Emission database for building products, services, and systems

Open LCA database for building construction

Description of the content of the database and working methods

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Contents

1 Purpose of the database

The emission database for building products and services – CO2DATA - was developed at the Finnish Environmental Institute (SYKE) by the request of the Ministry of the Environment and in collaboration with specialists of life cycle assessment (LCA) for building products and buildings.

The work was also supported by close co-operation and exchange of information with Sweden and other Nordic countries. Concurrent development of similar type of databases in Sweden by Boverket[1] and IVL[2] and in Finland helped both countries in solving problems and finding solutions.

The Finnish project is related to the three-stage roadmap for low-carbon building published by the Ministry of the Environment. The purpose of the database is to support design for low carbon and resource-efficient building and enable the consideration of the global warming potential (GWP) of buildings in the building permission process.

The main idea of the database is

- to provide typical GWP values for building products, services, and building services systems
- to enable the consideration of the entire life cycle of buildings
- to cover a major share of different kinds of building products and different energy, transportation, and other services needed during construction, use, and demolition of buildings
- to provide product information for resource-efficient construction.

The idea of the typical GWP value for different building products is to represent average values for different product types when considering the most significant manufactures from the viewpoint of the Finnish construction market. Because of lack of comprehensive information, the typical data values are not mean values calculated on the basis of market shares.

CO2DATA defines two kinds of GWP values for building products. In addition to the typical values, conservative values are provided. Conservative values are calculated by multiplying the typical GWP value by a chosen factor. By searching information about the range of GWP values of similar product types with the help of environmental product declarations (EPDs), a factor of 1.2 was chosen though the range varies much and the differences may be significantly bigger for some products.

[1] The Swedish National Board of Housing, Building and planning
[2] Swedish Environmental Research Institute

2 Contents of CO2DATA

The database includes roughly 250 products and services outlined as follows (Table 1).

Table 1 Description of the contents of the database
The list of included products is indicative as the database is updated when necessary.

PRODUCTS	**Insulation and water proofing**
	Mineral, plastic, and cellulose based insulations, water vapour barriers, and bitumen roofings
	Building boards
	Particle boards, fibre boards, plywood, OSB, gypsum boards, and fibre cement board
	Concrete
	Ready mixed concrete products, precast concrete products, and other products such as blocks and roofing tiles
	Steel and metals
	Load bearing structures, lightweight profiles, sheets, pipes, rebars, and wires
	Solid wood
	Sawn and planed timber, LVL, GLT, CLT, heat treated, and impregnated timber
	Mineral materials and glass
	Bricks, calcium silicate bricks and blocks, masonry mortars, autoclaved aerated concrete products, float glass and other glass types, natural stone products, aggregates
	Floorings and surface materials
	Ceramic tiles, wood and polymer-based floorings, plastering mortar and screed, and paints
	HVAC products and electrical installations
	Pipes, ducts, tubes, cables, wires, pumps, heat exchanger, radiator, exhaust ventilation system, elevator, solar panel and collector, electrical group center, faucets and other items and devices
	Supplementary products
	Doors, windows, partition walls, cabinets, chimneys, and staircases
	Infra, yard and foundations products
	Natural stone products, aggregates, concrete, piles, pipes, well elements, asphalt concrete, geotextile, stabilizers, insulations, impregnated timber, and other timber products

SERVICES	**Energy services**
	Electricity, district heat, district cooling, fossil fuels
	Transportation services
	Semi-trailers, heavy delivery lorries and earth movers Container train Container ship, Bulk carrier
	Construction service
	Construction, earthwork, and stabilization
	Demolition
	Deconstruction, waste processing, disposal
SYSTEMS	**Building services (preliminary outline)**
	Heating, cooling, ventilation, water and sewerage system, electricity, and sprinkler

3 Indicators

The selection of indicators, the outline of the stages of building's life cycle and the required methods for assessing the global warming potential (GWP) in different stages follows the basic principles stated in EN 15804 (2019)[3]. However, the scope of the indicators is more limited.

The main indicator of the database is global warming potential. The database defines GWP values for products, services, and systems.

