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CIC Green Product Certification
Assessment Guide

Portland Cement

CIC GREEN
PRODUCT CERTIFICATION

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USE OF THIS ASSESSMENT GUIDE

This Assessment Guide (the "Guide") details principles, requirements and guides for the quantification and reporting of the carbon footprint of products (CFP) under the Green Product Certification launched by the Construction Industry Council (CIC). The Guide sets the product category rules and benchmark for differentiating "low carbon" construction products in the market.

The CIC Green Product Certification is a voluntary eco-labelling scheme. The carbon assessment framework is based on the ISO Technical Specification 14067:2013 "Greenhouse Gases – Carbon Footprint of Products – Requirements and Guidelines for Quantification and Communication". Users of this Guide should note that this Scheme focuses on a single impact category: climate change, other environmental aspects along a product's life cycle are beyond the content of this Guide.

This standard may be used by CIC authorised Carbon Auditor and Greenhouse Gas (GHG) Validation / Verification Bodies to conduct carbon audit, reporting, verification according to the requirements set by this Guide. Where a product is certified under the CIC Green Product Certification, it may display the CIC Green Product Certification to show that the product has been independently verified and demonstrates conformance with the assessment criteria detailed in this Guide.

The purpose of the CIC Green Product Certification is the communication of verifiable and accurate information on the carbon footprint of construction materials for clients, designers, contractors and end to make informed decision. As required by the Trade Descriptions Ordinance the information cannot be misleading. Such information encourages the demand for, and supply of, low carbon products, thereby stimulating the potential for market-driven continuous environmental improvement. Where a company has a product certified as conforming to this Guide, it may gain a marketing advantage in government and business procurement programmes, as well as greater market recognition in general.

GHGs are emitted and removed throughout the life cycle of a product from raw material acquisition through production, use and end-of-life treatment. The quantification and reporting of the CFP under this Labelling Scheme is based on a life cycle assessment. As such, the CFP report based on this Guide may also offer guidance for manufacturers to design and refine the processing, manufacturing and delivery of their product(s) in reducing GHG emissions, energy consumption, and thereby cost.

While all CIC Guides for the Green Product Certification are voluntary, compliance with all applicable laws and regulations is a required requisite for the marketing of the products using the CIC Green Product Certification.

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1. INTRODUCTION

1.1 Background

The purpose of CIC Green Product Certification (the "Scheme") is to promote low carbon construction products in the market, and thus contributing to the transition of Hong Kong to a low carbon economy. With the Green Product Certification, construction practitioners may select low carbon products in a simple and unequivocal manner.

This Assessment Guide (the "Guide") sets the product category rules (PCR) and benchmark for labelling low carbon cement products under the Scheme. Cement is extensively used in the construction industry as an essential ingredient in producing concrete. As the production of cement is energy intensive, consuming large quantities of fuel during manufacturing, especially the kilning process, the cement industry alone generated approximately 5% of the global anthropogenic carbon dioxide (CO_2) emissions (IPCC, 2001).

This Guide details the principles, requirements and guides for the quantification and reporting of the carbon footprint of products (CFP) under the Scheme. The Guide is voluntary, and after verification, enables certified products to display the CIC Green Product Certification to show that it is environmentally preferable.

1.2 Scope

This Guide is applicable to CEM I - Portland Cement in accordance with BS EN 197-1:2000 "Composition, Specifications and Conformity Criteria for Common Cements". Portland cement is composed of 90-95% clinker and up to 5% of minor additional constituents. Other types of cement products may be added to the scope of this Guide at a later date.

This Scheme focuses on a single impact category: climate change by quantifying the greenhouse gases (GHGs) generated from the production of Portland cement in terms of CO_2 equivalents (CO_2e). It covers the six types of GHGs under the Kyoto Protocol (United Nations, 1997), namely, CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) which impact directly on global warming. Other environmental aspects along the product's life cycle are beyond the content of this Guide.

The benchmark for Portland cement is listed in Table 1 below.

Table 1. Benchmark for Portland Cement under the CIC Green Product Certification

Product category	Portland Cement
E_{da}	0.9763
Certification level	(tCO_2e / t of product)
Platinum	<0.732225
Gold	0.732225-0.878670
Silver	0.878680-1.073930
Bronze	1.073940-1.220375
Green	>1.220376

1.3 How to Apply for CIC Green Product Certification

Manufacturers or suppliers interested in CIC Green Product Certification are required to go through the following three major processes: (i) Carbon Auditing; (ii) Verification; and (iii) Certification as shown in Figure 1.

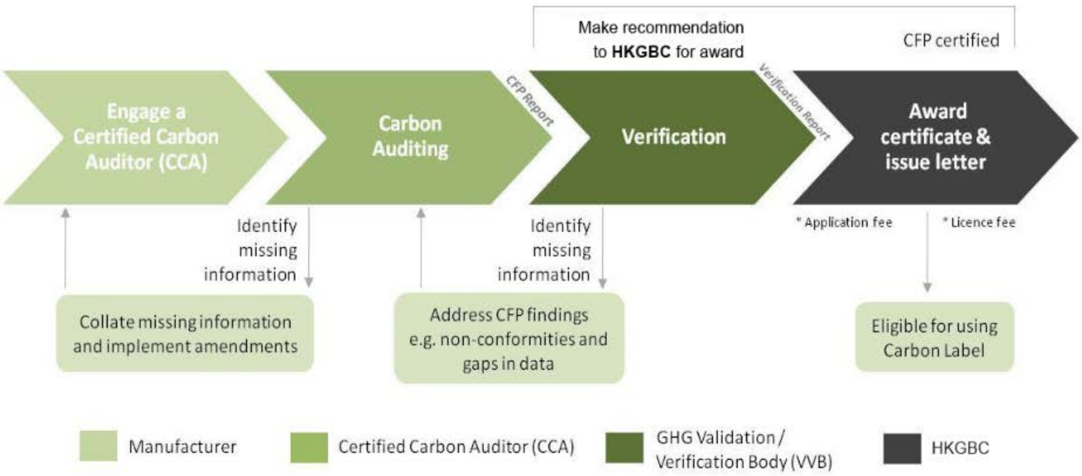

Figure 1. Certification Process

Carbon Auditing

To launch an application[1], the Applicant shall first engage a certified carbon auditor (CCA), either internally or externally, to carry out the carbon auditing and reporting duties. Based on the requirements stated in this Guide and the CFP quantification tool provided, a CFP study report should also be compiled by the appointed CCA detailing the carbon footprint of the studied product throughout the designated life cycle stages. As stated in ISO/TS 14067 (2013), the CFP study according to this Guide shall include

[1] An individual application shall be made for a specific product category that fulfils equivalent functions (ISO 14025:2006).

the four phases of life cycle assessment (LCA), i.e. goal and scope definition, life cycle inventory (LCI) analysis, life cycle impact assessment (LCIA), and life cycle interpretation.

