Methodological guide to assess the greenhouse gas emissions avoided thanks to the use of Construction Chemicals solutions manufactured by Saint-Gobain

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Table of contents

1. Context and objectives

1.1 Context

According to the International Energy Agency, in 2021, cement manufacture was responsible for around 7% of the global CO_2 emissions. In addition, the demand for concrete, and therefore for cement, is expected to increase by 12-23% by 2050 compared to 2014[1], due to increasing urban population.

Cement production leads to around 670 kg of CO_2 per ton of product[2], so substantial changes to reduce its associated emissions are required to meet the Paris Agreement goals that would allow to limit the rise of the global temperature to no more than 1.5°C above pre-industrial levels.

With the acquisition of Chryso and GCP in 2021 and 2022 respectively, Saint-Gobain enlarges its scope and enters in the business of construction chemicals that allow to reduce the carbon footprint of the concrete and cement industry. The following methodology has been developed to calculate the amount of greenhouse gas (GHG) avoided thanks to the use of some of the solutions sold by the "Construction Chemicals" BU which is composed by CHRYSO and GCP brands.

1.2 Objectives

The objective of this work is to enable the communication of avoided GHG emissions to all the group's key stakeholders including investors and regulators.

2. Glossary

As a first step, it is important to remind the meaning of the word "avoided" used in this guide. According to the World Business Council for Sustainable Development (WBCSD), avoided Greenhouse Gas (GHG) emissions are defined as the "positive" impact on society when comparing the GHG impact of a solution to an alternative reference scenario where the solution would not be used.

The following definitions will be useful to facilitate the understanding of this guide:

- **Emission factor**: Amount of greenhouse gas (GHG) emitted per activity unit
- **LCA** (Life cycle analysis): Quantitative assessment of various environmental impacts related to the complete life cycle of one product, from the extraction of raw materials used to manufacture the product until its end-of-life

[1] Technology Roadmap Low-Carbon Transition in the Cement Industry, International Energy Agency, 2018. https://www.iea.org/reports/technology-roadmap-low-carbon-transition-in-the-cement-industry
[2] "Green Wave and Border Taxes" report, On Field Investment Research, 2020.

- **Environmental Product Declaration (EPD)** is a document which transparently communicates the environmental performance or impact of any product or material over its lifetime. EPDs are based on Life Cycle Assessment (LCA) methodology and are standardized by international norms (ISO 14025 and EN 15804) to ensure consistency and accuracy in reporting.

3. Calculation rules

3.1 General principles

The calculation is based on the comparison between some of the solutions manufactured by Saint-Gobain and a solution considered as the reference on the market providing the same functionality. The hypothesis used for defining the reference are developed in the next chapters.

For the purpose of the study, an average of the solutions manufactured by Saint-Gobain and an average of the references on the market were used.

The solutions included in the scope are the Construction Chemical products that contribute to reduce the GHG emissions generated by the concrete and cement industry:

- **New generation plasticizers and superplasticizers:** also called water reducers, they enable cement content reduction or use of lower clinker content cement.
- **Cement additives:** enable lower clinker content in cement.
- **Flowable screed:** enable reduced volume of screed by m^2

The calculation of the amount of GHG emissions avoided is explained separately for the three categories of solutions.

The assumptions used for the study come from market studies conducted by third parties, study cases conducted at customer's sites or at Saint-Gobain's R&D centers by internal experts.

3.2 Scope of the study

In 2022, the Construction Chemicals BU had a direct commercial presence in 44 countries and had export and distribution agreements in 37 additional countries.