The GWP of products is always expressed in terms of kg CO_2e per kg of product. Additional information – such as weight per m, m^2 or m^3 - is typically also given to help the conversion of the mass-based value. The specific GWP values of energy services are given in kg CO_2e in relation to the energy unit of the service (kWh or MJ), and those of transportation services are defined in kg CO_2e per load unit (ton) and the unit of transportation distant (km). The GWP values for construction and demolition services are mostly given in terms of kg CO_2e per net building area unit (m^2).

Products are also characterised with the help of other indicators; the aim is to provide information that supports resource-efficient and circular building. The indicators and applied units are presented in the following tables.

Table 2 Carbon footprint indicators

Stage	Unit	Conversation
Product stage (A1-A3)	kg CO2e/kg	with the help of weight per m, m2, m3, or unit
Transportation (A4)	kg CO2e/ton km	
Construction (A5)	kg CO2e/m2	
Energy (B6)	kg CO2e/kWh	
Deconstruction (C1)	kg CO2e/m2	
Transportation (C2)	kg CO2e/ton km	
Waste processing (C3)	kg CO2e/kg	
Waste disposal (C4)	kg CO2e/kg mixed waste	

Table 3 Carbon handprint indicators

Phase	Unit	Comment
Carbon handprint, benefit because of reuse and recycling (D1)	kg CO2e/kg	Currently only for metals
Carbon handprint, benefit because of energy recovery (D2)	kg CO2e/kg	Currently not included Forthcoming in future update
Carbon handprint, benefit because of carbon storage (D4)	kg CO2e/kg	Only for wood products with long service life

[3] Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products

Carbon handprint, benefit because of carbonation (D5)	kg CO2e/kg	Currently not included

Table 4 Other indicators for products

Indicator	Unit
Share of renewable materials	%
Share of secondary materials	%
Share of substance of very high concern (SVHC)	%
End-of-life scenario divided to - reuse, - recycling as secondary raw material, - energy recovery, - final disposal (utilization in earth construction) - hazardous waste to be removed from use	%
Service life (if ≤ 50 years)	years
Waste factor	-

The waste factor is an assessed value for typical amount of waste on building site. The factor is given as value that covers the whole need of the product considering the weight of the product and the waste. However, regarding sawn and planed timber, the factor also covers waste at prefabrication site. This is because there are no separate GWP value for example for pre-cut timber products. The waste factors are rough estimates and vary between 1,01 and 1,10. The value 1,01 is used for many supplementary and HVAC units. The value 1,03 is used for most of the metal products, GLT, vertical CLT, glass, most of the insulation products, precast concrete, some supplementary products, plumbing products, ducts, and pipes. Factor 1,05 is used for most of the mineral based products, building boards and floorings. Factor 1,1 is for water proofing, bitumen roofing, paints, plasters, geotextiles, ceramic tiles, and sawn timber.

Service life values consider the general service life information given in environmental declarations. The values do not take into account different environmental or use conditions but refer to technical service life in normal or easy conditions. CO2DATA also provides a separate table for building-part specific service life values defined on conservative basis.

4 Typical data for building products

4.1 Introduction

The types of different building products included in the CO2DATA were selected and defined to cover a major share of all materials and products used in different building parts and important for carbon footprint calculations.

The naming of the selected products was made utilising the terms used in harmonised standards[4] and TALO 2000 classification system[5].

The selected terms and outlines were discussed together with representatives of building industry.

The global warming values and the values of other indicators are based on publicly available information, in practice mostly on relevant environmental product declarations. When assessing the relevance of information, the following was taken into account:

- domestic results – as the domesticity rate of building is high
- Nordic results – as manufacturing processes, methods and markets are often similar although the energy sources for electricity differ
- results from countries that export building products to Finland as some products - like for instance - MDF and OSB boards - are not manufactured in Finland
- generic results in foreign databases – as those represent average values.

The results were searched especially from databases such as

- RTS EPD [6]
- EPD Norge [7]
- Environdec [8]
- ÖkobauDat [9]
- IBU [10]
- ICE [11].