Verification

The CFP study report and relevant documentation should then be validated and verified by a GHG Validation / Verification Body (VVB) accredited by Hong Kong Accreditation Service (HKAS) or equivalent accreditation programmes[2], in accordance with ISO 14064-1:2006 "Greenhouse gases -- Part 1: Specification with Guidance at the Organization Level for Quantification and Reporting of Greenhouse Gas Emissions and Removals"[3] or ISO/TS 14067 (2013)[3]. The Applicant shall provide relevant supporting information as requested by the VVB, and this includes but not limited to the completed CFP assessment tool, the evidence of raw materials and fuel used, electricity bills, and type of machines used. Verification reports issued by non-accredited VVBs with at least 2-year experience in CFP auditing are acceptable.

Certification

Once the CFP study report and relevant documentation are verified, Applicants shall submit a completed application form and corresponding application fee to HKGBC. HKGBC would review the submitted CFP study report and relevant documentation and grade the carbon performance of the product(s) (Grades of carbon rating as shown below). Based on the review, HKGBC shall issue the CIC Green Product Certification with a corresponding carbon rating with a validity period of three years. Upon complying with the *Guideline for the Use of the CIC Green Product Certificate and Logos* (the "User Guide"), with the payment of a licence fee, the CIC Green Product Certification with product details may appear for consumer information by print, online or other accessible media. Subsequent to certification, HKGBC may conduct periodic surveillance assessments of the certified product. Licence renewal shall be applied at least two months prior to the licence expiry date. Further information and assistance can be obtained during application. Visit the Web site http://cicgpc.hkgbc.org.hk for more information.

[2] Accreditation programmes refer to those accredited by the International Accreditation Forum (IAF) i.e. the European co-operation for Accreditation (EA), the InterAmerican Accreditation Cooperation (IAAC), and the Pacific Accreditation Cooperation (PAC) through the Multilateral Recognition Arrangement (MLA).

[3] The operational boundary shall be extended to raw material acquisition and off-site transportation for assessing the carbon footprint at the product level.

Five Grades of the CIC Green Product Certification

Platinum

Gold

Silver

Bronze

Green

2. DEFINITIONS & ACRONYMS

2.1 Terms Relating to CFP Quantification and Labelling

Biomass: material of biological origin excluding material embedded in geological formations and material transformed to fossilised material, and excluding peat. Biomass includes organic material (both living and dead), e.g. trees, crops, grasses, tree litter, algae, animals, and waste of biological origin, e.g. manure.

Carbon Dioxide Equivalent (CO_2e): unit for comparing the radiative forcing of a greenhouse gas to that of carbon dioxide. Mass of a GHG is converted into CO_2e using global warming potentials provided in Annex A.

Carbon Footprint of Product (CFP): sum of greenhouse gas emissions and removals in a product system, expressed as CO_2 equivalents and based on a life cycle assessment using the single impact category of climate change.
[SOURCE: ISO/TS 14067:2013, 3.1]

Certified Carbon Auditor (CCA): an individual who is qualified to conduct carbon auditing for a particular product category under this Scheme.

CFP Study: study that quantifies the CFP.

Global warming potential (GWP): characterisation factor describing the radiative forcing impact of one mass-based unit of a given greenhouse gas relative to that of carbon dioxide over a given period of time as listed in Annex A.

Greenhouse Gas (GHG): gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the earth's surface, the atmosphere, and clouds. [note: the list of GHG with their recognised GWP is provided in Annex A of ISO 14067:2013 according to IPCC Fourth Assessment Report]

ICE: Inventory of Carbon and Energy

IPCC: Intergovernmental Panel on Climate Change.

ISO: International Organization for Standard.

Manufacturer: for the purpose of this Guide these terms comprise both manufacturers of a product as well as material suppliers. These may not necessary be the companies that apply for the CIC Green Product Certification, since certification can also be awarded to retailers of a product. However, data from original manufacturer of the product are required.

Product Category: group of products that can fulfil equivalent functions.

Product Category Rules (PCR): set of rules, requirements and guidelines for development Type III environmental declarations for one or more product categories.

Product System: collection of unit processes with elementary flows and product flows, performing one or more defined functions and which models the life cycle of a product.

System Boundary: set of criteria specifying which unit processes are part of a product system.

Type III Environmental Declaration: environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional

environmental information.
[SOURCE: ISO 14025:2006, 3.2]

V/VB: GHG Validation / Verification Body that provides GHG assertions' validation and verification services.

2.2 Terms Relating to Life Cycle Assessment

Life Cycle: consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal.

Life Cycle Assessment (LCA): compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.
[SOURCE: ISO 14044:2006, 3.2]

Life Cycle Impact Assessment (LCIA): phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product.
[SOURCE: ISO 14044:2006, 3.4]

Life Cycle Inventory Analysis (LCI): phase of life cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle.

Primary Data: quantified value of a unit process or an activity obtained from a direct measurement or a calculation based on direct measurements at its original source.
[note: primary data need not necessarily originate from the product system under study because primary data may relate to a different but comparable product system to that being studied; primary data may include GHG emission factors and/or GHG activity data.]

Site-specific Data: data obtained from a direct measurement or a calculation based on direct measurement at its original source within the product system.

Secondary Data: data obtained from sources other than a direct measurement or a calculation based on direct measurements at the original source such as databases and published literature validated by competent authorities.

Sensitivity Analysis: systematic procedures for estimating the effects of the choices made regarding methods and data on the outcome of a CFP study.
[SOURCE: ISO 14044:2006, 3.31]

Sensitivity Check: activity of verifying that the information obtained from a sensitivity analysis is relevant for reaching the conclusions and giving recommendations.

2.3 Terms Relating to Cement Production

Bypass dust: the discarded dust from the bypass system de-dusting unit of suspension pre-heater, pre-calciner and grate pre-heater kilns, consisting of fully calcined kiln feed material.

CaO: Calcium Oxide

Cement: a hydraulic binder, i.e. a finely ground inorganic material which, when mixed with water, forms a paste which sets and hardens by means of hydration reactions and which, after hardening, retains its strength and stability even under water.

[SOURCE: BS EN197-1:2000]

Cement kiln dust (CKD): the discarded dust from the long dry and wet kiln system de-dusting units, consisting of partly calcined kiln feed material. Extraction and discarding of the bypass dust and CKD serve to control excessive circulating elements input (alkali, sulphur, chlorine), particularly in the case of low alkaline clinker production. The term "CKD" is sometimes used to denote all dust from the cement kilns, i.e. also from the bypass systems.

