Amount Required	Unit Type	Unit
Cement	356	6764000	Mass	kg
Water	178	3382000	Mass	kg
Fine Aggregates	848	16112000	Mass	kg
Coarse Aggregates	1034	19646000	Mass	kg
Fly Ash		0	Mass	kg
Granulated Blast Furnace Slag		0	Mass	kg
Natural Pozzolan		0	Mass	kg
Limestone		0	Mass	kg
Total Cementitious Materials	356	6764000	Mass	kg
Admixtures (Chemical)				
Plasticiser		0	Mass	kg
Superplasticiser		0	Mass	kg

Material Quantities	Value (per m ³ of concrete)	Total Amount Required	Unit Type	Unit
Retarder	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Accelerating admixture	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Air entraining admixture	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Waterproofing	<input type="text"/>	<input type="text" value="0"/>	Mass	kg

CEMENT TYPE AND AMOUNTS OF RAW MATERIALS (DEFINED BY ASTM)

Cement Raw Materials	Average Values	Unit Type	Unit
Cement clinker	<input type="text" value="6425800"/>	Mass	kg
Cement Gypsum	<input type="text" value="338200"/>	Mass	kg
Cement Kiln Dust (CKD)	<input type="text" value="0"/>	Mass	kg
Fly ash, blended in cement	<input type="text" value="0"/>	Mass	kg
Granulated Blast Furnace Slag, blended in cement	<input type="text" value="0"/>	Mass	kg
Limestone	<input type="text" value="0"/>	Mass	kg

3. Quarry and Plant Location, Grid Mix Information

*Please **define the electricity grid mix** if you know the fuel mix %. Otherwise use the pre-defined State or US-Average mix values*

CEMENT RAW MATERIALS (EXCEPT GYPSUM) QUARRY AND PLANT

Electricity Mix for Raw Material Mining (Quarry)

Electricity Mix for Cement Plant

GYPSUM QUARRYING AND PROCESSING PLANT

Electricity Mix for Gypsum Quarrying and Processing

AGGREGATES QUARRY AND PROCESSING PLANT

Electricity Mix for Fine Aggregates Quarrying and Processing

Electricity Mix for Coarse Aggregates Quarrying and Processing

LIMESTONE (SUPPLEMENTING CEMENT IN CONCRETE) QUARRY AND PROCESSING PLANT

Electricity Mix for Limestone Quarrying and Processing

NATURAL POZZOLAN QUARRY AND PROCESSING PLANT

Electricity Mix for Natural Pozzolan Quarrying and Processing

FLY ASH PROCESSING PLANT

Electricity Mix for Fly Ash Processing Plant

US Average ▼

GRANULATED BLAST FURNACE SLAG PROCESSING PLANT

Electricity Mix for Granulated Blast Furnace Slag Processing Plant

US Average ▼

CONCRETE BATCHING PLANT

Electricity Mix for Concrete Batching Plant

US Average ▼

4. Operation Electricity Mix

Enter custom grid mix when grid electricity source % details are available (optional). If not available, use [default State grid mix](#)

Contribution of Electricity Source %

User Defined

US Average (2009)

Bituminous Coal	0 %	44.4 %
Natural Gas	8.7 %	23.3 %
Residual (Heavy) Oil	0 %	0.5 %
Distillate (Diesel or Light) fuel oil	0.2 %	0.2 %
Petroleum Coke	0 %	0.4 %
Nuclear (Uranium)	60 %	20.2 %
Hydro	24.1 %	6.9 %
Biomass	1 %	1.4 %
Geothermal	0 %	0.4 %
Solar	1.1 %	0.02 %
Wind	4.9 %	1.9 %
Lignite coal	0.0 %	0.0 %
SUM	100	

5. Transportation Input

Cement Raw Materials to Cement Plant

Distance Traveled (km)

Mode of Transportation

Gypsum to Cement Plant

1

Truck Class 8b (Model 2005) ▼

Fly Ash to Cement Plant (if Blended cement)

200

Truck Class 8b (Model 2005) ▼

Granulated Blast Furnace Slag to Cement Plant (if Blended cement)

500

Truck Class 8b (Model 2005) ▼

Cement to Concrete Plant

1000

Truck Class 8b (Model 2005) ▼

Fine Aggregates to Concrete Plant

500

Truck Class 8b (Model 2005) ▼

Coarse Aggregates to Concrete Plant

200

Truck Class 8b (Model 2005) ▼

Admixture to Concrete Plant

300

Truck Class 8b (Model 2005) ▼

Fly Ash to Concrete Plant

1000

Truck Class 8b (Model 2005) ▼

Granulated Blast Furnace Slag to Concrete Plant

500

Truck Class 8b (Model 2005) ▼

1000

Truck Class 8b (Model 2005) ▼

Natural Pozzolan to Concrete Plant
Limestone to Concrete Plant

Distance Traveled (km)

1000
500

Mode of Transportation

Truck Class 8b (Model 2005) ▾
Truck Class 8b (Model 2005) ▾

6. Cement Production Technology Options

TECHNOLOGY OPTIONS BY PHASE

Cement Production Phases

- Raw Materials Prehomogenization**
- Raw Materials Grinding**
- Raw Meal Blending/ Homogenization**
- Pyroprocessing**
- Clinker Cooling**
- Finish Milling/Grinding/Blending w/ PC**

Product of Each Phase

- Raw Meal**
- Ground Meal**
- Blended Meal**
- Clinker**
- Cooled Clinker**
- Blended/Traditional Portland Cement**

Technology

Dry process Raw storing, non-preblending ▾
Dry raw grinding, ball mill ▾
Raw meal homogenization, blending, and storage ▾
Preheater/Precalciner kiln ▾
Reciprocating Grate Cooler (Modern) ▾
Ball Mill ▾

7. Fuel Use Options for Cement Pyroprocessing

For Pyroprocessing, Specify Fuel Inputs to Preheater kiln

Fuel Options

- Bituminous coal**
- Lignite coal**
- Distillate (Diesel or Light) fuel oil**
- Petroleum Coke**
- Residual Fuel (Heavy) oil**
- Natural gas**
- Waste Oil**
- Waste Solvent**
- Waste Tire (whole)**
- Waste Tire (shredded)**
- Waste (Other) (non-hazardous)**
- Waste Paper, cardboard**
- Waste Plastics**
- Waste Sewage sludge (dry)**
- Waste (Other) (hazardous)**
- SUM**

% by Energy Source

64.1 %
0.0 %
0.8 %
21.2 %
0.2 %
3.7 %
0.3 %
4.0 %
1.8 %
1.8 %
2.3 %
0.0 %
0.0 %
0.0 %
0.0 %
0.0 %

% by Energy Source

64.1%
0.0%
0.8%
21.2%
0.2%
3.7%
0.3%
4.0%
1.8%
1.8%
2.3%
0.0%
0.0%
0.0%
0.0%
0.0%

CLINKER COOLING PM CONTROL TECHNOLOGY OPTIONS

For Clinker Cooling PM Control, Specify Technology Option
Option:

Electrostatic Precipitators (ESP) ▾

8. Conveying Technology Options

Product of Each Phase

Conveyence Distance [meters]

Conveyance Mode

Average Amount of Material Conveyed (kg)

Raw Meal

20

Screw Pump ▼

10862984

Ground Meal

20

Screw Pump ▼

10862984

Blended Meal

20

Screw Pump ▼

10862984

Clinker

20

Screw Pump ▼

6425800

Clinker Cooled

20

Screw Pump ▼

6425800

Blended/Traditional Portland Cement

20

Screw Pump ▼

6764000

9. Concrete Batching Plant Technology

BATCHING PLANT PM CONTROL TECHNOLOGY OPTIONS

For Process-related PM Control, Specify Technology Option (including material transfer, loading and unloading processes within the plant)

Option:

Controlled w/ Fabric Filter ▼

BATCHING PLANT LOADING/MIXING OPTIONS

For mixing/loading concrete materials into mixer trucks.

Option:

Mixer Loading (Central Mix) ▼

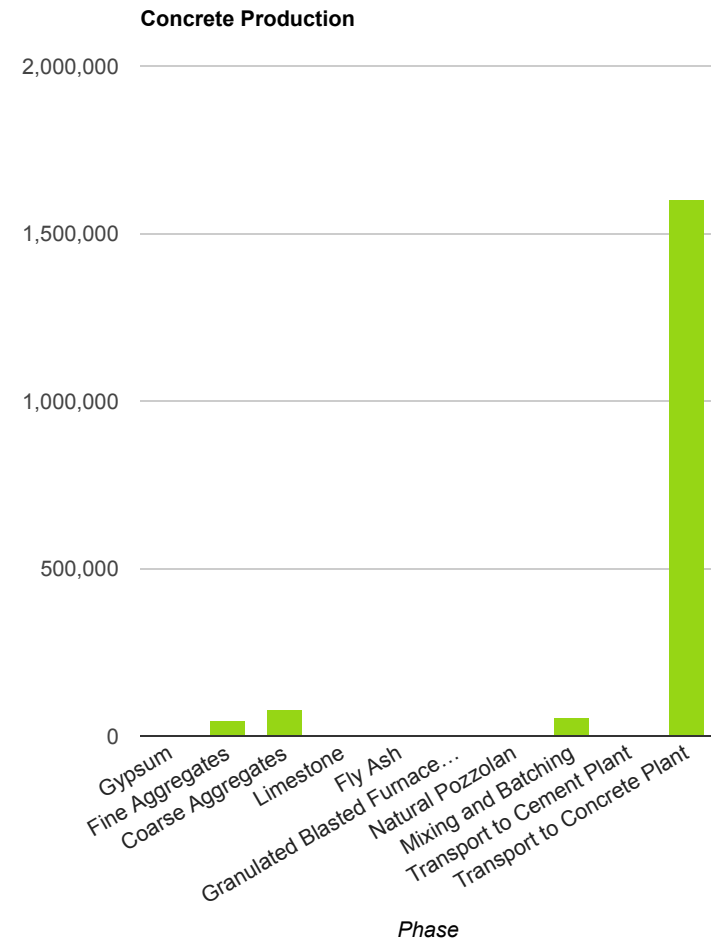
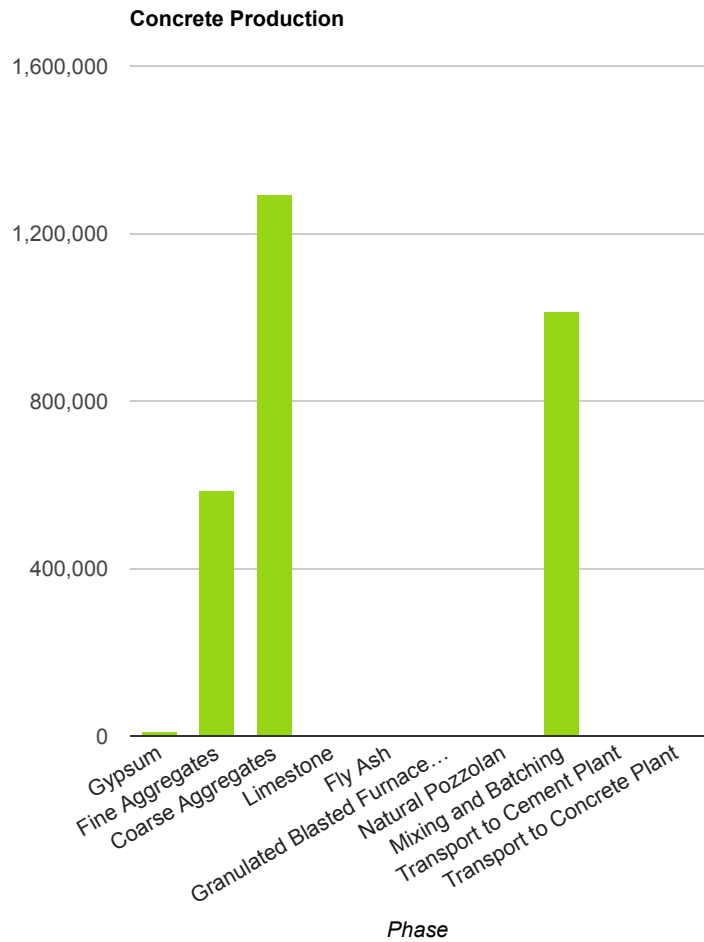
Run Analysis

Energy (MJ)

GWP CO2-eq

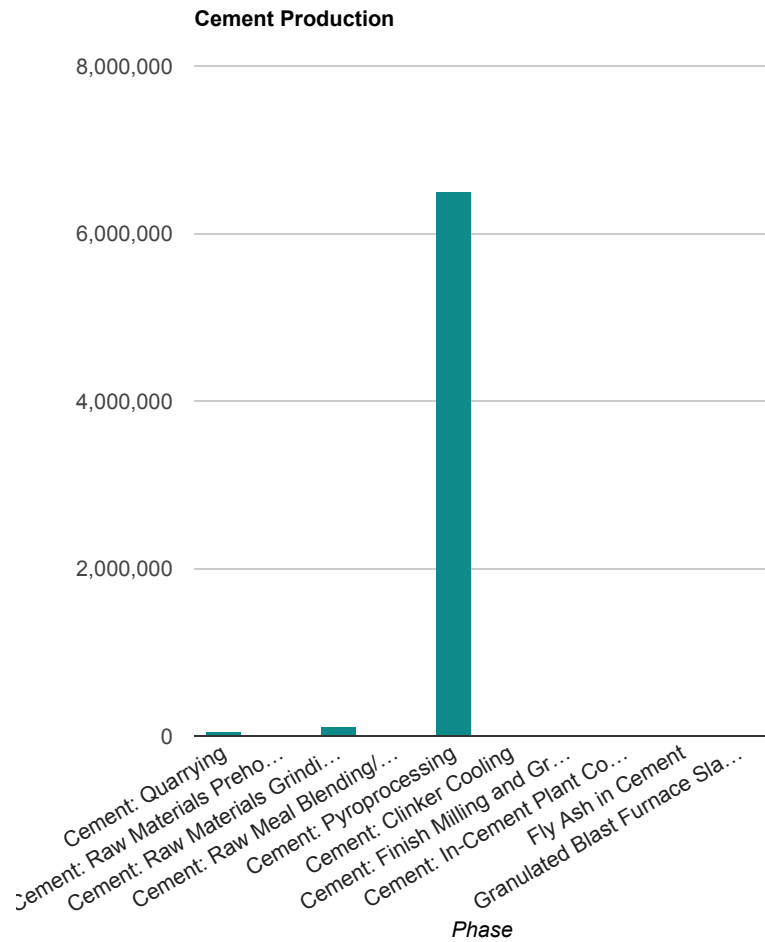
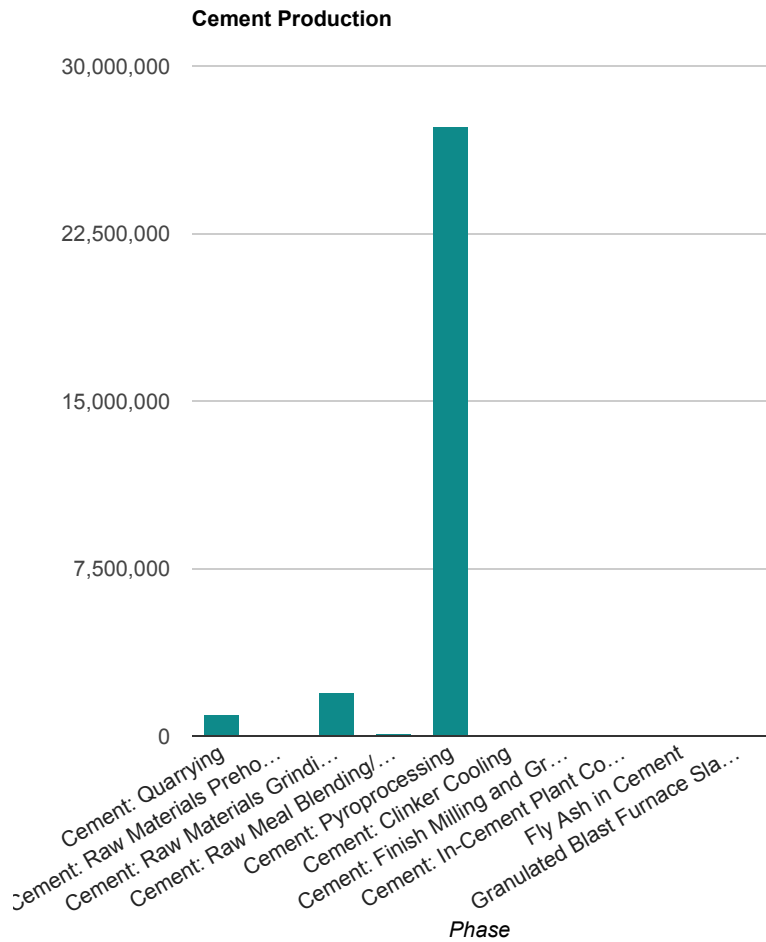
Energy (MJ)

