



EFFC DFI Carbon Calculator Methodological & User Guide

V2.2

Context

The *European Federation of Foundation Contractors* (EFFC) and the *Deep Foundations Institute* (DFI) joined forces to develop a sector-specific carbon accounting methodology and associated “carbon calculator” to make carbon footprint analyses of projects consistent and comparable across the industry.

This document presents the carbon accounting method employed in the tool and a practical guide on its use.

This document also presents a **comparative review of existing carbon footprinting standards and tools**, comparing their different scopes and methods of calculating emissions.

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March 2014.

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1 Review of Carbon Footprinting Standards

This section briefly describes the main carbon accounting standards existing in 2012.

Despite a relatively short history, beginning around the year 2000, various standards and methods have been developed worldwide to evaluate the carbon footprint of organisations, products and projects.

These standards and methods broadly fall within two categories, corporate standards and product standards.

Corporate standards generally focus on calculating an organization's carbon footprint
Product standards focus on specific products or projects and therefore include more elements of life cycle analysis (LCA).

Both allow for the analysis of a deep foundation technique or project, but with some differences.

Below is a short list of the main standards identified in Europe in 2012 (other more remote ones exists) and their development is illustrated in figure 1.

- **Corporate standards**
 - [GHG Protocol Corporate standard](#)
 - [ISO 14064](#)
 - [ADEME Bilan Carbone](#)
 - [ENCORD](#)
 - [European Organisation Environmental Footprint](#)
- **Product standards**
 - [PAS 2050](#)
 - [BP-X-30-323](#)
 - [GHG Protocol Product Life Cycle Accounting and Reporting Standard](#)
 - [European Product Environmental Footprint](#)
 - [ISO 14067](#)

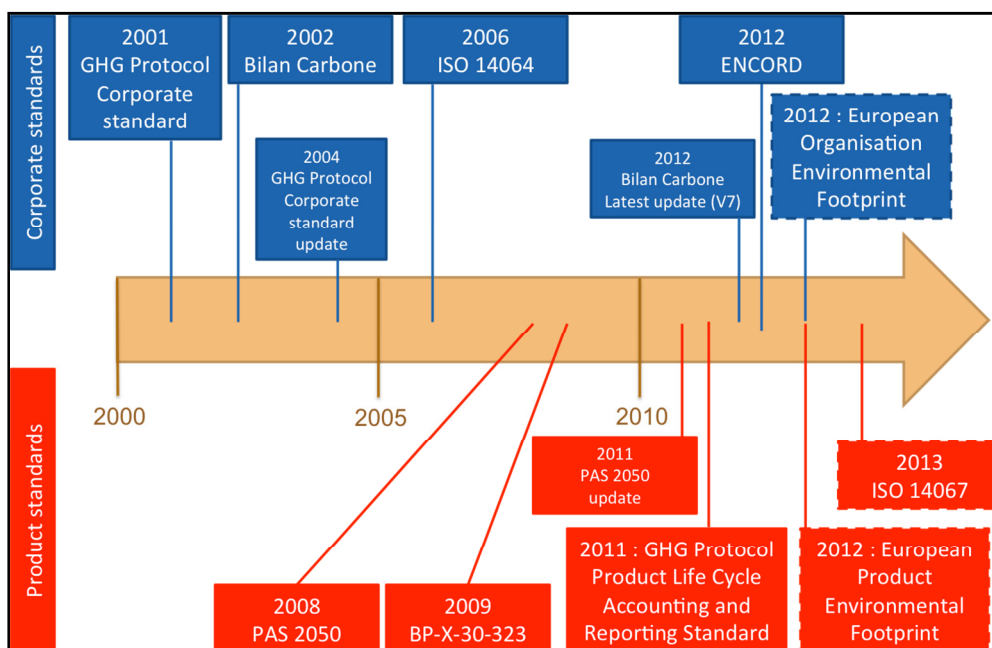


Figure 1 : Development of carbon accounting standards (source : Carbone 4)

Within all standards the underlying principle of carbon footprinting is always the same. As illustrated in Figure 2, activity data is multiplied by emission factors. These factors convert the emissions associated with each activity into an equivalent tonnage of carbon dioxide (CO₂eq) based on their global warming potential (GWP). The most commonly used GWP database, 2007 IPCC GWP @100 years¹, is used in the EFFC tool.

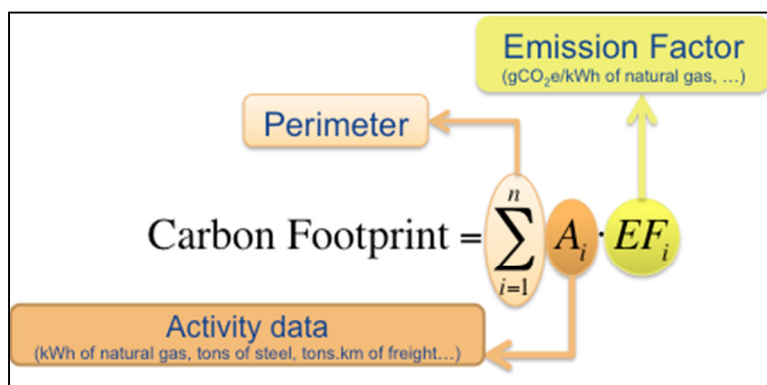


Figure 2 : Carbon footprint calculation principle

In addition to reinforcing this underlying principal, the different standards aim to:

- Define the perimeter of the calculation, (i.e. those activities to be included).
- Propose relevant processes and organisations for which carbon footprint calculations should be carried out.
- Give general principles for carbon footprint calculations.

Standards and methods often recommend a specific emission factor database, but also recognise the use of bespoke data if it is more relevant to the calculation.

With each new standard published, stakeholders seek to align the different standards in order to share common practices.

¹ GHG Protocol Product Life Cycle Accounting and Reporting Standard : Companies shall apply a 100-year GWP factor to GHG emissions and removals data to calculate the inventory results in units of CO₂ equivalent (CO₂e)

1.1 Standards Description

1.1.1 Corporate reporting standards

1.1.1.1 GHG Protocol Corporate standard

The Greenhouse Gas Protocol (GHG Protocol) is the most widely used international emission accounting tool for governments and business leaders. It facilitates understanding, quantification, and management of greenhouse gas emissions.

The GHG Protocol, a decade-long partnership between the World Resources Institute and the World Business Council for Sustainable Development, is working with businesses, governments and environmental groups around the world to build a new generation of credible and effective programs for tackling climate change.

It provides the accounting framework for nearly every GHG standard and program in the world - from the International Standards Organization to The Climate Registry - as well as hundreds of GHG inventories prepared by individual companies.

The GHG Protocol also offers developing countries an internationally accepted management tool to help their businesses to compete in the global marketplace and their governments to make informed decisions about climate change.

The GHG Protocol is today the main carbon accounting standard worldwide and, as an organisation, is beginning to propose method and process for specific sectors. GHG Protocol is recommended by the CDP (Carbon Disclosure Project).

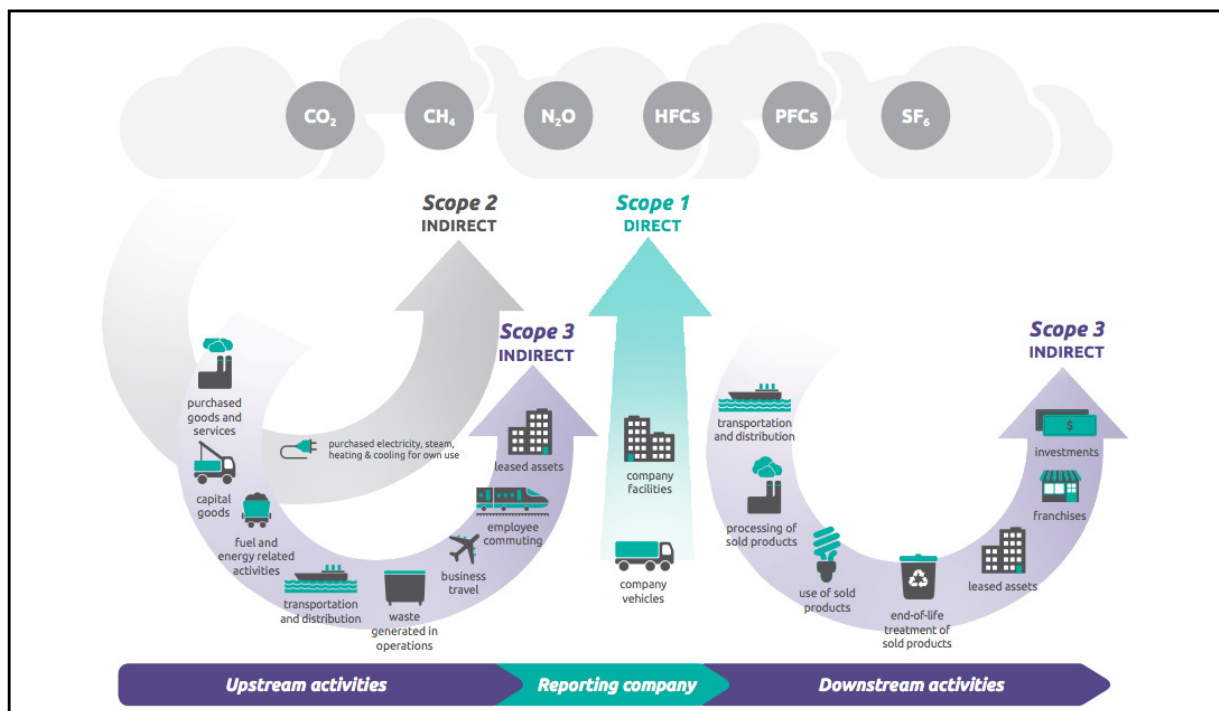


Figure 3 : GHG Protocol emission sources

1.1.1.2 ISO 14064

The International Organisation for Standardization (ISO) is the world's largest developer and publisher of International Standards. The ISO is a non-governmental organisation that forms a bridge between the public and private sectors. It is a network of the national standards institutes of 157 countries.

The International Organisation developed ISO 14064 over several years and it was formally launched in spring 2006.

The ISO 14064 standards provide governments, businesses, regions and other organisations with an integrated set of tools for programs aimed at measuring, quantifying and reducing greenhouse gas emissions. These standards allow organisations taking part in emissions trading schemes to use a globally recognised standard.

ISO 14064 is comprised of three separate sections. ISO 13064-1 provides guidance for organisational and project management, ISO 14064-2 relates to products and ISO 14064-3 details validation and verification techniques for the carbon accounting and reporting processes.

1.1.1.3 ADEME Bilan Carbone

The Bilan Carbone is a French carbon accounting method. It has been developed by Jean-Marc Jancovici (partner of Carbone 4) and distributed by ADEME, the French Environment and Energy Management Agency. The method has been an associated tool and an emission factors database.

While the GHG Protocol is more reporting-oriented, the Bilan Carbone is more organised towards operational management of emissions.

The Bilan Carbone method is fully compatible with GHG Protocol and ISO 14064.



Figure 4 : Bilan Carbone emission sources – Carbone 4

1.1.1.4 ENCORD

ENCORD is the European Network of Construction Companies for Research and Development.

Companies working within the construction sector with support from key stakeholders have developed the protocol. Individuals involved are from sustainability and research and development functions of each participating organisation and are experts in their field.

The aim was to adapt the GHG Protocol (a very generic method), to the construction sector. However, the construction field is still very wide and this protocol needs to be adapted to the deep foundation construction sector.

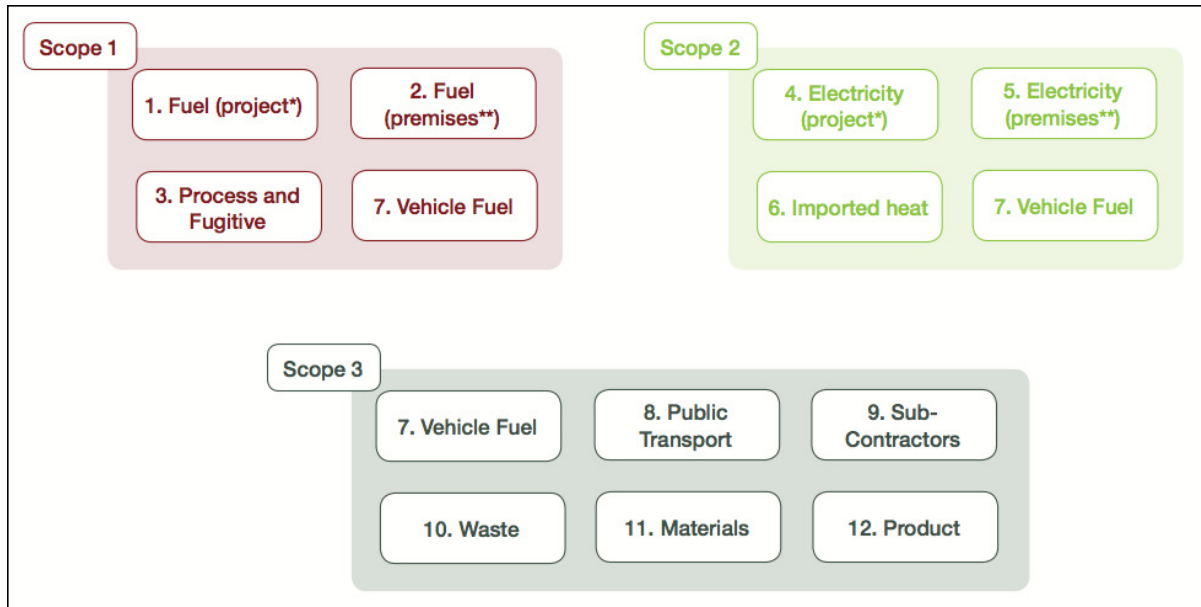


Figure 5 : ENCORD Protocol emission sources

1.1.1.5 Organisation Environmental Footprint

The Directorate-General for the Environment is one of the more than 40 Directorates-General and services that make up the European Commission.

DG Environment has worked together with the European Commission's Joint Research Centre (JRC IES) and other European Commission services towards the development of a technical guide for the calculation of the environmental footprint of organisations (including carbon).

The methodology has been developed building on the International Reference Life Cycle Data System Handbook (ILCD Handbook), as well as other existing methodological standards and guidance documents (Global Reporting Initiative, WRI GHG Protocol, CDP Water Footprint, ISO 140064, DEFRA guidance on GHG reporting, ADEME Bilan Carbone, etc). It has been released in May 2013.

1.1.2 Product reporting standards

1.1.2.1 PAS 2050

PAS 2050:2011 is publicly available and provides a method for assessing the life cycle greenhouse gas (GHG) emissions of goods and services.

The development of the PAS 2050 in UK was co-sponsored by:

- DEFRA (Department for Environment, Food and Rural Affairs, UK)
- DECC (Department of Energy and Climate Change, UK)
- BIS (Department for Business, Innovation and Skills, UK)

It has already been applied by many companies worldwide, and follows the main GHG Protocol principles.

PAS 2050 was the first product carbon accounting standard made public.

1.1.2.2 BP-X-30-323

The repository of good practices, BPX30-323, was prepared under the French law , “Grenelle I”, which establishes the principals for regulatory communication of environmental information relating to products.

This document was developed with over 300 organisations representing all the various relevant stakeholders, sectors and NGOs gathered in the ADEME (Agency for Environment and Energy Management) / AFNOR (French Association of Normalization) platform.

BPX 30-323 is in line with ISO 14040 and ISO 14044 and will evolve following international or European community norms and standards evolution. BPX 30-323 gives general principles for the environmental communication of products. The carbon footprint is required whatever the category of product. The environmental communication includes indicators limited in number and specific to a category of product. These indicators take into account the main relevant impacts generated by the product.

BPX 30-323 defines the main principles for drawing up methodological guides specific to product categories (PCR). These methodological guides are developed by relevant stakeholders of different sectors and are validated by the ADEME / AFNOR platform. Ten methodological guides (PCR) are already available.

In parallel, ADEME has initiated the development of a public database to provide generic data that will enable the calculation of these indicators.

The methodology proposed and discussed by BP-X-30-323 does not apply to the construction sector.

1.1.2.3 GHG Protocol Product Life Cycle Accounting and Reporting Standard

After the Corporate Standard, the GHG Protocol released the Product Life Cycle Accounting and Reporting Standard in 2011.

The Product Standard can be used to understand the full life cycle emissions of a product and focus efforts on the greatest GHG reduction opportunities.

The standard will also help companies respond to customer requests for environmental information and make it easier to communicate about the environmental aspects of products.

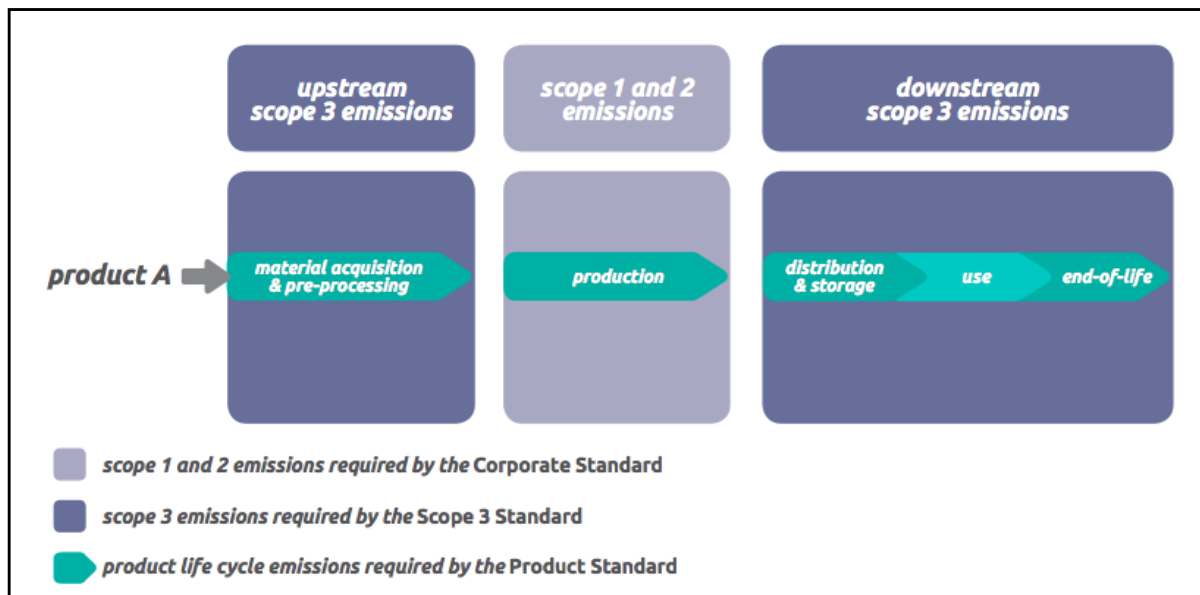


Figure 6 : Link between GHG Protocol Corporate Standard and Product Life Cycle Accounting and Reporting Standard

The GHG Protocol Product Life Cycle Accounting and Reporting Standard enables consolidation of the corporate and LCA methods although no automated link or tool exists.

1.1.2.4 Product Environmental Footprint

In parallel to the Organisation Environmental Footprint, DG Environment has worked together with the European Commission's Joint Research Centre (JRC IES) and other European Commission services towards the development of a harmonised methodology for the calculation of the environmental footprints of products (including carbon).

This methodology has been developed by building on the International Reference Life Cycle Data System (ILCD) Handbook as well as other existing methodological standards and guidance documents (ISO 14040-44, PAS 2050, BP X30, WRI/WBCSD GHG protocol, Sustainability Consortium, ISO 14025, Ecological Footprint, etc). It is scheduled for 1st quarter 2013 and is currently proposed for review.