Clinker: a semi-finished product of kiln which is ground to make cement; and it is obtained by grinding and burning a mixture of mainly calcareous and argillaceous materials in the kiln.

CSI: Cement Sustainability Initiative.

Mineral components (MICs): natural or artificial mineral materials with hydraulic properties, used as a clinker or cement substitutes (e.g. blast furnace slag, fly ash, pozzolana, etc.

MgO: Magnesium Oxide

TOC: Total organic carbon

WBCSD: World Business Council for Green Development.

WRI: World Resources Institute.

3. CFP-PCR FOR PORTLAND CEMENT

This section sets the PCR of Portland cement products for CFP quantification and reporting under the CIC Green Product Certification following the four phases of life cycle assessment (LCA), i.e. goal and scope, LCI, LCIA, and life cycle interpretation. Applicants should refer to the principles and methodology detailed in ISO/TS 14067 (2013) and WBCSD (2011) for CFP quantification and reporting.

3.1 Goal and Scope

Goal of CFP Study

The goal of carrying out a CFP study is to calculate the potential contribution of a specific Portland cement product to climate change expressed as CO_2e by quantifying all significant GHG emissions and removals over the cement product's life cycle.

The CFP study reports submitted by Applicants will then be evaluated by HKGBC for product certification purpose. This is facilitated by identical CFP quantification and communication requirements under the same product category as stipulated in Annex D of ISO/TS 14067.

The CIC Green Product Certification aims to facilitate clients, designers, contractors and end users to select low carbon construction products in a simple and unequivocal manner. Consequently, the demand for and supply of low carbon construction products can be stimulated, thereby to promote continuous environmental improvement.

Scope of CFP Study

This Guide is applicable to CEM I - Portland Cement (all strength classes) as defined in BS EN 197-1:2000. The functional unit of Portland cement products is 1 tonne, where 1 tonne = 1,000 kg. The CFP study shall focus on a single impact category i.e. climate change.

System Boundary

The assessment of carbon footprint of Portland cement under this Scheme shall be based on a "cradle-to-site" approach, covering all GHG emissions and removals arising from raw material acquisition through production, and transportation of the product to the border of Hong Kong as shown in Table 2. The GHG emissions and removals in the use stage are insignificant and therefore neglected. The irreversible nature of cement products justifies the exclusion of the end-of- life stage. In addition, recarbonisation of cement and concrete is not covered due to lack of accurate and quantifiable data.

Table 2. System Boundary for Quantifying Carbon Footprint of Portland Cement

System Boundaries	Processes
I. Upstream Processes	▪ Extraction and production of raw material and energy wares used in the production and packaging of the finished product ▪ Transportation of raw materials and recycled materials to the plant ▪ If relevant, recycling process of recycled materials used in the product
II. Core Processes	▪ Production of raw meal ▪ Production of clinker (calcinations) ▪ Grinding of cement ▪ Storage and packaging for dispatch
III. Downstream Process	▪ Transportation from manufacturing to site

Source: EPD (2010)

3.2 Life Cycle Inventory Analysis

LCI is the phase of LCA involving the compilation and quantification of inputs and outputs for a product throughout its life cycle. This Section states the key principles of CFP quantification, process map of Portland cement production, the associated sources of GHG emissions, and data requirements for LCI analysis under the CIC Green Product Certification.

Key Principles

The quantification and reporting of a CFP in accordance with this Guide is based on the following principles of the LCA methodology provided in ISO 14040:2006 and ISO 14044:2006:

i) **Relevance**
Select data and methods appropriate to the assessment of the GHG emissions and removals arising from the product system being studied.

ii) **Completeness**
Include all GHG emissions and removals that provide a significant contribution to the CFP of the product system being studied.

iii) **Consistency**
Apply assumptions, methods and data in the same way throughout the CFP study to arrive at conclusions in accordance with the goal and scope definition.

iv) **Accuracy**
Ensure that CFP quantification and communication are accurate, verifiable, relevant and not misleading and that bias and uncertainties are reduced as far as is practical.

v) **Transparency**
Address and document all relevant issues in an open, comprehensive and understandable presentation of information. Disclose any relevant assumptions and make appropriate references to the methodologies and data sources used. Clearly explain any estimates and avoid bias so that the CFP study report faithfully represents what it purports to represent.

Process Map

The key unit processes of the Portland cement manufacturing within the stipulated system boundary are presented in Figure 4 for CFP quantification. The raw materials of Portland cement i.e. calcium silicate minerals are first quarried or mined and transferred to the manufacturing facility to be crushed into fine powder, blended and milled before entering into a pre-heater and eventually a large rotary kiln where materials reach a temperature of 1,450ºC. The most carbon intensive stage of the process is clinker production, the chemical decomposition of limestone typically emits 60-65% of total emissions. Fuel combustion generates the rest, 65% of which occur in the precalciner (IEA/WBCSD, 2009). The clinker or kiln product is cooled to ensure the maximum yield for the compound that contributes to the hardening properties of cement and the excess heat is typically routed back to the preheater units. Prior to packaging, gypsum is added to the clinker to regulate the setting time. The end product is a very fine grained blended cement (≈ 10 micron).