GWP CO2-eq



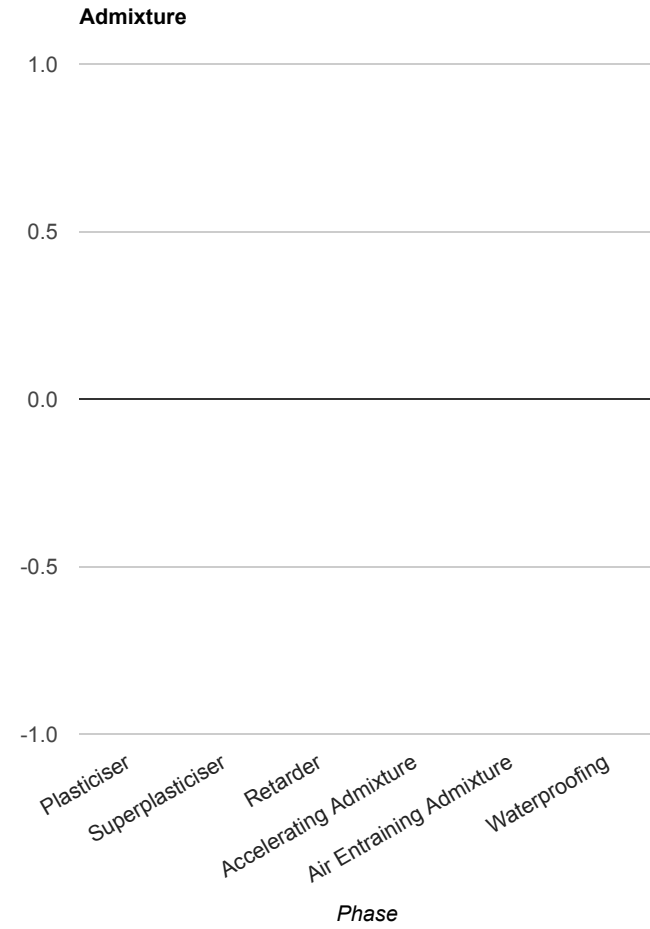
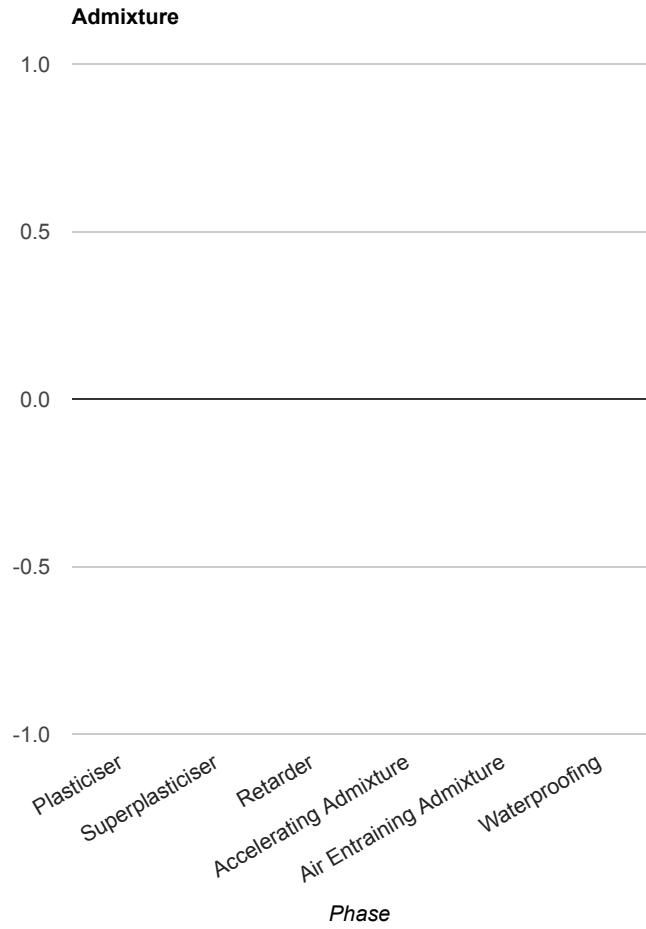
Energy (MJ)

GWP CO2-eq



Energy (MJ)

GWP CO2-eq



Phase	CO (kg)	Lead (kg)	NOx (kg)	PM10 (kg)	SO2 (kg)	VOC (kg)
Gypsum	2.494	0.000	0.807	37.899	1.166	0.023
Fine Aggregates	170.107	0.003	77.417	420.400	129.383	2.265
Coarse Aggregates	316.364	0.004	118.674	513.268	185.296	4.261
Cement: Quarrying	226.301	0.003	100.338	10.266	143.926	4.089
Cement: Raw Materials Prehomogenization	2.040	0.000	1.639	0.041	2.811	0.019
Cement: Raw Materials Grinding	187.698	0.009	150.749	3.813	258.638	1.744
Cement: Raw Meal Blending/Homogenization	8.814	0.000	7.079	0.179	12.145	0.082
Cement: Pyroprocessing	1,403,069.462	295.456	15,940.170	394.388	13,496.448	777.570
Cement: Clinker Cooling	0.003	0.000	0.003	0.000	0.005	0.000
Cement: Finish Milling and Grinding and Blending with PC	0.018	0.000	0.014	0.000	0.025	0.000
Cement: In-Cement Plant Convey	1.591	0.000	1.278	0.032	2.193	0.015
Fly Ash in Cement	0.000	0.000	0.000	0.000	0.000	0.000
Granulated Blast Furnace Slag in Cement	0.000	0.000	0.000	0.000	0.000	0.000
Plasticiser	0.000	0.000	0.000	0.000	0.000	0.000
Superplasticiser	0.000	0.000	0.000	0.000	0.000	0.000
Retarder	0.000	0.000	0.000	0.000	0.000	0.000
Accelerating Admixture	0.000	0.000	0.000	0.000	0.000	0.000
Air Entraining Admixture	0.000	0.000	0.000	0.000	0.000	0.000
Waterproofing	0.000	0.000	0.000	0.000	0.000	0.000
Limestone	0.000	0.000	0.000	0.000	0.000	0.000
Fly Ash	0.000	0.000	0.000	0.000	0.000	0.000
Granulated Blasted Furnace Slag	0.000	0.000	0.000	0.000	0.000	0.000
Natural Pozzolan	0.000	0.000	0.000	0.000	0.000	0.000
Mixing and Batching	99.174	0.005	79.652	2.015	136.658	0.921
Transport to Cement Plant	0.032	0.000	0.138	0.019	0.008	0.000
Transport to Concrete Plant	5,136.760	0.000	21,996.832	2,999.568	1,287.315	0.000

**For further information contact Petek Gursel at [pgursel\[at\]berkeley.edu](mailto:pgursel[at]berkeley.edu)
HTML and Javascript Coding by Claudine Custodio**

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READY-MIXED CONCRETE EXITING THE CONCRETE PLANT GATE

1. Modeling Parameters

Functional Unit

Unit Type

Unit

Unit Volume of Concrete Production

Volume

m³

Enter Amount of Concrete Produced

19000

2. Concrete Mix Proportions for Unit Volume (kg/m³)

Calculated based on the user input for material quantities

Enter Concrete Mix Design Name

Enter Cement Type

Portland cement Normal, Type I

Portland cement Low heat of hydration, Type IV is no longer made in the US because of low demand. (Mehta and Monteiro 2006)

Total Weight of Concrete (kg/m³)

2416

Total Cementitious Materials (Sum of PC and SCMs) (kg/m³)

356

Water/Binder Ratio

0.5

Please enter material quantities (per m³ of concrete)

Supplementary Cementitious Materials (also known as Mineral Admixtures).

Material Quantities	Value (per m ³ of concrete)	Total Amount Required	Unit Type	Unit
Cement	356	6764000	Mass	kg
Water	178	3382000	Mass	kg
Fine Aggregates	848	16112000	Mass	kg
Coarse Aggregates	1034	19646000	Mass	kg
Fly Ash		0	Mass	kg
Granulated Blast Furnace Slag		0	Mass	kg
Natural Pozzolan		0	Mass	kg
Limestone		0	Mass	kg
Total Cementitious Materials	356	6764000	Mass	kg
Admixtures (Chemical)				
Plasticiser		0	Mass	kg
Superplasticiser		0	Mass	kg

Material Quantities	Value (per m ³ of concrete)	Total Amount Required	Unit Type	Unit
Retarder	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Accelerating admixture	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Air entraining admixture	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Waterproofing	<input type="text"/>	<input type="text" value="0"/>	Mass	kg

CEMENT TYPE AND AMOUNTS OF RAW MATERIALS (DEFINED BY ASTM)

Cement Raw Materials	Average Values	Unit Type	Unit
Cement clinker	<input type="text" value="6425800"/>	Mass	kg
Cement Gypsum	<input type="text" value="338200"/>	Mass	kg
Cement Kiln Dust (CKD)	<input type="text" value="0"/>	Mass	kg
Fly ash, blended in cement	<input type="text" value="0"/>	Mass	kg
Granulated Blast Furnace Slag, blended in cement	<input type="text" value="0"/>	Mass	kg
Limestone	<input type="text" value="0"/>	Mass	kg

3. Quarry and Plant Location, Grid Mix Information

Please define the electricity grid mix if you know the fuel mix %. Otherwise use the pre-defined State or US-Average mix values

CEMENT RAW MATERIALS (EXCEPT GYPSUM) QUARRY AND PLANT

Electricity Mix for Raw Material Mining (Quarry)

Electricity Mix for Cement Plant

GYPSUM QUARRYING AND PROCESSING PLANT

Electricity Mix for Gypsum Quarrying and Processing

AGGREGATES QUARRY AND PROCESSING PLANT

Electricity Mix for Fine Aggregates Quarrying and Processing

Electricity Mix for Coarse Aggregates Quarrying and Processing

LIMESTONE (SUPPLEMENTING CEMENT IN CONCRETE) QUARRY AND PROCESSING PLANT

Electricity Mix for Limestone Quarrying and Processing

NATURAL POZZOLAN QUARRY AND PROCESSING PLANT

Electricity Mix for Natural Pozzolan Quarrying and Processing

FLY ASH PROCESSING PLANT

Electricity Mix for Fly Ash Processing Plant

User Defined Grid ▾

GRANULATED BLAST FURNACE SLAG PROCESSING PLANT

Electricity Mix for Granulated Blast Furnace Slag Processing Plant

User Defined Grid ▾

CONCRETE BATCHING PLANT

Electricity Mix for Concrete Batching Plant

User Defined Grid ▾

4. Operation Electricity Mix

Enter custom grid mix when grid electricity source % details are available (optional). If not available, use [default State grid mix](#)

Contribution of Electricity Source %

User Defined

US Average (2009)

Bituminous Coal	<input type="text" value="0"/> %	44.4 %
Natural Gas	<input type="text" value="8.7"/> %	23.3 %
Residual (Heavy) Oil	<input type="text" value="0"/> %	0.5 %
Distillate (Diesel or Light) fuel oil	<input type="text" value="0.2"/> %	0.2 %
Petroleum Coke	<input type="text" value="0"/> %	0.4 %
Nuclear (Uranium)	<input type="text" value="60"/> %	20.2 %
Hydro	<input type="text" value="24.1"/> %	6.9 %
Biomass	<input type="text" value="1"/> %	1.4 %
Geothermal	<input type="text" value="0"/> %	0.4 %
Solar	<input type="text" value="1.1"/> %	0.02 %
Wind	<input type="text" value="4.9"/> %	1.9 %
Lignite coal	<input type="text" value="0.0"/> %	0.0 %
SUM	<input type="text" value="100"/>	

5. Transportation Input

	Distance Traveled (km)	Mode of Transportation
Cement Raw Materials to Cement Plant	<input type="text" value="1"/>	<input type="text" value="Truck Class 8b (Model 2005) ▾"/>
Gypsum to Cement Plant	<input type="text" value="200"/>	<input type="text" value="Truck Class 8b (Model 2005) ▾"/>
Fly Ash to Cement Plant (if Blended cement)	<input type="text" value="500"/>	<input type="text" value="Truck Class 8b (Model 2005) ▾"/>
Granulated Blast Furnace Slag to Cement Plant (if Blended cement)	<input type="text" value="1000"/>	<input type="text" value="Truck Class 8b (Model 2005) ▾"/>
Cement to Concrete Plant	<input type="text" value="500"/>	<input type="text" value="Truck Class 8b (Model 2005) ▾"/>
Fine Aggregates to Concrete Plant	<input type="text" value="200"/>	<input type="text" value="Truck Class 8b (Model 2005) ▾"/>
Coarse Aggregates to Concrete Plant	<input type="text" value="300"/>	<input type="text" value="Truck Class 8b (Model 2005) ▾"/>
Admixture to Concrete Plant	<input type="text" value="1000"/>	<input type="text" value="Truck Class 8b (Model 2005) ▾"/>
Fly Ash to Concrete Plant	<input type="text" value="2000"/>	<input type="text" value="Truck Class 8b (Model 2005) ▾"/>
Granulated Blast Furnace Slag to Concrete Plant	<input type="text" value="1000"/>	<input type="text" value="Truck Class 8b (Model 2005) ▾"/>

Natural Pozzolan to Concrete Plant
Limestone to Concrete Plant

Distance Traveled (km)

1000
500

Mode of Transportation

Truck Class 8b (Model 2005) ▾
Truck Class 8b (Model 2005) ▾

6. Cement Production Technology Options

TECHNOLOGY OPTIONS BY PHASE

Cement Production Phases

- Raw Materials Prehomogenization**
- Raw Materials Grinding**
- Raw Meal Blending/ Homogenization**
- Pyroprocessing**
- Clinker Cooling**
- Finish Milling/Grinding/Blending w/ PC**

Product of Each Phase

- Raw Meal**
- Ground Meal**
- Blended Meal**
- Clinker**
- Cooled Clinker**
- Blended/Traditional Portland Cement**

Technology

Dry process Raw storing, non-preblending ▾
Dry raw grinding, ball mill ▾
Raw meal homogenization, blending, and storage ▾
Preheater/Precalciner kiln ▾
Reciprocating Grate Cooler (Modern) ▾
Ball Mill ▾

7. Fuel Use Options for Cement Pyroprocessing

For Pyroprocessing, Specify Fuel Inputs to Preheater kiln

Fuel Options

- Bituminous coal**
- Lignite coal**
- Distillate (Diesel or Light) fuel oil**
- Petroleum Coke**
- Residual Fuel (Heavy) oil**
- Natural gas**
- Waste Oil**
- Waste Solvent**
- Waste Tire (whole)**
- Waste Tire (shredded)**
- Waste (Other) (non-hazardous)**
- Waste Paper, cardboard**
- Waste Plastics**
- Waste Sewage sludge (dry)**
- Waste (Other) (hazardous)**
- SUM**

% by Energy Source

64.1 %
0.0 %
0.8 %
21.2 %
0.2 %
3.7 %
0.3 %
4.0 %
1.8 %
1.8 %
2.3 %
0.0 %
0.0 %
0.0 %
0.0 %
0.0 %

% by Energy Source

- 64.1%**
- 0.0%**
- 0.8%**
- 21.2%**
- 0.2%**
- 3.7%**
- 0.3%**
- 4.0%**
- 1.8%**
- 1.8%**
- 2.3%**
- 0.0%**
- 0.0%**
- 0.0%**
- 0.0%**

CLINKER COOLING PM CONTROL TECHNOLOGY OPTIONS

For Clinker Cooling PM Control, Specify Technology Option
Option:

Electrostatic Precipitators (ESP) ▾

8. Conveying Technology Options

Product of Each Phase

Conveyence Distance [meters]

Conveyance Mode

Average Amount of Material Conveyed (kg)

Raw Meal

20

Screw Pump ▼

10862984

Ground Meal

20

Screw Pump ▼

10862984

Blended Meal

20

Screw Pump ▼

10862984

Clinker

20

Screw Pump ▼

6425800

Clinker Cooled

20

Screw Pump ▼

6425800

Blended/Traditional Portland Cement

20

Screw Pump ▼

6764000

9. Concrete Batching Plant Technology

BATCHING PLANT PM CONTROL TECHNOLOGY OPTIONS

For Process-related PM Control, Specify Technology Option (including material transfer, loading and unloading processes within the plant)

Option:

Controlled w/ Fabric Filter ▼

BATCHING PLANT LOADING/MIXING OPTIONS

For mixing/loading concrete materials into mixer trucks.