Sales data used to calculate the GHG emissions avoided corresponds to the year 2022 in the following countries:

- Albania
- Argentina
- Australia
- Austria
- Bangladesh
- Belgium
- Guinea
- Hong Kong
- India
- Indonesia
- Iraq
- Ireland
- Romania
- Russian Fed.
- Saudi Arabia
- Serbia
- Singapore
- Slovak Republic

- Benin
- Brazil
- Bulgaria
- Burkina-Faso
- Cambodia
- Cameroon
- Canada
- Chile
- China
- Colombia
- Croatia
- Cyprus
- Czech Republic
- Egypt
- Estonia
- Finland
- France
- Germany
- Great Britain
- Greece
- Guatemala
- Italy
- Ivory Coast
- Japan
- Kenya
- Kosovo
- Kuwait
- Lebanon
- Malaysia
- Mexico
- Morocco
- Mozambique
- Namibia
- Netherlands
- New Zealand
- Oman
- Panama
- Paraguay
- Philippines
- Poland
- Portugal
- Qatar
- Slovenia
- South Africa
- South Korea
- Spain
- Sri Lanka
- Sweden
- Switzerland
- Taiwan
- Tanzania
- Thailand
- Tunisia
- Turkey
- UAE
- Ukraine
- Uruguay
- USA
- Uzbekistan
- Vietnam
- Yemen
- Zambia
- Zimbabwe

The Construction Chemicals BU manufactures and sells other construction materials such as standard plasticizers, release agents, fibers, and decorative concrete solutions. Nevertheless, only new generation plasticizers and superplasticizers, cement additives, and flowable screed were considered for this study.

The volumes of products considered for the study were collected as follows:

- 90% of the volumes were consolidated through the BU sales reporting system
- 10% was estimated thanks to the financial figures since several sites are not yet connected to the sales reporting system

3.3 Characteristics of the average Saint-Gobain solution and reference situation

The calculation of GHG emissions avoided requires the definition of the average Saint-Gobain solution that will be compared to the reference solutions sold in the market. In the case of plasticizers, super plasticizers and cement additives, the reference solution is also manufactured by Saint-Gobain.

a) Plasticizers and superplasticizers

Plasticizers and Superplasticizers (also called water reducers) reduce the water content of a concrete while maintaining the desired concrete workability and allow to reduce the quantity of cement required to achieve the desired performances (more specifically the design compressive strengths and durability).

The standard water reduction performance of a Plasticizer and a Superplasticizer is defined by the concrete admixtures' international standards (EN 934-2 and ASTM C 494) and are described as:

- Plasticizers: ≥ 5% water reduction
- Superplasticizers: ≥ 12% water reduction

Saint-Gobain manufactures two types of plasticizers and two types of superplasticizers:

- Plasticizers:
  - Standard Plasticizers (PLOG)
  - New Generation Plasticizers (PLNG)

- Superplasticizers:
  - Standard Superplasticizers (SPLOG)
  - New Generation Superplasticizers (SPLNG)

In the construction industry, it is well known that the New Generation water reducers' performances are significantly higher than the standard water reducers. They allow a more efficient cement dispersion and hydration. Therefore, less cement is used to achieve the same concrete performances.

Nowadays, practically all concrete plants use standard Water Reducers that meet the international standards EN 934-2 or ASTM C 494. Therefore, the standard Water Reducers manufactured by Saint-Gobain were considered as the reference solution.

Saint-Gobain solution used for the GHG avoided emissions calculation	**Reference solution**
New Generation Superplasticizers (SPLNG)	Standard Superplasticizers (SPLOG)
New Generation Plasticizers (PLNG)	Standard Plasticizers (PLOG)

The functional unit for the calculation of GHG emissions avoided is a **cubic meter (m^3)** of concrete.

For each type of water reducer (Standard and New generation), the following parameters were defined:

- Average dosage of water reducer by m^3 of concrete

- Average reduction of cement by m^3 of concrete thanks to the use of Saint-Gobain water reducers (standard and new generation).

These parameters were defined based on the average values obtained based on numerous study cases. Several examples are available in Appendix 1.

b) Cement grinding aids and additives

In Portland Cement, the main component impacting the CO_2 footprint is the clinker. Saint-Gobain manufactures grinding aids and additives that are involved in the manufacturing of cement.