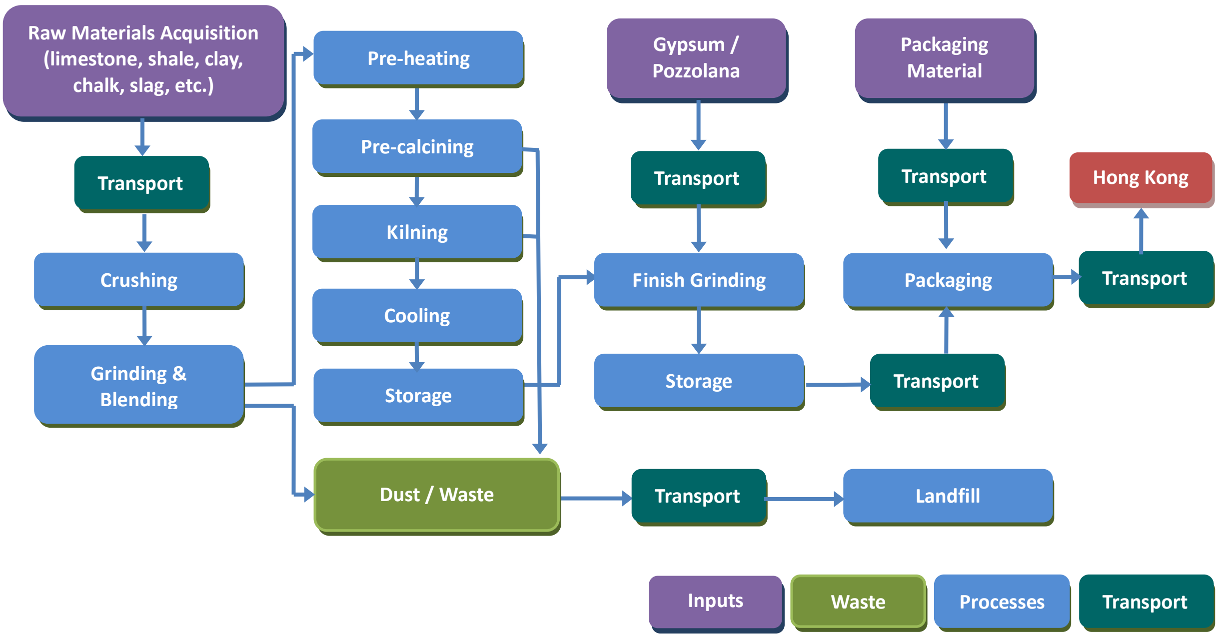

Figure 4. Process Map of Portland Cement Manufacturing[4]

[4] The figure shows a typical cement production process. There are older, much less efficient technologies, for example the wet kiln into which the raw material is fed as slurry and not as a powder (dry kiln).

Sources of GHG Emissions

The qualitative and quantitative data for inclusion in the life cycle inventory shall be collected for all unit processes that are included in the predefined system boundary and process map. The assessment and reporting of GHG emissions and removals of Portland cement are divided into direct emissions and indirect emissions.

> **Direct vs. Indirect Emissions**
>
> The direct emissions stem from sources that are owned or controlled by the material supplier. The indirect emissions originate from sources that are controlled by third parties, but they are nonetheless related to the activities of the material supplier.
>
> WBCSD (2013b)

The GHG assessment framework is developed based on the ISO Technical Specification 14067:2013 "Greenhouse Gases – Carbon Footprint of Products – Requirements and Guidelines for Quantification and Communication" and the "CO_2 and Energy Accounting and Reporting Standard for the Cement Industry" issued by WBCSD (2011). The Applicant is required to quantify and report the carbon footprint of a specific Portland cement product using the CFP quantification tool (in Excel format) provided by our designated operator , the HKGBC.

The assessment of the GHG emissions generated and removed throughout the cement product processes shall be made based on an attributional approach, i.e. by assessing the carbon contents associated with inputs and outputs of a specific process. For instance, the GHG emissions of by-product gases, either for internal or external use, should first be subtracted within the process boundary. Subsequently, the GHG emitted from the fuel combustion and chemical reduction owing to the use of the by-product gas associated with the assessed product should be assessed and reported in the subsequent processes.

Direct Emissions

The sources of direct GHG emissions include i) raw material calcinations and combustion; ii) combustion of kiln fuels; and iii) combustion of non-kiln fuels.

i) Raw Materials Calcination and Combustion

CO_2 will be released from the following three sources related to raw materials:

- Calcinations of carbonates during the pyroprocessing of raw meal for clinker production[5].
- Calcination of cement kiln dust (CKD) and bypass dust leaving the kiln system; and
- Combustion of total organic carbon (TOC) contained in raw materials.

Emissions of methane (CH_4) and nitrous oxide (N_2O) from cement kilns are insignificant due to the high combustion temperatures in the kilns. The other GHG covered by the Kyoto Protocol (PFC, HFC, SF_6) are not relevant in the cement context and can therefore be ignored.

[5] Calcination CO_2 can be calculated in two ways: based on the volume and carbonate content of the raw meal consumed (input method), or based on the volume and composition of clinker produced (output method) plus dust leaving the system. Output method is adopted in this Guide and the CFP assessment tool. However, Applicants may choose to apply the raw meal-based input method of the clinker-based output method based on data availability.

<u>Calcination of Raw Materials for Clinker Production</u>[6]

CO_2 from calcination of carbonates in raw meal shall be calculated based on the volume of clinker produced and an emission factor per tonne of clinker. The emission factor shall be determined based on the measured CaO and MgO contents of clinker, and corrected if relevant quantities of CaO and MgO in the clinker stem from non-carbonate sources. This could be the case when, for example, calcium silicate or fly ash being used as a raw material has entered the kiln. The determination of the emission factor for clinker shall be clearly documented. In the absence of any explicit data, a default of 525 kg CO_2/t clinker shall be used.

<u>Calcination of Dust</u>

CO_2 from bypass dust or CKD leaving the kiln system shall be calculated based on the complete volumes of dust leaving the kiln system and an emission factor. Bypass dust is usually fully calcined. Therefore, the emissions related to the bypass dust shall be calculated using the emission factor for clinker. CKD, as opposed to the bypass dust, is usually not fully calcined. The emission factor for CKD shall be determined based on the emission factor for clinker and the calcination rate of CKD, in accordance with Equation 1. This equation has been incorporated in the CFP quantification tool.

Equation 1

where:

EF_{CKD}	=	emission factor of partially calcined cement kiln dust (tCO_2/t CKD)
EF_{cli}	=	plant specific emission factor of clinker (tCO_2/t clinker)
d	=	CKD calcinations rate (released CO_2 expressed as a fraction of the total carbonated CO_2 in the raw meal)

The calcination rate *d* of CKD shall preferably be based on the plant-specific data. However, if such data does not exist, a default value of 0 shall be used for dry process kilns as CKD is usually not calcined in this process. A default value of 1 shall be used for other processes (half dry, half wet or wet). Should there be no plant-specific data on the dust volume, the Intergovernmental Panel on Climate Change (IPCC) default for CO_2 from discarded dust (2% of clinker CO_2) shall be used, but using the plant or company specific data is preferred.

<u>Combustion of Total Organic Carbon</u>

[6] The CO_2 emissions from the calcination of relatively small amounts of carbonates in fuel ashes added to the kiln system shall be accounted by the reporting of fuel CO_2 emissions. This is assured by determining the CO_2 emission factors for fuels based on the total carbon content of the fuels, which includes both total organic carbon (TOC) and total inorganic carbon (TIC). Materials with high contents of both TOC and TIC (e.g. municipal sewage sludge) can be regarded as fuel and/or raw material. In any case, the complete CO_2 emissions resulting from their use shall be accounted.