The main sources of information were environmental product declarations (EPDs) based on the European standard EN 15804 *Sustainability of construction works. Environmental product declarations. Core rules for the product category of construction*. At present the EPDs published in different databases can be based on either of the two versions of the standard. EN 15804:2012+A1:2013 says that that the global warming potential (GWP) shall be calculated based on[12] "Global Warming Potential for a 100-year time horizon as in IPCC: Climate Change 2007"[13] (AR4). However, the current version of EN 15804 + A2 2019 refers to the IPCC

[4] https://ec.europa.eu/growth/single-market/european-standards/harmonised-standards/construction-products_en

[5] Talo 2000 Rakennustuotenimikkeistö. https://www.rakennustieto.fi/material/attachments/5k2Ih5ORz/U93r9aP09/Talo2000_nimikkeisto_yleisseloste_Rakennustuotenimikkeisto.pdf

[6] https://www.rakennustieto.fi/index/tuotteet/EPD_ymparistoselosteet.html

[7] https://www.epd-norge.no/?lang=en_GB

[8] https://www.environdec.com/home

[9] https://www.oekobaudat.de/en.html

[10] https://ibu-epd.com/en/published-epds/

[11] https://circularecology.com/embodied-carbon-footprint-database.html

[12] Annex C Normative. Table C.8 Sources for life-cycle impact assessment (LCIA) models

[13] The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment

2013 (AR5)[14]. The GWP values for 100-year time horizon for greenhouse gases are somewhat different in accordance with AR4 and AR5 as presented in the following table for carbon dioxide, methane, and nitrogen oxide. At this stage there are only very few EPDs available that follow the new version. The difference in the calculation of the GWP values was ignored. However, more attention should be paid to this issue, when the CO2DATA is updated.

Table 5 Example of difference in the calculation of GWP values based on AR4 and AR5.

Chemical formula	GWP values for 100-year time horizon	
	AR4	AR5
CO_2	1	1
CH_4	25	28
N_2O	298	265

In addition to environmental product declarations, the generic environmental reports published by associations representing different industries on European or international level were used as sources of information. Thus, for example the data and reports by the following organisations were made use of:

- PlasticsEurope [15]
- European Aluminium [16]
- European Copper Institute, Copper Alliance [17]
- Manufacturers of LVL [18].

The results were also compared to the former databases collected by VTT (published in the connection of different research reports and by Green Building Council) and the database collected by IVL (not publicly available data).

[14] Annex C. Normative. Table C1

[15] https://www.plasticseurope.org/en/resources/eco-profiles

[16] https://www.european-aluminium.eu/data/environmental-data/

[17] http://copperalliance.fi/uploads/2018/04/fi_life_cycle_brochure-pdf.pdf

[18] https://www.metsawood.com/global/Tools/European-LVL-Handbook/Pages/European-LVL-Handbook.aspx

4.2 Mineral, wooden, metal and polymer-based building products

The following working process was carried out for most of the building products:

Table 6 Working process in the formulation of data for building products

	STEPS OF THE WORKING PROCESS
A	Search for data from different databases and other sources.
B	Comparison of data from different sources.
C	Assessing the relevance of data from different sources paying attention to the degree of domestic manufacturing and market shares.
D	Selection of data assessed as most relevant or calculation of average values based on different relevant sources.
E	In few cases, modification of values with the help of defined assumptions to improve the relevance of values (An example of the modification, is the application of Swedish data crushed aggregate and the modification of results based on different energy sources).
F	Definition of types of the product when relevant from the viewpoint environmental impacts (an example is the division of plywood into product the following types: uncoated birch plywood, coated birch plywood, uncoated spruce plywood, and coated spruce plywood).
G	Defining all indicator values based on searched information for the product types.
H	Writing a background report that lists the standard(s) and classification, shortly describes the product and current market, presents the collected information, and explains the selections made.
I	Contacting representatives of manufacturers to hear their comments.
J	Formulating the final version of the background report and providing the data for the database.