1.1.2.5 ISO 14067

The International Standards Organization has published a draft standard aimed at evaluating the carbon footprints for the lifecycle of products. The proposed standard, ISO 14067, will be used to calculate the greenhouse gas emissions from companies and their activities. This International Standard specifies principles and requirements for studies to quantify the carbon footprint of a product (CFP), based on life cycle assessment (LCA) specified in ISO 14040 and ISO 14044. Requirements and guidance for the assessment of a partial carbon footprint (partial CF) are also provided. ISO 14067 is applicable to CFP studies and partial CF studies with or without the intention to be publicly available.

1.2 Standards comparison

| Corporate standards | GHG Protocol Corporate | ISO 14064 | Bilan Carbone | ENCORD | DG Env Corporate Footprint |
|--|--|-------------------------------------|--------------------------------|-------------------------------------|---|
| Activity Sector | All | All | All | Construction | All |
| Geographic zone of coverage² | World | World | France | Europe | Europe |
| Impact categories | Climate Change (GHG emissions) | Climate Change (GHG emissions) | Climate Change (GHG emissions) | Climate Change (GHG emissions) | 14 LCA indicators including GHG emissions |
| Concerned GHG | Six substances under Kyoto protocol ³ | Six substances under Kyoto protocol | All GHG emissions | Six substances under Kyoto protocol | All GHG emissions |

² A GHG accounting method gives general rules to be applied that stay true all around the world. What can change depending on the geographic zone are the emission factors. As these methods are not prescriptive in their selection of emission factors, they can be used in any geographic zone. Thus, this field corresponds more to the zone where the method is used than the zone where the method is valid.



³ Carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), sulfur hexafluoride (SF₆), perfluorocarbons (PFCs), and hydrofluorocarbons (HFCs)


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| Product standards | PAS 2050 | BP-X-30-323 | GHG Protocol Product | DG Env Product Environmental Footprint | ISO 14067 |
|--------------------------|--------------------------------|---|--------------------------------|--|--------------------------------|
| Sector | All | All | All | Construction | All |
| Geographic zone | UK | France | World | Europe | World |
| Impact categories | Climate Change (GHG emissions) | Climate Change (GHG emissions) Biodiversity Land use Water | Climate Change (GHG emissions) | 14 LCE indicators including climate change (GHG emissions) | Climate Change (GHG emissions) |
| Concerned GHG | All GHG emission | All GHG emission | All GHG emission | All GHG emission | All GHG emission |

Emission sources taken into account by existing standards

Legend

-  Source taken into account in the tool
-  Source not taken into account in the tool

| Corporate standards | GHG Protocol | ISO 14064 | Bilan Carbone | ENCORD | Organisation Environmental Footprint |
|--------------------------------|--------------|-----------|---------------|---|--------------------------------------|
| Energy | Scope 1 | | | | |
| Materials | Scope 3 | | | | |
| People transportation | Scope 1 or 3 | | | | |
| Freight (materials) | Scope 1 or 3 | | | | |
| Freight (equipment) | Scope 1 or 3 | | | | |
| Equipment manufacturing | Scope 3 | | |  | |
| Waste (transport) | Scope 1 or 3 | | | | |
| Waste (treatment) | Scope 3 | | | | |

GHG Protocol, ISO 14064, Bilan Carbone and European Organisation Environmental Footprint are general methods, thus, as a general principle all the GHG emission sources must be taken into account.

ENCORD Protocol lists the main sources in the construction sector, and equipment depreciation is not listed.

The method proposed in this deep foundations and ground improvement techniques guide and the accompanying calculator is to include all emission sources in the analysis, but not with the same methodological approach in order to reduce the workload and concentrate on differentiating emission sources.

| Products standards | PAS 2050 | BP-X-30-323 | GHG Protocol Product | Product Environmental Footprint | ISO 14067 |
|-------------------------|--|-------------|----------------------|---------------------------------|----------------|
| Energy | | | | | |
| Materials | | | | | |
| People transportation | | | Optional | Not conclusive | Not conclusive |
| Freight (materials) | | | | | |
| Freight (equipment) | | | | | |
| Equipment manufacturing | Excluded except where supplementary requirements dictate otherwise | | Optional | | |
| Waste (transport) | | | | | |
| Waste (treatment) | | | | | |

Regarding emissions from the transportation of people which can be time consuming to calculate with real activity data, the recommendation is to use assumptions and standard ratios, in order to calculate the associated emissions.

2 Existing carbon footprint calculators

Some members of the EFFC and DFI already have already developed their own carbon calculator. An overview of these existing solutions is presented below.

The tool developed by Carbone 4 for the EFFC and DFI integrates the best practices identified in these solutions:

- PCC (BAM)
- Green Siesta (Balfour Beatty) Carbon Calculator
- Bachy Soletanche Carbon Calculator
- Prism (Soletanche Bachy) – LCA calculator
- Keller Carbon calculator
- Cementation Skanska Carbon calculator
- Tata Steel / BCSA Carbon calculator
- Environment Agency (UK) Carbon calculator

2.1 Existing tools review

2.1.1 PCC (BAM)

PCC is a Microsoft Access based calculator not specifically focused on foundations. It is designed to cover a range of construction activities and so is not focused on the emissions specific to foundations. The calculation is based on the concrete quantity with limited variations possible and no means for project comparisons.

Restrictions: the emission factors database needs to be updated and this could require the intervention of an external consultant.

2.1.2 Green Siesta (Balfour Beatty)

A carbon calculator bespoke to BBGE tools which is simple to use.

Dedicated to simple deep foundation techniques carbon footprint analysis.

Restrictions: the tool cannot be used by an external user and is UK focused. It covers part of the EFFC foundation techniques only and requires and the emission factors used need to be updated, requiring the intervention of an external consultant.

2.1.3 Bachy Soletanche Carbon Calculator

A Microsoft Excel based tool that is fully transparent and relatively easy to use. It has been developed internally by BSL but could be used by an external user.

Emission factor sources are clearly identified so that the tool can be easily updated, without the intervention of any external consultant.

Restrictions: the tool covers part of the EFFC activities only and is UK focused. Its Excel format makes it look more complex and less ergonomic than a web based tool, at least for a first usage.

2.1.4 Prism (Soletanche Bachy)

Multi-criteria, international tool, bespoke to foundation activities and designed to cover all EFFC activities. The first version is based on Microsoft Excel and fully transparent, it can be easily updated, without the intervention of any external consultant. In addition to a user guide, it is provided with a detailed methodological guide.

It can calculate the emissions from all the sources (scope 1 2 3).

Restrictions: the Excel platform and multi-criteria restitution format make the tool look relatively complex at first approach, compared with a web based format. The web based version which will be soon available will keep the same functionalities and propose a much more user friendly solution, covering all DFI techniques.

2.1.5 Keller calculator

A Microsoft Excel based calculator that can be used by an external user. It is fully transparent: data sources, emissions factors, and results are directly visible.

Emission factors sources are clearly identified so that the tool can be easily updated, without the intervention of any external consultant. The complete summary of a calculation can be exported on a single spread sheet and the tool covers a wide range of techniques.

2.1.6 Cementation Skanska calculator

Carbon calculator bespoke to Skanska tools.

Easy to use; transparent emission factor databases.

The following techniques are supported: Rotary Bored Piles, Continuous Flight Auger (CFA) Piles, Driven/Cast In Situ Piles, Displacement Piles, Diaphragm Wall, Mini-piles, Ground Anchors, Soil Nails, Permeation Grouting.

Restrictions: an external user cannot use the tool.

2.1.7 Tata Steel / BCSA Carbon calculator

A Microsoft Excel based calculator that is designed for steel / concrete composite **bridges**. The construction part is divided into 3 elements: foundations, substructure and super-structure. There is an advanced mode to go into more detail.



However, it does not cover all the EFFC techniques.

2.1.8 Environment Agency (UK) Carbon calculator

A Microsoft Excel based calculator that is designed for construction activities. It calculates the embodied carbon in a wide range of materials and most of them are not used in foundations. A transparent emission factor database is also provided and could be used for the UK section of the EFFC DFI calculator if validated by the members.

Sources of emissions taken into account by the existing tools (synthesis)

Legend

-  Source taken into account in the tool
 Source not taken into account in the tool

| | PCC | Green Siesta | BSL | Prism | Keller | Skanska | Tata Steel - BCSA Carbon calculator | Environment Agency (UK) Carbon calculator |
|-------------------------|-----|--------------|-----|-------|--------|---------|-------------------------------------|---|
| Energy | | | | | | | | |
| Materials | | | | | | | | |
| People transportation | | | | | | | | |
| Freight (materials) | | | | | | | | |
| Freight (equipment) | | | | | | | | |
| Equipment manufacturing | | | | | | | | |
| Waste (transport) | | | | | | | | |
| Waste (treatment) | | | | | | | | |

Based on this analysis the key emission sources (energy on site, materials) are covered by all tools.

Methodological comment

All the existing tools are more or less comparable.

The two main differences are:

Some emission sources are not always taken into account:

- Equipment (freight and depreciation) is difficult to calculate, because it requires a lot of data to enter and a large database of equipment. Therefore in many cases it is not taken into account.
- Personnel transport is not difficult to calculate but raw data may not be available, the use of statistical values may be necessary.

The user does not always have access to the detailed composition of the concrete or the complete set of emission factors for all materials.

2.2 Method and Standards Used & Emission Factor Databases

All the tools contain a set of emission factors. These factors quantify the carbon content of all the elements needed for the calculation, for example, the carbon content of a ton of steel or the carbon content of a kilometer traveled by car.

These emission factors come from public or private databases, which can contain thousands of emission factors, cover a broader range of activities than just deep foundations & ground improvement.

The table below presents the emission factor databases used by the reviewed tools.

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| | Method / Standard references | Emission factors database |
|--|--|---|
| PCC | <ul style="list-style-type: none"> • GHG Protocol | <ul style="list-style-type: none"> • Various, including data from: • KPMG Sustainability • DEFRA 2008 • Senter Novem (a former Dutch agency of the Ministry of Economic Affairs, Agriculture and Innovation) for concrete • 2006 IPCC Guidelines for National Greenhouse Gas Inventories |
| Green Siesta | <ul style="list-style-type: none"> • GHG Protocol | <ul style="list-style-type: none"> • Various (provided by NIFES consulting), including data from : • WBCSD • GHG Protocol • Key suppliers |
| BSL | <ul style="list-style-type: none"> • PAS 2050 | <ul style="list-style-type: none"> • BATH inventory of Carbon Energy • Sustainable Concrete |
| Prism | <ul style="list-style-type: none"> • ISO14040/44/64 • GHG Protocol • PAS 2050 • Bilan Carbone • NF EN 15804 | <ul style="list-style-type: none"> • EcoInvent • Ademe Base Carbone • Base de donnée interne VINCI |
| Keller | <ul style="list-style-type: none"> • ISO 14040 • ISO 14044 | <ul style="list-style-type: none"> • GEMIS (Central Europe & Asia) • ADEME (France & Spain) • DEFRA (UK) |
| Skanska | | <ul style="list-style-type: none"> • ICE • DEFRA • GHG Protocol • Carbon Trust & BATH |
| Tata Steel - BCSA Carbon calculator | | <ul style="list-style-type: none"> • Atkins Remediation Options Carbon Calculator • DMRB 2007 • Sustainable concrete • British Constructional Steel Association • BS EN 206-1 • DEFRA 2009 • Environment agency • ICE |
| Environment Agency (UK) Carbon calculator | | <ul style="list-style-type: none"> • ICE • University of Bath • AggRegain • Mineral Products Association • Jacob UK calculation • Sustainable concrete • DEFRA (2011) • BMAPA |

Emission factor databases – comment & recommendations

Members use a number of different emission factor databases. Although international emission factor databases do exist (IPCC, ECOINVENT), the majority of the tools use national databases such as ADEME Bilan Carbone, DEFRA and Sustainable Concrete. The visibility of these databases and factors varies between tools and in some cases the user is not made aware of the parameters which are being used.

An important principle of the EFFC DFI carbon footprinting method and associated tool is a generic database for use across Europe and beyond, based on the best international sources (IPCC, EcoInvent). The tool will also contain sets of national values where relevant and available which can be selected by the user.

The tool will allow the use of user defined emission factors with a validation process (ref to §7) involving EFFC DFI specialist's review, with transparent data made available and external review when and if relevant. However, it is a recommendation of this methodology to rely on publicly available databases in order to avoid the problems of access to private data (confidentiality, cost associated to access to data etc).

3 Deep Foundation and Ground Improvement Methodology Specification

This section specifies the requirements of the EFFC DFI tool, based on the following elements: methodological principles and objectives, tool architecture and emission factor database.

The objective is to adapt existing, general standards to the specific application of deep foundations and ground improvement activities. It is also to produce an easy to use, project focused tool in order to compare the carbon footprint of various techniques or projects.

3.1 Standard compatibility

The proposed carbon footprint calculation tool and associated methodological guide are fully compatible with the **GHG Protocol Product Life Cycle Accounting and Reporting Standard** and with the French "**Bilan Carbone**."

The PAS 2050 has recently been aligned with the GHG Protocol.

The yet to be published ISO 14067 will also be in line with GHG Protocol.

Thus, this methodology is compatible with the following standards:

- ✓ GHG Protocol Product Life Cycle Accounting and Reporting Standard
- ✓ Bilan Carbone
- ✓ PAS 2050
- ✓ ISO 14067

3.2 General principles of the carbon accounting method for EFFC DFI (derived from the GHG Protocol)

3.2.1 Relevance

"Ensure the GHG inventory appropriately reflects the GHG emissions of the project and serves the decision-making needs of users – both internal and external to the company."

By using a project-based carbon calculator, companies are able to compare the carbon footprints of their different techniques and promote low-carbon offers to their customers.

The tool calculates the carbon footprint of projects based on real activity data, ensuring the relevance of the calculation made.

3.2.2 Completeness

"Account for and report on all GHG emission sources and activities within the chosen perimeter. Disclose and justify any key exclusion. "

The tool always considers the same perimeter (shown in 4.1). The emission sources that are not calculated using activity data are estimated based on statistical data obtained from various relevant projects and made publicly available.

3.2.3 Consistency

“Use consistent methodologies to allow for meaningful comparisons of emissions over time. Transparently document any changes to the data, inventory perimeter, methods, or any other relevant factors in the time series.”

The proposed tool and method is documented and a version numbering system proposed in order to allow change tracking.

Emission factor databases will have to be updated regularly by the EFFC and DFI to keep the tool up to date and to ensure comparability of the calculation made with other similar approaches.

3.2.4 Transparency

“Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used.”

A Microsoft Excel based tool has the advantage that all the calculations are visible. All the values already in the tool are sourced with no “black box” approach. The methodology will disclose all the assumptions and the tool will be transparent (all proposed emission factors are documented with complete references and from available public sources).

As a consequence of this principle, all emission factors integrated by the users must also be transparently sourced.

3.2.5 Accuracy

“Ensure that the quantification of GHG emissions is systematically neither over nor under actual emissions, as far as can be judged, and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information.”

This principle is integrated by evaluating an emission source’s importance for the covered techniques. The uncertainty is evaluated and simple ratios proposed for secondary emission sources.

3.3 Emission Sources in Deep Foundations and Ground Improvement Activities

The main emission sources in a deep foundation or ground improvement project are typically the same, although their relative significance will vary for different techniques. These can be divided into primary and secondary sources based upon their significance.

- Primary Emission Sources
 - Embodied carbon in materials, due to their manufacturing (cement, steel...)
 - Materials transportation, from factory to construction site (trucks, train, boat...)
 - Energy consumed on the construction site (grid electricity, diesel, gasoline...)
- Secondary sources of emissions
 - People’s transportation to the construction site
 - Equipment’s transportation
 - Equipment’s manufacturing (depreciation)
 - Waste transportation, from construction site to treatment site

- Waste treatment

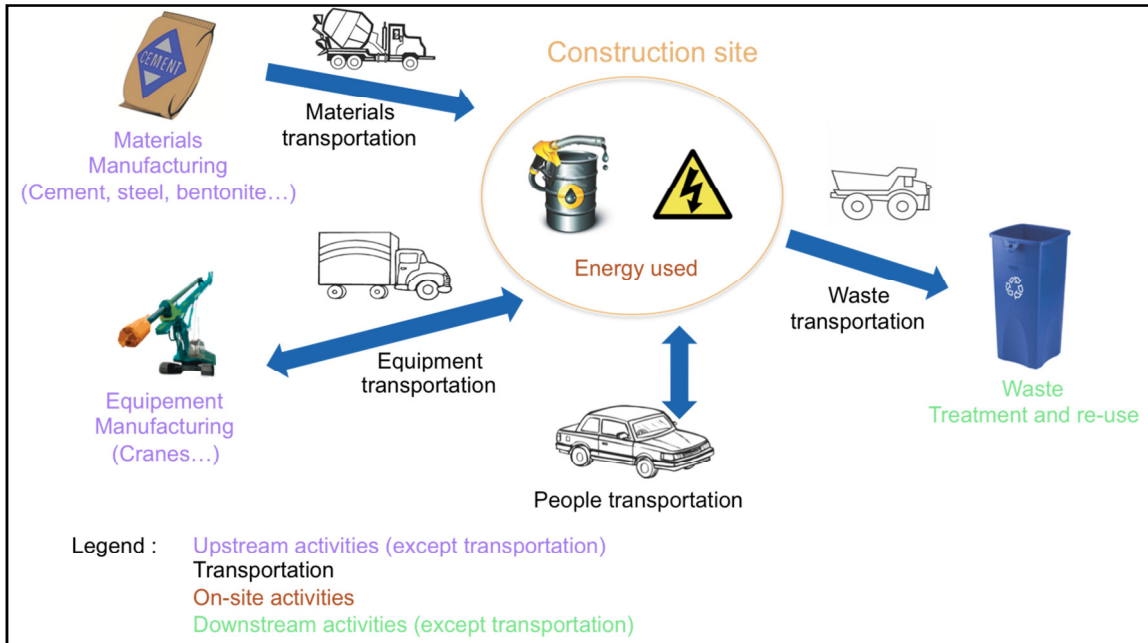


Figure 7 : GHG emission sources in a deep foundation project – Carbone 4

4 Deep Foundation and Ground Improvement Techniques Carbon Accounting Methodology

This section presents the methodology for carbon accounting of EFFC and DFI activities. In 2012 seven techniques were covered:

- Bored piles
- Displacement piles
- Micro piles
- Diaphragm and slurry walls
- Sheet pile walls
- Grouting
- Soil Mixing

In 2013, the remaining techniques were covered:

- Pile walls⁴
- Anchors
- Soil Nails
- Jet Grouting
- Stone Columns
- Vibro Compaction
- Dynamic compaction
- Vertical Drains

Dewatering, underpiling and horizontal drilling have not been studied. Through, those projects can be calculated with a generic tab.

An important objective of the work is to focus on key emission sources and propose standards ratios for secondary emission sources, simplifying the calculation. The relatively small contribution of these secondary sources means that a ratio based approach will not significantly decrease the accuracy of the calculation.