Option:

Mixer Loading (Central Mix) ▼

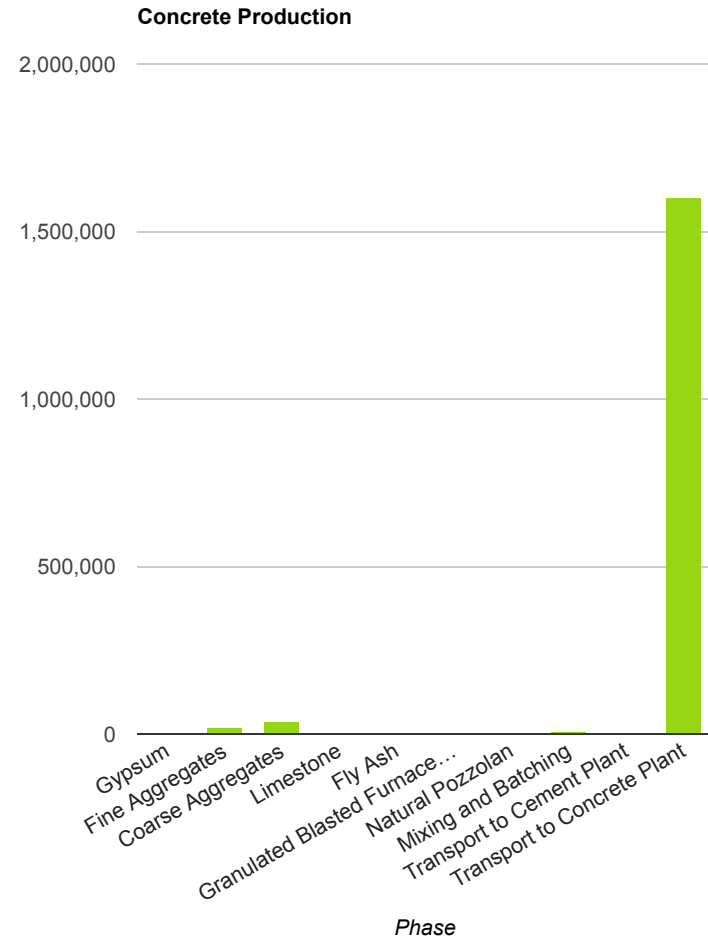
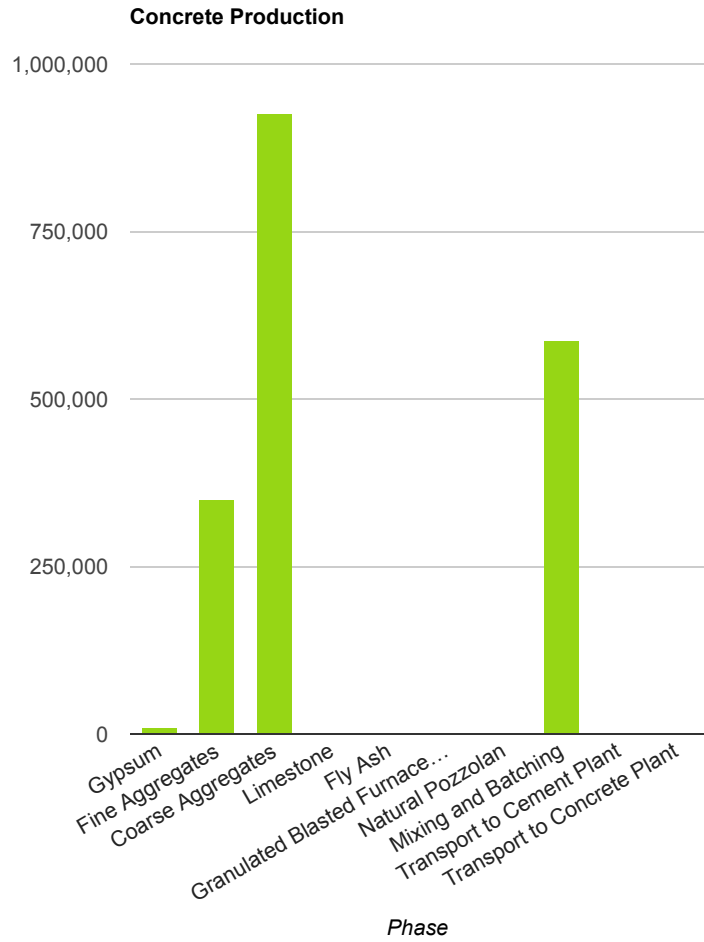
Run Analysis

Energy (MJ)

GWP CO2-eq

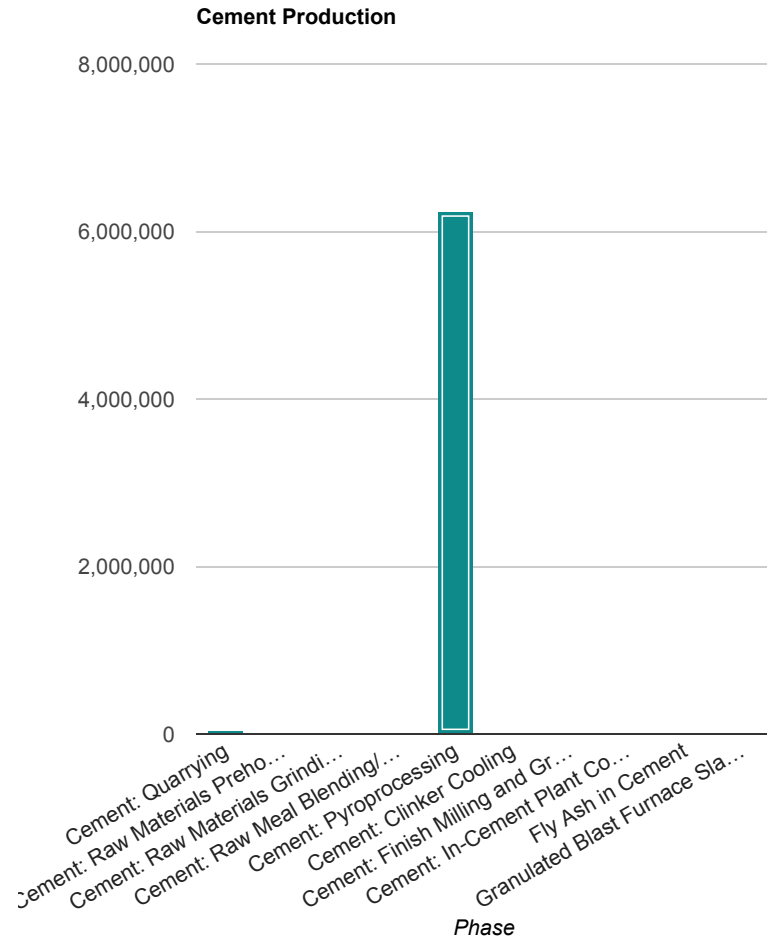
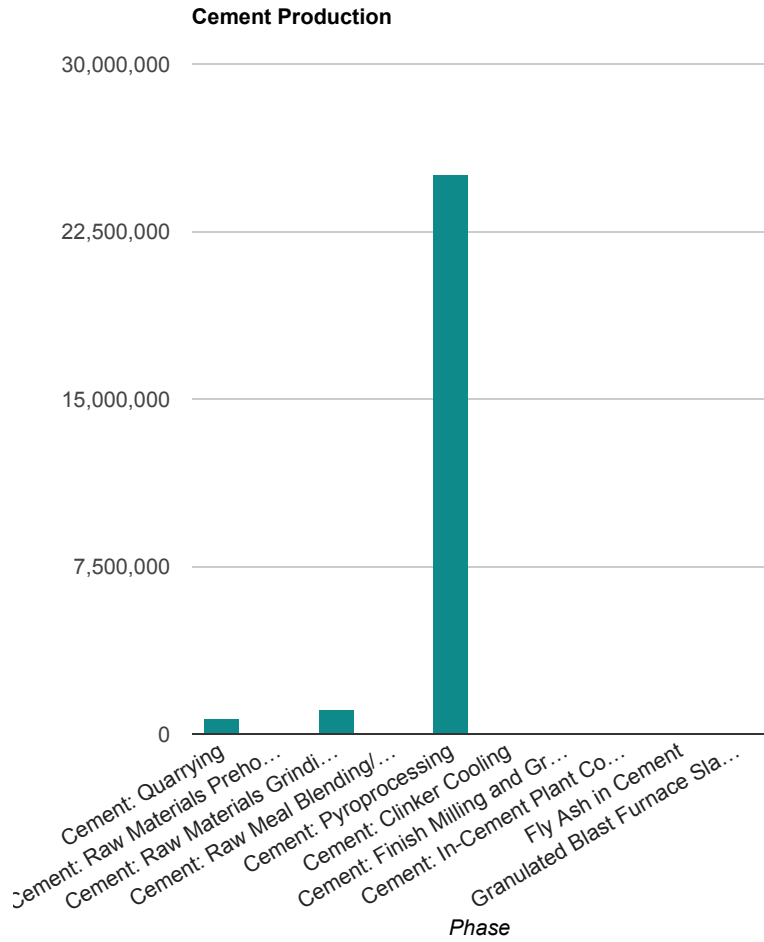
Energy (MJ)

GWP CO2-eq



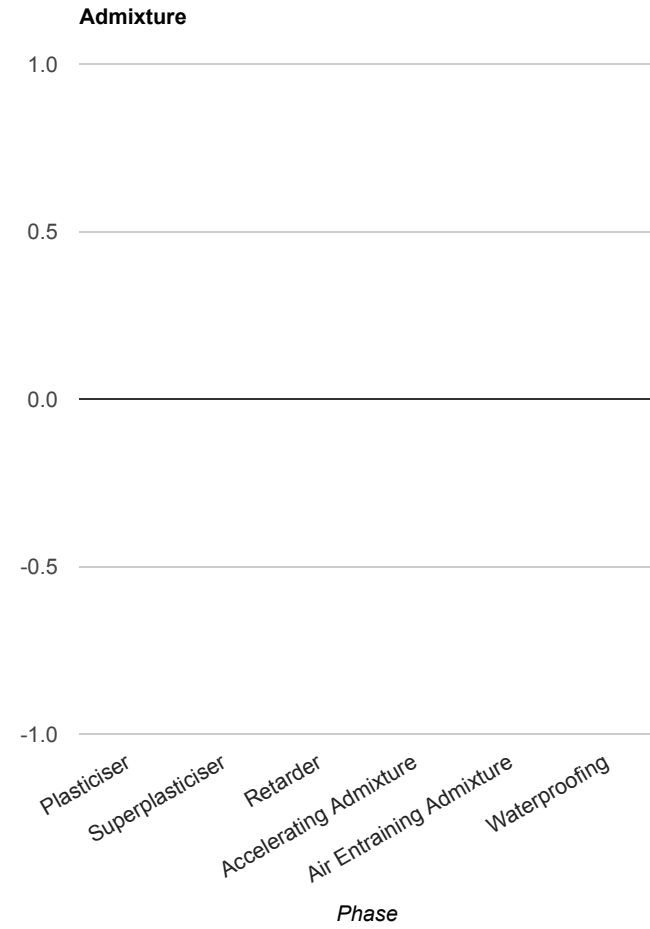
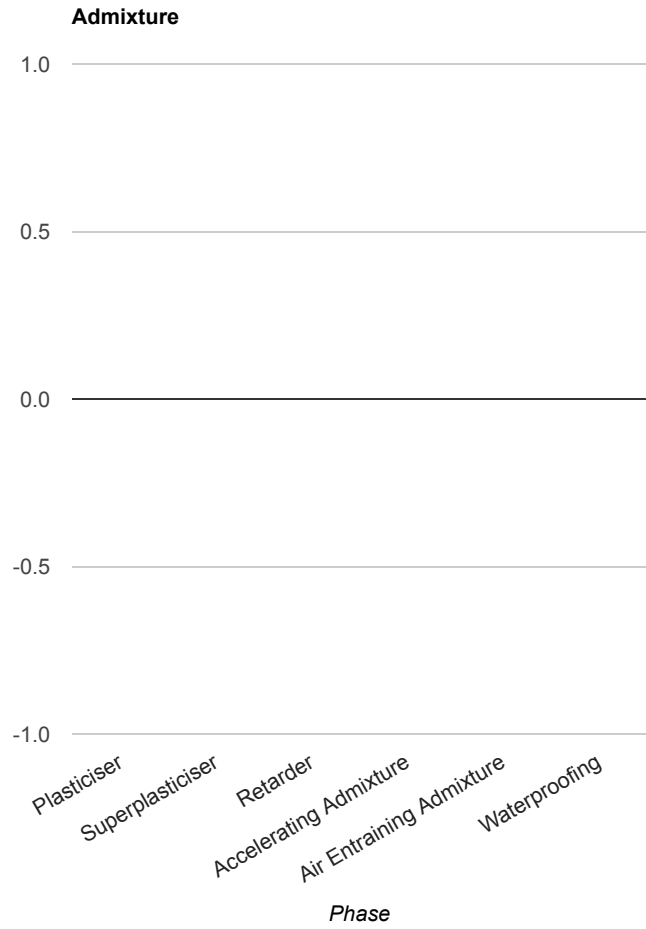
Energy (MJ)

GWP CO2-eq



Energy (MJ)

GWP CO2-eq



Phase	CO (kg)	Lead (kg)	NOx (kg)	PM10 (kg)	SO2 (kg)	VOC (kg)
Gypsum	2.120	0.000	0.533	37.891	0.648	0.020
Fine Aggregates	118.561	0.000	39.624	419.299	58.012	1.765
Coarse Aggregates	235.248	0.000	59.201	511.535	72.983	3.474
Cement: Quarrying	170.826	0.000	59.664	9.080	67.116	3.551
Cement: Raw Materials Prehomogenization	0.101	0.000	0.217	0.000	0.126	0.000
Cement: Raw Materials Grinding	9.270	0.000	19.927	0.000	11.589	0.013
Cement: Raw Meal Blending/Homogenization	0.435	0.000	0.936	0.000	0.544	0.001
Cement: Pyroprocessing	1,402,575.386	295.431	15,577.916	383.829	12,812.352	772.778
Cement: Clinker Cooling	0.000	0.000	0.000	0.000	0.000	0.000
Cement: Finish Milling and Grinding and Blending with PC	0.001	0.000	0.002	0.000	0.001	0.000
Cement: In-Cement Plant Convey	0.079	0.000	0.169	0.000	0.098	0.000
Fly Ash in Cement	0.000	0.000	0.000	0.000	0.000	0.000
Granulated Blast Furnace Slag in Cement	0.000	0.000	0.000	0.000	0.000	0.000
Plasticiser	0.000	0.000	0.000	0.000	0.000	0.000
Superplasticiser	0.000	0.000	0.000	0.000	0.000	0.000
Retarder	0.000	0.000	0.000	0.000	0.000	0.000
Accelerating Admixture	0.000	0.000	0.000	0.000	0.000	0.000
Air Entraining Admixture	0.000	0.000	0.000	0.000	0.000	0.000
Waterproofing	0.000	0.000	0.000	0.000	0.000	0.000
Limestone	0.000	0.000	0.000	0.000	0.000	0.000
Fly Ash	0.000	0.000	0.000	0.000	0.000	0.000
Granulated Blasted Furnace Slag	0.000	0.000	0.000	0.000	0.000	0.000
Natural Pozzolan	0.000	0.000	0.000	0.000	0.000	0.000
Mixing and Batching	4.898	0.000	10.529	0.000	6.123	0.007
Transport to Cement Plant	0.032	0.000	0.138	0.019	0.008	0.000
Transport to Concrete Plant	5,136.760	0.000	21,996.832	2,999.568	1,287.315	0.000

**For further information contact Petek Gursel at [pgursel\[at\]berkeley.edu](mailto:pgursel[at]berkeley.edu)
HTML and Javascript Coding by Claudine Custodio**

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READY-MIXED CONCRETE EXITING THE CONCRETE PLANT GATE

1. Modeling Parameters

Functional Unit

Unit Type

Unit

Unit Volume of Concrete Production

Volume

m³

Enter Amount of Concrete Produced

19000

2. Concrete Mix Proportions for Unit Volume (kg/m³)

Calculated based on the user input for material quantities

Enter Concrete Mix Design Name

Enter Cement Type

Portland cement Normal, Type I

Portland cement Low heat of hydration, Type IV is no longer made in the US because of low demand. (Mehta and Monteiro 2006)

Total Weight of Concrete (kg/m³)

2416

Total Cementitious Materials (Sum of PC and SCMs) (kg/m³)

356

Water/Binder Ratio

0.5

Please enter material quantities (per m³ of concrete)

Supplementary Cementitious Materials (also known as Mineral Admixtures).

Material Quantities	Value (per m ³ of concrete)	Total Amount Required	Unit Type	Unit
Cement	356	6764000	Mass	kg
Water	178	3382000	Mass	kg
Fine Aggregates	848	16112000	Mass	kg
Coarse Aggregates	1034	19646000	Mass	kg
Fly Ash		0	Mass	kg
Granulated Blast Furnace Slag		0	Mass	kg
Natural Pozzolan		0	Mass	kg
Limestone		0	Mass	kg
Total Cementitious Materials	356	6764000	Mass	kg
Admixtures (Chemical)				
Plasticiser		0	Mass	kg
Superplasticiser		0	Mass	kg

Green Concrete LCA Web Tool

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READY-MIXED CONCRETE EXITING THE CONCRETE PLANT GATE

1. Modeling Parameters

Functional Unit

Unit Type

Unit

Unit Volume of Concrete Production

Volume

m³

Enter Amount of Concrete Produced

19000

2. Concrete Mix Proportions for Unit Volume (kg/m³)

Calculated based on the user input for material quantities

Enter Concrete Mix Design Name

Enter Cement Type

Portland cement Low heat of hydration, Type IV is no longer made in the US because of low demand. (Mehta and Monteiro 2006)

Total Weight of Concrete (kg/m³)

2416

Total Cementitious Materials (Sum of PC and SCMs) (kg/m³)

356

Water/Binder Ratio

0.5

Please enter material quantities (per m³ of concrete)

Supplementary Cementitious Materials (also known as Mineral Admixtures).