The work focused on defining as reliable values for GWP(A1-A3) fossil as possible. In most cases, the availability of applicable data was rather good. The biggest difficulties were related to the defining of GWP(A1-A3) (fossil) values for wooden products when the available EPDs were written without making a difference between fossil and biogenic GWP. In few cases the comparison of GWP values between similar types of products raised doubts about the correctness of results and led to the exclusion of some results otherwise seen relevant.

The above described method was applied for most of the building products: mineral building products (except concrete), glass products, building boards, insulation and water proofing products, solid timber products, steel and other metal products, most surface/coating materials, and part of the infra and yard products. However, different approach was used for supplementary products such as windows and doors, HVAC products and electrical installations, and for concrete products.

4.3 Concrete products

Concrete is the most used building material in construction. Thus, the availability of good quality GWP data for different kinds of concrete products is extremely important for the success of environmental assessments of buildings. Defining good average data is, however, challenging. One difficulty in choosing representative data for concrete products is because concrete products are characterised by performance (such as strength) and because similar performance can be achieved with the help of different proportions where – on the other hand - especially the type of cementitious materials significantly affects the global warming potential.

Another issue that needed to be considered in the selection of the working process for concrete product data for CO2DATA was the limited availability of EPDs for concrete manufactured in Finland and the high degree of domestic manufacturing of concrete products for the Finnish construction. The applicability of generic and specific EPDs worked out in other countries is not good, because the performance requirements, typical ways of proportioning concrete, and the GWP of local Portland cements – the most used cementitious material in concrete – vary.

The formulation of data for concrete products based on two different approaches.

Table 7 Approaches in formulating environmental data for concrete products for the CO2DATA database

I	CALCULATION BASED ON MODEL RECIPES • Selection and definition of types on concretes to be studied. • Determination of model recipes for these different kinds of concrete products based on research data. Considering also reinforcement when relevant. • Defining typical values for energy consumption in manufacturing and average distances of transportation based on research data. • Calculation of GWP values and other indicators based on the above definitions and with the help of publicly available and relevant GWP data for cements, aggregates, energy, and transportation.
II	FORMULATION OF GENERIC EPDS FOR CONCRETE PRODUCTS • Selection of the most important concrete types to be studied. • Collecting information about the use of different components in the manufacturing of different kinds of concrete products from the biggest manufacturers in Finland. • Collecting information about transportation distances and modes and information about energy use and energy sources. • Calculation of weighted average (based on manufacturing volumes) GWP values and other indicators for the selected products based on the collected data and with the help of relevant GWP data for cements, aggregates, energy, and transportation.

Concrete products were divided into three main groups: ready-mix concrete, precast concrete elements, and other products such as blocks and concrete roofing tiles. The current database values are mainly based on the second approach. The results based on the first approach were used to supplement the results with the types that were not included in the list of selected products by manufacturers.

The role of information collected from EPD databases and other data sources was much smaller compared to the working process used for other building products.

The ready-mix concrete products are named on the basis of the compression strength classes (such as C25/30 where the first number refers to cylinder strength and the last number to cubic strength in MPa). The precast concrete products and other concrete products are named in accordance with the use purpose such as beam, column, solid slab, hollow core slab, and pile, and concrete block, cavity block, paving block, and roofing tile.

4.4 HVAC products, electrical installations, and supplementary products

The formulation of environmental data for products related to heating, ventilation, and air conditioning (HVAC), for electrical installation and for supplementary product was solely based on modelling. The main steps of the process are presented in the following table. The GWP data is typically given in terms of kg CO_2e per unit.

Formulation of typical data for all products of this group is difficult. The main reasons for the difficulty are 1) the lack of environmental product declarations, 2) the lack of such grouping and naming system that supports reasonable approach in the consideration and assessment of GWP of HVAC and electrical products. The number of items in classification systems (such as LVI2010 and S2010) is very high but many of the products are insignificant from the viewpoint of weight and GWP impact on building level.