4.1 Emission sources

The generic emission sources in a deep foundation or ground improvement project are the following, with ranking depending on the technique:

- Material manufacturing, (cement, bentonite, steel, etc)
- Materials transportation, from factory to construction site,
- Energy consumed on the construction site,
- People's transport to the construction site,
- Equipment transportation (machines etc)
- Equipment manufacturing (depreciation),
- Waste transportation, from construction site to treatment site,

⁴ including secant pile wall, contiguous pile wall et soldier pile wall

- Waste treatment

4.2 Prioritization of GHG emission sources

4.2.1 Primary and secondary emission sources

For each technique, 5 to 10 examples of carbon footprints have been calculated in order to analyse and classify the relative magnitude of each emission source. The samples were proposed by the members of the working group and analysed by Carbone 4.

The emission sources are divided in two categories:

- **Primary emission sources:** GHG emission sources that represent at least 5% of the global footprint for the technique,
- **Secondary emission sources:** GHG emission sources that represent less than 5% of the global footprint for the technique.

In all case studies, it was found that the total of the primary emission sources represented more than 90% of the total carbon footprint.

The 5% emission threshold is widely recognised as the standard value and often used in different carbon accounting tools and methods. It is not, however, formally defined as a standard rule by any standard setting organisation at this stage. However, based on Carbone 4 experience it can be considered appropriate.

4.2.2 Calculation process

For the calculation, the focus is put on the primary emission sources which are analysed in detail in order to maintain the accuracy of this dominant part of the calculation. The uncertainty level for primary emission sources is often significantly less than the uncertainty associated with secondary sources

For a simple calculation, the secondary emission sources can be estimated. No data collection is necessary for this part of the calculation as the use of specific ratios calculated during the tools development is proposed.

A typical breakdown of the calculation and its uncertainty is shown in figure 8.

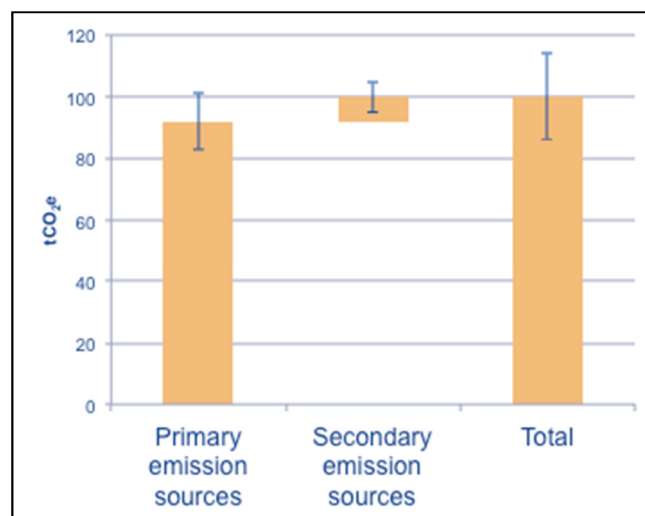


Figure 8: Uncertainty levels for primary and secondary emission sources – Carbone 4

4.3 Estimation Methods for the Secondary Emission Sources

There are two ways to estimate the contribution of the secondary emission sources:

- As a percentage of the total primary emissions;
- By considering standardized activity data for a given secondary emission source.

A **percentage** based calculation considers each secondary emission source as a percentage of the primary emissions. This percentage is an average of calculated values from sample projects. It is a direct CO₂ emission calculation.

$$\text{Secondary emission source Y} = \text{Primary emission sources} \times \%_Y$$

A **standardized activity data** based calculation consists of a predefined ratio or value that will represent the activity data needed for a secondary emission source. For example, in order to calculate the freight emissions of an incoming material, you need to know the number of vehicle kilometres travelled. This can be obtained by assuming a standard travel distance and typical load per journey. The secondary emissions can then be calculated directly from the quantity of the incoming material.

$$\text{Secondary emission source Z} = \text{Activity data needed otherwise} \times \text{Standard activity data/ratio} \times \text{Emission factor}$$

Refined mode: for a more detailed approach, the secondary emission sources can also be calculated based on real values. With the percentage based method, the real activity data can be entered and the applied percentage will default to 0. With the standard activity data method, real activity data can be entered in place of standardised data.

5 Detailed Carbon Footprint Methodology by Emission Source

This section describes the individual GHG accounting methodology for each source of emissions to be integrated into the analysis.

This section is valid for all deep foundation and ground improvement techniques.

5.1 Materials

The GHG emissions in this part correspond to the emission from the manufacture of the materials used.

The main materials used are:

- Cement / grout / concrete / bentonite;
- Steel used as tube, sheet, or reinforcement for concrete.

5.1.1 Cement and cement based materials

For each technique covered in the first phase of the project, cement production is the main emission source.

Cement production accounts on its own for no less than 5% of anthropogenic GHG emissions, and this is linked to the cement production process.

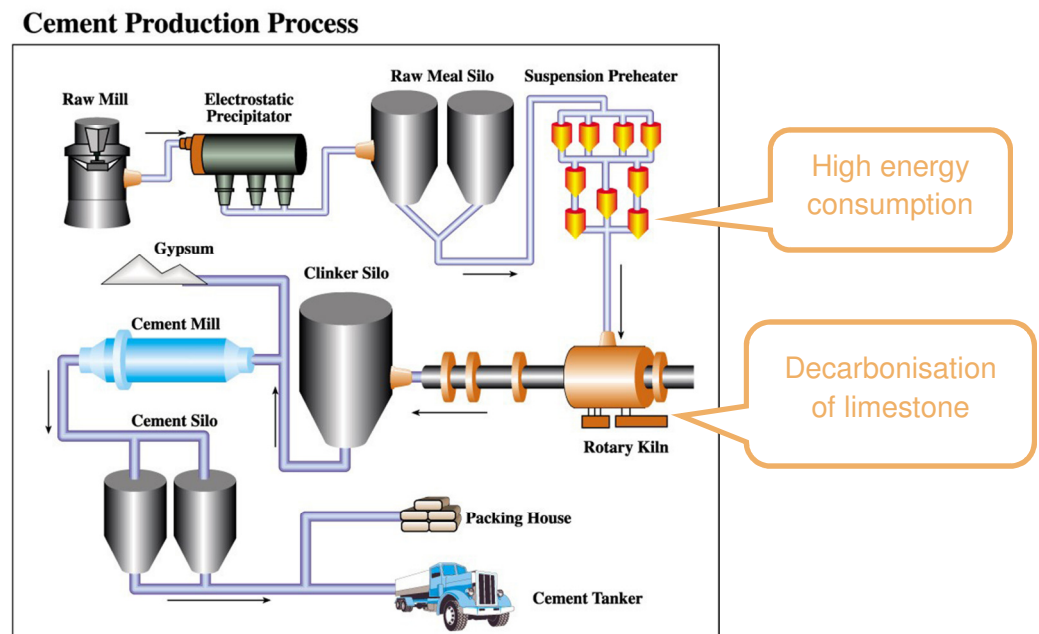


Figure 9: cement production process

Cement production requires high temperatures and burns fossil fuels (coal, heavy oil), and the decarbonisation of limestone is a chemical reaction, which emits CO₂.

A mean value for the carbon content of Portland cement is between 900 and 1000 kg CO₂e. per tonne, whereas for the other components of concrete the emission factors are below 100 kg CO₂e per tonne.

Therefore, it is mandatory to evaluate the quantity of Portland cement in every cement-based material. The methodology is proposed by the sustainable concrete method.

Given that the Portland cement content is not always known, the following assumptions are made, depending on the cement type (see NF EN 197-1 standard):

| Type | Cement Portland content | Secondary constituent | Secondary constituent average content |
|------------------|-------------------------|-----------------------|---------------------------------------|
| CEM I | 100% | - | 0% |
| CEM II/A-LL or L | 87% | Limestone | 13% |
| CEM II/A-V | 87% | Fly Ash | 13% |
| CEM II/B-V | 72% | Fly Ash | 28% |
| CEM II/B-S | 72% | GGbs | 28% |
| CEM III/A | 50% | GGbs | 51% |
| CEM III/B | 27% | GGbs | 73% |
| CEM III/C | 12% | GGbs | 88% |
| CEM IV/B-V | 55% | Fly Ash | 45% |

The cement type must always be known for any deep foundation and ground improvement technique carbon footprint calculation. If this is not possible, a conservative choice of CEM I must be made, possibly leading to an overestimation of the carbon footprint of the project.

On top of its quality, the cement quantity must always be known.

5.1.2 Steel

EFFC members use mainly four kind of steel:

- Bars
- Tubes
- Sheets
- Wires and cables

The EFFC team has validated that steel emission factors are taken from the EcoInvent database.

EcoInvent gives the embodied carbon of virgin steel slab, produced by a converter, and recycled steel slab, produced by an electric arc furnace.

The slab is then hot rolled.

EFFC DFI Carbon Calculator
Methodological Guide – V2.2 March 2014

The next process depends on the final shape of the steel.

| Shape | EcoInvent emission factor |
|------------------|----------------------------|
| Rebars | Section bar rolling, steel |
| Tubes | Drawing of pipes, steel |
| Sheets | Cold rolling, steel |
| Wires and cables | Wire drawing, steel |

| Steel sheets emission factor | Brand new | Recycled | Units | Source |
|--|--------------|------------|-------------------------------|----------------|
| Steel, converter, unalloyed, at plant | 1 659 | | kg CO₂e / t | EcoInvent v2.2 |
| Steel, electric, un- and low-alloyed, at plant | | 425 | | |
| Hot rolling, steel | 280 | 280 | | |
| Total | 1 938 | 705 | | |

| Steel rebars emission factor | Brand new | Recycled | Units | Source |
|--|--------------|------------|-------------------------------|----------------|
| Steel, converter, unalloyed, at plant | 1 659 | | kg CO₂e / t | EcoInvent v2.2 |
| Steel, electric, un- and low-alloyed, at plant | | 425 | | |
| Section bar rolling, steel | 199 | 199 | | |
| Total | 1 857 | 624 | | |

| Steel tubes emission factor | Brand new | Recycled | Units | Source |
|--|--------------|--------------|-------------------------------|----------------|
| Steel, converter, unalloyed, at plant | 1 659 | | kg CO₂e / t | EcoInvent v2.2 |
| Steel, electric, un- and low-alloyed, at plant | | 425 | | |
| Hot rolling, steel | 280 | 280 | | |
| Drawing of pipes, steel | 437 | 437 | | |
| Total | 2 375 | 1 142 | | |

| Steel wires emission factor | Brand new | Recycled | Units | Source |
|--|--------------|--------------|-------------------------------|----------------|
| Steel, converter, unalloyed, at plant | 1 659 | | kg CO₂e / t | EcoInvent v2.2 |
| Steel, electric, un- and low-alloyed, at plant | | 425 | | |
| Hot rolling, steel | 280 | 280 | | |
| Wire drawing, steel | 397 | 397 | | |
| Total | 2 335 | 1 102 | | |

These emission factors are considered as standard values in the calculator.

Many users want to use specific emission factors (example: specific steel composition proposed by a steel manufacturer). In these cases, the emission factor used will appear in the result sheet and should be proposed to EFFC DFI for validation. A third party validation policy may be proposed in a later phase.

This process is important to avoid any distortion in the calculation made by all members.

5.1.3 Recycled & reused materials

If a material is **reused** without transformation (e.g. excavated ground used for soil mixing is not transformed), there is no emission due to the material manufacturing, because the emissions have already been taken into account in its first life. Some emissions may occur for the material transportation.

Emissions associated with the reuse of materials are very low.

However, a **recycled** material has gone through an industrial process (e.g. recycle steel has to be heated again), from which the emissions must be accounted for.

In most cases, the recycling process has lower emissions than raw materials processing.

Depending on the case, the emission calculation is as follows:

- Raw material: $Q_{\text{raw}} \times EF_{\text{raw}}$
- Recycled material: $Q_{\text{recycled}} \times EF_{\text{recycled}}$
- Mix of raw and recycled material : $\%_{\text{recycled}} \times Q \times EF_{\text{recycled}} + (1 - \%_{\text{recycled}}) \times Q \times EF_{\text{raw}}$
- Reused material : 0 for the material production itself.

Q: Quantity

EF: Emission Factor

$\%_{\text{recycled}}$: Recycled Content

5.2 Energy used on site

The two main energy sources used on deep foundation and ground improvement projects are:

- Light fuel oil,
- Electricity.

The following relate to the energy used on site:

- Energy used by machines and power generators,
- Energy used to mobilize and demobilize machines and equipment,
- Energy used to heat site offices.

Fuel used by vehicles for transportation is not included here.

The emissions associated with transportation are covered by the freight section (for material transportation) and in mob/demob source (for machines & equipment transportation). Refer to relevant section below for more information.

5.2.1 Light fuel oil

The proposed emission factor comes from DEFRA 2012.

This emission factor takes into account the fuel combustion (direct emission, Scope 1) and upstream emission (scope 3): extraction, production and transport of the oil.

5.2.2 Electricity

The electricity emission factor depends on the local / national production mix. The common approach in this case is to use a country-based emission factor, taking into account the different power plant sources.

The source used for electricity is IEA publication *CO₂ Emissions from Fuel Combustion – HIGHLIGHTS 2011*.

An additional 8% will be added to these values, representing the transport and distribution losses on grid. This is proposed by the Bilan Carbone method.

In most cases, the exact amount of electricity consumed is not known and will be neglected since quantities consumed in the case studies were very low.

However in some cases switching to electricity is a good practice to reduce GHG emissions.

5.3 People's transportation

This section covers personal and business travel to reach the working site.

5.3.1 Emission factors

The emission factors come from DEFRA 2012. They cover:

- Fuel combustion
- Fuel upstream
- Vehicles construction

5.3.2 Secondary emission source assumptions

The tool proposes a simple way to calculate emissions relative to people transportation.

Assumptions do not depend on the actual technique because emissions depend only on the location of the construction site, and on the team composition.

The following assumptions are made by default:

- Daily commuting (home to work);
- All workers come by car every day (= one round-trip per worker) ;
- The average distance between construction site and the place they sleep (their house, hostels...) is 50 km;

It is possible (and recommended!) to adjust these values for the project, because this emission source can vary significantly from one project to another.

It is also possible to have a longer journey to site once a week. This can also be accounted for in the tool (refer to user guide).

5.4 Freight transportation

5.4.1 Road, air and sea transportation

The emission factors come from DEFRA 2012. They take into account:

- Fuel combustion
- Fuel upstream
- Vehicles construction & depreciation.

Air and maritime transportation are rarely used. Only average emission factors are proposed by tonne per kilometer and independently of the transported load

However, road transportation is considered very accurately.

Different types of vehicles are proposed with the emission factors per kilometre. If the number of journeys is not known, it is calculated by dividing the material quantity delivered by default vehicle load capacities.

5.4.2 Secondary emission source assumptions

Depending on the material category, assumptions are made for simpler calculation:

| Material type | Default freight Type | Default distance (km) |
|---------------|-------------------------|-----------------------|
| Water | Road - Rigid >3.5-7.5t | 0 |
| Cement | Road - Rigid >17t | 20 |
| Sand | Road - Articulated >33t | 20 |
| Aggregate | Road - Articulated >33t | 20 |
| Other | Road - Articulated >33t | 300 |

These values can be modified by the user, provided all adequate information is given to support the new values (transparency principle).

5.5 Assets depreciation

In deep foundation projects, “assets” refers to the machines used such as cranes, drilling or piling rigs and power generators.

Greenhouse gases are emitted during their manufacture which needs to be accounted for in the products they produce.

Therefore the emissions are divided by the lifetime of the equipment and then multiplied by the length of the project

5.5.1 Emission factors

The emission factor used comes from ADEME Bilan Carbone V7: 3667 kgCO₂e / tonne of equipment. The level of uncertainty is high and can be reduced by providing life cycle analysis of the equipment, or complete carbon footprint.

5.5.2 Secondary emission sources key assumptions

The depreciation of assets emission source is estimated by adding an additional percentage, depending on the considered technique.

A more precise calculation consists of evaluating the mass of machines used on site (including power generators). The depreciation is then automatically calculating by dividing the number of working days of the subproject by a default lifetime of 10 years.

A working year is taken to be 220 working days. If the machine is not used during the whole project, the real time can be entered, as can the real lifetime of the machine.

Lastly, it is possible to enter a specific value upon request.

5.6 Waste emissions

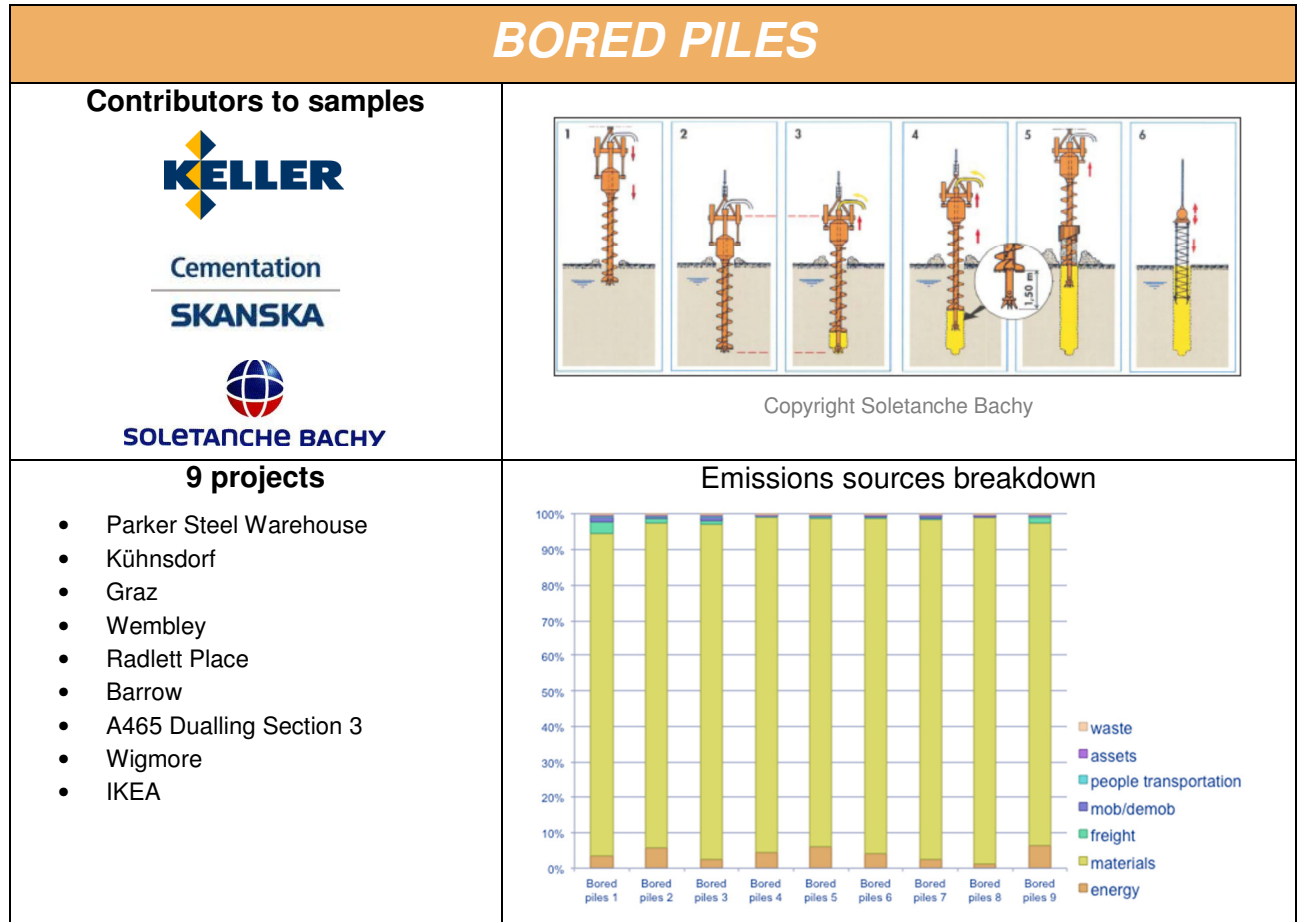
The majority of the waste produced in these projects is inert waste that will be landfilled. In this case, the associated GHG emissions are limited to the transportation of the wastes. Since it is only a secondary emissions source, waste emissions are automatically taken into account with an additional ratio.