Grinding aids

Grinding aids improve limestone and clinker grinding efficiency and in consequence, reduce energy consumptions in cement plants.

Over the past years, the Saint-Gobain technical teams all around the world have observed that practically all cement plants use grinding aids with overall similar performances. Therefore, grinding aids manufactured by Saint-Gobain were considered as the reference solution.

Cement additives

Cement Additives combine the effect of a grinding aid with cement performance boosters.

Saint-Gobain manufactures three types of cement additives that enable lower clinker content in cement compared to the reference solution:

- High dosage additives
- Low dosage additives
- Next generation additives

For each type of additive, the following parameters were defined:

- Dosage of additive by ton of cement
- Clinker reduction by ton of cement thanks to the use of Saint-Gobain Additives.

These parameters were defined based on the average values obtained based on numerous study cases. An example is available in Appendix 2.

Saint-Gobain solution used for the GHG avoided emissions calculation	Reference solution
High dosage additives	Grinding aids
Low dosage additives	Grinding aids
Next generation additives	Grinding aids

The functional unit for the calculation of GHG avoided is a **ton (t) of cement**.

c) Flowable screed

The use of Cement based flowable screed allows to reduce the thickness of the screed layer compared to standard screed by 50% thanks to its flow properties.

Saint-Gobain solution used for the GHG avoided emissions calculation	Reference solution
Cement based flowable screed	Screed in concrete and cement-based mortar (thickness from 7 to 10cm)

The functional unit for the calculation of GHG avoided is a **square meter (m^2)** of screed.

3.4 Rules to calculate the total amount of GHG emissions avoided

3.4.1 General principles

The methodology is based on the following principles:

- The amount of GHG emissions avoided is obtained by subtracting the amount of emissions generated by the solution's lifecycle from the amount of emissions avoided thanks to the use of the Saint-Gobain solution by comparison with the reference situation.
- The use of the total volumes sold over the year to aggregate the amount of emissions avoided for the full Saint-Gobain portfolio.

The calculation of the yearly amount of GHG emissions avoided, ΔGHG (considering that ΔGHG > 0 corresponds to a saving) is calculated by aggregating the amount of GHG emissions avoided for each material category (plasticizers, superplasticizers, cement additives, flowable screed), according to the following formula:

$$\Delta \mathrm{GHG} = \sum_{\mathrm{materials}} \Delta \mathrm{GHG}_{\mathrm{material\ i}}$$

For a given solution category, the amount of GHG avoided is calculated as follows:

$$\Delta \mathrm{GHG}_{\mathrm{material}} = \left(\mathrm{Savings}_{\mathrm{functional\ unit}} - \mathrm{Impact}_{functional\ \mathrm{unit}}\right) * V_{\mathrm{sales}}$$

$\mathrm{Savings}_{\mathrm{functional\ unit}}$ ($kgCO_{2eq}.m^{-2}$ or $kgCO_{2eq}.m^{-3}$ or $kgCO_{2eq}.t^{-1}$): emissions from the manufacturing of one functional unit thanks to the use of the Saint-Gobain solution

$\mathrm{Impact}_{\mathrm{functional\ unit}}$ ($kgCO_{2eq}.m^{-2}$ or $kgCO2eq.m^{-3}$ or $kgCO_{2eq}.t^{-1}$): emissions generated during the lifecycle of the Saint-Gobain materials involved in the manufacturing of one functional unit.

V_{sales}: Total volumes sold during the year for the concerned solution.

The emissions generated during the lifecycle of Saint-Gobain solutions are obtained either from the LCA produced by Saint-Gobain or from other Environmental Product Declaration (EPD) available. The detail of this data is presented in section 3.4.3.