Table 8 Modelling process for the establishment of typical GWP values for HVAC products, electrical installations, and supplementary products

	PROCESS STEPS
A	Selection of the product types to be modelled based on their assessed significance from the viewpoint of weight and volume of use in buildings.
B	Identifying the typical composition and typically used materials of the selected product types. Modelling the product "recipe".
C	Roughly assessing the use of energy in manufacturing process and other issues that might significantly affect the GWP of the product under scrutiny.
D	Calculating the GWP of the modelled products based on the GWP values of steel, other metals, plastics, glass etc. collected in the context of defining GWPs for other building products of CO2DATA database and based on other relevant data when needed.
E	Writing background reports for all product types. The report shortly describes the modelled product, market in the Finnish construction (when information was available), presents one or few examples of GWP and other environmental values for similar type of products based on EPDs (if available), and defines the proposed values for the CO2DATA indicators.

5 Typical data for building services systems

The database will include information for selected building services systems.

The main steps of the working process are as follows:

- collection of information of bill of quantities with the help of reference projects,
- selection and defining the building services systems to be taken into account,
- investigation to define typical quantities and product types in different systems possibly separately for different kinds of buildings, and
- use of product level data to define GWP values for systems.

GWP data will be given in terms of kg CO_2e/m^2.

6 Typical data for construction and demolition services

6.1 Construction module

The typical GWP data was formulated for construction services of different kinds of buildings. However, because of lack of publicly available data, the quality of data is assessed to be weaker than the quality of the main part of the product related information.

The main source of information was different research studies based on real construction cases. According to the results, heating is one of the main issues that have an important effect on the GWP of construction processes. Thus, climate and temperature zones among other things may have a significant influence. Correspondingly, the applicability of research results from different zones may be poor. For this reason, Finnish case studies were used as main sources of information.

Another problem related to the availability of data is that the case studies typically focus on building construction, while the earthwork is out of the scope in some of the relevant studies.

The main steps of working were as follows.

Table 9 Main process steps in defining typical values for construction services

	PROCESS STEPS
A	Searching research reports and other sources that report information about the use of energy in different phases of construction process regarding different types of buildings.
B	Collecting, calculating, and comparing data.
C	Selecting the values interpreted most relevant representing typical values.
D	Writing a background report that explains the data sources, calculations and presents the proposed values in terms of kg CO_2e/m^2 for different building types.

The database presents separate results for the following construction services (module A5 in accordance with EN 15804).

Table 10 The outline of construction services in the CO2DATA database

SCOPE	UNIT	REMARK
A 5 Residential building	kg CO_2e/m^2 (net)	excluding earth work
A 5 Daycare centres and schools	kg CO_2e/m^2 (net)	excluding earth work
A5 Office building	kg CO_2e/m^2 (net)	excluding earth work
A 5 Earth work	kg CO_2e/m^2 (net)	base case
A 5 Stabilization	kg CO_2e/kg of stabilizer	when relevant Note, the value is given per the amount of stabilizer
A 5 Earth work / working machine related service	kg CO_2e/l	when the estimate can be based on monitored consumption based on earlier similar cases

		Note, the value is given per estimated amount of fuel.

The GWP result for stabilization is based on information received from industry.

The GWP result for earthwork is based on LIPASTO database[19] by VTT. The effect of the procurement of fuels was added by applying the results presented by JRC[20]:

6.2 End-of waste module

The typical GWP data was formulated for different phases of demolition services and for different kinds of buildings. However, because of lack of publicly available data, the quality of data is assessed to be weaker than the quality of the main part of the product related information.

The main sources of information were different research studies based on real construction cases, environmental product declarations that provide assessed waste processing data for different kinds of building products, information collected by Delete Demolition Services, and statistics.

The main steps of working were as follows.

Table 11 Main process steps in defining typical values for end-of-life services

	PROCESS STEPS
A	Searching research reports and other sources that report information about the use of energy in different phases of demolition (module C in accordance with EN 15804) regarding different types of buildings.
B	Collecting, calculating, and comparing data.
C	Defining the structure for the data and selecting the most relevant results representing typical values.
D	Writing a background report that explains the data sources, calculations and presents the proposed values for different building types, deconstruction wastes, and for final waste disposal.