If no waste is transported for a particular project, the ratio can be set to zero in the tool.

For a more detailed approach, real transportation data can be entered.

6 Carbon Footprint Detailed Results for each Technique

Below is a breakdown of the emission sources in the sample project for each technique.



The main quantitative results and associated ratios are shown below:

| Primary Emission sources – BORED PILES | | 98% |
|--|---|---------------------|
| Source | Activity data | Relative importance |
| Materials | Quantity of materials | 96% |
| Energy | Amount of energy | 4% |
| Secondary Emission sources | | 2% |
| Source | Estimation method | Relative importance |
| Freight | Standard activity data (details in the freight section) | 0,6% |
| Assets | Additional rate : 0,4% | 0,4% |
| Mob/demob | Additional rate : 0,3% | 0,3% |
| Waste | Additional rate : 0,3% | 0,3% |
| People transportation | Standard activity data | 0,2% |

DISPLACEMENT PILES

Contributors to samples

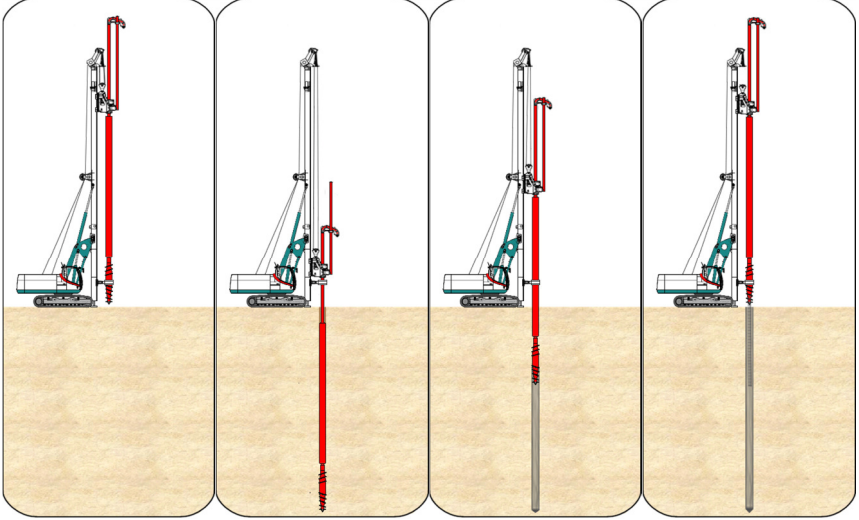
Balfour Beatty
Ground Engineering

Cementation

SKANSKA

bam
infra
BAM Infraconsult bv

SOLETANCHE BACHY

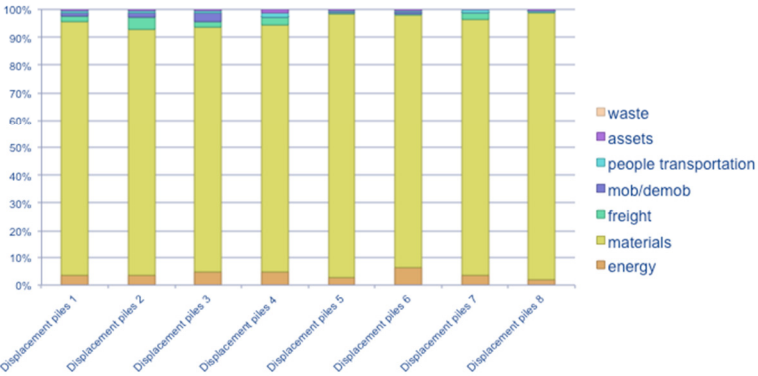


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8 projects

- Southampton Dock
- Houses Rotterdam
- Burnley
- DP World Welfare and Workshop Block
- Rochdale
- BridgeWater
- Hoe Valley Leisure Centre
- Riverside Museum

Emissions sources breakdown







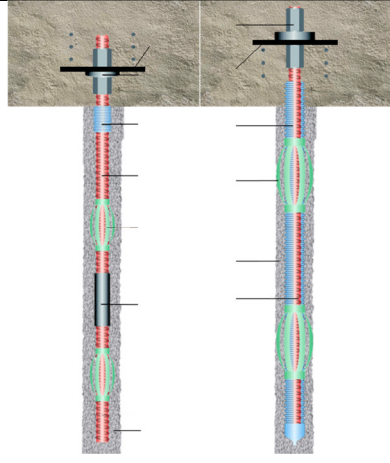
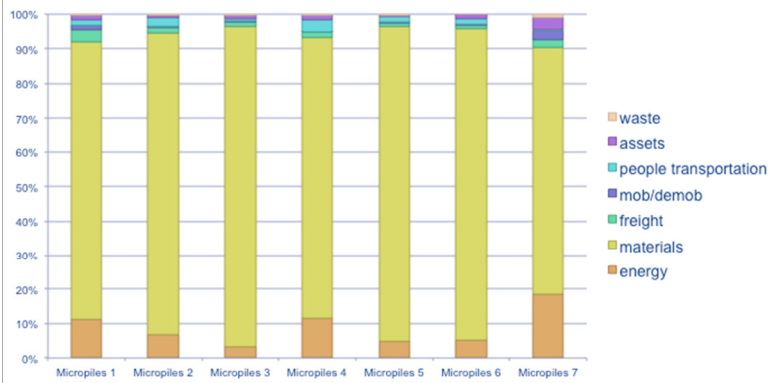
| Primary Emission sources - Displacement piles | | 96% |
|---|--|---------------------|
| Source | Activity data | Relative importance |
| Materials | Quantity of materials | 92% |
| Energy | Amount of energy | 4% |
| Secondary Emission sources | | 4% |
| Source | Estimation method | Relative importance |
| Freight | Standard activity data (details in the freight section) | 1,9% |
| Mob/demob | Additional rate : 1,0% | 1,0% |
| People transportation | Standard activity data | 0,7% |
| Assets | Additional rate : 0,6% | 0,6% |
| Waste | Additional rate : 0,2% | 0,0% |

In the sample were studied:

- Bored displacement piles
- Driven cast in situ
- Driven precast piles

The results showed that there is no need to perform the calculation differently for these 3 sub techniques.

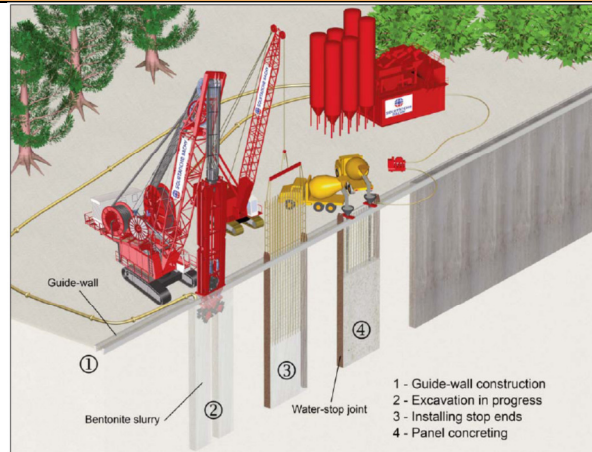
MICROPILES

| | |
|---|---|
| <p>Contributors to samples</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  Brenelli <small>COSTRUZIONI s.r.l.</small> </div> <div style="text-align: center;">  KELLER </div> </div> <div style="display: flex; justify-content: space-around; align-items: center; margin-top: 10px;"> <div style="text-align: center;">  SOLETANCHE BACHY </div> <div style="text-align: center;">  <small>SERVIZI COSTRUZIONI</small> </div> </div> | <div style="text-align: center;">  </div> <p style="text-align: center; font-size: small;">Copyright Soletanche Bachy</p> |
| <p>7 projects</p> <ul style="list-style-type: none"> • Pöls • RD1 • Rome • Savona • Sèvres • Sugarhouse Close • Trento | <p style="text-align: center;">Emissions sources breakdown</p>  |

| Primary Emission sources | | 94% |
|----------------------------|--|---------------------|
| Source | Activity data | Relative importance |
| Materials | Quantity of materials | 85% |
| Energy | Amount of energy | 9% |
| Secondary Emission sources | | 6% |
| Source | Estimation method | Relative importance |
| Freight | Standard activity data (details in the freight section) | 1,7% |
| People transportation | Standard activity data | 1,7% |
| Assets | Additional rate : 1,4% | 1,3% |
| Mob/demob | Additional rate : 0,8% | 0,7% |
| Waste | Additional rate : 0,5% | 0,4% |

DIAPHRAGM AND SLURRY WALLS

Contributors to samples

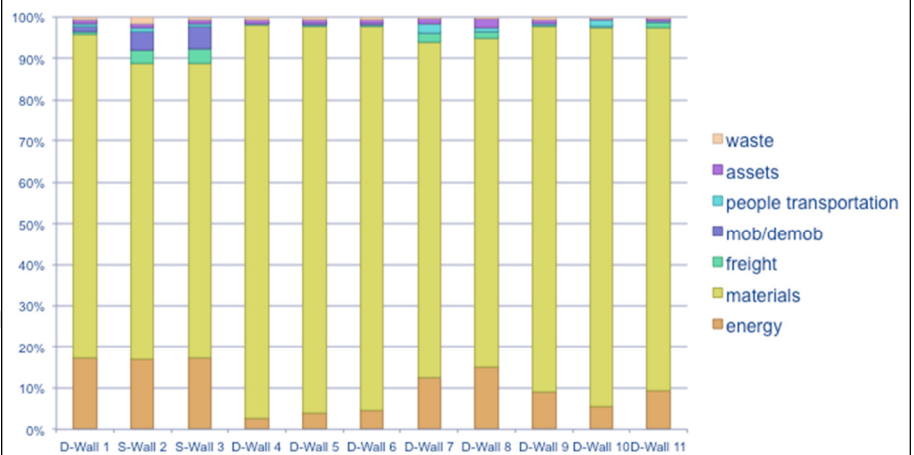


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11 projects

- PML
- Barangaroo
- Crossrail
- Toulon
- Paddington
- TourD2
- Reservoir Enhancement
- Singapour
- ROP
- Shoreham Adur Tidal Walls East Bank
- Valenton

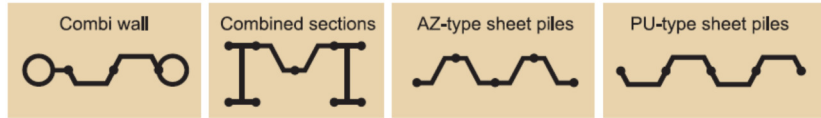
Emissions sources breakdown



| Primary Emission sources | | 95% |
|----------------------------|---|---------------------|
| Source | Activity data | Relative importance |
| Materials | Quantity of materials | 85% |
| Energy | Amount of energy | 10% |
| Secondary Emission sources | | 5% |
| Source | Estimation method | Relative importance |
| Freight | Standard activity data (details in the freight section) | 1,2% |
| Mob/demob | Additional rate : 1,2% | 1,1% |
| Assets | Additional rate : 1,1% | 1,0% |
| People transportation | Standard activity data | 0,7% |
| Waste | Additional rate : 0,6% | 0,6% |

SHEET PILE WALLS

Contributors to samples

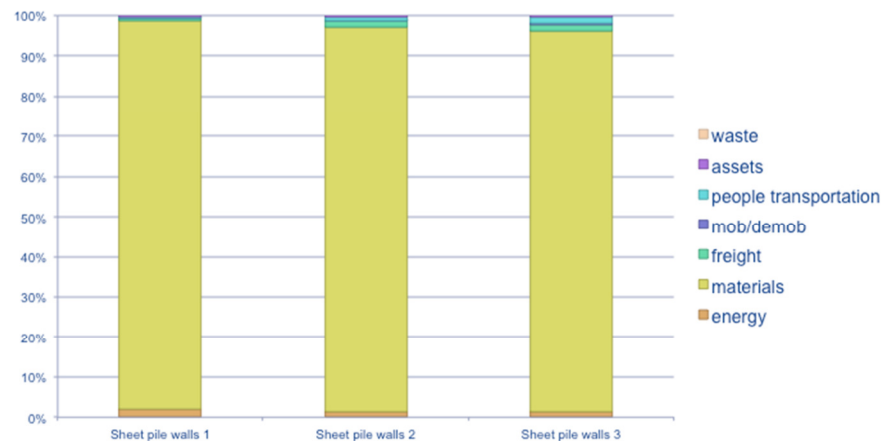


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3 Projects

- Berges de Varennes sur Seine
- Highway A4
- FBH Klagenfurt


Emissions sources breakdown

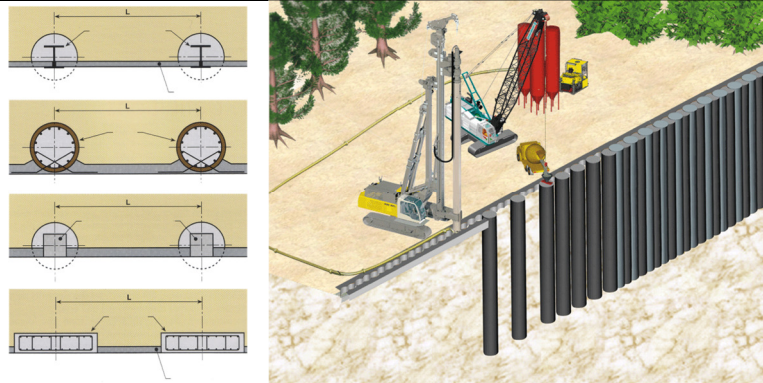


| Primary Emission sources | | 96% |
|----------------------------|---|---------------------|
| Source | Activity data | Relative importance |
| Materials | Quantity of materials | 96% |
| Secondary Emission sources | | 4% |
| Source | Estimation method | Relative importance |
| Energy | Additional rate : 1,7% | 1,6% |
| Freight | Standard activity data (details in the freight section) | 1,2% |
| People transportation | Standard activity data | 0,9% |
| Assets | Additional rate : 0,4% | 0,3% |
| Mob/demob | Additional rate : 0,1% | 0,1% |
| Waste | No data : this emission source is neglected | 0,0% |

BORED PILE WALLS

Contributors to samples





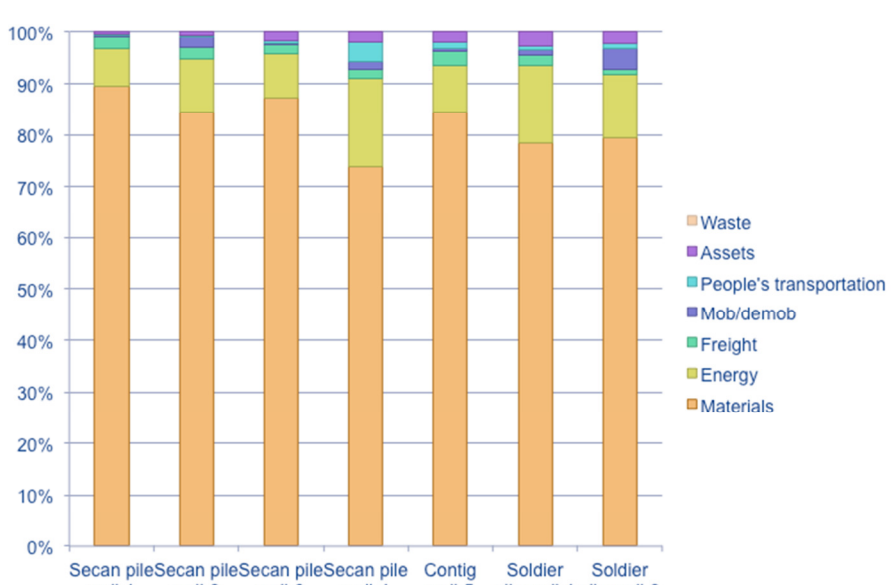
solider pile wall secant pile wall

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7 Projects

- Prochazkova
- Mesdag
- Essex Waste
- Maasvlakte2
- Brussel
- Holland Park
- Metro Ceveny vrch

Emissions sources breakdown



| Primary Emission sources | | 94% |
|----------------------------|---|---------------------|
| Source | Activity data | Relative importance |
| Materials | Quantity of materials | 84% |
| Energy | Amount of energy | 10% |
| Secondary Emission sources | | 6% |
| Source | Estimation method | Relative importance |
| Freight | Standard activity data (details in the freight section) | 2,2% |
| Assets | Additional rate : 1,4% | 1,3% |
| People transportation | Standard activity data | 1,2% |
| Mob/demob | Additional rate : 1,0% | 0,9% |
| Waste | Waste weight if relevant | 0% |

ANCHORS

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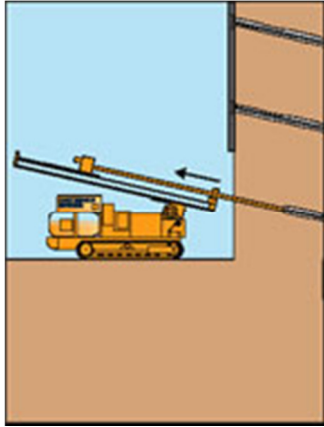
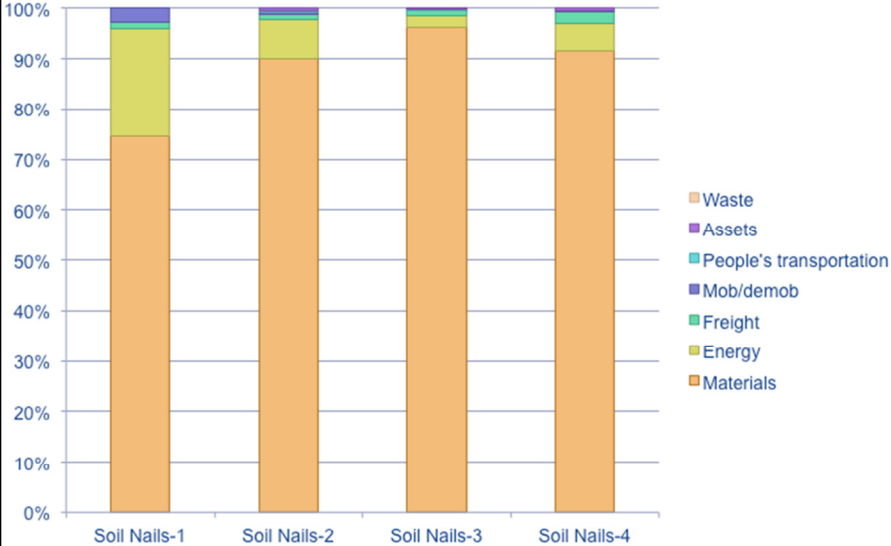
12 Projects

- Voltaire
- LKH Leoben
- "Aurelia" Bergeggi
- Bypass Bad St. Leonhard
- Zwijndrecht
- ROSAPARKS
- Terneuzen
- Schiedam
- BARANGAROO
- ALWA Donnersbach
- Anchors – 32mm – 4 rigs
- PRESSENSE