3.4.2 Calculation of GHG emission avoided by the Saint-Gobain solution

The GHG avoided thanks to the use of Saint-Gobain solutions compared to the use of the reference solutions are calculated using the formulas below.

a) Plasticizers and superplasticizers

Savings from cement reduction

$$Savings_{functional\ unit} = Cement\ avoided\ with\ a\ PLOG_{functional\ unit} * Cement\ emission\ factor - Cement\ avoided\ with\ a\ PLNG_{functional\ unit} * Cement\ emission\ factor$$

- $Savings_{functional\ unit}$ ($kgCO_{2eq}.m^{-3}$): emissions avoided from the manufacturing of one cube meter of concrete thanks to the use of the Saint-Gobain solution
- Cement avoided ($kg.m^{-3}$): quantity of cement avoided per m^3 of concrete.
- Cement emission factor ($kgCO_{2eq}.kg^{-1}$): CO_{2eq} emission factor per kg of cement

When cement is removed from the concrete mix design, it must be replaced by another material. It was assumed that cement is replaced by limestone. The formula below takes into consideration the addition of filler for the calculation of the absolute GHG savings:

$$Absolute\ savings_{functional\ unit} = Savings_{functional\ unit} - Filler_{functional\ unit} * Fillier\ emission\ factor$$

- Absolute $savings_{functional\ unit}$ ($kgCO_{2eq}.m^{-3}$): emissions avoided from the manufacturing of one cube meter of concrete thanks to the use of the Saint-Gobain solution and the addition of a filler to replace cement
- Filler ($kg.m^{-3}$): quantity of filler required to replace the volume of cement removed per m^3 of concrete.
- Filler emission factor ($kgCO_{2eq}.kg^{-1}$): CO_{2eq} emission factor per kg of filler

b) Cement grinding aids and additives

$$Savings_{functional\ unit} = (Clinker\ avoided\ with\ additives_{functional\ unit} * Clinker\ emission\ factor + Energy\ savings\ with\ additives_{functional\ unit} * Energy\ emission\ factor) - Energy\ savings\ with\ grinding\ aids_{functional\ unit} * Energy\ emission\ factor$$

- $Savings_{functional\ unit}$ ($kgCO_{2eq}.t^{-1}$): emissions avoided from the manufacturing of one ton of cement thanks to the use of the Saint-Gobain solution
- Clinker avoided ($kg.t^{-1}$): quantity of clinker avoided per ton of cement
- Clinker emission factor ($kgCO_{2eq}.kg^{-1}$): CO_{2eq} emission factor per kg of clinker
- Energy savings ($kWh.t^{-1}$): energy consumptions avoided per ton of cement – worldwide average
- Energy emission factor ($kgCO_{2eq}.kWh^{-1}$): CO_{2eq} emission factor per kWh of energy – worldwide average

The energy savings done with grinding aids and additives are essentially the same, since by nature, additives combine the effect of a grinding aid with cement performance boosters. However, with the aim of highlighting the role of additives in the reduction of clinker ratio, the energy reduction related to the use of additives was excluded from the formula.

$$Savings_{functional\ unit} = Clinker\ avoided\ with\ activators_{functional\ unit} * Clinker\ emission\ factor - Energy\ savings\ with\ grinding\ aids_{functional\ unit} * Energy\ emission\ factor$$

When clinker is removed from the cement mix design, it must be replaced by another material. It was assumed that cement is replaced by limestone. The formula below takes into consideration the addition of filler for the calculation of the absolute GHG savings:

$$Absolute\ savings_{functional\ unit} = Savings_{functional\ unit} - Filler_{functional\ unit} * Fillier\ emission\ factor$$

- $Absolute\ savings_{functional\ unit}$ ($kgCO_{2eq}.t^{-1}$): emissions avoided from the manufacturing of one ton of cement thanks to the use of the Saint-Gobain solution and the addition of a filler to replace clinker.
- Filler ($kg.t^{-1}$): quantity of filler required to replace the clinker removed per m^3 of concrete.
- Filler emission factor ($kgCO_{2eq}.kg^{-1}$): CO_{2eq} emission factor per kg of filler

c) Flowable screed

$$Savings_{functional\ unit} = Traditional\ screed_{functional\ unit} * Screed\ emission\ factor - Flowable\ screed_{functional\ unit} * Screed\ emission\ factor$$