The database presents separate results for the following demolition services (modules C1 – C4 in accordance with EN 15804).

Table 12 The outline of end-of-life services in the CO2DATA database

SCOPE	UNIT	REMARK

[19] LIPASTO database is available through the following link
http://lipasto.vtt.fi/yksikkopaastot/muut/tyokoneet/tyokoneet.htm

[20] JRC Technical reports.) WELL-TO-TANK. Report Version 4.a JEC WELL-TO-WHEELS ANALYSIS. Authors: Robert EDWARDS (JRC), Jean-François LARIVÉ (CONCAWE), David RICKEARD (CONCAWE), Werner WEINDORF (LBST). WTT Appendix 4 (Version 4.a) – Description, results and input data per pathway.
Available: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/well-tank-report-version-4a-jec-well-wheels-analysis

C 1 Deconstruction, residential building	kg CO_2e/m^2	
C1 Deconstruction, daycare centres and schools	kg CO_2e/m^2	
C 1 Deconstruction, office building	kg CO_2e/m^2	
C 2 Transportation	kg CO_2e/ton km	The final result is calculated in terms of kg CO_2e/m^2 based on the case specific volumes of demolition waste and with the help of CO2DATA for transportation
C 3 Waste processing, mineral materials	kg CO_2e/kg of waste	
C 3 Waste processing, wood materials	kg CO_2e/kg of waste	
C 3 Waste processing, metal materials	kg CO_2e/kg of waste	
C 4 Final waste disposal	kg CO_2e/kg	Based on the assumed share of combustible waste in mixed waste and the value for recovered fuels according to the Statistics Finland[21].

[21] https://www.stat.fi/static/media/uploads/khkaasut_polttoaineluokitus_2020_v3.xlsx

7 Typical emission data for transportation services

Emission data for transportation services are mainly based on LIPASTO database. VTT LIPASTO[22] is an open license traffic unit emission database for Finland. The unit emission database includes emission factors for road, rail, and waterborne as well as working machines. Unit emissions mean the amount of emissions emitted during operation of vehicles, measured in mass units and allocated to tonne of freight transported over one kilometre (g/tonne kilometre).

The results for road transportation service (for modules A4 and C2 in accordance with EN 15804) are based on the LIPASTO database published and maintained by VTT and the database for transport by Finnish Transport Infrastructure Agency. LIPASTO values include the common fuel types and are in accordance with EEA Guidebook 2019. LIPASTO can be used to calculate the emissions for different loads and for different capacity trucks with the help of given instructions[23]. The emission database by Finnish Transport Infrastructure Agency uses LIPASTO for earth moving truck emission factor as well as their own default speed for the trucks in highway and urban driving[24].

LIPASTO emission factors for shipping are based on MEERI-calculation system for shipping for the year 2016. CO2DATA uses average emissions and energy use of maritime freight transport. Port emissions are included in the emission factors. LIPASTO values include the common fuel types and are in accordance with EEA Guidebook 2019. The selected ship types are the types that were considered relevant for calculating the emissions of waterborne freight transport used in construction process. Return trip does not need to be calculated separately as it is included in the emission factors in LIPASTO.

Emission values for rail transport are based on RAILI calculation model of LIPASTO Unit Emissions database. VTT LIPASTO provides average rail transport emission values for the year 2016. LIPASTO unit emission factors for diesel trains are based on measurements by VR Group, measurements commissioned by VR and information from producers of locomotives. LIPASTO values are in accordance with EEA Guidebook 2019. The selected train type was the one considered relevant for calculating the emissions of rail freight transport used in construction process. Backhaul does not need to be considered separately.

The working steps were as follows:

Table 13 Main process steps in defining typical values for transportation services

	PROCESS STEPS
A	Studying the available and relevant databases for transportation.
B	Selecting transportation parameters applicable for use for modules A4 and C2 (according to EN 15804) in CO2DATA
C	Adding the impact of procurement on GWP values.