In addition to the inorganic carbonates, the raw materials used for clinker production usually contain a small fraction of organic carbon which is mostly converted to CO_2 during the pyroprocessing of raw meal. CO_2 emissions from organic carbon in raw materials shall be quantified and reported to for the sake of completeness of the inventory. Since their contribution to the overall emissions is small, a simplified self-calculating mechanism has been implemented in the CFP quantification tool using the following default values:

- Default raw meal to clinker ratio: 1.55
- Default TOC content of raw meal: 2 kg/t raw meal (dry weight, corresponding to 0.2%)

The Applicant is not required to analyse these emissions any further unless there are indications that the organic carbon is more relevant in their context. Furthermore, any volumes of dust leaving the kiln system are not automatically reflected in this default calculation. To analyse the TOC related emissions in greater detail, manufacturers producing substantial quantities of dust should enter their plant-specific raw meal to clinker ratios. The plant-specific raw meal to clinker ratios should exclude the ash content of the fuels used in order to avoid double counting.

ii) Combustion of Kiln Fuels

Kiln fuels include all conventional and alternative fuels fed to the kiln system plus fuels used for drying and processing the raw materials or other kiln fuels, irrespective of the potential use of waste heat for the production of electrical power.

<u>Conventional Fuels</u>

Conventional kiln fuels are fossil fuels including e.g. coal, petcoke, fuel oil and natural gas. The preferred approach is to calculate CO_2e from conventional kiln fuels (the same applies to alternative and non-kiln fuels), based on fuel consumption, lower heating values, and matching CO_2e emission factors. Fuel consumption and lower heating values of fuels should be regularly measured at the plant level. It is important to note that the applied heating value always has to match the status of the fuel, especially with respect to the correct moisture content during its weighing (raw coal or dried coal).

Default emission factors per GJ lower heating value are extracted from IPCC (2006) and listed in the CFP quantification tool. Manufacturers are encouraged to use the plant or country specific emission factors if reliable data is available. The emission factor of fuels shall be based on the total carbon content. Direct calculation of emissions based on fuel consumption (in tonnes) and fuel carbon content (in percent) is acceptable on condition that the material variations in the composition of fuel, and especially its water content, are adequately accounted for. Generally, IPCC recommends the accounting for incomplete combustion of fossil fuels. In cement kiln, however, this effect is negligible, due to the very high combustion temperature and a long residence time in kilns along with a minimal residual carbon found in clinker. Consequently, carbon in all kiln fuels shall be treated as fully oxidised.

<u>Alternative Fuels</u>

The cement industry increasingly uses a variety of alternative fuels which are typically derived from wastes and therefore, without this application, the waste would have to be disposed of in some other forms, usually by landfilling or incineration. Alternative fuels include fossil fuel based fractions, such as waste oil and plastics, and biomass fractions, such as waste wood and sewage sludge. They serve as a substitute for conventional fossil fuels, and IPCC 2006 guidelines for national GHG inventories require the following:

- The amount of GHGs taken up in biomass and the equivalent amount of GHG emissions from the biomass at the point of complete oxidation result in zero net GHG emissions when biomass carbon is not converted into methane, non methane volatile organic compounds or other precursor gases.

- GHG emissions from fossil fuel-derived wastes (also called alternative fossil fuels), in contrast, is not a *priori* climate neutral. Direct GHG emissions from the combustion of fossil alternative fuels shall, therefore, be calculated and included in the total of direct emissions.

- GHG emissions from mixed fuels with biomass and fossil fraction (e.g. pre-treated industrial and/or domestic wastes), a split between the fossil and non-fossil fraction of the fuel should be established and the emission factors applied to the appropriate fractions.

- CO_2e emission factors shall be specified at the plant level where practical. In the absence of any plant or company specific data, manufacturers shall use the default emission factors provided in the CFP quantification tool in accordance with the IPCC and Cement Sustainability Initiative (CSI).

iii) Combustion of Non-Kiln Fuels

Non-kiln fuels include all fuels which are not covered in the definition of kiln fuels used for the cement production. GHG emitted from non-kiln fuels is reported separately, by the following application types, to provide flexibility in the aggregation of emissions:

- Quarrying / mining raw materials
- On-site transportation
- Equipment
- Room heating / cooling
- On-site power generation

Carbon in non-kiln fuels is assumed to be fully oxidised, i.e. carbon storage in soot or ash is not accounted for. The resulting overestimation of emissions will usually be small (approximately 1%) and can be neglected in the CFP assessment. Analogous to the case of kiln fuels, the non-kiln fuels are categorised into conventional, alternative and biomass fuels for carbon footprint quantification and reporting.

To calculate GHG emissions from non-kiln fuels, fuel consumption, lower heating values and the matching GHG emission factors are required. If available, measured plant-specific lower heating values shall be used. If the same type of fuel is used as non-kiln fuel and kiln fuel, then the CO_2e emission factors used for reporting shall correspond. Otherwise, measured plant-specific emission factors shall be used, if available. Alternatively, default values provided in the CFP quantification tool can be applied. When electricity is internally (e.g. on-site generated electricity) produced and consumed for a product under study, life cycle data for that electricity shall be used for that product.

Emissions from Wastewater

Some cement plants inject waste water in their kilns, for example as a flame coolant to control nitrogen oxides (NO_x). The carbon contained in the wastewater is emitted as CO_2. However, Applicants are not required to quantify their CO_2 emissions related to wastewater consumption, because these emissions are insignificant (usually less than 1% of the plant's overall CO_2 emissions), and difficult to quantify. However, Applicants should be prepared to demonstrate that their wastewater discharge has no significant impact on their overall CO_2 emissions.

WBCSD (2011)

Indirect Emissions

Key indirect GHG emissions arising from the production of Portland cement include: i) external production of electricity consumed by cement manufacturers; ii) production of bought raw materials, energy wares and clinker; iii) off-site transportation; and iv) land use change.

i) External Electricity Production

When a supplier of grid electricity can deliver a specific electricity product with specific life cycle data and guarantee that the electricity sale and the associated GHG emissions are not double counted, life cycle data for that electricity product shall be used. When the supplier of electricity does not provide specific GHG data for the specific electricity product, the GHG emissions associated with the national grid where the life cycle stage occurs shall be used. Where a country does not have a national grid but has several unconnected grids or several countries share a common grid, GHG emissions associated with the relevant grid from which the electricity is obtained shall be used. If specific life cycle data on a process within the electricity supply system are difficult to access, data from recognised databases may be used.