Emissions sources breakdown


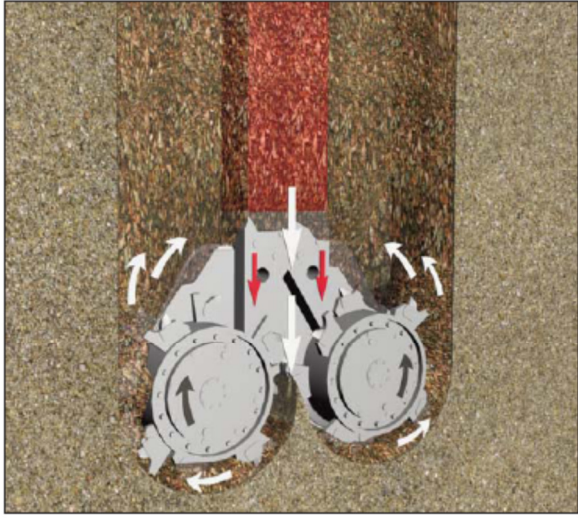
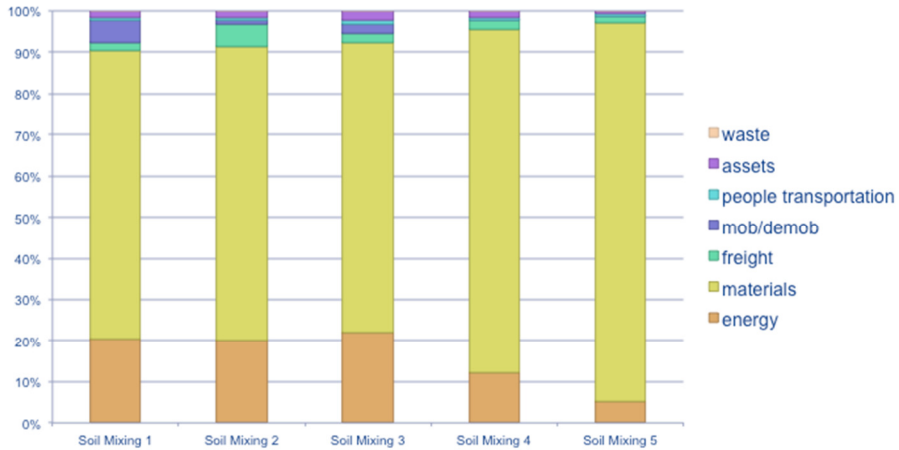
| Primary Emission sources | | 93% |
|----------------------------|---|---------------------|
| Source | Activity data | Relative importance |
| Materials | Quantity of materials | 76% |
| Energy | Amount of energy | 17% |
| Secondary Emission sources | | 7% |
| Source | Estimation method | Relative importance |
| Freight | Standard activity data (details in the freight section) | 2,3% |
| People transportation | Standard activity data | 2,3% |
| Assets | Additional rate : 1,5% | 1,4% |
| Mob/demob | Additional rate : 1,0% | 0,9% |
| Waste | Additional rate : 0,1% | 0,1% |

SOIL NAILS

| | |
|---|---|
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| <p>4 Projects</p> <ul style="list-style-type: none"> • Waidhofen/Ybbs • Storehouse Triotronik • Businesspark • Hollow-bar • Health resort Bad Gleichenberg | <p>Emissions sources breakdown</p>  |

| Primary Emission sources | | 97% |
|----------------------------|--|---------------------|
| Source | Activity data | Relative importance |
| Materials | Quantity of materials | 88% |
| Energy | Amount of energy | 9% |
| Secondary Emission sources | | 3% |
| Source | Estimation method | Relative importance |
| Freight | Standard activity data (details in the freight section) | 1,5% |
| Mob/demob | Additional rate : 0,9% | 0,9% |
| People transportation | Standard activity data | 0,4% |
| Assets | Additional rate : 0,2% | 0,2% |
| Waste | Waste weight if relevant | 0% |

SOIL MIXING

| | |
|---|---|
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| <p>5 projects</p> <ul style="list-style-type: none"> • Shoreham Adur Tidal Walls East Bank • Aigle • Noville • Forth Replacement • Suisse | <p>Emissions sources breakdown</p>  |

| Primary Emission sources | | 93% |
|----------------------------|---|---------------------|
| Source | Activity data | Relative importance |
| Materials | Quantity of materials | 77% |
| Energy | Amount of energy | 16% |
| Secondary Emission sources | | 5% |
| Source | Estimation method | Relative importance |
| Freight | Standard activity data (details in the freight section) | 2,7% |
| Mob/demob | Additional rate : 1,9% | 1,8% |
| Assets | Additional rate : 1,5% | 1,4% |
| People transportation | Standard activity data | 0,7% |
| Waste | Additional rate : 0,1% | 0,1% |

STONE COLUMNS

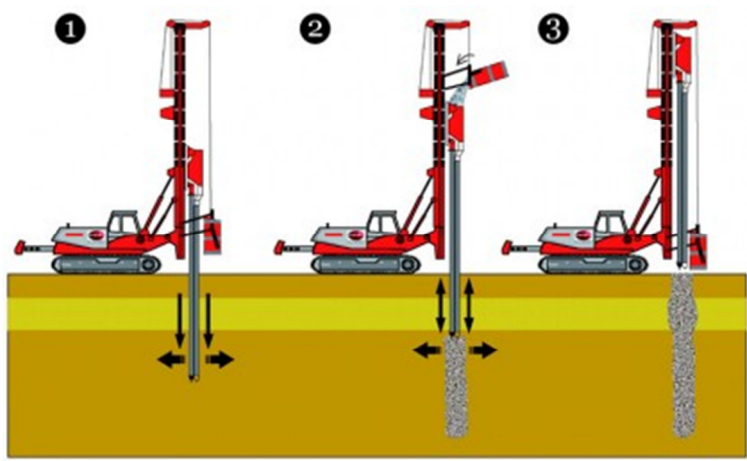
Contributors to samples

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GRUPO TERRATEST

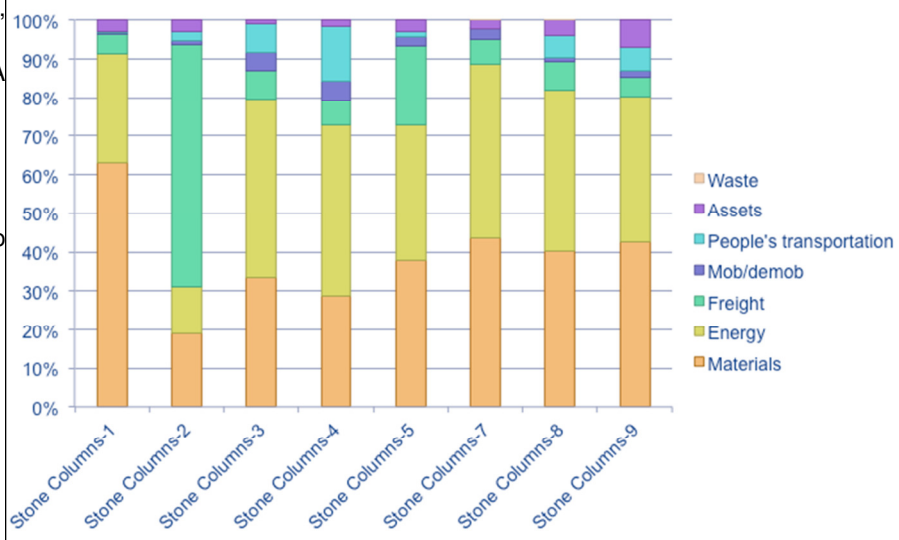


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9 projects

- Esholt, Bradford, Yorkshire
- AIRPORT OF LA CORUÑA
- Leicester (UK)
- Halle Felbermayer
- Hofer Pischelsdorf
- Shopping Center Dipo Koper
- Seeresort Hautzendorf
- Coleshill 32773
- Bilston, W.Midlands UK
- Gas Station Petrol Koper


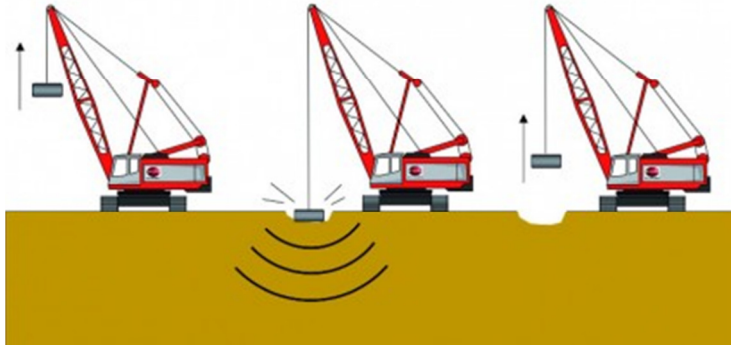
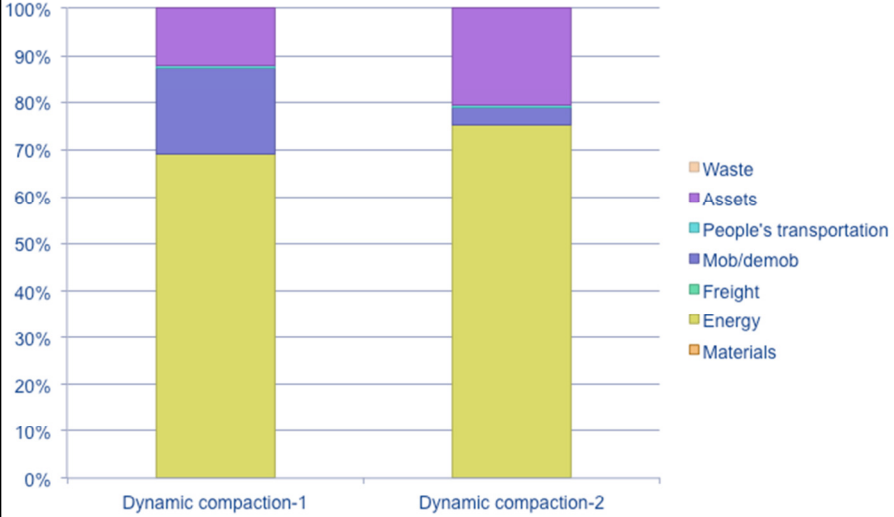
Emissions sources breakdown




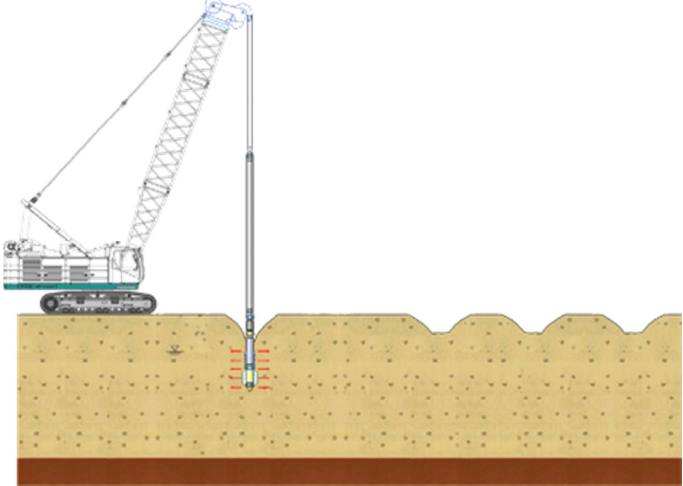
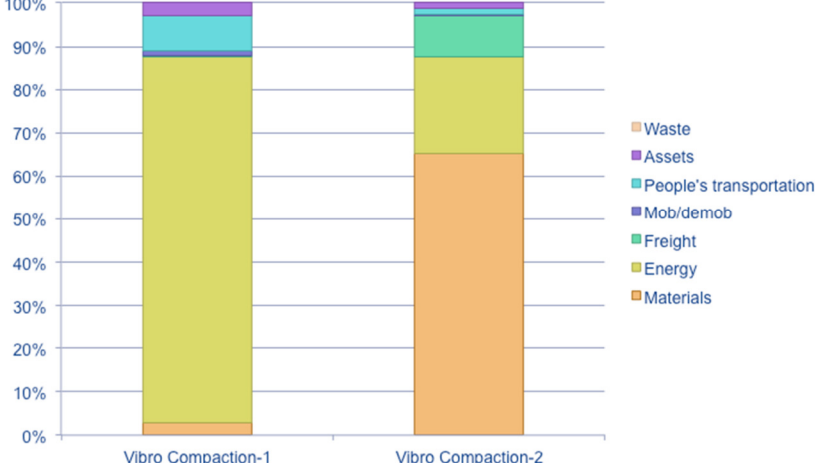
| Stone Column | Materials | Energy | Freight | Mob/demob | People's transportation | Assets | Waste |
|-----------------|-----------|--------|---------|-----------|-------------------------|--------|-------|
| Stone Columns-1 | 65% | 25% | 5% | 2% | 1% | 1% | 0% |
| Stone Columns-2 | 20% | 10% | 65% | 1% | 1% | 1% | 0% |
| Stone Columns-3 | 35% | 45% | 15% | 1% | 1% | 1% | 0% |
| Stone Columns-4 | 30% | 45% | 15% | 1% | 1% | 1% | 0% |
| Stone Columns-5 | 40% | 35% | 15% | 1% | 1% | 1% | 0% |
| Stone Columns-7 | 45% | 45% | 5% | 1% | 1% | 1% | 0% |
| Stone Columns-8 | 40% | 45% | 10% | 1% | 1% | 1% | 0% |
| Stone Columns-9 | 45% | 35% | 15% | 1% | 1% | 1% | 0% |

| Primary Emission sources | | 90% |
|----------------------------|---|---------------------|
| Source | Activity data | Relative importance |
| Materials | Quantity of materials | 38% |
| Energy | Amount of energy | 36% |
| Freight | Freight distances and number of trips (or load factors) | 15% |
| Secondary Emission sources | | 10% |
| Source | Estimation method | Relative importance |
| People transportation | Standard activity data | 4,7% |
| Assets | Additional rate : 3,3% | 3,0% |
| Mob/demob | Additional rate : 2,4% | 2,4% |
| Waste | Waste weight if relevant | 0% |

DYNAMIC COMPACTION


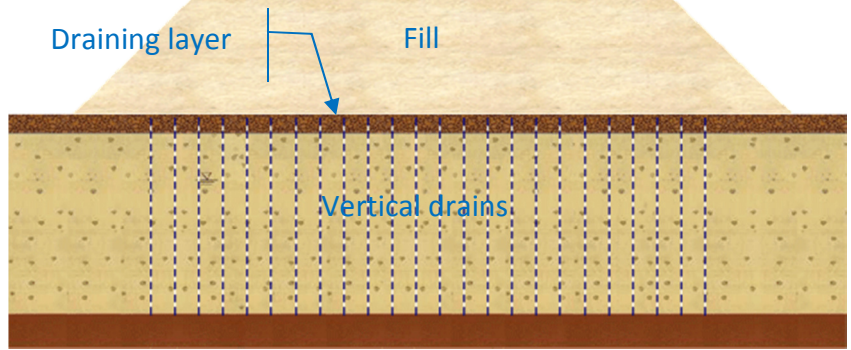
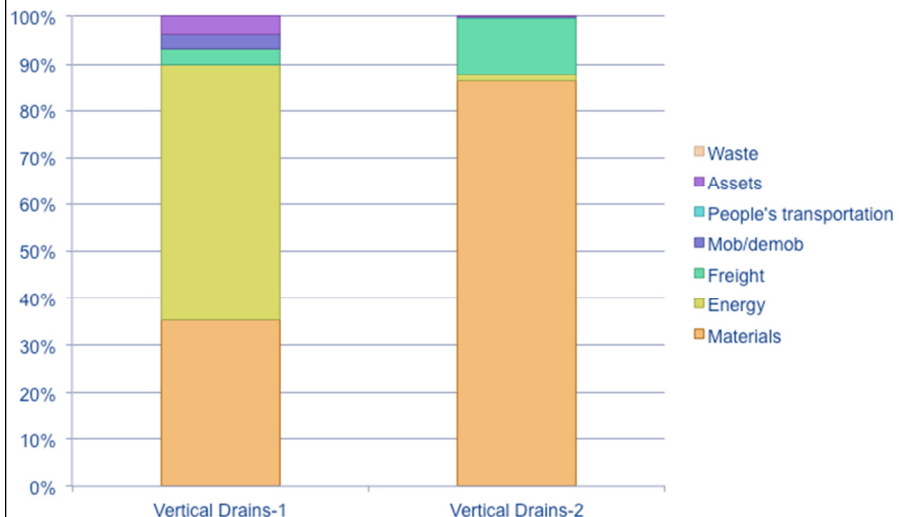
| <p>Contributors to samples</p> <p>Balfour Beatty Ground Engineering</p>  |  <p style="text-align: center; font-size: small;">Copyright Menard</p> | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|-----------|--------|-----------|-------------------------|---------|-------------------------|---------|-----------|----------------------|-----|-----|-----|----|----|----|----|----------------------|-----|----|-----|----|----|----|----|
| <p>2 projects</p> <ul style="list-style-type: none"> Cannock SOIL IMPROVEMENT NEW GERMAN SCHOOL | <p style="text-align: center;">Emissions sources breakdown</p>  <table border="1" style="display: none;"> <caption>Emissions sources breakdown data (estimated from chart)</caption> <thead> <tr> <th>Project</th> <th>Energy</th> <th>Mob/demob</th> <th>Assets</th> <th>Waste</th> <th>People's transportation</th> <th>Freight</th> <th>Materials</th> </tr> </thead> <tbody> <tr> <td>Dynamic compaction-1</td> <td>72%</td> <td>11%</td> <td>16%</td> <td>0%</td> <td>0%</td> <td>0%</td> <td>0%</td> </tr> <tr> <td>Dynamic compaction-2</td> <td>75%</td> <td>5%</td> <td>16%</td> <td>0%</td> <td>0%</td> <td>0%</td> <td>0%</td> </tr> </tbody> </table> | Project | Energy | Mob/demob | Assets | Waste | People's transportation | Freight | Materials | Dynamic compaction-1 | 72% | 11% | 16% | 0% | 0% | 0% | 0% | Dynamic compaction-2 | 75% | 5% | 16% | 0% | 0% | 0% | 0% |
| Project | Energy | Mob/demob | Assets | Waste | People's transportation | Freight | Materials | | | | | | | | | | | | | | | | | | |
| Dynamic compaction-1 | 72% | 11% | 16% | 0% | 0% | 0% | 0% | | | | | | | | | | | | | | | | | | |
| Dynamic compaction-2 | 75% | 5% | 16% | 0% | 0% | 0% | 0% | | | | | | | | | | | | | | | | | | |

| Primary Emission sources | | 99% |
|----------------------------|--|---------------------|
| Source | Activity data | Relative importance |
| Energy | Amount of energy | 72% |
| Assets | Assets weight, life time and used time | 16% |
| Mob/demob | Distance and number of trips | 11% |
| | | |
| Secondary Emission sources | | 1% |
| Source | Estimation method | Relative importance |
| People transportation | Standard activity data | 0,6% |
| Materials | Quantity of materials if relevant | |
| Freight | Standard activity data | |
| Waste | Waste weight if relevant | |

| VIBRO COMPACTION | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|--|--------------------|--------------------|--------------------|-----------|-----|------|--------|------|------|---------|-----|-----|-----------|-----|-----|-------------------------|-----|-----|--------|-----|-----|-------|-----|-----|
| <p>Contributors to samples</p>  |  <p>Copyright Soletanche Bachy</p> | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>2 projects</p> <ul style="list-style-type: none"> • ZPA Pöls • Agrana Pischelsdorf | <p>Emissions sources breakdown</p>  <table border="1"> <caption>Approximate Emissions Sources Breakdown (%)</caption> <thead> <tr> <th>Source</th> <th>Vibro Compaction-1</th> <th>Vibro Compaction-2</th> </tr> </thead> <tbody> <tr> <td>Materials</td> <td>~2%</td> <td>~65%</td> </tr> <tr> <td>Energy</td> <td>~85%</td> <td>~20%</td> </tr> <tr> <td>Freight</td> <td>~1%</td> <td>~8%</td> </tr> <tr> <td>Mob/demob</td> <td>~1%</td> <td>~1%</td> </tr> <tr> <td>People's transportation</td> <td>~5%</td> <td>~2%</td> </tr> <tr> <td>Assets</td> <td>~1%</td> <td>~1%</td> </tr> <tr> <td>Waste</td> <td>~0%</td> <td>~0%</td> </tr> </tbody> </table> | Source | Vibro Compaction-1 | Vibro Compaction-2 | Materials | ~2% | ~65% | Energy | ~85% | ~20% | Freight | ~1% | ~8% | Mob/demob | ~1% | ~1% | People's transportation | ~5% | ~2% | Assets | ~1% | ~1% | Waste | ~0% | ~0% |
| Source | Vibro Compaction-1 | Vibro Compaction-2 | | | | | | | | | | | | | | | | | | | | | | | |
| Materials | ~2% | ~65% | | | | | | | | | | | | | | | | | | | | | | | |
| Energy | ~85% | ~20% | | | | | | | | | | | | | | | | | | | | | | | |
| Freight | ~1% | ~8% | | | | | | | | | | | | | | | | | | | | | | | |
| Mob/demob | ~1% | ~1% | | | | | | | | | | | | | | | | | | | | | | | |
| People's transportation | ~5% | ~2% | | | | | | | | | | | | | | | | | | | | | | | |
| Assets | ~1% | ~1% | | | | | | | | | | | | | | | | | | | | | | | |
| Waste | ~0% | ~0% | | | | | | | | | | | | | | | | | | | | | | | |