Material Quantities	Value (per m ³ of concrete)	Total Amount Required	Unit Type	Unit
Cement	356	6764000	Mass	kg
Water	178	3382000	Mass	kg
Fine Aggregates	848	16112000	Mass	kg
Coarse Aggregates	1034	19646000	Mass	kg
Fly Ash		0	Mass	kg
Granulated Blast Furnace Slag		0	Mass	kg
Natural Pozzolan		0	Mass	kg
Limestone		0	Mass	kg
Total Cementitious Materials	356	6764000	Mass	kg
Admixtures (Chemical)				
Plasticiser		0	Mass	kg
Superplasticiser		0	Mass	kg

Material Quantities	Value (per m ³ of concrete)	Total Amount Required	Unit Type	Unit
Retarder	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Accelerating admixture	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Air entraining admixture	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Waterproofing	<input type="text"/>	<input type="text" value="0"/>	Mass	kg

CEMENT TYPE AND AMOUNTS OF RAW MATERIALS (DEFINED BY ASTM)

Cement Raw Materials	Average Values	Unit Type	Unit
Cement clinker	<input type="text" value="6425800"/>	Mass	kg
Cement Gypsum	<input type="text" value="338200"/>	Mass	kg
Cement Kiln Dust (CKD)	<input type="text" value="0"/>	Mass	kg
Fly ash, blended in cement	<input type="text" value="0"/>	Mass	kg
Granulated Blast Furnace Slag, blended in cement	<input type="text" value="0"/>	Mass	kg
Limestone	<input type="text" value="0"/>	Mass	kg

3. Quarry and Plant Location, Grid Mix Information

Please define the electricity grid mix if you know the fuel mix %. Otherwise use the pre-defined State or US-Average mix values

CEMENT RAW MATERIALS (EXCEPT GYPSUM) QUARRY AND PLANT

Electricity Mix for Raw Material Mining (Quarry)

Electricity Mix for Cement Plant

GYPSUM QUARRYING AND PROCESSING PLANT

Electricity Mix for Gypsum Quarrying and Processing

AGGREGATES QUARRY AND PROCESSING PLANT

Electricity Mix for Fine Aggregates Quarrying and Processing

Electricity Mix for Coarse Aggregates Quarrying and Processing

LIMESTONE (SUPPLEMENTING CEMENT IN CONCRETE) QUARRY AND PROCESSING PLANT

Electricity Mix for Limestone Quarrying and Processing

NATURAL POZZOLAN QUARRY AND PROCESSING PLANT

Electricity Mix for Natural Pozzolan Quarrying and Processing

FLY ASH PROCESSING PLANT

Electricity Mix for Fly Ash Processing Plant

User Defined Grid ▼

GRANULATED BLAST FURNACE SLAG PROCESSING PLANT

Electricity Mix for Granulated Blast Furnace Slag Processing Plant

User Defined Grid ▼

CONCRETE BATCHING PLANT

Electricity Mix for Concrete Batching Plant

User Defined Grid ▼

4. Operation Electricity Mix

Enter custom grid mix when grid electricity source % details are available (optional). If not available, use [default State grid mix](#)

Contribution of Electricity Source %

User Defined

US Average (2009)

Bituminous Coal	<input type="text" value="0"/> %	44.4 %
Natural Gas	<input type="text" value="8.7"/> %	23.3 %
Residual (Heavy) Oil	<input type="text" value="0"/> %	0.5 %
Distillate (Diesel or Light) fuel oil	<input type="text" value="0.2"/> %	0.2 %
Petroleum Coke	<input type="text" value="0"/> %	0.4 %
Nuclear (Uranium)	<input type="text" value="60"/> %	20.2 %
Hydro	<input type="text" value="24.1"/> %	6.9 %
Biomass	<input type="text" value="1"/> %	1.4 %
Geothermal	<input type="text" value="0"/> %	0.4 %
Solar	<input type="text" value="1.1"/> %	0.02 %
Wind	<input type="text" value="4.9"/> %	1.9 %
Lignite coal	<input type="text" value="0.0"/> %	0.0 %
SUM	<input type="text" value="100"/>	

5. Transportation Input

	Distance Traveled (km)	Mode of Transportation
Cement Raw Materials to Cement Plant	<input type="text" value="2"/>	Truck Class 8b (Model 2005) ▼
Gypsum to Cement Plant	<input type="text" value="400"/>	Truck Class 8b (Model 2005) ▼
Fly Ash to Cement Plant (if Blended cement)	<input type="text" value="1000"/>	Truck Class 8b (Model 2005) ▼
Granulated Blast Furnace Slag to Cement Plant (if Blended cement)	<input type="text" value="2000"/>	Truck Class 8b (Model 2005) ▼
Cement to Concrete Plant	<input type="text" value="1000"/>	Truck Class 8b (Model 2005) ▼
Fine Aggregates to Concrete Plant	<input type="text" value="400"/>	Truck Class 8b (Model 2005) ▼
Coarse Aggregates to Concrete Plant	<input type="text" value="600"/>	Truck Class 8b (Model 2005) ▼
Admixture to Concrete Plant	<input type="text" value="2000"/>	Truck Class 8b (Model 2005) ▼
Fly Ash to Concrete Plant	<input type="text" value="1000"/>	Truck Class 8b (Model 2005) ▼
Granulated Blast Furnace Slag to Concrete Plant	<input type="text" value="2000"/>	Truck Class 8b (Model 2005) ▼

Natural Pozzolan to Concrete Plant
Limestone to Concrete Plant

Distance Traveled (km)

2000
1000

Mode of Transportation

Truck Class 8b (Model 2005) ▾
Truck Class 8b (Model 2005) ▾

6. Cement Production Technology Options

TECHNOLOGY OPTIONS BY PHASE

Cement Production Phases

- Raw Materials Prehomogenization**
- Raw Materials Grinding**
- Raw Meal Blending/ Homogenization**
- Pyroprocessing**
- Clinker Cooling**
- Finish Milling/Grinding/Blending w/ PC**

Product of Each Phase

- Raw Meal**
- Ground Meal**
- Blended Meal**
- Clinker**
- Cooled Clinker**
- Blended/Traditional Portland Cement**

Technology

Dry process Raw storing, non-preblending ▾
Dry raw grinding, ball mill ▾
Raw meal homogenization, blending, and storage ▾
Preheater/Precalciner kiln ▾
Reciprocating Grate Cooler (Modern) ▾
Ball Mill ▾

7. Fuel Use Options for Cement Pyroprocessing

For Pyroprocessing, Specify Fuel Inputs to Preheater kiln

Fuel Options

- Bituminous coal**
- Lignite coal**
- Distillate (Diesel or Light) fuel oil**
- Petroleum Coke**
- Residual Fuel (Heavy) oil**
- Natural gas**
- Waste Oil**
- Waste Solvent**
- Waste Tire (whole)**
- Waste Tire (shredded)**
- Waste (Other) (non-hazardous)**
- Waste Paper, cardboard**
- Waste Plastics**
- Waste Sewage sludge (dry)**
- Waste (Other) (hazardous)**
- SUM**

% by Energy Source

50 %
0 %
0 %
50 %
0 %
0 %
0 %
0 %
0 %
0 %
0 %
0 %
0 %
0 %
0 %
100

% by Energy Source

- 64.1%**
- 0.0%**
- 0.8%**
- 21.2%**
- 0.2%**
- 3.7%**
- 0.3%**
- 4.0%**
- 1.8%**
- 1.8%**
- 2.3%**
- 0.0%**
- 0.0%**
- 0.0%**
- 0.0%**
- 0.0%**

CLINKER COOLING PM CONTROL TECHNOLOGY OPTIONS

For Clinker Cooling PM Control, Specify Technology Option
Option: Electrostatic Precipitators (ESP) ▾

8. Conveying Technology Options

Product of Each Phase

Conveyence Distance [meters]

Conveyance Mode

Average Amount of Material Conveyed (kg)

Raw Meal

20

Screw Pump ▼

10862984

Ground Meal

20

Screw Pump ▼

10862984

Blended Meal

20

Screw Pump ▼

10862984

Clinker

20

Screw Pump ▼

6425800

Clinker Cooled

20

Screw Pump ▼

6425800

Blended/Traditional Portland Cement

20

Screw Pump ▼

6764000

9. Concrete Batching Plant Technology

BATCHING PLANT PM CONTROL TECHNOLOGY OPTIONS

For Process-related PM Control, Specify Technology Option (including material transfer, loading and unloading processes within the plant)

Option:

Controlled w/ Fabric Filter ▼

BATCHING PLANT LOADING/MIXING OPTIONS

For mixing/loading concrete materials into mixer trucks.

Option:

Mixer Loading (Central Mix) ▼

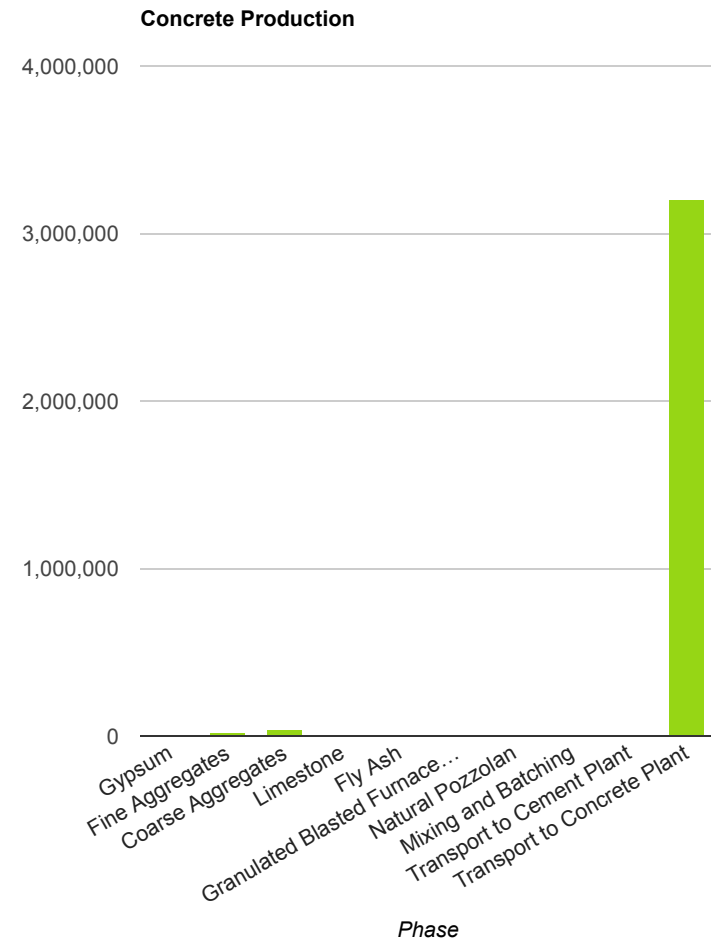
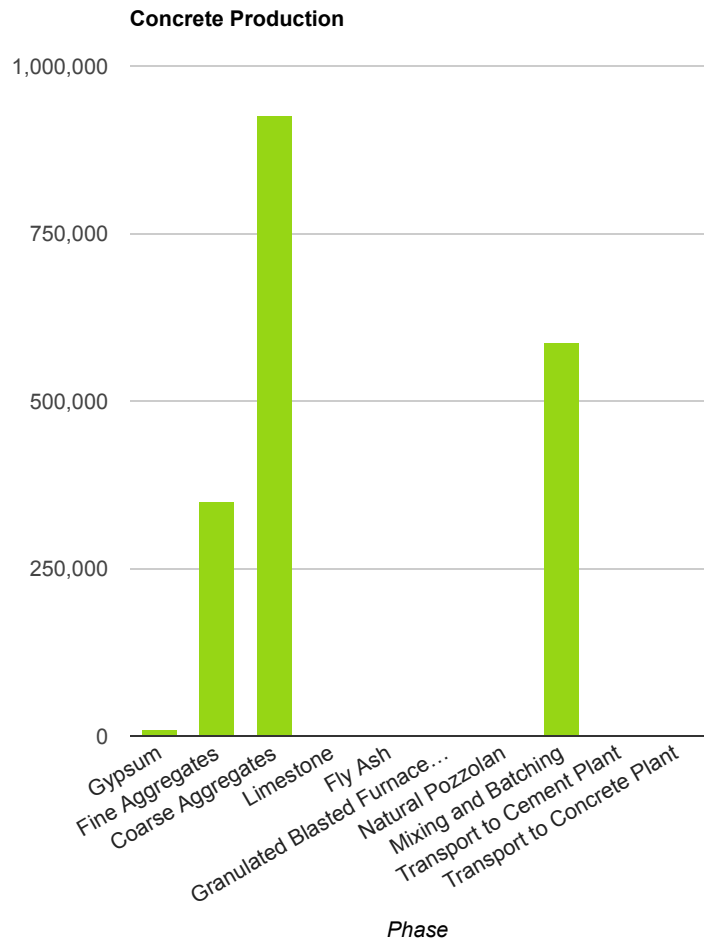
Run Analysis

Energy (MJ)

GWP CO2-eq

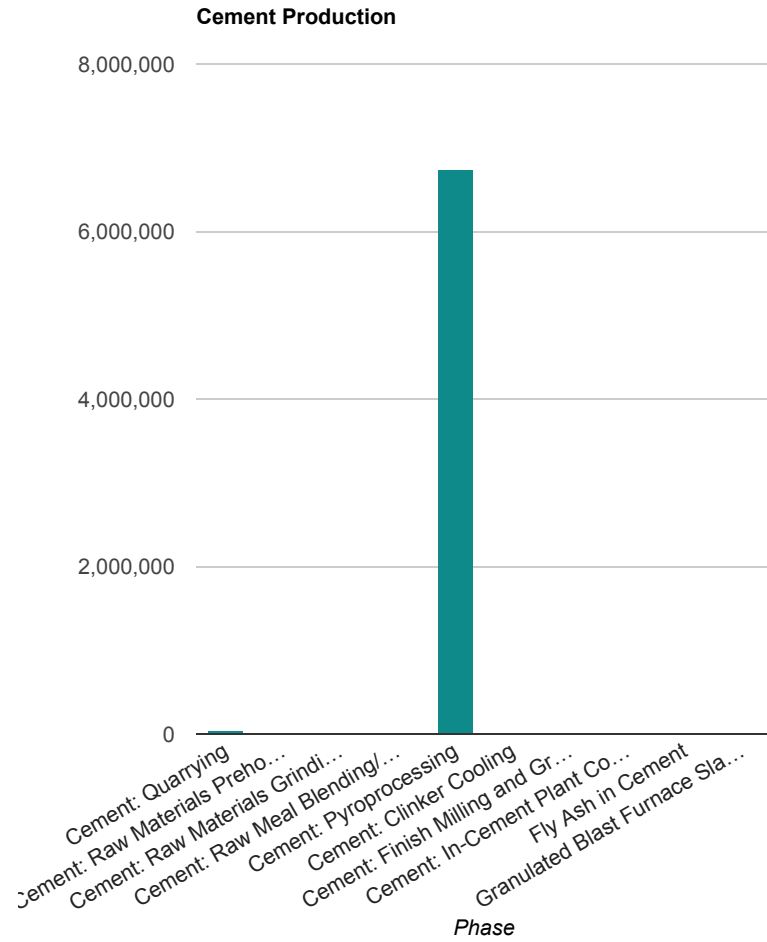
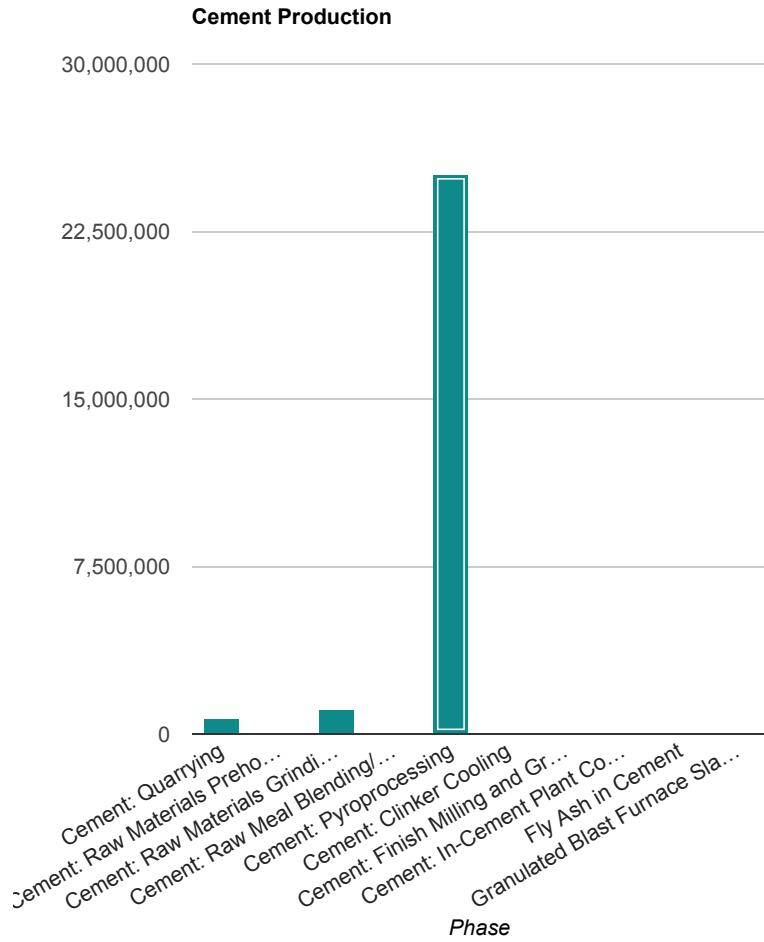
Energy (MJ)

GWP CO2-eq



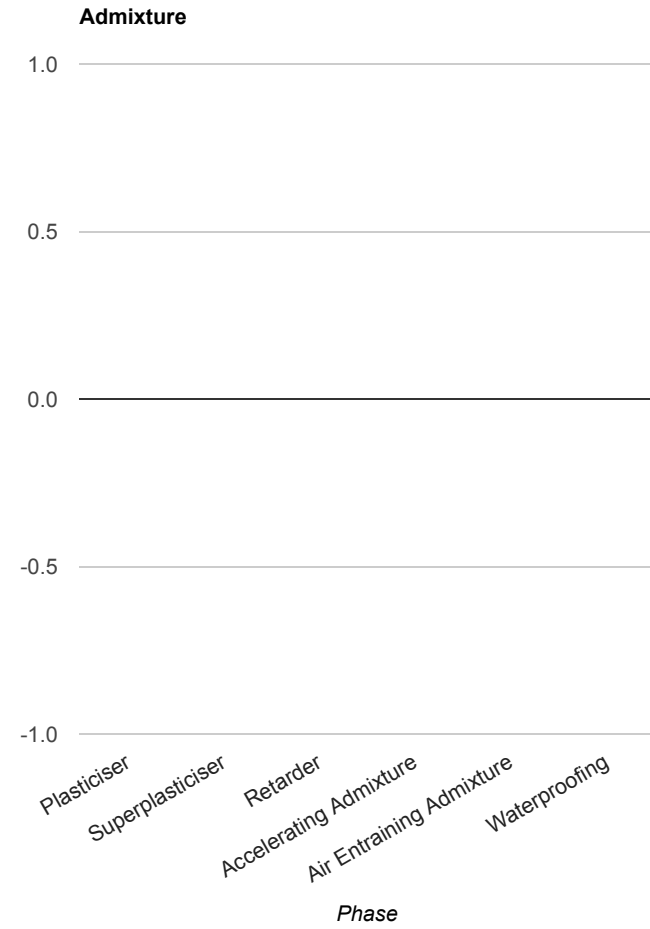
Energy (MJ)

GWP CO2-eq



Energy (MJ)