The GHG emissions shall include: the emissions arising from the generation of electricity, e.g. combustion of fuels, and generation of electricity lost in transmission and distribution in the grid; upstream GHG emissions (e.g. the mining and transport of fuel to the electricity generator or the growing and processing of biomass for use as a fuel); downstream GHG emissions (e.g. the treatment of waste arising from the operation of nuclear electricity generators or treatment of ashes from coal fired electricity plants); as well as GHG emissions related to construction, maintenance and decommission of the electricity supply system.

ii) Production of Bought Raw Materials, Energy Wares and Clinker

GHG emissions and removals associated with the use of raw materials such as limestone, gypsum, clay, etc. in the production and packaging of the finished Portland cement product shall be calculated by multiplying the consumption of those raw materials by the embodied carbon emission factors adopted from the Inventory of Carbon and Energy (ICE) provided in the CFP quantification tool. Primary emission factors should be used if data is available.

GHG emissions from the mining and production of energy ware such as coal, natural gas, oil, petcoke, etc. used in the cement manufacturing process should also be accounted for under the indirect emissions. Applicants should apply the emission factor provided by region specific databases or well recognised sources (e.g. Ecoinvent, China Energy Statistical Yearbook, Japan CFP database, etc.).

The emissions from the production of clinker shall be assessed based on the net clinker purchases (i.e. bought clinker minus sold clinker) of the Applicant, and the emission factor of the clinker. With respect to clinker transfer within a company, the actual emission factor of the sending plant should be used. If the clinker is bought externally, a default value from the GNR website shall be used (www.wbcsdcement.org, go to Getting the Numbers Right, GNR). As a second priority, the default emission factor of 882 kg CO_2/t value adopted from WBCSD (2013a) can be used for calculating the indirect emissions impact associated with the clinker purchases.

iii) Off-site Transportation

Applicants are required to specify the mode of transportation (e.g. road, rail, water or aircraft), type of activity data, vehicle type, distance travelled, fuel used, etc. to measure the GHG emissions generated from the off-site transportation associated with the studied cement product from "cradle to site" (see Figure 5). When transportation is outside Hong Kong or the fuel consumption of non-road transport is not known, the fuel / distance-based approach is applicable to the case. The transport emissions associated with the cement product can be measured by adopting the WRI's protocol, namely "Mobile Combustion GHG Emission Calculation Tool[7]" (version 2.5, 2013) or equivalent tool if deemed appropriate. The fuel-based approach only applies to the case when the transportation happens within Hong Kong and the fuel consumption data are known. The fuel-based emission factors can be obtained from the EPD / EMSD guideline, namely "Guidelines to Account for and Report on Greenhouse Gas Emissions and Removals for Buildings (Commercial, Residential or Institutional Purposes) in Hong Kong[8]" (2010 Edition). Fuel consumption data can also be estimated based on the energy consumption indicators as provided by EMSD Energy Consumption Indicator[9].

[7] The tool is accessible at: http://www.ghgprotocol.org/files/ghgp/Transport_Tool_v2%205-1_0.xlsm.
[8] The guideline is accessible at http://www.epd.gov.hk/epd/english/climate_change/files/Guidelines_English_2010.pdf
[9] The indicators are accessible at: http://ecib.emsd.gov.hk/en/indicator_trp.htm

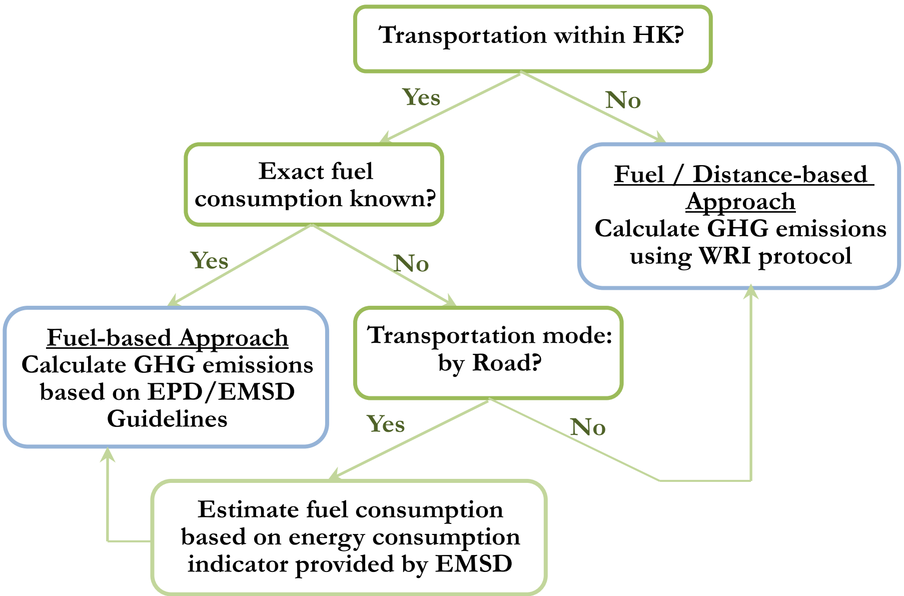

Figure 5. Method Selection for Off-site Transportation Emissions Calculation

Note: If the transportation occurs within Hong Kong, the emissions arising product transportation can be ignored based on the "cradle-to-site" system boundary as stipulated in Section 3.1.

iv) Land Use Change

The GHG emissions and removals occurring as a result of direct land use change shall be assessed in accordance with internationally recognised methods such as the IPCC Guidelines for National Greenhouse Gas Inventories and included in the CFP. If plant-specific data are applied, they shall be transparently documented in the CFP study report. If a national approach is used, the data shall be based on a verified study, a peer reviewed study or similar scientific evidence and shall be documented in the CFP study report. Indirect land use change can be ignored in CFP studies under the CIC Green Product Certification.

Table 3 summarises the parameters involved, and the data sources for the calculation of carbon footprint of Portland cement products.

Table 3. Parameters and Data Sources for Calculating the Carbon Footprint of Portland Cement

	Emission components	Parameters	Units	Sources of parameters
Direct Emissions	***Raw Materials Calcination and Combustion***			
	Calcination of raw materials for clinker production	Clinker produced Emission factor clinker	t kg CO_2/t clinker	Measured at plant level Default = 525; or corrected according to the measured CaO and MgO contents of clinker
	Calcination of dust	Dust leaving kiln system Emission factor clinker	t tCO_2/t clinker	Measured at plant level Calculated as detailed in Section 3.2
	Combustion of total organic carbon	Clinker produced Raw meal : clinker ratio TOC content of raw meal Conversion factor for carbon to carbon dioxide	t fraction t /t clinker tCO2/t	Measured at plant level Default = 1.55 (can be adjusted) Default = 0.2% Default = 3.667 (or 44/12)
	Kiln and Non-Kiln Fuel Combustion			
	Conventional kiln fuels	Fuel consumption Lower heating value Emission factor	t GJ/t fuel tCO_2e/GJ fuel	Measured at plant level Measured at plant level IPCC/CSI defaults, or measured
	Alternative fossil fuels	Fuel consumption Lower heating value Emission factor	t GJ/t fuel tCO_2e/GJ fuel	Measured at plant level Measured at plant level CSI defaults, or measured
	Biomass fossil fuels	Fuel consumption Lower heating value Emission factor	t GJ/t fuel tCO_2e/GJ fuel	Measured at plant level Measured at plant level Default = 0 kg CO_2e
Indirect Emissions	**External electricity production**	Power bought from external grid Emission factor	GWh tCO_2e/GWh	Measured at plant level Applicant-specific value or country grid factor
	Production of bought raw materials, energy wares and clinker	Net raw materials, energy wares and clinker purchased Emission factor	t tCO_2e/t	Measured at plant level Default factor / Input
	Off-site transportation	Mode of transportation Type of activity data Vehicle type Distance travelled Fuel consumed Emission factor	Measured using WRI protocol / EPD/EMSD Guidelines	
	Land use change	Emission factor	Measured in accordance with IPCC Guidelines	