Due to the variation observed in the data it is not possible to establish standard ratios for this technique. All sources need to be considered directly, except waste which will not be significant.

| Primary Emission sources | |
|-----------------------------------|---|
| Source | Activity data |
| Materials | Quantity of materials |
| Energy | Amount of energy |
| Freight | Freight distances and number of trips (or load factors) |
| Assets | Assets weight, life time and used time |
| Mob/demob | Distance and number of trips |
| People transportation | Standard activity data |
| Secondary Emission sources | |
| Source | Estimation method |
| Waste | Waste weight if relevant |

| VERTICAL DRAINS | |
|--|---|
| <p>Contributors to samples</p>  |  <p style="text-align: center;">Copyright Soletanche Bachy</p> |
| <p>2 projects</p> <ul style="list-style-type: none"> • Lidl Ljubljana • Polypropylene injection tubes | <p style="text-align: center;">Emissions sources breakdown</p>  |

Due to the variation observed in the data it is not possible to establish standard ratios for this technique. All sources need to be considered directly, except waste which will not be significant.

| Primary Emission sources | |
|-----------------------------------|---|
| Source | Activity data |
| Materials | Quantity of materials |
| Energy | Amount of energy |
| Freight | Freight distances and number of trips (or load factors) |
| Assets | Assets weight, life time and used time |
| Mob/demob | Distance and number of trips |
| People transportation | Standard activity data |
| Secondary Emission sources | |
| Source | Estimation method |
| Waste | Waste weight if relevant |

GROUTING

Contributors to samples





Placement of mortar

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4 projects

- Canal Cavour
- Monformoso Vercelli
- Chapel Mill Reservoir
- HWS Lankowitz
- Exit channel garden dam

Emissions sources breakdown



| Primary Emission sources | | 92% |
|----------------------------|--|---------------------|
| Source | Activity data | Relative importance |
| Materials | Quantity of materials | 70% |
| Energy | Amount of energy | 22% |
| Secondary Emission sources | | 8% |
| Source | Estimation method | Relative importance |
| People transportation | Standard activity data | 3,6% |
| Freight | Standard activity data (details in the freight section) | 2,3% |
| Assets | Additional rate : 1,7% | 1,6% |
| Mob/demob | Additional rate : 0,8% | 0,7% |
| Waste | Additional rate : 0,1% | 0,0% |

JET GROUTING

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14 projects

- Fincantieri shipyard Sestri Ponente Genova
- landfill Eco-Libarna Serravalle Scrivia
- Jet grouting project
- Channel of Santa Brigida creek
- Industrial building in Genoa
- Airport runway
- Industrial building in Albenga
- Hofwirt Seckau
- Utrecht
- McDonald's
- Church of SS. Annunziata
- Oldenzaal
- bioethanol fuel tank
- Arnhem

Emissions sources breakdown

| Primary Emission sources | | 95% |
|----------------------------|---|---------------------|
| Source | Activity data | Relative importance |
| Materials | Quantity of materials | 82% |
| Energy | Amount of energy | 13% |
| Secondary Emission sources | | 5% |
| Source | Estimation method | Relative importance |
| Freight | Standard activity data (details in the freight section) | 1,8% |
| Assets | Additional rate : 1,3% | 1,3% |
| People transportation | Standard activity data | 1,0% |
| Mob/demob | Additional rate : 0,8% | 0,8% |
| Waste | Additional rate : 0,4% | 0,4% |

7 Emission Factors Database Management

7.1 EFFC DFI emission factors database

Emission factors are updated and evolve as time goes by. Common database providers regularly release new versions of their emission factors. For example, IEA Electricity emission factors are updated every year.

Moreover, carbon calculator tool users can face projects with materials that have no emission factors in the tool's database. In this case the following approach is proposed:

- 1 – consider similar materials already available in the database
- 2 – if no comparable factors exists, then add a new material with an associated emission factor, and provide to EFFC-DFI and to the customer third party validated documents demonstrating the accuracy and relevance of the emission factor.

It is recommended to question suppliers regarding the carbon content of their products. It is a recommended best practice to enlarge the emission factor database or to make it more accurate to the deep foundations sector. This will ensure that any innovations which reduce the carbon footprint of supplied products will have a positive effect on the calculated values.

The main principle is the following:

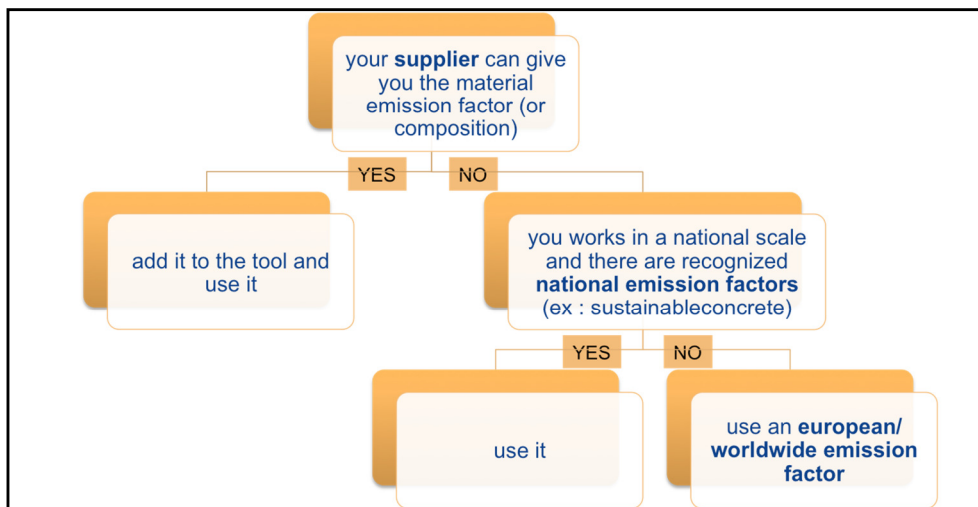


Figure 11: emission factor database choice process

The tool contains an emission factors database from public sources and product / supplier specific information. Where suppliers already communicate the carbon content of their product, users will be able to enter this value into the tool for an individual calculation.

It will be possible for EFFC DFI to add new emission factors to the database, but this will required a new version of the tool to ensure that all the users share the same database. The tool will need to be validated in accordance with this methodology.

7.2 Country Specific Emission Factors Database

By default, the tool uses the “EFFC DFI recommended” emission factors database described in this document with factors applicable to the whole Europe.

For some very specific needs, the user can select another emission factors database that is country specific.

This country specific database is built as follows: for a given emission factor

- If the national official emission factor database provides a value, it will be used,
- If not, the EFFC DFI recommended emission factor will be used.

To date, there are three country specific databases:

| Country | National emission factors database |
|----------------|------------------------------------|
| France | Base Carbone (= Bilan Carbone v7) |
| United Kingdom | DEFRA + ICE |
| USA | EPA |

REMINDER: the standard EFFC DFI methodology recommends the use of the “EFFC DFI recommended” database as the default one. Should the national database be used, please justify your choice.

8 Carbon Calculator Presentation

8.1 Tool objectives & principles

8.1.1 A project-based tool

The tool aims to calculate the carbon footprint of a deep foundation or ground improvement project. A project can be subdivided into different subprojects. Each of these subprojects corresponds to the use of one technique. Subprojects are created simply by adding as many worksheets as required for each technique used in the project.

The tool allows project comparisons, enabling the user to select the techniques with the lowest associated emissions and to compare the performance of different solutions for the same customer need.

The results of calculations performed with different techniques or by different companies, for the same project, will be comparable and the use of the EFFC DFI tool may be proposed by a customer.

The methodology chosen and deployed in this tool ensures that all the EFFC and DFI members calculate their product carbon footprints in the same way, with consistency in perimeter and emission factors. This will ensure that results calculated separately will be comparable.

8.1.2 Techniques covered

The techniques covered, depending on the version of the tool are :

| | | |
|----------------------------|----------------------------|---|
| Piles | Bored piles | V1 & V2 |
| | Displacement piles | V1 & V2 |
| | Micropiles | V1 & V2 |
| Retaining Walls | Diaphragm and slurry walls | V1 & V2 |
| | Pile walls | V2 |
| | Sheet pile walls | V1 & V2 |
| Anchors | Anchors | V2 |
| | Soil Nails | V2 |
| Ground Improvement | Dynamic compaction | V2 |
| | Vibro compaction | V2 |
| | Grouting | V1 & V2 |
| | Jet Grouting | V2 |
| | Stone Columns | V2 |
| | Soil Mixing | V1 & V2 |
| | Vertical Drains | V2 |
| Dewatering | | There are no specific ratios associated – Calculation with a generic worksheet (all sources to be taken into account) |
| Underpinning | | |
| Horizontal Drilling | | |

8.1.3 Generic principles

The tool is user driven and customer focused.

The tool is easy-to-use so that non-expert people can use it (a commercial team for example). It can be used for decision making during the design phase as well as for external / internal communication or commercial activities.

Emission sources are analyzed, organized and appear by order of importance, specific to each technique: this optimizes the time spend of the user by focusing the data collection for key emission sources. The use of statistical ratios is proposed for the secondary sources.

At any time these ratios may be replaced by specific activity data should it be available.

8.2 Perimeter

The general life cycle perimeter - cradle-to-grave - is shown on the following figure:



Figure 10: Cradle-to-grave life cycle analysis phases

(source : GHG Protocol Product Life Cycle Accounting and Reporting Standard)

For the deep foundations activity, the cradle-to-gate perimeter will be considered which contains only the **material acquisition & pre-processing** phase and the **production** phase.

Distribution phase: The distribution and storage phase has no significance for foundations activities because the foundations are produced on site.

However, the required transportation for the production phase (materials transportation for example) will be considered.

Use phase: As a foundation is a passive product, it does not consume energy. The specific case of geothermal piles is not considered here.

No greenhouse gas is released in the atmosphere during a foundations lifetime. If some maintenance is needed, the amount of energy and materials are considered negligible compared to the construction phase.

End of life phase: The end-of-life of a foundation may happen dozens of years after the construction. Moreover, from a carbon point of view, inert wastes are not significant in a carbon footprint. This phase has therefore been neglected.

As this is a project-based tool, all emissions from premises and office work are excluded. These should not differentiate various technique's carbon footprints

The impact of land use change is not taken into account at this stage as it should be allocated to building or infrastructure rather than to the foundations themselves.

8.3 Data collection / primary and secondary emission sources

The methodology and associated tool will expose all the data needed for the calculation, for every technique, in the form of cells to be filled.

The data can be entered in two stages:

- data concerning the main emission sources
- data concerning other emission sources

A simple mode will enable the entry of only the data concerning the main emission sources, the remainder will be automatically calculated based on ratios provided by the methodology. This simple mode gives an approximated result very quickly.

The advanced mode will enable the user to enter all the data concerning the project, which is longer, but more accurate.

8.4 Uncertainties

The aim of a carbon footprint is to calculate the order of magnitude of the emissions due to the project. There are uncertainties associated with emission factors and activity data, both of which are taken into account in the tool.

The global uncertainty is an indicator of the accuracy of the calculation.

8.5 Tools presentation and interface

8.5.1 Read-me sheet

The first sheet is a “read-me” sheet that reminds the user of all the principles of the calculation and the way to use the tool.

8.5.2 Calculation sheet

The calculation for each technique is done on one Excel sheet. On this sheet, the activity data concerning all the emission sources is filled in.

8.5.3 Consolidation sheet

If the project contains different techniques, a separate sheet will consolidate the different calculation sheets.

This consolidation sheet can also be used if the project is made of different parts (with different techniques or not) which contribute to the carbon footprint of the global project.

8.5.4 Results sheet

The main results are summarized on an Excel worksheet with A4 size for easy sharing and printing.

9 Carbon footprint calculator – user guide

This section is the “EFFC-DFI carbon footprint user guide” and presents generic and specific aspects of the carbon calculator. It does not replace a complete training session.

The aim of the tool is to calculate the carbon footprint of a deep foundation or ground improvement project.

As these can be large and complex, **projects** are divided in smaller elements, called **subprojects**.

Information regarding one subproject, called activities data, must be entered in one sheet, called a **subproject sheet**.

Subproject sheets are the only sheets where the user should enter data. The other sheets aim to manage and present data from these sheets:

- Project sheets: total results of relevant subproject sheets
- Results sheet: displays the results of another sheet in a regular layout
- Comparison sheet: compares the results of different subproject or project sheets

| Kind of Worksheet | Purpose | Input |
|-------------------|---|-------------------------------------|
| Subproject | Calculate the carbon footprint of a part of a project | Field activities data |
| Project | Consolidate various subproject as a single project | Subproject sheets Project sheets |
| Results | Extract the main data in a printable layout | Subproject sheets Project sheets |
| Comparison | Compare different projects or subprojects in a printable layout | Subproject sheets Project sheets |

The “HOME” sheet enables to create and duplicate other kind of sheet.

EFFC DFI Carbon Calculator
Methodological Guide – V2.2 March 2014

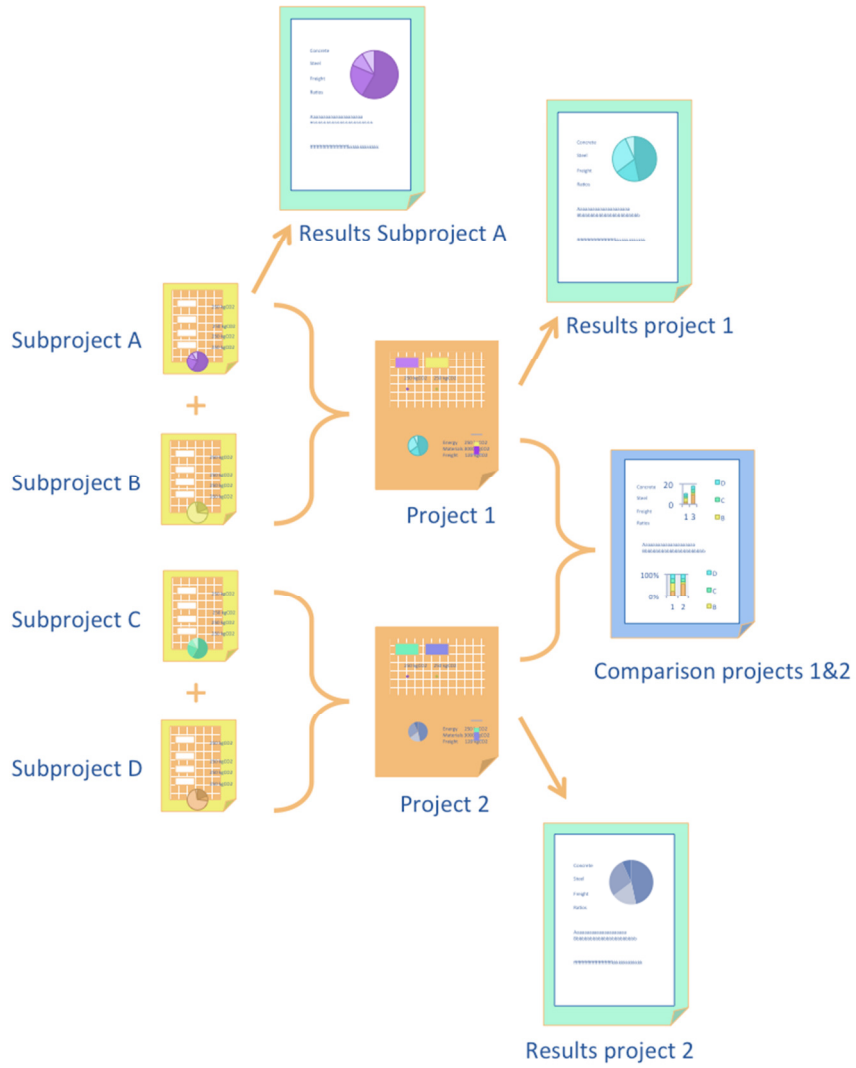
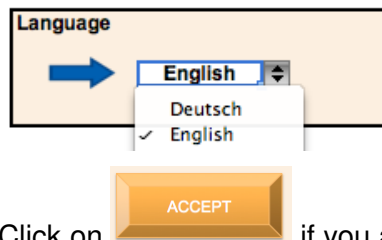



Diagram of the carbon calculator. Here two projects, each of them composed of two subprojects (A+B) and (C+D) can be compared, analyzed, and their results exported.

9.1 Opening the tool

VBA Macros must be enabled to a proper use of the tool.

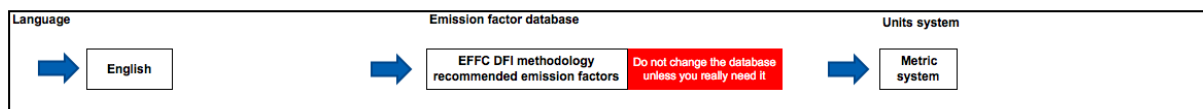
When opening the tool, a small disclaimer is presented. This disclaimer must be accepted to use the tool. You can select the language used to display the disclaimer with a drop-down list.



Click on  if you accept the disclaimer.