GWP CO2-eq



Phase	CO (kg)	Lead (kg)	NOx (kg)	PM10 (kg)	SO2 (kg)	VOC (kg)
Gypsum	2.120	0.000	0.533	37.891	0.648	0.020
Fine Aggregates	118.561	0.000	39.624	419.299	58.012	1.765
Coarse Aggregates	235.248	0.000	59.201	511.535	72.983	3.474
Cement: Quarrying	170.826	0.000	59.664	9.080	67.116	3.551
Cement: Raw Materials Prehomogenization	0.101	0.000	0.217	0.000	0.126	0.000
Cement: Raw Materials Grinding	9.270	0.000	19.927	0.000	11.589	0.013
Cement: Raw Meal Blending/Homogenization	0.435	0.000	0.936	0.000	0.544	0.001
Cement: Pyroprocessing	1,081,223.555	164.942	14,540.771	278.835	12,243.815	125.174
Cement: Clinker Cooling	0.000	0.000	0.000	0.000	0.000	0.000
Cement: Finish Milling and Grinding and Blending with PC	0.001	0.000	0.002	0.000	0.001	0.000
Cement: In-Cement Plant Convey	0.079	0.000	0.169	0.000	0.098	0.000
Fly Ash in Cement	0.000	0.000	0.000	0.000	0.000	0.000
Granulated Blast Furnace Slag in Cement	0.000	0.000	0.000	0.000	0.000	0.000
Plasticiser	0.000	0.000	0.000	0.000	0.000	0.000
Superplasticiser	0.000	0.000	0.000	0.000	0.000	0.000
Retarder	0.000	0.000	0.000	0.000	0.000	0.000
Accelerating Admixture	0.000	0.000	0.000	0.000	0.000	0.000
Air Entraining Admixture	0.000	0.000	0.000	0.000	0.000	0.000
Waterproofing	0.000	0.000	0.000	0.000	0.000	0.000
Limestone	0.000	0.000	0.000	0.000	0.000	0.000
Fly Ash	0.000	0.000	0.000	0.000	0.000	0.000
Granulated Blasted Furnace Slag	0.000	0.000	0.000	0.000	0.000	0.000
Natural Pozzolan	0.000	0.000	0.000	0.000	0.000	0.000
Mixing and Batching	4.898	0.000	10.529	0.000	6.123	0.007
Transport to Cement Plant	0.065	0.000	0.276	0.038	0.016	0.000
Transport to Concrete Plant	10,273.520	0.000	43,993.664	5,999.136	2,574.629	0.000

**For further information contact Petek Gursel at [pgursel\[at\]berkeley.edu](mailto:pgursel[at]berkeley.edu)
HTML and Javascript Coding by Claudine Custodio**

This page was last modified: 08/02/2012 13:17:18

Material Quantities	Value (per m ³ of concrete)	Total Amount Required	Unit Type	Unit
Retarder	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Accelerating admixture	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Air entraining admixture	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Waterproofing	<input type="text"/>	<input type="text" value="0"/>	Mass	kg

CEMENT TYPE AND AMOUNTS OF RAW MATERIALS (DEFINED BY ASTM)

Cement Raw Materials	Average Values	Unit Type	Unit
Cement clinker	<input type="text" value="6425800"/>	Mass	kg
Cement Gypsum	<input type="text" value="338200"/>	Mass	kg
Cement Kiln Dust (CKD)	<input type="text" value="0"/>	Mass	kg
Fly ash, blended in cement	<input type="text" value="0"/>	Mass	kg
Granulated Blast Furnace Slag, blended in cement	<input type="text" value="0"/>	Mass	kg
Limestone	<input type="text" value="0"/>	Mass	kg

3. Quarry and Plant Location, Grid Mix Information

*Please **define the electricity grid mix** if you know the fuel mix %. Otherwise use the pre-defined State or US-Average mix values*

CEMENT RAW MATERIALS (EXCEPT GYPSUM) QUARRY AND PLANT

Electricity Mix for Raw Material Mining (Quarry)

Electricity Mix for Cement Plant

GYPSUM QUARRYING AND PROCESSING PLANT

Electricity Mix for Gypsum Quarrying and Processing

AGGREGATES QUARRY AND PROCESSING PLANT

Electricity Mix for Fine Aggregates Quarrying and Processing

Electricity Mix for Coarse Aggregates Quarrying and Processing

LIMESTONE (SUPPLEMENTING CEMENT IN CONCRETE) QUARRY AND PROCESSING PLANT

Electricity Mix for Limestone Quarrying and Processing

NATURAL POZZOLAN QUARRY AND PROCESSING PLANT

Electricity Mix for Natural Pozzolan Quarrying and Processing

FLY ASH PROCESSING PLANT

Electricity Mix for Fly Ash Processing Plant

User Defined Grid ▼

GRANULATED BLAST FURNACE SLAG PROCESSING PLANT

Electricity Mix for Granulated Blast Furnace Slag Processing Plant

User Defined Grid ▼

CONCRETE BATCHING PLANT

Electricity Mix for Concrete Batching Plant

User Defined Grid ▼

4. Operation Electricity Mix

Enter custom grid mix when grid electricity source % details are available (optional). If not available, use [default State grid mix](#)

Contribution of Electricity Source %

User Defined

US Average (2009)

Bituminous Coal	<input type="text" value="0"/> %	44.4 %
Natural Gas	<input type="text" value="8.7"/> %	23.3 %
Residual (Heavy) Oil	<input type="text" value="0"/> %	0.5 %
Distillate (Diesel or Light) fuel oil	<input type="text" value="0.2"/> %	0.2 %
Petroleum Coke	<input type="text" value="0"/> %	0.4 %
Nuclear (Uranium)	<input type="text" value="60"/> %	20.2 %
Hydro	<input type="text" value="24.1"/> %	6.9 %
Biomass	<input type="text" value="1"/> %	1.4 %
Geothermal	<input type="text" value="0"/> %	0.4 %
Solar	<input type="text" value="1.1"/> %	0.02 %
Wind	<input type="text" value="4.9"/> %	1.9 %
Lignite coal	<input type="text" value="0.0"/> %	0.0 %
SUM	<input type="text" value="100"/>	

5. Transportation Input

	Distance Traveled (km)	Mode of Transportation
Cement Raw Materials to Cement Plant	<input type="text" value="1"/>	Truck Class 8b (Model 2005) ▼
Gypsum to Cement Plant	<input type="text" value="200"/>	Truck Class 8b (Model 2005) ▼
Fly Ash to Cement Plant (if Blended cement)	<input type="text" value="500"/>	Truck Class 8b (Model 2005) ▼
Granulated Blast Furnace Slag to Cement Plant (if Blended cement)	<input type="text" value="1000"/>	Truck Class 8b (Model 2005) ▼
Cement to Concrete Plant	<input type="text" value="500"/>	Truck Class 8b (Model 2005) ▼
Fine Aggregates to Concrete Plant	<input type="text" value="200"/>	Truck Class 8b (Model 2005) ▼
Coarse Aggregates to Concrete Plant	<input type="text" value="300"/>	Truck Class 8b (Model 2005) ▼
Admixture to Concrete Plant	<input type="text" value="1000"/>	Truck Class 8b (Model 2005) ▼
Fly Ash to Concrete Plant	<input type="text" value="500"/>	Truck Class 8b (Model 2005) ▼
Granulated Blast Furnace Slag to Concrete Plant	<input type="text" value="1000"/>	Truck Class 8b (Model 2005) ▼

Natural Pozzolan to Concrete Plant
Limestone to Concrete Plant

Distance Traveled (km)

1000
500

Mode of Transportation

Truck Class 8b (Model 2005) ▾
Truck Class 8b (Model 2005) ▾

6. Cement Production Technology Options

TECHNOLOGY OPTIONS BY PHASE

Cement Production Phases

- Raw Materials Prehomogenization**
- Raw Materials Grinding**
- Raw Meal Blending/ Homogenization**
- Pyroprocessing**
- Clinker Cooling**
- Finish Milling/Grinding/Blending w/ PC**

Product of Each Phase

- Raw Meal**
- Ground Meal**
- Blended Meal**
- Clinker**
- Cooled Clinker**
- Blended/Traditional Portland Cement**

Technology

Dry process Raw storing, non-preblending ▾
Dry raw grinding, ball mill ▾
Raw meal homogenization, blending, and storage ▾
Preheater/Precalciner kiln ▾
Reciprocating Grate Cooler (Modern) ▾
Ball Mill ▾

7. Fuel Use Options for Cement Pyroprocessing

For Pyroprocessing, Specify Fuel Inputs to Preheater kiln

Fuel Options

- Bituminous coal**
- Lignite coal**
- Distillate (Diesel or Light) fuel oil**
- Petroleum Coke**
- Residual Fuel (Heavy) oil**
- Natural gas**
- Waste Oil**
- Waste Solvent**
- Waste Tire (whole)**
- Waste Tire (shredded)**
- Waste (Other) (non-hazardous)**
- Waste Paper, cardboard**
- Waste Plastics**
- Waste Sewage sludge (dry)**
- Waste (Other) (hazardous)**
- SUM**

% by Energy Source

50 %
0 %
0 %
50 %
0 %
0 %
0 %
0 %
0 %
0 %
0 %
0 %
0 %
0 %
0 %
0 %
100

% by Energy Source

- 64.1%**
- 0.0%**
- 0.8%**
- 21.2%**
- 0.2%**
- 3.7%**
- 0.3%**
- 4.0%**
- 1.8%**
- 1.8%**
- 2.3%**
- 0.0%**
- 0.0%**
- 0.0%**
- 0.0%**
- 0.0%**

CLINKER COOLING PM CONTROL TECHNOLOGY OPTIONS

For Clinker Cooling PM Control, Specify Technology Option
Option: Electrostatic Precipitators (ESP) ▾

8. Conveying Technology Options

Product of Each Phase

Conveyence Distance [meters]

Conveyance Mode

Average Amount of Material Conveyed (kg)

Raw Meal

20

Screw Pump ▼

10862984

Ground Meal

20

Screw Pump ▼

10862984

Blended Meal

20

Screw Pump ▼

10862984

Clinker

20

Screw Pump ▼

6425800

Clinker Cooled

20

Screw Pump ▼

6425800

Blended/Traditional Portland Cement

20

Screw Pump ▼

6764000

9. Concrete Batching Plant Technology

BATCHING PLANT PM CONTROL TECHNOLOGY OPTIONS

For Process-related PM Control, Specify Technology Option (including material transfer, loading and unloading processes within the plant)

Option:

Controlled w/ Fabric Filter ▼

BATCHING PLANT LOADING/MIXING OPTIONS

For mixing/loading concrete materials into mixer trucks.

Option:

Mixer Loading (Central Mix) ▼

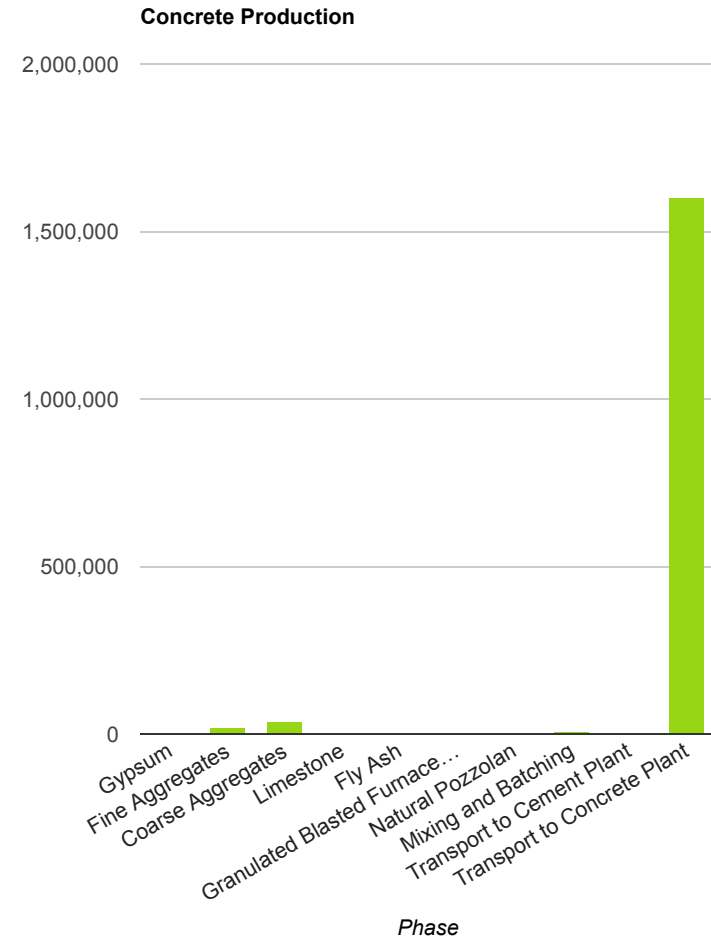
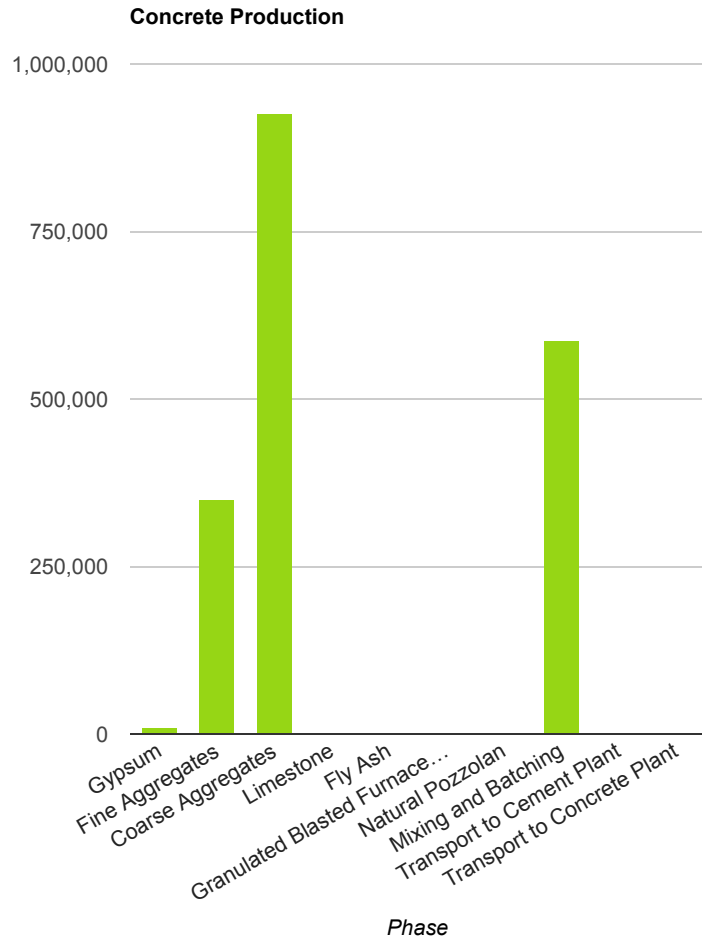
Run Analysis

Energy (MJ)

GWP CO2-eq

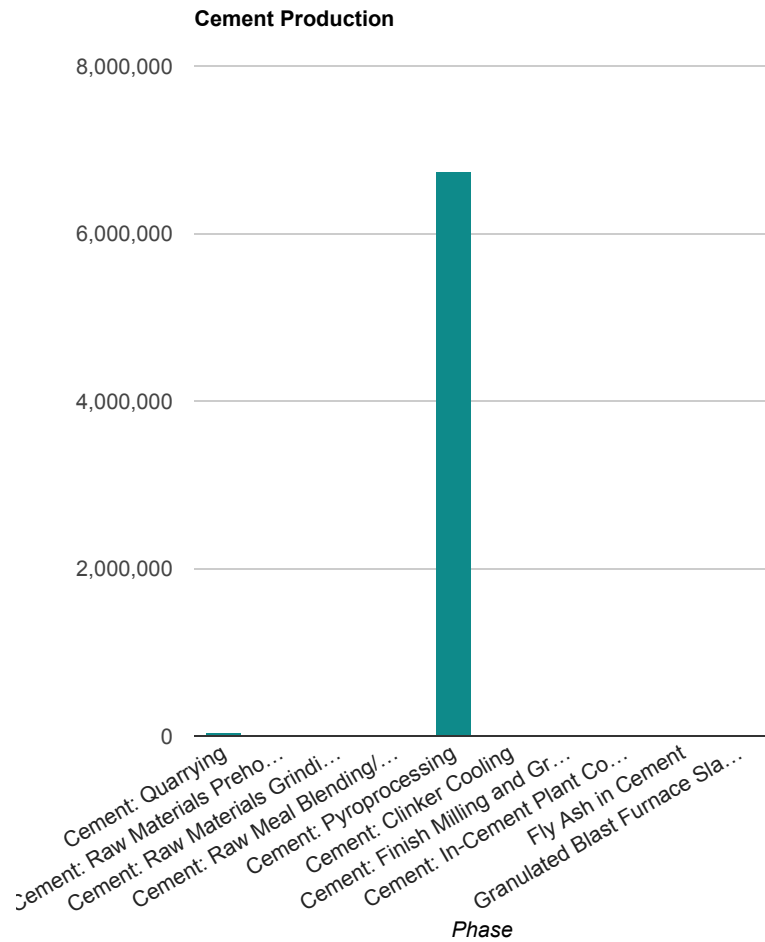
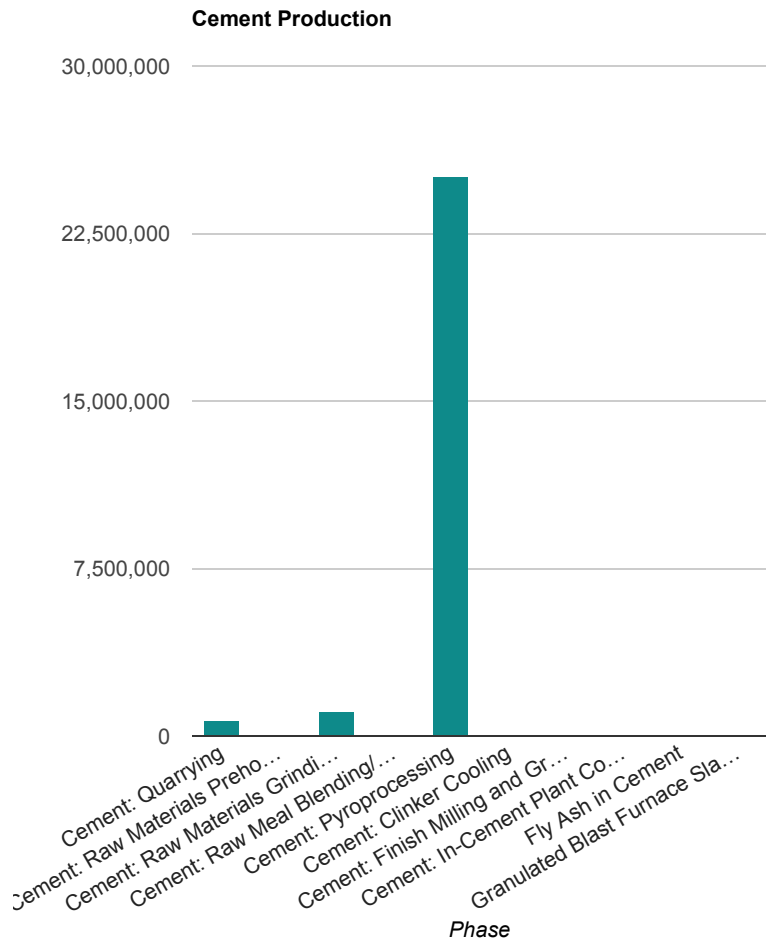
Energy (MJ)