Data Requirements

CFP quantification carried out in accordance with this Guide shall include all GHG emissions and removals of those unit processes within the predefined system boundary that have the potential to make a significant contribution to the CFP. The calculation shall relate system input and output data to the functional unit i.e. tCO_2e / t of Portland cement produced. The assessment shall include:

i) contribution from any one source of GHG emissions of more than 1% of the anticipated total GHG emissions associated with the product being assessed; and
ii) at least 95% of the anticipated life cycle GHG emissions and removals associated with the functional unit.

Site-specific data shall be collected for individual processes under the financial or operational control of the organisation undertaking the CFP study, and shall be representative of the processes for which they are collected. Site-specific data should also be used where practicable for those unit processes that contribute significantly to the CFP, but are not under the financial or operational control of the organisation undertaking the CFP study.

Site Specific Data

Site-specific data can be collected from a specific site, or can be averaged across all sites that contain the process within the product system under study. They can be measured or modelled, as long as the result is specific to the process in the product's life cycle.

ISO/TS 14067 (2013)

Secondary data and primary data that are not site-specific data shall only be used for inputs where the collection of site-specific data is not practicable such as GHG emissions in the upstream processes, or for processes of minor importance and may include literature data, such as default emission factors, calculated data, estimates or other representative data. Primary data that are not site-specific data, based on global or regional averages, collected by regional or international organisations and which have undergone third-party verification should be used when the collection of site-specific data is not practicable. Secondary data shall be justified and documented with references in the CFP study report. A CFP study should use data that reduce bias and uncertainty as far as practical by using the best quality data available. Primary and secondary data shall be selected to enable the goal and scope of the CFP study to be met.

If allocation of GHG emissions and removals is needed, the inputs and outputs of the product system should be partitioned between its different products or functions in a way that reflects the underlying physical relationships between them. For instance, should more than one product be transported by a transport system (e.g. truck, ship, aircraft, train), the emissions arising from the transport system shall be divided amongst the products on the basis of: (i) the relative mass of different products being transported; or (ii) the relative volume of different products being transported. Where physical relationship alone cannot be used as the basis for allocation, the inputs should be allocated between the products and functions in a way that reflects other relationships between them (e.g. economic value). The selected allocation methods shall be documented in the CFP study report in detail and the GHGs taken into account shall be clearly stated.

Applicants undertaking a CFP study should have a data management system and should seek to continuously improve the consistency and quality of their data and retention of relevant documents and other records. Since data collection may span several reporting locations and published references, measures should be taken to reach uniform and consistent understanding of the product systems to be assessed. A check on data validity shall be conducted during the process of data collection to ensure compliance with the requirements of this Guide.

The quantified figures for supporting the assessment of GHG emissions and removals of the product shall be collected and submitted for analysis and verification over a minimum of six months and a maximum of the most recent two years. The CFP results obtained from accredited VVB shall be valid for a maximum period of two years. If a significant change associated with the life cycle GHG emissions and removals of the product is observed, the validity ceases in such situation.

3.3 Life Cycle Impact Assessment

In the LCIA phase of a CFP study, the potential climate change impact of each GHG emitted and removed by the product system shall be calculated by multiplying the mass of GHG released or removed by the 100-year GWP given by the IPCC in units of "kg CO_2e per kg emission" (see Annex A). The CFP is the sum of these calculated impacts which shall be automatically generated in the "performance indicators" using the CFP quantification tool in terms of tCO_2e/t of Portland cement produced. Where GWP values are amended by the IPCC, the latest values shall be used in the CFP calculations. If the latest IPCC GWP data are not used, this shall be stated and justified in the CFP study report.

3.4 Life Cycle Interpretation

In the life cycle interpretation phase of a CFP study, a CFP study report, for the assessed Portland cement product, shall be compiled to document the results of the quantification of the CFP study, and to demonstrate that the provisions of this Guide and relevant standards have been met. The results and conclusions of the CFP study shall be documented in the CFP study report without bias. The results, data, methods, assumptions and the life cycle interpretation shall be transparent and presented in sufficient detail to allow the reader to comprehend the complexities and trade-offs inherent in the CFP study.

The CFP study report shall comprise the followings:

- Goal and scope in accordance with this Guide (or modified scope if applicable along with justifications and exclusions, of the CFP study), including but not limited to:
  - Functional unit;
  - System boundary; and
  - Production process map.

- LCI and LCIA:
  - General plant information;
  - Reporting period;
  - Cut-off criteria and cut-offs;
  - Choices and assumptions;
  - Selected allocation approach;
  - Description of data, including decisions concerning data, sources of data, details of individual data, and assessment of data quality, e.g. results of sensitivity analysis and uncertainty assessments;
  - Sensitivity check regarding the significant inputs
  - Treatment of electricity; and
  - Disclosure and justification of value choices that have been made in the context of decisions within the CFP study.
- CFP quantification results:
  - GHG emissions and removals linked to the main life cycle stages, i.e. raw material acquisition; production; and transportation to HK, including the absolute and the relative contribution of each life cycle stage;
  - GHG emissions and removals arising from conventional fossil fuels, alternative fuels and biogenic carbon sources and sinks;
  - GHG emissions and removals arising from direct and indirect emissions according to Section 3.2; and
  - GHG emissions of the product assessed in terms of tCO_2e/t of Portland cement produced.
- Significant issues based on the results of the quantification of the CFP according to LCI and LCIA phases.
- Evaluation that considers completeness, sensitivity and consistency checks.
- Conclusions, limitations, and recommendations.
- Declaration of the information provided is true and correct.