The “Read me” sheet is now active. Three important choices need to be made on this sheet:

- Language: select the language of the tool.
- Emission factor database: select the database of the calculation. The *EFFC DFI methodology recommended emission factors* database has been compiled to best represent Europe.
- Units system: select the units system that match with your field data

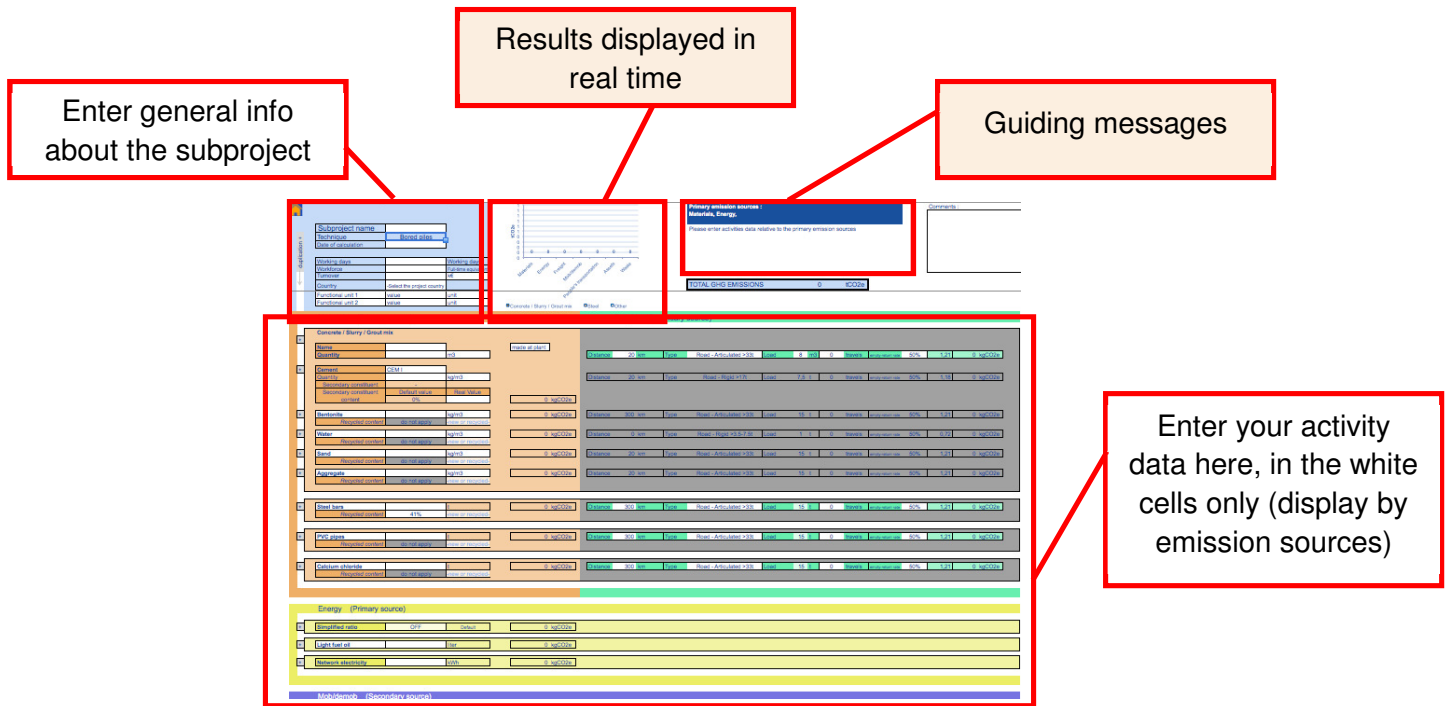


Take time to read the quick tips at the end of the sheet.

9.2 Subproject sheet organisation

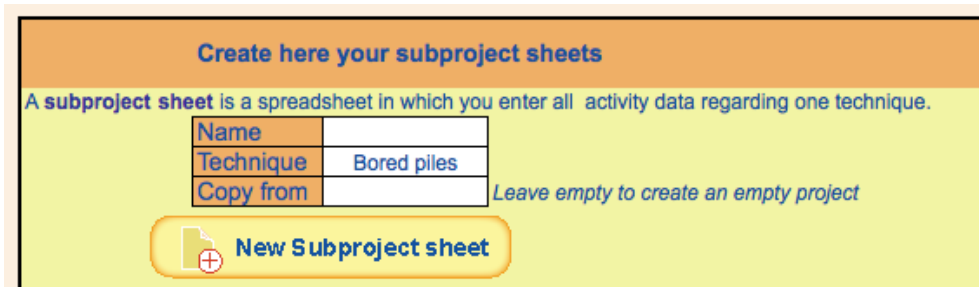
9.2.1 Subproject sheet presentation

This excel based carbon calculator is user friendly and the elementary sheet is the “subproject” sheet presented here. Calculations are made line by line, and only white cells are to be filled with activity data.



9.2.2 How to create a Subproject sheet?

In the **HOME** worksheet, you will find the *Subproject sheet creation* box.

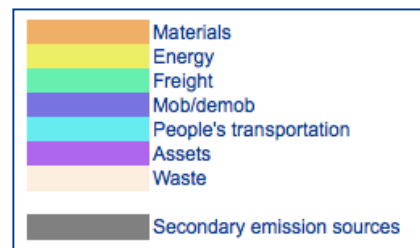


Enter a name, select a technique and click on the *New Subproject sheet* button to generate a new subproject sheet.

9.2.3 Subproject sheet colour code & interface

9.2.3.1 Colour code

Selecting a technique will highlight the primary emission sources by filling them with their own colours. The secondary emission sources will be coloured in gray, indicating that they are low priority emission sources. They are integrated in the calculation, but normally with a small percentage (below 5%, as per methodology design).



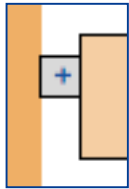
9.2.3.2 Interface and sheet control



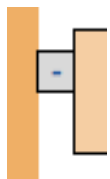
The white cells are the ones that have to be filled in.



If a list box selection icon appears when selecting the cell, you can only chose one of the proposed values.



In order to **duplicate** an emission source box, just double click on the on the left. In order to **delete** a duplicated emission source box, just double click on the on the left.



You can manually change the to and vice versa in order to duplicate or delete boxes.

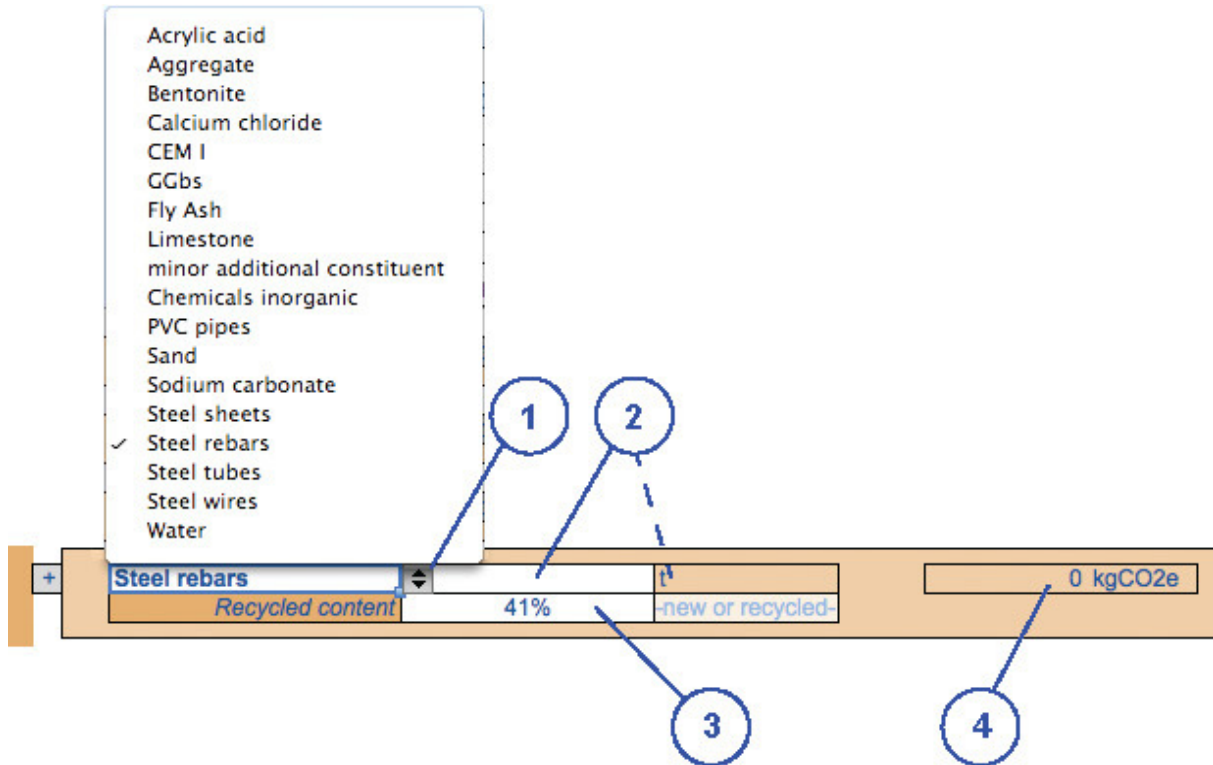
9.2.4 Subproject sheet main principle

The principle of any carbon calculation is to multiply activity data (which characterize the project in a physical way) by an emission factor (which convert the quantity of the activity data into quantity of CO₂ equivalent emissions). The following paragraph summarises the steps to practically perform this calculation.

- List all the physical inputs to your (sub)project, for the primary emission sources :
 - Materials: types of materials
 - Energy: energy sources
 - Freight and Mob/demob and waste: vehicles
 - People transportation: transportation modes
 - Assets: machines

You must be as exhaustive as possible on the primary emission sources. It is better to estimate values rather than ignore some activity data that you may not know at the draft stage of a project.

1. Select the category corresponding to your activity data (this step will set up the corresponding emission factor for the calculation)
2. Enter the activity data corresponding to the unit proposed
3. If relevant, specify options (see 9.2.5)
4. The results of the calculation appears automatically



- Repeat this for all the activity data of the primary emission sources. The results are displayed on the top of the worksheet.
- If activities data of the secondary emission sources are known, you can also enter them in the same way.

9.2.5 Subproject sheet detailed functionalities

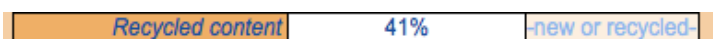
9.2.5.1 Materials

For a given material, origin and production process can widely differ:

- Raw material;
- Recycled material;
- Mixed raw and recycled material;
- Reused material.

If the material concerned has been recycled, the recycled content can be entered. A default value is provided, but you must enter the real value if known:

- Raw material: 0%
- Recycled material: 100%
- Mixed raw and recycled material: real value



If the material is reused, select *-reused-* instead of *-new or recycled-*



9.2.5.2 Freight

| | | | | | | | | | | | |
|----------|--------|------|-------------------------|------|------|---|---------|-------------------|-----|------|----------|
| Distance | 300 km | Type | Road - Articulated >33t | Load | 15 t | 0 | travels | empty-return rate | 50% | 1,21 | 0 kgCO2e |
|----------|--------|------|-------------------------|------|------|---|---------|-------------------|-----|------|----------|

Freight is populated automatically with default values. If known, enter the real activity data:

- Real distance between the material manufacturer and the construction site.
- Type of vehicles used.
- Number of journeys. If the number of journeys is not known, enter the average load per truck. The number of journeys will be calculated by dividing the quantity of material by the truck load.
- Enter the real empty-return rate = empty truck kilometers / filled truck kilometers

9.2.5.3 Ratios functionality

| | | |
|------------------|-----|---------|
| Simplified ratio | OFF | Default |
|------------------|-----|---------|

If the emission source is a primary one, the ratio will be turned **off** and real values must be entered.

If the emission source is a secondary one, then the ratio is **on** unless real activity data is entered.

If, for some reason, you know that this source does not concern your project (for example if no waste will be generated), you can manually turn off the ratio.

| | | |
|------------------|-----|---------------------|
| Simplified ratio | OFF | Manually turned OFF |
|------------------|-----|---------------------|

| | Primary Emission Source | Secondary Emission Source | |
|---------------------|-------------------------|---------------------------|-------------------|
| | | No real data entered | Real data entered |
| Default | OFF | ON | OFF |
| Manually turned off | OFF | OFF | |

9.2.5.4 Mob/demob

| | | | | | | |
|-------------------|------------|----------|---------------|----------|-------------------|----|
| Road - Rigid >17t | roundtrips | Distance | 50 km one way | 0 kgCO2e | empty-return rate | 0% |
|-------------------|------------|----------|---------------|----------|-------------------|----|

- Select the type of vehicles used
- Enter the number of roundtrips
- Enter the distance to the construction site
- If known, enter the empty-return rate (Zero if the transportation remains on the construction site until demobilization.)

9.2.5.5 People's transportation

- Daily journeys

| Coming by | Number of roundtrips | every X day(s) | Average distance (km one-way) |
|-----------|----------------------|----------------|-------------------------------|
| + Car | 0 | 1 | 50 |
| + Bus | | 1 | 50 |
| + Train | | 5 | 300 |

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- Select the transportation mode (for example: **car**)
- Enter the number of round-trips (for example: **3** people traveling by car)
- Enter the frequency of the journeys (for example: 3 people traveling by car every **2** days)
- Enter the distance (each-way) of the journey

➤ Professional travels

A horizontal input bar with a '+' icon on the left. It contains a text box with 'Train', a unit box with 'pkm', and a result box with '0 kgCO2e'.

- Selection the transportation mode
- Enter the total distance of the travel

9.2.5.6 Asset depreciation

A horizontal input bar with a '+' icon on the left. It contains several fields: 'Machines weight' (unit 't'), '0 kgCO2e', 'Machines lifetime' (unit '10 years'), 'Use time', and '0 days'.

To add a machine, double click on the box and:

- Select the weight of your machine
- Enter the lifetime of the machine (in years)
- Enter the number of days the machine is being used (in days)

9.2.5.7 Waste

Waste transportation is calculated in the same way as freight.

9.3 “Project” sheet organisation and functionalities

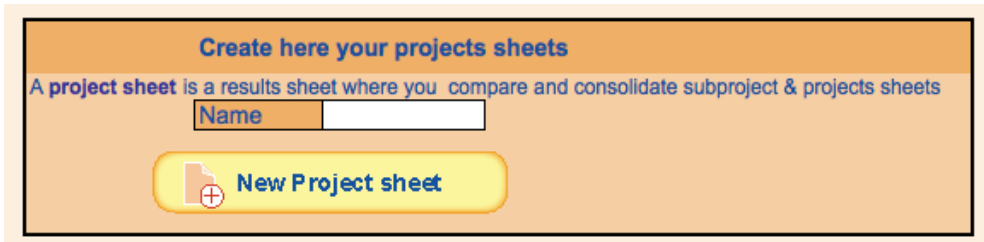
9.3.1 Project sheet overview

The screenshot shows a software interface for project management. Three red callout boxes provide instructions:

- Top left: 'Enter general info about the project' points to a form with fields for 'Project name', 'Site', 'Machines weight', and 'Machines lifetime'.
- Top right: 'Results displayed in real time' points to a bar chart and a table of data.
- Bottom left: 'Select here different parts of the project in the subproject list' points to a table with columns for 'Subproject name', 'Machines weight', and 'Machines lifetime'.

9.3.2 Project sheet creation

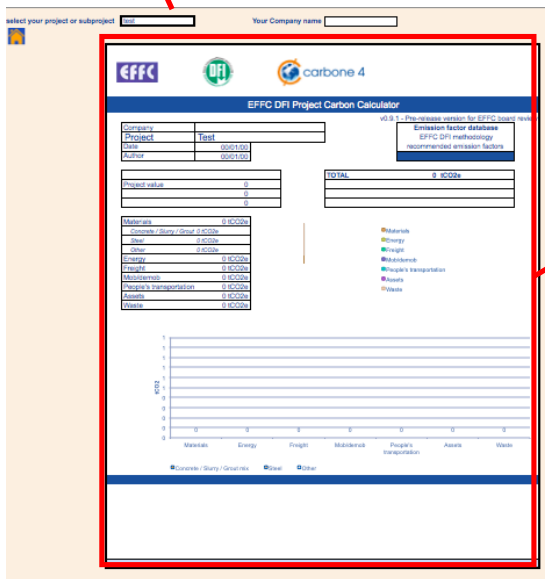
In the HOME worksheet, you will find the *Project sheet creation* box.



9.4 Results sheet

9.4.1 Results sheet overview

Select a subproject or project sheet

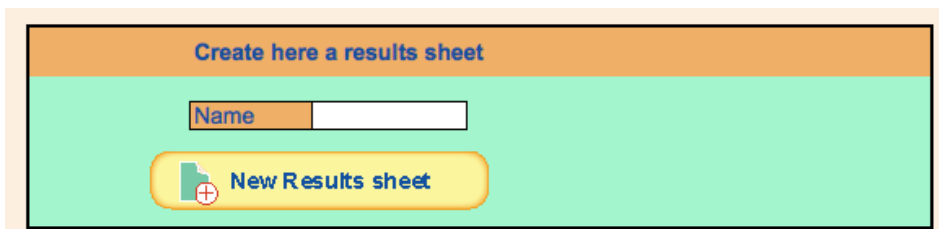


Results ready to be printed

The result sheet is a standard A4 format printable layout, which is to be considered as the standard document to be included in your tenders for example.

9.4.2 Results sheet creation

In the HOME worksheet, you will find the *Results sheet creation* box.



9.5 Comparison sheet organisation and functionalities

9.5.1 Comparison sheet overview

In the comparison sheet you can select and compare up to 6 different project or subprojects.

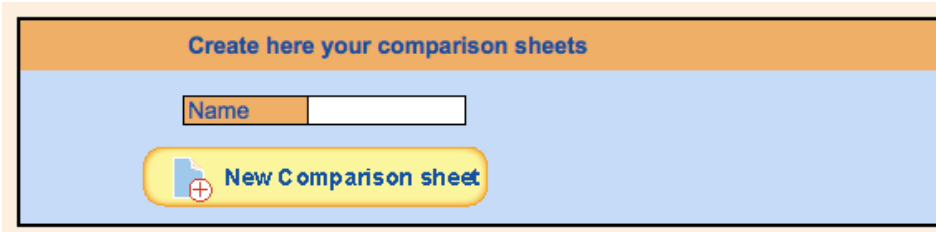
Select subprojects or projects to compare

Results ready to be printed

The comparison sheet can take an input project or subproject sheets.

9.5.2 Comparison sheet creation

In the HOME worksheet, you will find the *Comparison sheet creation* box. You can create as many comparison sheets as you want.



9.6 Navigating in the tool

The **HOME** sheet lists all the created sheets, categorized by their type.

| Existing Subprojects | Existing Projects | Results sheets | Comparison sheets |
|----------------------|-------------------|----------------|-------------------|
| Part 3 bis | FR-87 bis | Results | Comp North |
| Part 3 | FR-87 | | Comp South |
| Part 2 | | | |
| Part 1 | | | |

To view a sheet, just double click on its name.



To come back to the HOME sheet, click on  in the upper left corner of the sheet.

10 Emission Factors Database

Below is a list of the main emission factors used in the tool.

The choice of an emission factor is always subjective since many databases exist. It is important to select comparable factors (calculated using the same methodology) and we propose in this document the most relevant emission factors based on the team's experience.

The sources used in the recommended emission factors database are:

- Ecoinvent
- Bilan Carbone V7
- Sustainableconcrete
- ICE v2
- DEFRA
- IEA 2012
- EcoTransit

It is well understood that the objective of this calculator is to encourage carbon calculation and to enable easy comparison between projects, based on a standardized carbon footprinting approach. The standardization of an emission factors database allows comparison of different projects, provided that the calculations have been carried out using the same tool.

The emission factors database will be supplemented with country specific values if relevant and will be regularly updated by EFFC DFI.