GWP CO2-eq



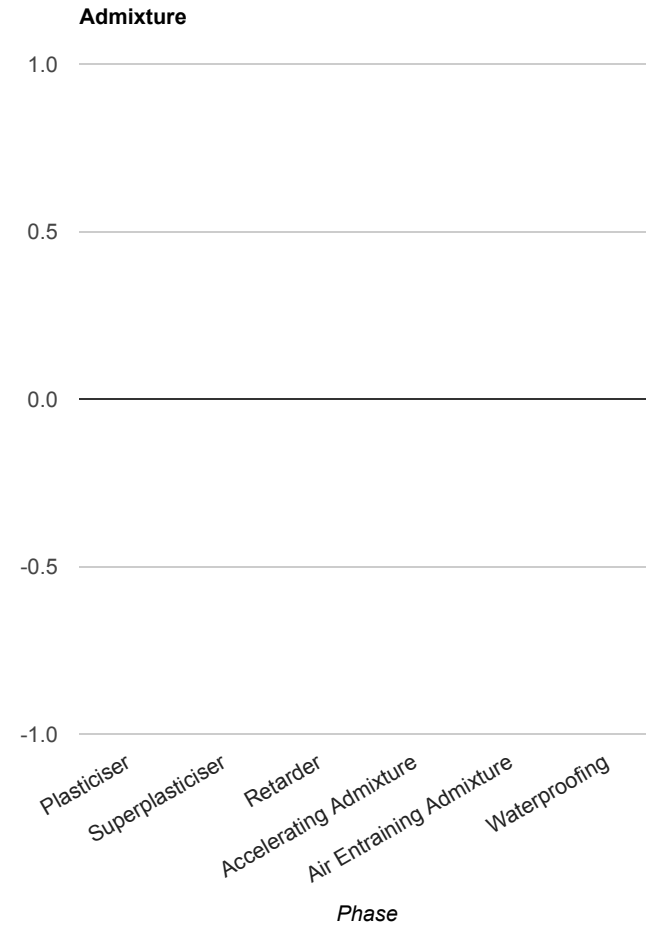
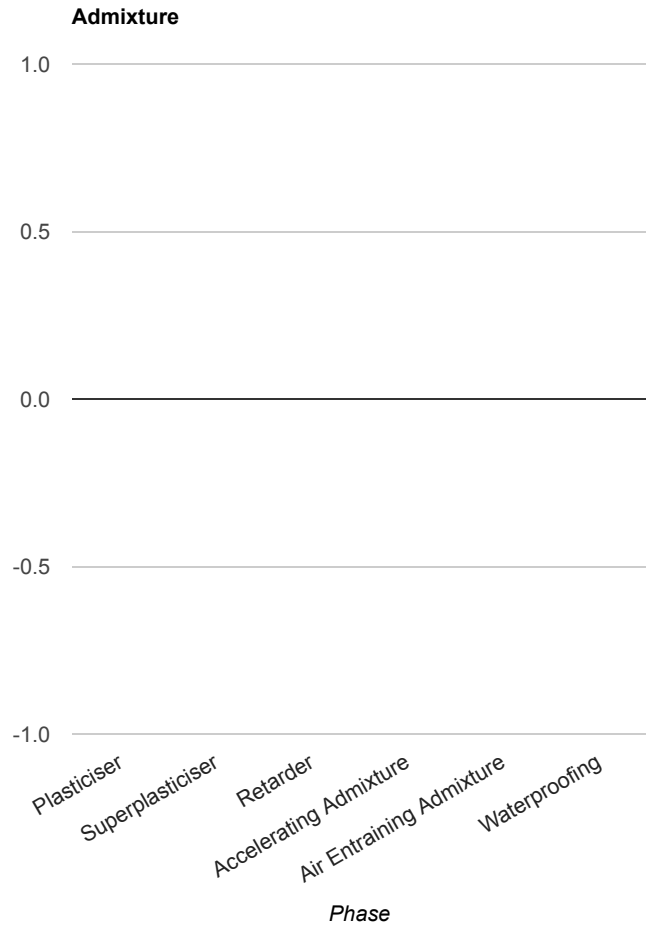
Energy (MJ)

GWP CO2-eq



Energy (MJ)

GWP CO2-eq



Phase	CO (kg)	Lead (kg)	NOx (kg)	PM10 (kg)	SO2 (kg)	VOC (kg)
Gypsum	2.120	0.000	0.533	37.891	0.648	0.020
Fine Aggregates	118.561	0.000	39.624	419.299	58.012	1.765
Coarse Aggregates	235.248	0.000	59.201	511.535	72.983	3.474
Cement: Quarrying	170.826	0.000	59.664	9.080	67.116	3.551
Cement: Raw Materials Prehomogenization	0.101	0.000	0.217	0.000	0.126	0.000
Cement: Raw Materials Grinding	9.270	0.000	19.927	0.000	11.589	0.013
Cement: Raw Meal Blending/Homogenization	0.435	0.000	0.936	0.000	0.544	0.001
Cement: Pyroprocessing	1,081,223.555	164.942	14,540.771	278.835	12,243.815	125.174
Cement: Clinker Cooling	0.000	0.000	0.000	0.000	0.000	0.000
Cement: Finish Milling and Grinding and Blending with PC	0.001	0.000	0.002	0.000	0.001	0.000
Cement: In-Cement Plant Convey	0.079	0.000	0.169	0.000	0.098	0.000
Fly Ash in Cement	0.000	0.000	0.000	0.000	0.000	0.000
Granulated Blast Furnace Slag in Cement	0.000	0.000	0.000	0.000	0.000	0.000
Plasticiser	0.000	0.000	0.000	0.000	0.000	0.000
Superplasticiser	0.000	0.000	0.000	0.000	0.000	0.000
Retarder	0.000	0.000	0.000	0.000	0.000	0.000
Accelerating Admixture	0.000	0.000	0.000	0.000	0.000	0.000
Air Entraining Admixture	0.000	0.000	0.000	0.000	0.000	0.000
Waterproofing	0.000	0.000	0.000	0.000	0.000	0.000
Limestone	0.000	0.000	0.000	0.000	0.000	0.000
Fly Ash	0.000	0.000	0.000	0.000	0.000	0.000
Granulated Blasted Furnace Slag	0.000	0.000	0.000	0.000	0.000	0.000
Natural Pozzolan	0.000	0.000	0.000	0.000	0.000	0.000
Mixing and Batching	4.898	0.000	10.529	0.000	6.123	0.007
Transport to Cement Plant	0.032	0.000	0.138	0.019	0.008	0.000
Transport to Concrete Plant	5,136.760	0.000	21,996.832	2,999.568	1,287.315	0.000

**For further information contact Petek Gursel at [pgursel\[at\]berkeley.edu](mailto:pgursel[at]berkeley.edu)
HTML and Javascript Coding by Claudine Custodio**

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Green Concrete LCA Web Tool

[Home](#) [Structure](#) [Webtool](#) [Results](#) [References](#)

READY-MIXED CONCRETE EXITING THE CONCRETE PLANT GATE

1. Modeling Parameters

Functional Unit

Unit Type

Unit

Unit Volume of Concrete Production

Volume

m³

Enter Amount of Concrete Produced

19000

2. Concrete Mix Proportions for Unit Volume (kg/m³)

Calculated based on the user input for material quantities

Enter Concrete Mix Design Name

Enter Cement Type

Portland cement Normal, Type I

Portland cement Low heat of hydration, Type IV is no longer made in the US because of low demand. (Mehta and Monteiro 2006)

Total Weight of Concrete (kg/m³)

2416

Total Cementitious Materials (Sum of PC and SCMs) (kg/m³)

356

Water/Binder Ratio

0.5

Please enter material quantities (per m³ of concrete)

Supplementary Cementitious Materials (also known as Mineral Admixtures).

Material Quantities	Value (per m ³ of concrete)	Total Amount Required	Unit Type	Unit
Cement	356	6764000	Mass	kg
Water	178	3382000	Mass	kg
Fine Aggregates	848	16112000	Mass	kg
Coarse Aggregates	1034	19646000	Mass	kg
Fly Ash		0	Mass	kg
Granulated Blast Furnace Slag		0	Mass	kg
Natural Pozzolan		0	Mass	kg
Limestone		0	Mass	kg
Total Cementitious Materials	356	6764000	Mass	kg
Admixtures (Chemical)				
Plasticiser		0	Mass	kg
Superplasticiser		0	Mass	kg

Material Quantities	Value (per m ³ of concrete)	Total Amount Required	Unit Type	Unit
Retarder	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Accelerating admixture	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Air entraining admixture	<input type="text"/>	<input type="text" value="0"/>	Mass	kg
Waterproofing	<input type="text"/>	<input type="text" value="0"/>	Mass	kg

CEMENT TYPE AND AMOUNTS OF RAW MATERIALS (DEFINED BY ASTM)

Cement Raw Materials	Average Values	Unit Type	Unit
Cement clinker	<input type="text" value="6425800"/>	Mass	kg
Cement Gypsum	<input type="text" value="338200"/>	Mass	kg
Cement Kiln Dust (CKD)	<input type="text" value="0"/>	Mass	kg
Fly ash, blended in cement	<input type="text" value="0"/>	Mass	kg
Granulated Blast Furnace Slag, blended in cement	<input type="text" value="0"/>	Mass	kg
Limestone	<input type="text" value="0"/>	Mass	kg

3. Quarry and Plant Location, Grid Mix Information

*Please **define the electricity grid mix** if you know the fuel mix %. Otherwise use the pre-defined State or US-Average mix values*

CEMENT RAW MATERIALS (EXCEPT GYPSUM) QUARRY AND PLANT

Electricity Mix for Raw Material Mining (Quarry)

Electricity Mix for Cement Plant

GYPSUM QUARRYING AND PROCESSING PLANT

Electricity Mix for Gypsum Quarrying and Processing

AGGREGATES QUARRY AND PROCESSING PLANT

Electricity Mix for Fine Aggregates Quarrying and Processing

Electricity Mix for Coarse Aggregates Quarrying and Processing

LIMESTONE (SUPPLEMENTING CEMENT IN CONCRETE) QUARRY AND PROCESSING PLANT

Electricity Mix for Limestone Quarrying and Processing

NATURAL POZZOLAN QUARRY AND PROCESSING PLANT

Electricity Mix for Natural Pozzolan Quarrying and Processing

FLY ASH PROCESSING PLANT

Electricity Mix for Fly Ash Processing Plant

User Defined Grid ▾

GRANULATED BLAST FURNACE SLAG PROCESSING PLANT

Electricity Mix for Granulated Blast Furnace Slag Processing Plant

User Defined Grid ▾

CONCRETE BATCHING PLANT

Electricity Mix for Concrete Batching Plant

User Defined Grid ▾

4. Operation Electricity Mix

Enter custom grid mix when grid electricity source % details are available (optional). If not available, use [default State grid mix](#)

Contribution of Electricity Source %

	User Defined	US Average (2009)
Bituminous Coal	0 %	44.4 %
Natural Gas	8.7 %	23.3 %
Residual (Heavy) Oil	0 %	0.5 %
Distillate (Diesel or Light) fuel oil	0.2 %	0.2 %
Petroleum Coke	0 %	0.4 %
Nuclear (Uranium)	60 %	20.2 %
Hydro	24.1 %	6.9 %
Biomass	1 %	1.4 %
Geothermal	0 %	0.4 %
Solar	1.1 %	0.02 %
Wind	4.9 %	1.9 %
Lignite coal	0.0 %	0.0 %
SUM	100	

5. Transportation Input

	Distance Traveled (km)	Mode of Transportation
Cement Raw Materials to Cement Plant	1	Truck Class 8b (Model 2005) ▾
Gypsum to Cement Plant	100	Truck Class 8b (Model 2005) ▾
Fly Ash to Cement Plant (if Blended cement)	250	Truck Class 8b (Model 2005) ▾
Granulated Blast Furnace Slag to Cement Plant (if Blended cement)	500	Truck Class 8b (Model 2005) ▾
Cement to Concrete Plant	250	Truck Class 8b (Model 2005) ▾
Fine Aggregates to Concrete Plant	100	Truck Class 8b (Model 2005) ▾
Coarse Aggregates to Concrete Plant	150	Truck Class 8b (Model 2005) ▾
Admixture to Concrete Plant	500	Truck Class 8b (Model 2005) ▾
Fly Ash to Concrete Plant	250	Truck Class 8b (Model 2005) ▾
Granulated Blast Furnace Slag to Concrete Plant	500	Truck Class 8b (Model 2005) ▾

Natural Pozzolan to Concrete Plant
Limestone to Concrete Plant

Distance Traveled (km)

500
250

Mode of Transportation

Truck Class 8b (Model 2005) ▾
Truck Class 8b (Model 2005) ▾

6. Cement Production Technology Options

TECHNOLOGY OPTIONS BY PHASE

Cement Production Phases

- Raw Materials Prehomogenization**
- Raw Materials Grinding**
- Raw Meal Blending/ Homogenization**
- Pyroprocessing**
- Clinker Cooling**
- Finish Milling/Grinding/Blending w/ PC**

Product of Each Phase

- Raw Meal**
- Ground Meal**
- Blended Meal**
- Clinker**
- Cooled Clinker**
- Blended/Traditional Portland Cement**

Technology

Dry process Raw storing, non-preblending ▾
Dry raw grinding, ball mill ▾
Raw meal homogenization, blending, and storage ▾
Preheater/Precalciner kiln ▾
Reciprocating Grate Cooler (Modern) ▾
Ball Mill ▾

7. Fuel Use Options for Cement Pyroprocessing

For Pyroprocessing, Specify Fuel Inputs to Preheater kiln

Fuel Options

- Bituminous coal**
- Lignite coal**
- Distillate (Diesel or Light) fuel oil**
- Petroleum Coke**
- Residual Fuel (Heavy) oil**
- Natural gas**
- Waste Oil**
- Waste Solvent**
- Waste Tire (whole)**
- Waste Tire (shredded)**
- Waste (Other) (non-hazardous)**
- Waste Paper, cardboard**
- Waste Plastics**
- Waste Sewage sludge (dry)**
- Waste (Other) (hazardous)**
- SUM**

% by Energy Source

64.1 %
0.0 %
0.8 %
21.2 %
0.2 %
3.7 %
0.3 %
4.0 %
1.8 %
1.8 %
2.3 %
0.0 %
0.0 %
0.0 %
0.0 %
0.0 %

% by Energy Source

- 64.1%**
- 0.0%**
- 0.8%**
- 21.2%**
- 0.2%**
- 3.7%**
- 0.3%**
- 4.0%**
- 1.8%**
- 1.8%**
- 2.3%**
- 0.0%**
- 0.0%**
- 0.0%**
- 0.0%**

CLINKER COOLING PM CONTROL TECHNOLOGY OPTIONS

For Clinker Cooling PM Control, Specify Technology Option
Option: Electrostatic Precipitators (ESP) ▾

8. Conveying Technology Options

Product of Each Phase

Conveyence Distance [meters]

Conveyance Mode

Average Amount of Material Conveyed (kg)

Raw Meal

20

Screw Pump ▼

10862984

Ground Meal

20

Screw Pump ▼

10862984

Blended Meal

20

Screw Pump ▼

10862984

Clinker

20

Screw Pump ▼

6425800

Clinker Cooled

20

Screw Pump ▼

6425800

Blended/Traditional Portland Cement

20

Screw Pump ▼

6764000

9. Concrete Batching Plant Technology

BATCHING PLANT PM CONTROL TECHNOLOGY OPTIONS

For Process-related PM Control, Specify Technology Option (including material transfer, loading and unloading processes within the plant)

Option:

Controlled w/ Fabric Filter ▼

BATCHING PLANT LOADING/MIXING OPTIONS

For mixing/loading concrete materials into mixer trucks.