4. REFERENCES

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ANNEX A – THE 100 YEAR GWP

The global warming potential (GWP) is an index, based upon radiative properties of well mixed GHGs, measuring the radiative forcing of a unit mass of a given well-mixed GHG in the present day atmosphere over a chosen time horizon, relative to that of carbon dioxide. Table A1 shows the 100-year GWP of GHGs according to IPCC Fourth assessment report. When new data are published by the IPCC, the new data supersede those in Table A1.

Table A1 GWP Relative to CO_2 for the 100-year Time Horizon

Industrial designation or common name	Chemical formula	GWP for 100-year time horizon
Carbon dioxide	CO_2	1
Methane	CH_4	25
Nitrous oxide	N_2O	298
Substances controlled by the Montreal Protocol		
CFC-11	CCl_3F	4,750
CFC-12	CCl_2F2	10,900
CFC-13	$CClF_3$	14,400
CFC-113	CCl_2FCClF_2	6,130
CFC-114	$CClF_2CClF_2$	10,000
CFC-115	$CClF_2CF_3$	7,370
Halon-1301	$CBrF_3$	7,140
Halon-1211	$CBrClF_2$	1,890
Halon-2402	$CBrF_2CBrF_2$	1,640
Carbon tetrachloride	CCl_4	1,400
Methyl bromide	CH_3Br	5
Methyl chloroform	CH_3CCl_3	146
HCFC-21	CHClF	151
HCFC-22	$CHClF_2$	1,810
HCFC-123	$CHCl_2CF_3$	77
HCFC-124	$CHClFCF_3$	609
HCFC-141b	CH_3CCl_2F	725
HCFC-142b	CH_3CClF_2	2,310
HCFC-225ca	$CHCl_2CF_2CF_3$	122
HCFC-225cb	$CHClFCF_2CClF_2$	595
Hydrofluorocarbons		
HFC-23	CHF_3	14,800
HFC-32	CH_2F_2	675
HFC41	CH_3F	92
HFC-125	CHF_2CF_3	3,500

HFC-134	CHF_2CHF_2	1,100
HFC-134a	CH_2FCF_3	1,430
HFC-143	CH_2FCHF_2	353
HFC-143a	CH_3CF_3	4,470
HFC-152	CH_2FCH_2F	53
HFC-152a	CH_3CHF_2	124
HFC-161	CH_3CH_2F	12
HFC-227ea	CF_3CHFCF_3	3,220
HFC-236cb	$CH_2FCF_2CF_3$	1,340
HFC-236ea	CHF_2CHFCF_3	1,370
HFC-236fa	$CF_3CH_2CF_3$	9,810
HFC-245ca	$CH_2FCF_2CHF_2$	693
HFC-245fa	$CHF_2CH_2CF_3$	1,030
HFC-365mfc	$CH_3CF_2CH_2CF_3$	794
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	1,640
Perfluorinated compounds		
Sulfur hexafluoride	SF_6	22,800
Nitrogen trifluoride	NF_3	17,200
PFC-14	CF_4	7,390
PFC-116	C_2F_6	12,200
PFC-218	C_3F_8	8,830
PFC-318	c-C_4F_8	10,300
PFC-3-1-10	C_4F_{10}	8,860
PFC-4-1-12	C_5F_{12}	9,160
PFC-5-1-14	C_6F_{14}	9,300
PFC-9-1-18	$C_{10}F_{18}$	>7,500
Trifluoromethyl sulfur pentafluoride	SF_5CF_3	17,700
Perfluorocyclopropane	c-C_3F_6	> 17,340
Fluorinated ethers		
HFE-125	CHF_2OCF_3	14,900
HFE-134	CHF_2OCHF_2	6,320
HFE-143a	CH_3OCF_3	756
HCFE-235da2	$CHF_2OCHClCF_3$	350
HFE-245cb2	$CH_3OCF_2CHF_2$	708
HFE-245fa2	$CHF_2OCH_2CF_3$	659
HFE-254cb2	$CH_3OCF_2CHF_2$	359
HFE-347mcc3	$CH_3OCF_2CF_2CF_3$	575
HFE-347pcf2	$CHF_2CF_2OCH_2CF_3$	580

HFE-356pcc3	$CH_3OCF_2CF_2CHF_2$	110
HFE-449sl (HFE-7100)	$C_4F_9OCH_3$	297
HFE-569sf2 (HFE-7200)	$C_4F_9OC_2H_5$	59
HFE-43-10-pccc124 (H-Galden 1040x)	$CHF_2OCF_2OC_2F_4OCHF_2$	1,870
HFE-236ca12 (HG-10)	$CH_2OCF_2OCHF_2$	2,800
HFE-338pcc13 (HG-01)	$CHF_2OCF_2CF_2OCHF_2$	1,500
	$(CF_3)_2CFOCH_3$	343
	$CF_3CF_2CH_2OH$	42
HFE-338pcc13 (HG-01)	$(CF_3)_2CHOH$	195
HFE-227ea	$CF_3CHFOCF_3$	1,540
HFE-236ea2	$CHF_2OCHFCF_3$	989
HFE-236fa	$CF_3CH_2OCF_3$	487
HFE-245fa1	$CHF_2CH_2OCF_3$	286
HFE-263fb2	$CF_3CH_2OCH_3$	11
HFE-329mcc2	$CHF_2CF_2OCF_2CF_3$	919
HFE-338mcf2	$CF_3CH_2OCF_2CF_3$	552
HFE-347mcf2	$CHF_2CH_2OCF_2CF_3$	374
HFE-356mec3	$CH_3OCF_2CHFCF_3$	101
HFE-356pcf2	$CHF_2CH_2OCF_2CHF_2$	265
HFE-356pcf3	$CHF_2OCH_2CF_2CHF_2$	502
HFE-365mcf3	$CF_3CF_2CH_2OCH_3$	11
HFE-374pc2	$CHF_2CF_2OCH_2CH_3$	557
	- $(CF_2)_4CH(OH)$ -	73
	$(CF_3)_2CHOCHF_2$	380
	$(CF_3)_2CHOCH_3$	27
Perfluoropolyethers		
PFPMIE	$CF_3OCF(CF_3)CF_2OCF_2OCF_3$	10,300
Hydrocarbons and other compounds – direct effects		
Dimethylether	CH_3OCH_3	1
Chloroform	$CHCl_3$	31
Methylene chloride	CH_2Cl_2	8.7
Methyl chloride	CH_3Cl	13
Methylene bromide	CH_2Br_2	1.54
Halon-1201	$CHBrF_2$	404
Trifluoroiodomethane	CF_3I	0.4

Source: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html#table-2-14, "Changes in Atmospheric Constituents and in Radiative Forcing", Table 2.14.