The tool can also use country specific databases where these are more appropriate. In version 2, three country-specific database are included (see details below):

- France, with *Bilan Carbone* emission factors
- UK, with *Defra* and *ICE* emissions factors
- US specific database. Materials and asset emission factors are those from the European EFFC DFI recommended database. Transportation and energy emission factors come from EPA⁵.

⁵ <http://www.epa.gov/climateleadership/guidance/ghg-emissions.html>

10.1 EFFC-DFI recommended emission factors database

| Emission factor name | unit | Emission factor used (kg CO ₂ e /unit) | Emission factor database used |
|--------------------------------|-------|---|-------------------------------|
| Materials | | | |
| Acrylic acid | t | 2 261 | EcoInvent v2.2 |
| Aggregate | t | 11 | Bilan Carbone v7 |
| Bentonite | t | 496 | EcoInvent v2.2 |
| Synthetic polymer slurry | m3 | 3,6 | EcoInvent v2.2 |
| Cellulose-based polymer slurry | m3 | 4,5 | EcoInvent v2.2 |
| Calcium chloride | t | 855 | EcoInvent v2.2 |
| CEM I | t | 930 | Sustainable concrete |
| GGbs | t | 52 | Sustainable concrete |
| Fly Ash | t | 4 | Sustainable concrete |
| Limestone | t | 32 | Sustainable concrete |
| minor additional constituent | t | 32 | Sustainable concrete |
| Chemicals inorganic | t | 1 860 | EcoInvent v2.2 |
| EPDM-rubber | t | 2 655,9 | EcoInvent v2.2 |
| Polypropylene | t | 1 982,5 | EcoInvent v2.2 |
| PVC pipes | t | 3 230 | ICE V2 |
| Sand | t | 5 | ICE V2 |
| Sodium carbonate | t | 942 | EcoInvent v2.2 |
| Steel sheets | t | 1 938 | EcoInvent v2.2 |
| Steel rebars | t | 1 857 | EcoInvent v2.2 |
| Steel tubes | t | 2 375 | EcoInvent v2.2 |
| Steel wires | t | 2 335 | EcoInvent v2.2 |
| Water | t | 0,30 | Defra 2012 |
| Steel sheets - recycled | t | 705 | EcoInvent v2.2 |
| Steel rebars - recycled | t | 624 | EcoInvent v2.2 |
| Steel tubes - recycled | t | 1 142 | EcoInvent v2.2 |
| Steel wires - recycled | t | 1 102 | EcoInvent v2.2 |
| Energy | | | |
| Light fuel oil | liter | 3,6 | DEFRA 2012 |
| Electricity | kWh | Depend on the country | IEA 2012 |
| Freight | | | |
| Diesel (100% mineral diesel) | liter | 3,24 | DEFRA 2012 |
| Road - Rigid >3.5-7.5t | vkm | 0,72 | DEFRA 2012 |
| Road - Rigid >7.5-17t | vkm | 0,88 | DEFRA 2012 |
| Road - Rigid >17t | vkm | 1,18 | DEFRA 2012 |
| Road - Articulated >3.5-33t | vkm | 1,08 | DEFRA 2012 |
| Road - Articulated >33t | vkm | 1,21 | DEFRA 2012 |
| Air - Domestic | tkm | 2,71 | DEFRA 2012 |
| Air - Short-haul international | tkm | 1,63 | DEFRA 2012 |

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| | | | |
|--|-------|-------|------------------|
| Air - Long-haul international | tkm | 0,84 | DEFRA 2012 |
| Maritime - General cargo | tkm | 0,016 | DEFRA 2012 |
| Maritime - Container | tkm | 0,019 | DEFRA 2012 |
| Rail - Average freight - thermic | tkm | 0,029 | EcoTransit |
| Rail - Average freight - electric - United Kingdom | tkm | 0,014 | EcoTransit |
| People's transportation | | | |
| Diesel oil | liter | 3,17 | Defra 2012 |
| Bus | vkm | 0,15 | Defra 2012 |
| Car | vkm | 0,23 | Defra 2012 |
| Train | pkm | 0,07 | Defra 2012 |
| Air passenger - Domestic | pkm | 0,22 | Defra 2012 |
| Air passenger - Short-haul international | pkm | 0,13 | Defra 2012 |
| Air passenger - Long-haul international | pkm | 0,14 | Defra 2012 |
| Assets | | | |
| Machines | t | 3 667 | Bilan Carbone v7 |

10.2 US specific emission factors database

| Emission factor name | unit | Emission factor used (kgCO ₂ /unit) | Emission factor database used |
|------------------------------|------|--|------------------------------------|
| Materials | | | |
| Acrylic acid | lb | 1,0257 | Converted from EcoInvent v2.2 |
| Aggregate | lb | 0,0050 | Converted from Bilan Carbone v7 |
| Bentonite | lb | 0,2250 | Converted from EcoInvent v2.2 |
| Calcium chloride | lb | 0,3878 | Converted from EcoInvent v2.2 |
| CEM I | lb | 0,4218 | Converted from sustainableconcrete |
| GGbs | lb | 0,0236 | Converted from sustainableconcrete |
| Fly Ash | lb | 0,0018 | Converted from sustainableconcrete |
| Limestone | lb | 0,0145 | Converted from sustainableconcrete |
| minor additional constituent | lb | 0,0145 | Converted from sustainableconcrete |
| Chemicals inorganic | lb | 0,8437 | Converted from EcoInvent v2.2 |
| EPDM-rubber | lb | 1,2047 | Converted from EcoInvent v2.2 |
| Polypropylene | lb | 0,8992 | Converted from EcoInvent v2.2 |
| PVC pipes | lb | 1,4651 | Converted from ICE V2 |
| Sand | lb | 0,0023 | Converted from ICE V2 |
| Sodium carbonate | lb | 0,4273 | Converted from EcoInvent v2.2 |

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| | | | |
|-------------------------|----|--------|-------------------------------|
| Steel sheets | lb | 0,8791 | Converted from EcoInvent v2.2 |
| Steel rebars | lb | 0,8423 | Converted from EcoInvent v2.2 |
| Steel tubes | lb | 1,0773 | Converted from EcoInvent v2.2 |
| Steel wires | lb | 1,0591 | Converted from EcoInvent v2.2 |
| Water | lb | 0,0001 | Converted from Defra 2012 |
| Steel sheets - recycled | lb | 0,3198 | Converted from EcoInvent v2.2 |
| Steel rebars - recycled | lb | 0,2830 | Converted from EcoInvent v2.2 |
| Steel tubes - recycled | lb | 0,5180 | Converted from EcoInvent v2.2 |
| Steel wires - recycled | lb | 0,4999 | Converted from EcoInvent v2.2 |

Energy

| | | | |
|----------------|--------|----|-----|
| Diesel | gallon | 10 | EPA |
| Heavy fuel oil | gallon | 10 | EPA |

Electricity EPA

Freight

| | | | |
|---|--------------|-------|--|
| Diesel (100% mineral diesel) | gallon | 10,27 | EPA |
| Road - Rigid >3.5-7.5t | vehicle-mile | 0,53 | EPA |
| Road - Rigid >7.5-17t | vehicle-mile | 1,73 | EPA |
| Road - Rigid >17t | vehicle-mile | 1,73 | EPA |
| Road - Articulated >3.5-33t | vehicle-mile | 1,73 | EPA |
| Road - Articulated >33t | vehicle-mile | 1,73 | EPA |
| Air - Domestic | ton-mile | 1,54 | EPA |
| Air - Short-haul international | ton-mile | 1,54 | EPA |
| Air - Long-haul international | ton-mile | 1,54 | EPA |
| Maritime - General cargo | ton-mile | 0,049 | EPA |
| Maritime - Container | ton-mile | 0,049 | EPA |
| Rail - Average freight - thermic | ton-mile | 0,025 | EPA |
| Rail - Average freight - electric - United States | ton-mile | 0,023 | Converted from european recommended database |

People's transportation

| | | | |
|--|----------------|-------|-----|
| Diesel oil | gallon | 10,27 | EPA |
| Bus | passenger-mile | 0,11 | EPA |
| Car | vehicle-mile | 0,37 | EPA |
| Train | passenger-mile | 0,19 | EPA |
| Air passenger - Domestic | passenger-mile | 0,29 | EPA |
| Air passenger - Short-haul international | passenger-mile | 0,17 | EPA |
| Air passenger - Long-haul international | passenger-mile | 0,20 | EPA |

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| Assets | | | |
|----------|----|-----|------------------------------|
| Machines | lb | 1,7 | Converted from Bilan Carbone |

10.3 France specific emission factors database

| Emission factor name | unit | Emission factor used (kgCO ₂ /unit) | Emission factor database used |
|------------------------------|-------|--|-------------------------------|
| Materials | | | |
| Acrylic acid | t | 2 261 | EcoInvent v2.2 |
| Aggregate | t | 11 | Bilan Carbone v7 |
| Bentonite | t | 496 | EcoInvent v2.2 |
| Calcium chloride | t | 855 | EcoInvent v2.2 |
| CEM I | t | 990 | Bilan Carbone v7 |
| GGbs | t | 52 | sustainableconcrete |
| Fly Ash | t | 4 | sustainableconcrete |
| Limestone | t | 32 | sustainableconcrete |
| minor additional constituent | t | 32 | sustainableconcrete |
| Chemicals inorganic | t | 1 860 | EcoInvent v2.2 |
| PVC pipes | t | 1 888 | Bilan Carbone v7 |
| Sand | t | 5 | ICE V2 |
| Sodium carbonate | t | 942 | EcoInvent v2.2 |
| Steel sheets | t | 1 938 | Bilan Carbone v7 |
| Steel rebars | t | 1 857 | Bilan Carbone v7 |
| Steel tubes | t | 3 190 | Bilan Carbone v7 |
| Steel wires | t | 3 190 | Bilan Carbone v7 |
| Water | t | 0,30 | Defra 2012 |
| Steel sheets - recycled | t | 705 | Bilan Carbone v7 |
| Steel rebars - recycled | t | 624 | Bilan Carbone v7 |
| Steel tubes - recycled | t | 1 100 | Bilan Carbone v7 |
| Steel wires - recycled | t | 1 100 | Bilan Carbone v7 |
| Energy | | | |
| Diesel | liter | 3 | Bilan Carbone v7 |
| Heavy fuel oil | liter | 3 | Bilan Carbone v7 |
| Electricity | | | |
| Freight | | | |
| Diesel (100% mineral diesel) | liter | 3,25 | Bilan Carbone v7 |
| Road - Rigid >3.5-7.5t | vkm | 0,85 | Bilan Carbone v7 |

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| | | | |
|--|-------|-------|------------------|
| Road - Rigid >7.5-17t | vkm | 0,93 | Bilan Carbone v7 |
| Road - Rigid >17t | vkm | 1,06 | Bilan Carbone v7 |
| Road - Articulated >3.5-33t | vkm | 1,20 | Bilan Carbone v7 |
| Road - Articulated >33t | vkm | 1,32 | Bilan Carbone v7 |
| Air - Domestic | tkm | 2,47 | Bilan Carbone v7 |
| Air - Short-haul international | tkm | 1,29 | Bilan Carbone v7 |
| Air - Long-haul international | tkm | 1,10 | Bilan Carbone v7 |
| Maritime - General cargo | tkm | 0,019 | Bilan Carbone v7 |
| Maritime - Container | tkm | 0,020 | Bilan Carbone v7 |
| Rail - Average freight - thermic | tkm | 0,028 | Bilan Carbone v7 |
| Rail - Average freight - electric - United Kingdom | tkm | 0,002 | Bilan Carbone v7 |
| People's transportation | | | |
| Diesel oil | liter | 3,17 | Bilan Carbone v7 |
| Bus | vkm | 0,18 | Bilan Carbone v7 |
| Car | vkm | 0,25 | Bilan Carbone v7 |
| Train | pkm | 0,01 | Bilan Carbone v7 |
| Air passenger - Domestic | pkm | 0,25 | Bilan Carbone v7 |
| Air passenger - Short-haul international | pkm | 0,13 | Bilan Carbone v7 |
| Air passenger - Long-haul international | pkm | 0,11 | Bilan Carbone v7 |
| Assets | | | |
| Machines | t | 3 667 | Bilan Carbone v7 |

10.4 UK specific emission factors database

| Emission factor name | unit | Emission factor used (kgCO ₂ /unit) | Emission factor database used |
|------------------------------|------|--|-------------------------------|
| Materials | | | |
| Acrylic acid | t | 2 261 | EcoInvent v2.2 |
| Aggregate | t | 5 | ICE V2 |
| Bentonite | t | 496 | EcoInvent v2.2 |
| Calcium chloride | t | 855 | EcoInvent v2.2 |
| CEM I | t | 950 | ICE V2 |
| GGbs | t | 83 | ICE V2 |
| Fly Ash | t | 8 | ICE V2 |
| Limestone | t | 90 | ICE V2 |
| minor additional constituent | t | 32 | sustainableconcrete |
| Chemicals inorganic | t | 1 860 | EcoInvent v2.2 |
| PVC pipes | t | 3 230 | ICE V2 |
| Sand | t | 5 | ICE V2 |
| Sodium carbonate | t | 942 | EcoInvent v2.2 |
| Steel sheets | t | 1 938 | ICE V2 |

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| | | | |
|--|-------|-------|------------------|
| Steel rebars | t | 1 857 | ICE V2 |
| Steel tubes | t | 2 870 | ICE V2 |
| Steel wires | t | 3 020 | ICE V2 |
| Water | t | 0,30 | Defra 2012 |
| Steel sheets - recycled | t | 705 | ICE V2 |
| Steel rebars - recycled | t | 624 | ICE V2 |
| Steel tubes - recycled | t | 440 | ICE V2 |
| Steel wires - recycled | t | 440 | ICE V2 |
| Energy | | | |
| Diesel | liter | 4 | Defra 2012 |
| Heavy fuel oil | liter | 4 | Defra 2012 |
| Electricity | | | |
| Freight | | | |
| Diesel (100% mineral diesel) | liter | 3,24 | Defra 2012 |
| Road - Rigid >3.5-7.5t | vkm | 0,72 | Defra 2012 |
| Road - Rigid >7.5-17t | vkm | 0,88 | Defra 2012 |
| Road - Rigid >17t | vkm | 1,18 | Defra 2012 |
| Road - Articulated >3.5-33t | vkm | 1,08 | Defra 2012 |
| Road - Articulated >33t | vkm | 1,21 | Defra 2012 |
| Air - Domestic | tkm | 2,71 | Defra 2012 |
| Air - Short-haul international | tkm | 1,63 | Defra 2012 |
| Air - Long-haul international | tkm | 0,84 | Defra 2012 |
| Maritime - General cargo | tkm | 0,016 | Defra 2012 |
| Maritime - Container | tkm | 0,019 | Defra 2012 |
| Rail - Average freight - thermic | tkm | 0,029 | EcoTransit |
| Rail - Average freight - electric - United Kingdom | tkm | 0,014 | EcoTransit |
| People's transportation | | | |
| Diesel oil | liter | 3,17 | Defra 2012 |
| Bus | vkm | 0,15 | Defra 2012 |
| Car | vkm | 0,23 | Defra 2012 |
| Train | pkm | 0,07 | Defra 2012 |
| Air passenger - Domestic | pkm | 0,22 | Defra 2012 |
| Air passenger - Short-haul international | pkm | 0,13 | Defra 2012 |
| Air passenger - Long-haul international | pkm | 0,14 | Defra 2012 |
| Assets | | | |
| Machines | t | 3 667 | Bilan Carbone v7 |

10.5 Database Comparison

| | EFFC-DFI recommended database | US database | French database | UK database |
|-----------------------|---|---|---|---|
| Materials | <ul style="list-style-type: none"> • Ecoinvent • Bilan Carbone V7 • Sustainableconcrete • ICE v2 • DEFRA | <ul style="list-style-type: none"> • Ecoinvent • Bilan Carbone V7 • Sustainableconcrete • ICE v2 • DEFRA | <ul style="list-style-type: none"> • Ecoinvent • Bilan Carbone V7 • Sustainableconcrete • ICE v2 • DEFRA | <ul style="list-style-type: none"> • Ecoinvent • Sustainableconcrete • ICE v2 • DEFRA |
| Energy | <ul style="list-style-type: none"> • DEFRA 2012 • IEA 2012 | <ul style="list-style-type: none"> • EPA | <ul style="list-style-type: none"> • Bilan Carbone V7 • IEA 2012 | <ul style="list-style-type: none"> • DEFRA 2012 • IEA 2012 |
| Transportation | <ul style="list-style-type: none"> • DEFRA 2012 • EcoTransit | <ul style="list-style-type: none"> • EPA | <ul style="list-style-type: none"> • Bilan Carbone V7 | <ul style="list-style-type: none"> • DEFRA 2012 • EcoTransit |
| Assets | <ul style="list-style-type: none"> • Bilan Carbone V7 | <ul style="list-style-type: none"> • Bilan Carbone V7 | <ul style="list-style-type: none"> • Bilan Carbone V7 | <ul style="list-style-type: none"> • Bilan Carbone V7 |

11 References

11.1 Standards

- **Corporate standards**

GHG Protocol Corporate standard

<http://www.ghgprotocol.org/standards/corporate-standard>

ISO 14064

http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=38381

ADEME Bilan Carbone

<http://www.associationbilancarbhone.fr/>

ENCORD

http://www.encord.org/?page_id=260

European Organisation Environmental Footprint

http://ec.europa.eu/environment/eussd/corporate_footprint.htm

- **Product standards**

PAS 2050

<http://www.bsigroup.com/en/Standards-and-Publications/How-we-can-help-you/Professional-Standards-Service/PAS-2050/PAS-2050/>

BP-X-30-323

<http://www.boutique.afnor.org/norme/bp-x30-323-0/principes-generaux-pour-l-affichage-environnemental-des-produits-de-grande-consommation-partie-0-principes-generaux-et-cadre/article/740401/fa170405>

GHG Protocol Product Life Cycle Accounting and Reporting Standard

<http://www.ghgprotocol.org/standards/product-standard>

European Product Environmental Footprint

http://ec.europa.eu/environment/eussd/product_footprint.htm

ISO 14067

http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=59521

11.2 Emission factor databases

Bilan Carbone v7

<http://www.associationbilancarbonate.fr/>

<http://www.basecarbone.fr/>

DEFRA 2012

<http://www.defra.gov.uk/publications/2012/05/30/pb13773-2012-ghg-conversion/>

EcoInvent v2.2

<http://www.ecoinvent.org/>

EcoTransit

http://www.ecotransit.org/download/ecotransit_background_report.pdf

EPA

<http://www.epa.gov/climateleadership/guidance/ghg-emissions.html>

ICE V2

<http://www.bath.ac.uk/mech-eng/research/sert/>

IEA 2012

<http://www.iea.org/publications/freepublications/publication/name.32870.en.html>

Sustainable concrete

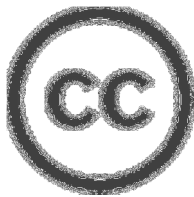
http://www.concretecentre.com/sustainability/energy_efficiency/embodied_c02.aspx

12 Acknowledgements and copyrights

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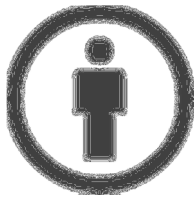


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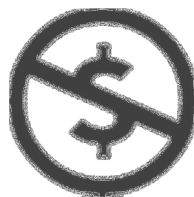
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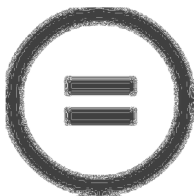
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12.2 Acknowledgements

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