- Savings$_{functional\ unit}$ ($kgCO_{2eq}.m^{-2}$): emissions avoided from the manufacturing of one square meter of floor thanks to the use of the Saint-Gobain solution
- Screed ($m^2.m^{-3}$): volume of screed per square meter of floor
- Screed emission factor ($kgCO_{2eq}.m^{-2}$): CO_{2eq} emission factor per m² of screed

3.4.2 GHG Emission factors

The report “Green Wave and Carbon Boarder Taxes” developed by “On Field Investment Research” (OFIR) in 2020 includes worldwide average emission factors for cement, clinker, and the average energy mix of cement plants. These emission factors were used for the study.

3.4.3 GHG emissions generated during the lifecycle of the average Saint-Gobain solutions

In order to calculate the net GHG emissions avoided, it is necessary to remove from the savings the emissions generated during the different stages of the solutions’ lifecycle. The same rule is applied to the reference solution.

These amounts of emissions are calculated following the LCA methodology and summarized in Environmental Product Declarations (EPD), verified by external third parties.

- **Plasticizers and superplasticizers new and old generation:** the generic EPD developed by the European Federation of Concrete Admixtures (EFCA) for water reducers was used. The current EPD covers the “cradle to gate” scope.
- **Low dosage additives:** Saint-Gobain has not developed yet a specific EPD for this product. Therefore, the value used was obtained by calculating the average of two public EPDs of similar additives.
- **High dosage additives:** Saint-Gobain has not developed yet a specific EPD for this product. Therefore, the GHG factor of Triisopropanolamine (main component of high dosage additives) was used as a reference.
- **Traditional screed:** the EPD available in the INIES database was used.
- **Flowable screed:** the EPD developed by Saint-Gobain was used.
- **Filler:** the EPD developed by Interbeton was used.

The impacts are then calculated by considering the dosage of Saint-Gobain products and reference products per functional unit.

4. Information and communication

4.1 External communication guidance

All communication related to the amount of avoided GHG emission avoided by one company's solutions must be managed with the highest care in order to avoid any risk of greenwashing. The following principles shall especially be considered:

- Never communicate any amount of avoided GHG emissions without providing at the same time and in the same place the following information
  - The reference situation considered to calculate the savings,
  - The scope of solutions considered,
  - The geographical scope considered,
  - The period of time considered to calculate the amount of emissions avoided;

- Never subtract the amount of avoided GHG emissions from the total amount of GHG emissions generated by the company's activities and operations (scopes 1, 2 and 3), whatever the reason (calculating "net emissions", etc.);

- Especially, the amount of avoided GHG emissions cannot be used to satisfy any "carbon neutrality" objective or to lower the reality of GHG emissions generated by the company;

- Avoid comparing the amount of avoided GHG emissions from one year to another, given the high level of complexity of the calculation and the large number of assumptions taken, which can make comparison difficult or event irrelevant

This methodological guide has been developed to illustrate in a robust and transparent way the methodology used to calculate the amount of avoided GHG emissions.

5. Appendixes

5.1 Appendix 1: New Generation vs. Old Generation Water Reducers - Cement reduction examples

The following trials were conducted in a Saint-Gobain R&D center.

Density of concrete varies based on the density of its constituents (from 1.2 to 3.2 and more usually between 2.3 and 2.4 t/m^3).

In this case the density is the result of a concrete mix designed to match 1 m3 (1000 L). The mix designs featuring in examples 1 to 3 have been selected because they are representative of concrete generally used in the market and have been tested to compare New Generation and standard water reducers.