Option:

Mixer Loading (Central Mix) ▼

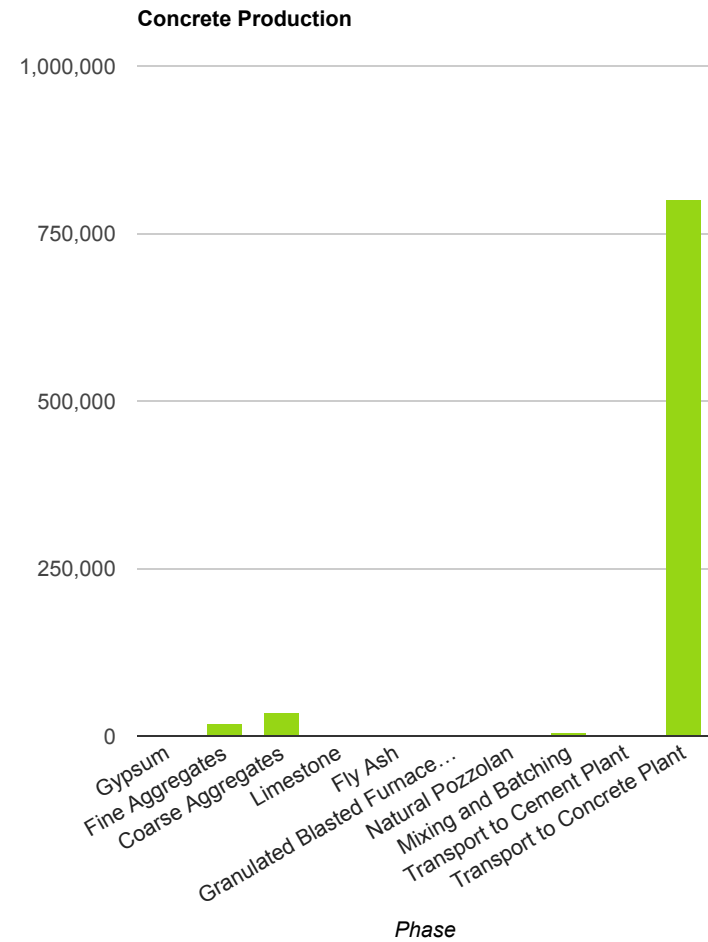
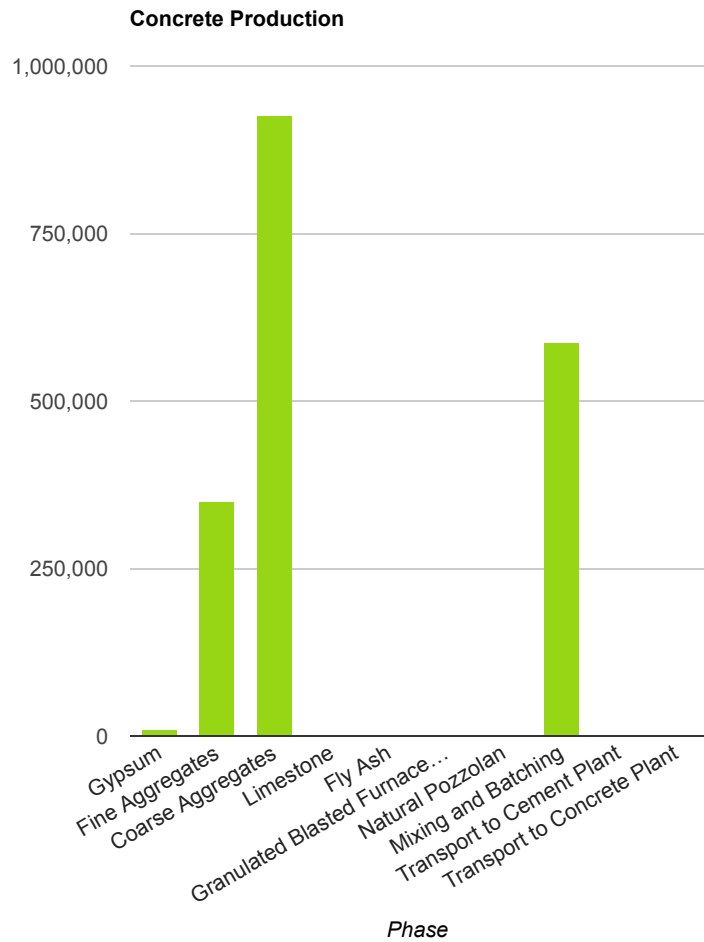
Run Analysis

Energy (MJ)

GWP CO2-eq

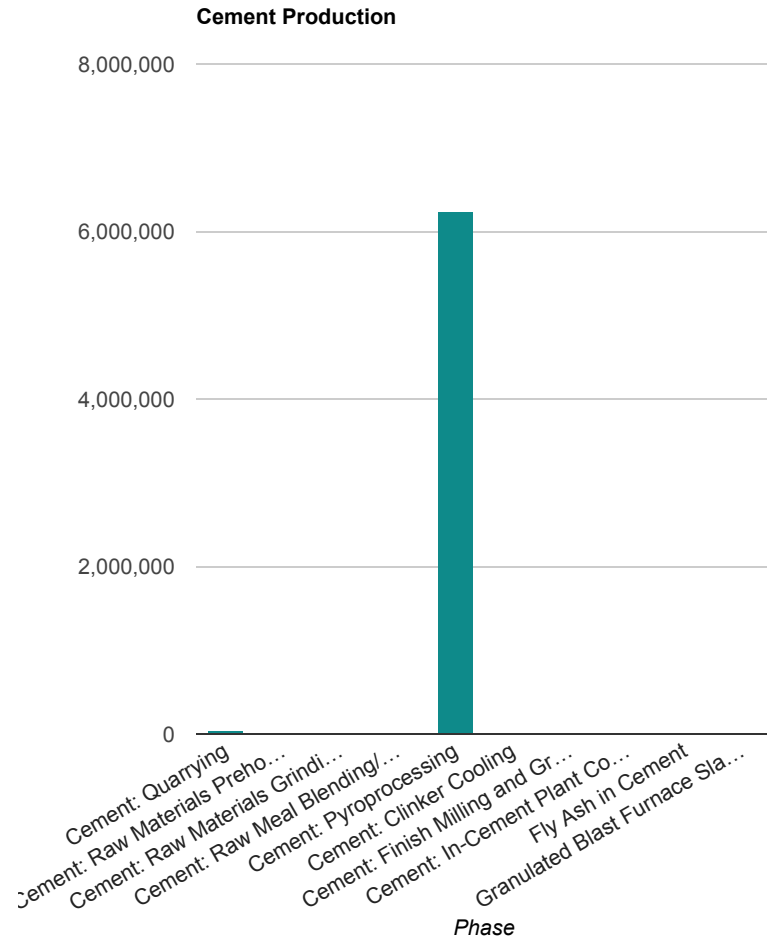
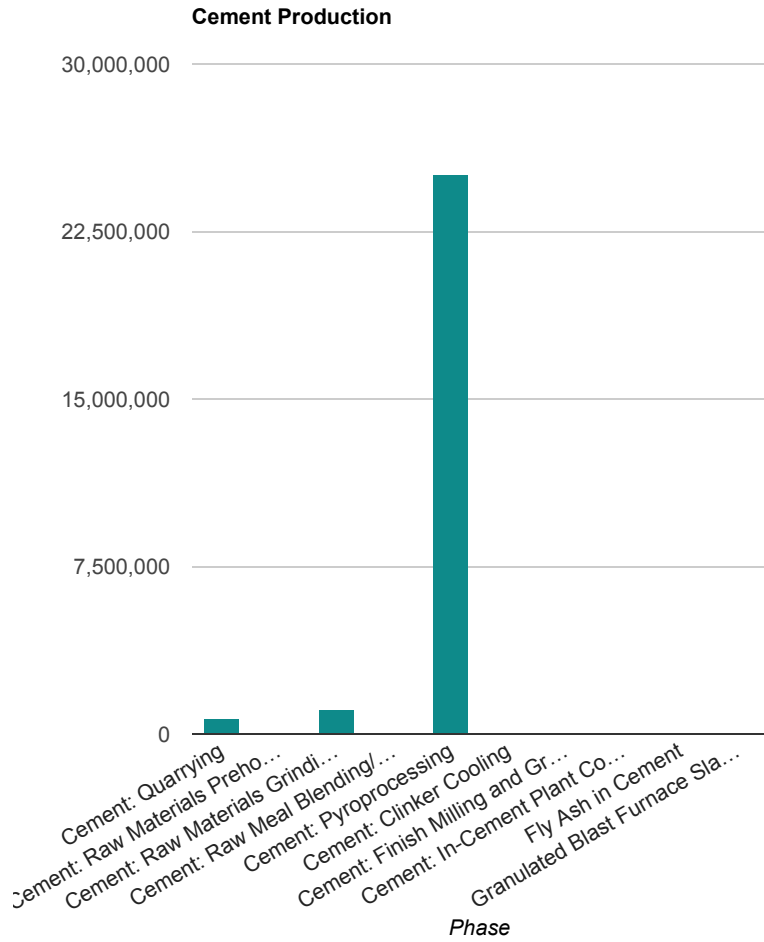
Energy (MJ)

GWP CO2-eq



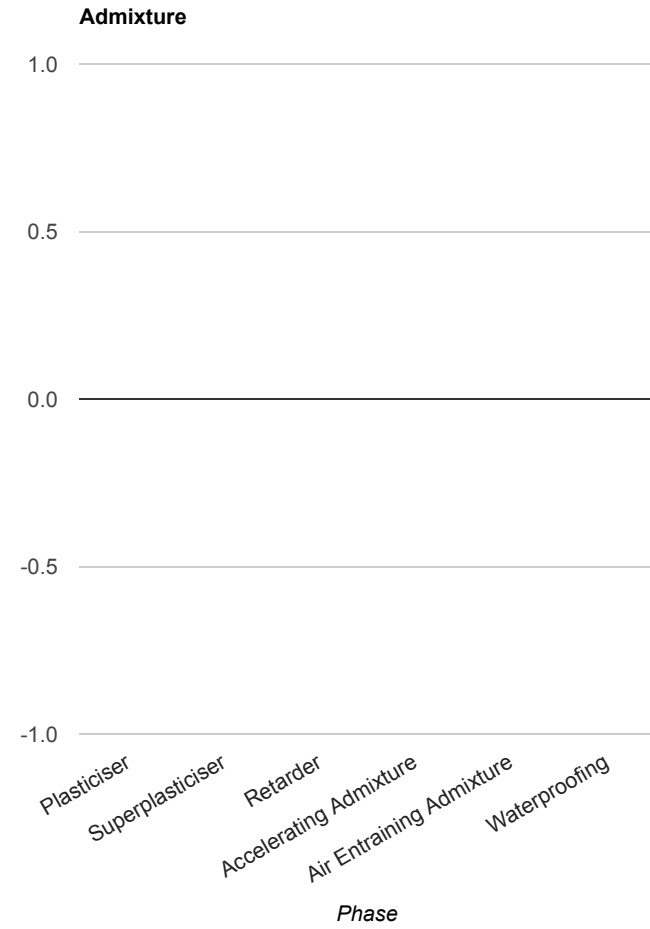
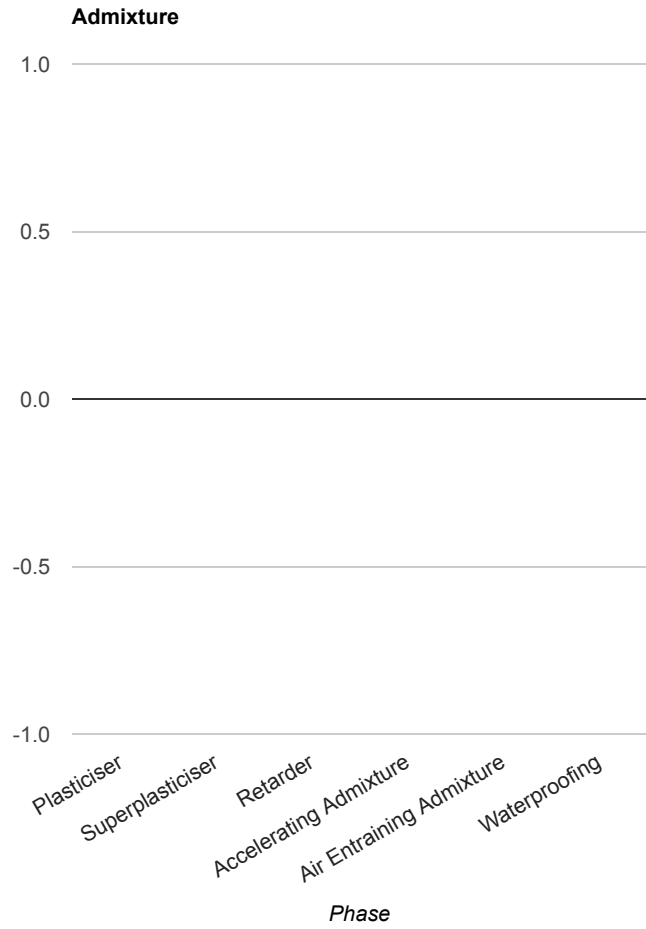
Energy (MJ)

GWP CO2-eq



Energy (MJ)

GWP CO2-eq



Phase	CO (kg)	Lead (kg)	NOx (kg)	PM10 (kg)	SO2 (kg)	VOC (kg)
Gypsum	2.120	0.000	0.533	37.891	0.648	0.020
Fine Aggregates	118.561	0.000	39.624	419.299	58.012	1.765
Coarse Aggregates	235.248	0.000	59.201	511.535	72.983	3.474
Cement: Quarrying	170.826	0.000	59.664	9.080	67.116	3.551
Cement: Raw Materials Prehomogenization	0.101	0.000	0.217	0.000	0.126	0.000
Cement: Raw Materials Grinding	9.270	0.000	19.927	0.000	11.589	0.013
Cement: Raw Meal Blending/Homogenization	0.435	0.000	0.936	0.000	0.544	0.001
Cement: Pyroprocessing	1,402,575.386	295.431	15,577.916	383.829	12,812.352	772.778
Cement: Clinker Cooling	0.000	0.000	0.000	0.000	0.000	0.000
Cement: Finish Milling and Grinding and Blending with PC	0.001	0.000	0.002	0.000	0.001	0.000
Cement: In-Cement Plant Convey	0.079	0.000	0.169	0.000	0.098	0.000
Fly Ash in Cement	0.000	0.000	0.000	0.000	0.000	0.000
Granulated Blast Furnace Slag in Cement	0.000	0.000	0.000	0.000	0.000	0.000
Plasticiser	0.000	0.000	0.000	0.000	0.000	0.000
Superplasticiser	0.000	0.000	0.000	0.000	0.000	0.000
Retarder	0.000	0.000	0.000	0.000	0.000	0.000
Accelerating Admixture	0.000	0.000	0.000	0.000	0.000	0.000
Air Entraining Admixture	0.000	0.000	0.000	0.000	0.000	0.000
Waterproofing	0.000	0.000	0.000	0.000	0.000	0.000
Limestone	0.000	0.000	0.000	0.000	0.000	0.000
Fly Ash	0.000	0.000	0.000	0.000	0.000	0.000
Granulated Blasted Furnace Slag	0.000	0.000	0.000	0.000	0.000	0.000
Natural Pozzolan	0.000	0.000	0.000	0.000	0.000	0.000
Mixing and Batching	4.898	0.000	10.529	0.000	6.123	0.007
Transport to Cement Plant	0.018	0.000	0.079	0.011	0.005	0.000
Transport to Concrete Plant	2,568.380	0.000	10,998.416	1,499.784	643.657	0.000

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HTML and Javascript Coding by Claudine Custodio**

This page was last modified: 08/02/2012 13:17:18

A.3 – Summary of Direct GHG Emission Calculations



Summary of Variables Used for Emission Estimates on Worksheets

"Daily" or "Annual" Multiplier Used? **Daily**

Material Handling Calculation Method: Drop Equation AP-42 13.2.4, November 2006

Variable	Assumed Value	Units	Comments
Construction Weeks per year	40	weeks per year	Not Used in Calculations 52 weeks per year minimum 12 weeks during winter = 40 weeks
Construction Days per week	5	days per week	Not Used in Calculations
Construction Hours per day	12	hours per day	
Capacity per Haul Truck	35	tonnes	
Moisture Content of clean fill	10%	%	Arcadis Experience
Wind Speed	5	m/s	MOE Outdoor default wind speed
Control Efficiency	0%	%	No Control Efficiencies for drops to haul trucks and clean fill drops to excavation
24 hour average Adjustment Factor		0.5	

Truck Idling Tailpipe Emissions Calculation Method: Mobile 6C (Haul Trucks and Pick-Up Trucks)

Variable	Assumed Value	Units	Comments
Haul trucks - g/VKT	various	g PM/VKT	Based on Mobile 6C EF's for Haul Trucks and Light Duty Trucks - HDDV8b and ALLVEH Emission factors were used
Assumption: Site haul roads are short, therefore road dust and tailpipe emissions during truck travel on site is considered negligible.			