Example 1: C50 concrete (Design Strengths 50 MPa @ 28 days) – Trials performed at iso-workability (S4)

Concrete Mix Design for 1m³ of concrete – C50 – Reference as defined in EN 206	
Constituents	**Quantity (kg/m³)**
Cement - CEM I 52,5 N Xeuilley	350
Natural aggregates	376
Natural aggregates	276
Natural aggregates	423
Natural aggregates	57
Natural aggregates	245
Natural aggregates	134
Natural aggregates	198
Natural aggregates	107
Natural aggregates	23
Water	175
Total weight / m3	**2364**

Admixture type	SPLOG	SPLNG	SPLNG
Name	CHRYSO®Plast Delta 20 (Reference)	CHRYSO®Quad 709	CHRYSO®Delta 515 EMx (Enviromix range)
Dosage (% of cement weight)	0,75%	0,80%	0,80%
W/C	0,48	0,45	0,46
Compressive Strengths 7 days (MPa)	46,9	50,0	53,3
Compressive strengths 28 days (MPa)	54,4	59,2	58,5
Gain CS 7 days (%)		6,6%	13.6%
Gain CS 28 (%)		8.8%	7.5%
Cement Gain %		8%	7%
Cement Gain kg/m3		28 kg	24 kg

The technical datasheet of CHRYSO®Plast Delta 20 indicates that the dosage can go from 0.3% to 0.8% of the weight of cement and in general, a 0.35% dosage of the product is used. In this example, a 0.75% dosage was necessary to meet the design strengths and workability.

Example 2: C50 concrete (Design Strengths 50 MPa @ 28 days) – Trials performed at iso-workability (S4)

Admixture type	SPLOG	SPLNG	SPLNG
Name	**CHRYSO®Plast Delta CER**	**CHRYSO®Delta 515 EMx (Enviromix range)**	**CHRYSO®Quad 821**
Dosage (% of cement weight)	0,80%	0,80%	0,80%
W/C	0,48	0,46	0,45
Compressive Strengths 7 days (MPa)	46,5	53,3	50,7
Compressive strengths 28 days (MPa)	54,4	58,5	58,6
Gain CS 7 days (%)		14,6%	9,0%
Gain CS 28 days (%)		7,5%	7,7%
Cement Gain %		7%	7%
Cement Gain kg/m3		**24 kg**	**24 kg**

The technical datasheet of CHRYSO®Plast Delta CER indicates that the dosage can go from 0.2% to 0.8% of the weight of cement and in general, a 0.3% dosage of the product is used. In this example, a 0.8% dosage was necessary to meet the design strengths and workability.

Example 3: C30 concrete (Design Strengths 30 MPa @ 28 days) – Trials performed at iso-workability (S4)

Concrete Mix Design for 1m3 of concrete – C30 – Reference as defined in EN 206	
Constituents	**Quantity (kg/m^3)**
CEM II/A-LL 42,5 R LA COURONNE	280
10/20 natural aggregate	660
4/10 manufactured aggregate	320
0/4 manufactured sand	820
Water	167
Total weight / m3	**2247**

Admixture type	**SPLOG**	**SPLNG**
Name	**CHRYSO®Plast Delta CER**	**CHRYSO®Quad 561**
Dosage (% of cement weight)	0,80%	1,00%
W/C	0,54	0,50
Compressive strengths 28 days (MPa)	37	42
Cement Gain %		7%
Cement Gain kg/m3		**20 kg**

5.2 Appendix 2: Grinding aids vs additives – Clinker reduction example

The following trial was conducted at a customer site.

Example 1: Standard additive vs AMA additives

Cement mix Design for 1 ton of cement

		Standard additive	**High dosage additives**	
		CHRYSO®ADM 1	**CHRYSO®AMA 160 EL**	**CHRYSO®AMA 180 EL**
Additive dosage	ppm	450	1500	1500
Throughput	tph	88	88	88
Specific energy	kWh/t	39,8	39,8	39,8
Limestone	%	0,00%	8,00%	12,50%
"Gypsum"	%	5,00%	5,00%	5,00%
Clinker	%	95,0%	87,0%	82,5%
Clinker reduction vs ADM 1	kg/t		80kg	125kg