Stationary Equipment Tailpipe Emissions Calculation Method: AP-42 Section 3.3 Small Diesel Generators (<600 hp)

Variable	Assumed Value	Units	Comments
Assumption from URBEMIS2007 Model Appendix G Air Compressors and Generator Sets			
Equipment hp ratings	various	hp	Actual hp ratings from assumed diesel fired generator equipment

NonRoad Equipment Tailpipe Emissions Calculation Method: US EPA Nonroad (Excavators & Loaders)

Variable	Assumed Value	Units	Comments
Assumption from URBEMIS2007 Model Appendix G for each piece of Equipment (equipment not listed in Appendix G assumed to be "Other General Industrial Equipment")			
Equipment hp ratings	various	hp	Actual hp ratings from assumed equipment
Excavators and Loaders - g/hp-hr	various	g/hp-hr	US EPA Nonroad (EPA420-P-04-009) April 2004

Concrete Saw Cutting Emissions Calculation Method: Emission Factors from URBEMIS2007

Variable	Assumed Value	Units	Comments
Assumption: Concrete Saw cutting activities are controlled with water			

Welder with Power from a Diesel Generator Calculation Method: Emission Factors from URBEMIS2007

Variable	Assumed Value	Units	Comments
Assumption: Welders are 15 hp each			

Model Source	Calculation	Activity
1 - Demolition	NonRoad -	One 100T Crane for demolition
		One Excavator with Shears
		One Backhoe for loading and movement of debris
	Concrete Saw -	Two concrete saws to cut building materials

Haul Truck Tailpipe Emissions

Vehicle Type	One Way Road Length	Number of 16T Vehicles per hour	SPM	PM ₁₀	PM _{2.5}	NO _x	SO ₂	CO	Acrolein	CO ₂	CH ₄	N ₂ O
			(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)
Concrete Batch to Demolition Area	0.46	4	1.90E-04	1.90E-04	1.57E-04	7.11E-03	1.92E-04	3.41E-03	1.59E-06	9.67E-01	2.02E-05	7.8E-06
Clay delivery for cover	100	4	4.15E-02	4.15E-02	3.43E-02	1.55E+00	4.20E-02	7.44E-01	3.46E-04	2.11E+02	4.40E-03	1.7E-03

Mobile 6C Emission Factors - Year 2007	
Vehicle Type	
Off-Site Haul Trucks - 35T Capacity (Values in g/km) (4 km/hr HDDV8b)	
Pick-up Trucks - Approx 3T (4 km/hr ALLVEH)	

SPM	PM ₁₀	PM _{2.5}	NO _x	SO _x	CO	Acrolein	CO ₂	CH ₄	N ₂ O
0.199	0.199	0.164	7.440	0.201	3.565	0.00166	1012	0.021	0.008
0.0296	0.0296	0.0194	1.1881	0.0189	11.712	0.0004039	339	0.040	0.003

Stationary Diesel Equipment Tailpipe Emissions

Vehicle Use	Power Rating (hp)	% of Maximum Operating Capacity ¹	Uncontrolled (g/s) - Emitted During Operating Hours							
			TSP	PM ₁₀	PM _{2.5}	NOx	SO _x	CO	Acrolein	CO ₂
Diesel Generator for Back-up power	100	74	0.0206	0.0206	0.0206	0.2896	0.0192	0.0624	0.000864	10.7449
Diesel Generator for Concrete batch	40	74	0.0082	0.0082	0.0082	0.1159	0.0077	0.0250	0.000346	4.2980
Assumption from URBEMIS2007 Model Appendix G Air Compressors and Generator Sets			0.0288							

AP-42 Emission Factors for Diesel Generators (lb/hp-hr)										
Vehicle Type	SPM	PM ₁₀	PM _{2.5}	NOx	SO _x	CO	Acrolein	CO ₂	CH ₄	N ₂ O*
Small Diesel Generators (less than 600 hp) Table 3.3-1 and Table 3.3-2	0.0022	0.0022	0.0022	0.031	0.00205	0.00668	0.0000925	1.15	6.29E-05	9.31E-06

NOx Emissions Sample Calculation for generator less than 600 hp:

$$\text{NOx Emission} = \text{power}(hp) \times \frac{0.031 \text{ lb}}{hp - hr} \times \left(\frac{1 \text{ hr}}{3,600 \text{ sec}} \right) \times \left(\frac{1 \text{ kg}}{2.2 \text{ lb}} \right) \times \left(\frac{1000 \text{ g}}{\text{kg}} \right) \times \% \text{ operating time}$$

Tailpipe Emissions - Working Face Excavators and Loaders

Vehicle Use	Number of Units	Power Rating (hp)	Emission Factor in g/hp-hr				Transient Adjustment Factor (TAF)				BSFC	PM Adj g/hp.hr	Emission Factor per Unit in g/hp-hr										% of Maximum Operating Capacity ¹	Uncontrolled (g/s) during Operating					
			PM EF _{ss}	NOx EF _{ss}	CO EF _{ss}	HC EF _{ss}	PM TAF	NOx TAF	CO TAF	HC TAF			SPM	PM ₁₀	PM _{2.5}	NOx	SO _x	CO	Acrolein*	CO ₂	CH ₄ *	N ₂ O*		TSP	PM ₁₀	PM _{2.5}	NOx	SO _x	CO
100T Crane for Demolition (Liebert LR1100)	1	362	0.402	8.38	2.70	0.68	1.23	0.95	1.53	1.05	1.01	0.0584	0.436	0.436	0.436	7.961	2.227	4.131	0.000402	1459	0.437	1.18E-02	10%	0.0044	0.0044	0.0044	0.0801	0.0224	0.0415
10T Excavator (CAT 330D L) with various attachments	2	268	0.402	8.38	2.70	0.68	1.23	0.95	1.53	1.05	1.01	0.0584	0.436	0.436	0.436	7.961	2.227	4.131	0.000402	1459	0.437	1.18E-02	10%	0.0065	0.0065	0.0065	0.1185	0.0332	0.0615
Backhoe (CAT 430E)	2	102	0.402	8.38	2.70	0.68	1.23	0.95	1.53	1.05	1.01	0.0584	0.436	0.436	0.436	7.961	2.227	4.131	0.000402	1459	0.437	1.18E-02	10%	0.0025	0.0025	0.0025	0.0451	0.0126	0.0234

Assumption from URBEMIS2007 Model Appendix G for each piece of Equipment (equipment not listed in Appendix G assumed to be "Other General Industrial Equipment")

Note: EF_{ss} values are from US EPA Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling--Compression-Ignition, April 2004 (EPA420-P-04-009), Pages 9 to 12.
TAF and BSFC values are from EPA420-P-04-009, Page A9, based on SCC 2270002069, Tier 0.

Emission Factors are calculated based on calculation outlined on EPA420-P-04-009 page 6, except for Acrolein and CH₄ (Methane).

*Acrolein Emission Factor is calculated based on the ratio of CO emission factor in AP-42 Table 3.3-1 (0.95 lb/MMBtu) to the CO emission factor above (4.131 g/hp-hr), and the Acrolein emission factor in AP-42 Table 3.3-2 (9.25E-05 lb/MMBtu).

*CH₄ Emission Factor is calculated based on the ratio of CO emission factor in AP-42 Table 3.4-1 (0.85 lb/MMBtu) to the CO emission factor above (4.131 g/hp-hr), and the CH₄ emission factors in AP-42 Table 3.4-1 (0.09 lb/MMBtu).

Concrete Saw Cutting Emissions

Concrete Saw Use	Power Rating (hp)	SPM	PM ₁₀	PM _{2.5}	NOx	SO ₂	CO	Acrolein	CO ₂	CH ₄	N ₂ O
		(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)	(g/s)
Demolition	25	1.64E-03	1.64E-03	1.64E-03	2.57E-02	3.33E-04	1.23E-02	1.20E-06	2.88E+00	1.31E-03	2.3E-05
Demolition	25	1.64E-03	1.64E-03	1.64E-03	2.57E-02	3.33E-04	1.23E-02	1.20E-06	2.88E+00	1.31E-03	2.3E-05

Assumption: Concrete Saw cutting activities are controlled with water

Sc1	3.28E-03
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Emission Factors - URBEMIS2007 Model Appendix I

	SPM	PM ₁₀ ¹	PM _{2.5} ¹	NOx	SO _x	CO	Acrolein ²	CO ₂	CH ₄ ³	N ₂ O*
Concrete/Industrial Saw - 25hp Emission Factors in g/hp/hr	0.236	0.236	0.236	3.699	0.048	1.776	0.00017	415	0.188	3.4E-03

Note: EF's include dust generated by saw and tailpipe emissions

Metals / Particulate Emissions - Metal Cutting

Air Quality Management District Welding Report	Pacific Environmental Services, Inc. 2000. Development of Emission Inventory for Metal Welding, Cutting and Spraying Operations; prepared for South Coast Air Quality Management District. May. http://www.arb.ca.gov/ei/AQMD_welding_report.zip
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			Emission Rate		Estimated Air Concentration				
			g/min	g/s	R1	R2	R3	R4	
1 Hour Average		Fume Generation Rate (PM2.5)	0.38	1.06E-04	4.1E-03	3.2E-03	3.3E-03	3.2E-03	
		Nickel	1.90E-04	5.28E-08	2.1E-06	1.6E-06	1.7E-06	1.6E-06	
		Zinc	1.40E-03	3.89E-07	1.5E-05	1.2E-05	1.2E-05	1.2E-05	
		Total Chromium	7.60E-05	2.11E-08	8.2E-07	6.4E-07	6.6E-07	6.4E-07	
		Assumed chromium content Fume (based on welding emissions)							
		Chromium, non-hexavalent, and its compounds	7.22E-05	2.01E-08	7.8E-07	6.0E-07	6.3E-07	6.0E-07	0.072%
		Chromium VI (hexavalent), and its compounds	3.80E-06	1.06E-09	4.1E-08	3.2E-08	3.3E-08	3.2E-08	0.0010%
24 Hour Average		Fume Generation Rate (PM2.5)	0.38	8.80E-06	1.1E-05	1.1E-05	7.9E-06	1.1E-05	
		Nickel	1.90E-04	4.40E-09	5.7E-09	5.7E-09	4.0E-09	5.3E-09	0.00004%
		Zinc	1.40E-03	3.24E-08	4.2E-08	4.2E-08	2.9E-08	3.9E-08	0.000004%
		Total Chromium	7.60E-05	1.76E-09	2.3E-09	2.3E-09	1.6E-09	2.1E-09	
		Assumed chromium content Fume (based on welding emissions)							
	0.95	Chromium, non-hexavalent, and its compounds	7.22E-05	1.67E-09	2.2E-09	2.2E-09	1.5E-09	2.0E-09	0.0144%
	0.05	Chromium VI (hexavalent), and its compounds	3.80E-06	8.80E-11	1.1E-10	1.1E-10	7.9E-11	1.1E-10	0.000033%
Annual		Fume Generation Rate (PM2.5)	0.38	1.20E-06	5.4E-07	5.4E-07	5.4E-07	5.4E-07	
		Nickel	1.90E-04	6.02E-10	2.7E-10	2.7E-10	2.7E-10	2.7E-10	0.0000014%
		Zinc	1.40E-03	4.44E-09	2.0E-09	2.0E-09	2.0E-09	2.0E-09	
		Total Chromium	7.60E-05	2.41E-10	1.1E-10	1.1E-10	1.1E-10	1.1E-10	
		Assumed chromium content Fume (based on welding emissions)							
	0.95	Chromium, non-hexavalent, and its compounds	7.22E-05	2.29E-10	1.0E-10	1.0E-10	1.0E-10	1.0E-10	-
	0.05	Chromium VI (hexavalent), and its compounds	3.80E-06	1.20E-11	5.4E-12	5.4E-12	5.4E-12	5.4E-12	0.000008%

% of lowest (Ontario / Quebec) criteria

Metal Cutting Time (Assumed)	
Hours/day	2
days/year	50

0.95 Approximate proportion of non-hex chrome based on welding emissions
0.05 Approximate proportion of hex chrome based on welding emissions

Approximate Dilution factor from NO2 modelling

	1 hour	24 hour	Annual		1 hour	24 Hour	Annual
Emission Rate	0.71	0.22	0.22				
					ug/m3/g/s	ug/m3/g/s	ug/m3/g/s
Incremental concentration							
R1	27.7	1.3	0.1		39.0	5.8	0.4
R2	21.4	1.3	0.1		30.1	5.8	0.4
R3	22.3	0.9	0.1		31.4	4.0	0.4
R4	21.4	1.2	0.1		30.1	5.4	0.4

Acetylene torch - GHG Emissions

AlternConsult, 2012. Renault Trucks Deliver - Greenhouse Gas Emissions Report. <http://corporate.renault-trucks.com/media/document/DP-pdf/greenhouse-gas-emissions-report.pdf>. Oct 25, 2016

The emission factor based on stoichiometry is 3.38 kg CO2 / kg acetylene.

Assumption - 5 size G Acetylene cylinders are used Full Weight 70 kg; empty weight 62.8 kg (8.7 m3)

<http://www.supagas.net.au/industrial-gases/acetylene/acetylene-8-7m3-cylinder.html#.WCD0cy0rK71>

Estimated Quantity of Acetylene gas used kg	36
CO2 emissions (kg/y)	121.68

Summary of CO2 Emissions (g/s) - 1 hour average

	SOURCE				
	Demolition	Concrete Batching	Stockpile	Road from concrete Batch to Placement Area	Material Transport 100km
	DEM	CON	STK	CONDel	Clay Delivery
Spreadsheet ID					
Material Handling					
Unpaved roads					
Haul Truck Tailpipe				9.7E-01	2.1E+02
Stationary Equipment Tailpipe	10.7	4.3			
Non-Road Tailpipe	44.7				
Dozer					
Concrete Saw	5.8				
Crushing and Screening					
Concrete Batch Plant					
	6.12E+01	4.30E+00	0.00E+00	9.67E-01	2.11E+02

assumes standby generator at site operations 1 hour per day; concrete batch plant - 12 hours per day

24 Hour Average (g/s)

	SOURCE				
	Demolition	Concrete Batching	Stockpile	Road from concrete Batch to Placement Area	Material Transport 100km
	DEM	CON	STK	CONDel	Clay Delivery
Spreadsheet ID					
Material Handling					
Unpaved roads					
Haul Truck Tailpipe				0.48	105.54
Stationary Equipment Tailpipe	0.45	2.15			
Non-Road Tailpipe	22.33				
Dozer					
Concrete Saw	2.88				
Crushing and Screening					
Concrete Batch Plant					
	2.57E+01	2.15E+00	0.00E+00	4.84E-01	1.06E+02

assumes standby generator at site operations 1 hour per day; concrete batch plant - 12 hours per day

Annual Average (kg)

	SOURCE				
	Demolition	Concrete Batching	Stockpile	Road from concrete Batch to Placement Area	Material Transport 100km
	DEM	CON	STK	CONDel	Clay Delivery
Spreadsheet ID					
Material Handling					
Unpaved roads					
Haul Truck Tailpipe				0.812	177.307
Stationary Equipment Tailpipe	0.752	3.610			
Non-Road Tailpipe	37.520				
Dozer					
Concrete Saw	4.844				
Acetylene Cutting	121.7				
Crushing and Screening					
Concrete Batch Plant					
	164.797	3.610	0.000	0.812	177.307

Demolition Activities
Concrete batching

60 days/year
70 days/year

Conservatively assumed all activities would occur for 70 days.

Summary of CH4 Emissions (g/s) - 1 hour average

	SOURCE				
	Demolition	Concrete Batching	Stockpile	Road from concrete Batch to Placement Area	Material Transport 100km
	DEM	CON	STK	CONDel	Clay Delivery
Spreadsheet ID					
Material Handling					
Unpaved roads					
Haul Truck Tailpipe				2.0E-05	4.4E-03
Stationary Equipment Tailpipe	5.9E-04	2.4E-04			
Non-Road Tailpipe	1.3E-02				
Dozer					
Concrete Saw	2.6E-03				
Crushing and Screening					
Concrete Batch Plant					
	1.66E-02	2.35E-04	0.00E+00	2.02E-05	4.40E-03

assumes standby generator at site operations 1 hour per day; concrete batch plant - 12 hours per day

24 Hour Average (g/s)

	SOURCE				
	Demolition	Concrete Batching	Stockpile	Road from concrete Batch to Placement Area	Material Transport 100km
	DEM	CON	STK	CONDel	Clay Delivery
Spreadsheet ID					
Material Handling					
Unpaved roads					
Haul Truck Tailpipe				1.0E-05	2.2E-03
Stationary Equipment Tailpipe	2.4E-05	1.2E-04			
Non-Road Tailpipe	6.7E-03				
Dozer					
Concrete Saw	1.3E-03				
Crushing and Screening					
Concrete Batch Plant					
	8.03E-03	1.18E-04	0.00E+00	1.01E-05	2.20E-03

assumes standby generator at site operations 1 hour per day; concrete batch plant - 12 hours per day

Annual Average (kg)

	SOURCE				
	Demolition	Concrete Batching	Stockpile	Road from concrete Batch to Placement Area	Material Transport 100km
	DEM	CON	STK	CONDel	Clay Delivery
Spreadsheet ID					
Material Handling					
Unpaved roads					
Haul Truck Tailpipe				1.7E-05	3.7E-03
Stationary Equipment Tailpipe	4.1E-05	2.0E-04			
Non-Road Tailpipe	1.1E-02				
Dozer					
Concrete Saw	2.2E-03				
Crushing and Screening					
Concrete Batch Plant					
	1.35E-02	1.97E-04	0.00E+00	1.69E-05	3.70E-03

Demolition Activities
Concrete batching

60 days/year
70 days/year

Conservatively assumed all activities would occur for 70 days.

Summary of N2O Emissions (g/s) - 1 hour average

	SOURCE				
	Demolition	Concrete Batching	Stockpile	Road from concrete Batch to Placement Area	Material Transport 100km
	DEM	CON	STK	CONDel	Clay Delivery
Spreadsheet ID					
Material Handling					
Unpaved roads					
Haul Truck Tailpipe				7.8E-06	1.7E-03
Stationary Equipment Tailpipe	8.7E-05	3.5E-05			
Non-Road Tailpipe	6.7E-03				
Dozer					
Concrete Saw	1.3E-03				
Crushing and Screening					
Concrete Batch Plant					
	8.11E-03	3.48E-05	0.00E+00	7.83E-06	1.71E-03

assumes standby generator at site operations 1 hour per day; concrete batch plant - 12 hours per day

24 Hour Average (g/s)

	SOURCE				
	Demolition	Concrete Batching	Stockpile	Road from concrete Batch to Placement Area	Material Transport 100km
	DEM	CON	STK	CONDel	Clay Delivery
Spreadsheet ID					
Material Handling					
Unpaved roads					
Haul Truck Tailpipe				3.9E-06	8.5E-04
Stationary Equipment Tailpipe	3.6E-06	1.7E-05			
Non-Road Tailpipe	3.3E-03				
Dozer					
Concrete Saw	6.6E-04				
Crushing and Screening					
Concrete Batch Plant					
	4.02E-03	1.74E-05	0.00E+00	3.92E-06	8.55E-04

assumes standby generator at site operations 1 hour per day; concrete batch plant - 12 hours per day

Annual Average (kg)

	SOURCE				
	Demolition	Concrete Batching	Stockpile	Road from concrete Batch to Placement Area	Material Transport 100km
	DEM	CON	STK	CONDel	Clay Delivery
Spreadsheet ID					
Material Handling					
Unpaved roads					
Haul Truck Tailpipe				6.6E-06	1.4E-03
Stationary Equipment Tailpipe	6.1E-06	2.9E-05			
Non-Road Tailpipe	5.6E-03				
Dozer					
Concrete Saw	1.1E-03				
Crushing and Screening					
Concrete Batch Plant					
	6.75E-03	2.92E-05	0.00E+00	6.58E-06	1.44E-03

Demolition Activities
Concrete batching

60 days/year
70 days/year

Conservatively assumed all activities would occur for 70 days.

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