[22] LIPASTO unit emissions database. http://lipasto.vtt.fi/yksikkopaastot/indexe.htm

[23] http://lipasto.vtt.fi/yksikkopaastot/guidee.htm

[24] Aulakoski, A., Montin, P., Lydman, P. & Häyrinen K. 2014. Panospohjaisen CO2- laskennan pilotointi väylähankkeessa - Kehä I liittymän parantaminen Kivikontien eritasoliittymän kohdalla. Liikennevirasto, infra- ja ympäristöosasto. Helsinki 2014. Liikenneviraston tutkimuksia ja selvityksiä 18/2014. 38 s; 2 liitettä. ISSN-L 1798-6656, ISSN 1798-6664, ISBN 978-952-255-443-7

JRC Well-to-tank JEC v4.a report[25] describes processes of producing, transporting, manufacturing, and distributing fuels and gives emission factors for different types of fuels, production routes and transport methods. JEC well-to-tank values were added to LIPASTO emission values to represent the actual values of the whole transportation process. JEC-values were added to emission factor by multiplying the share of well-to-tank process of diesel to the whole emission factor including combustion.

Recently a new version[26] have been published by JRC for the inclusion of procurement related emissions of fuels. This new version was not considered. However, the recommendation is to recalculate values based on the newer version in the next update of the database.

More detailed information about the calculations is given in the background reports written by Ismo Hämäläinen (SYKE).

The database provides GWP values for the following transportation alternatives:

Table 14 The list of transportation services included in the database
The unit for the emissions is kg CO_2e/ton km

TRANSPORTATION SERVICES FOR FREIGHT TRANSPORT	
ROAD	Earth moving trucks 32t (50% load) highway driving
	Earth moving trucks 32t (50% load) urban driving
	Heavy delivery lorry (50 % load) highway driving
	Heavy delivery lorry (50 % load) urban driving
	Semi trailer light (50 % load) highway driving
	Semi trailer light (50 % load) urban driving
WATERBORNE	Container ship, 1 000 TEU
	Bulk carrier, medium
RAIL	Container train, diesel (Net Load 686t):

[25] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/well-tank-report-version-4a-jec-well-wheels-analysis
[26] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/jec-well-tank-report-v5

8 Typical emission data for energy services

The CO2DATA database provides emission factors for fuels, renewable energy technologies, and for electricity, district heat, and district cooling. The results are based on extensive statistical data and research results. The details are explained in the background report for energy services written by Sampo Soimakallio (SYKE). The following text summarises the main principles and information sources on the bases of the background report.

The emission factors were defined for the following fuels and renewable energy technologies to calculate the GWP of electricity, district heat and cooling:

- heavy fuel oil
- coal
- natural gas
- peat
- wood chips
- waste
- nuclear power
- wind power
- solar power and
- hyrdo power.

The specific emissions from the use of electricity, district heat, and district cooling by buildings were calculated for years 2020 – 2120. The results are given for each decade. The specific emissions were defined on the basis of GHGs from yearly domestic production and considering the net import of electricity.

The specific GHG emissions from electricity and district heat production were estimated considering CO_2, CH_4, and N_2O emissions from the combustion and procurement of fuels (except CO_2 from combustion of biomass-based fuels), and the construction of the capacity infrastructure for fuel supply and heat and power generation.

Specific emissions were calculated per energy content of the fuel with regard to the production based on fuel combustion, while regarding nuclear, water, wind and solar power, the emissions were calculated in relation to the produced electricity.

The CO_2 emissions from the combustion of fuels are based on the Finnish Statistics[27].

The specific CH_4 and N_2O emissions from the combustion of fuels were assessed on the basis of total CH_4 and N_2O emissions from public sector heat and power generation in 2018 and on the basis of the energy content of fuels used for the generation of heat and power[28].

The CO_2 emissions from the combustion of biomass were calculated as zero emissions. The influence of harvesting of biomass on carbon sinks of forests or soil was not considered. The method follows the

[27] Tilastokeskus 2018. Polttoaineluokitus 2018. https://www.tilastokeskus.fi/fi/luokitukset/polttoaineet/

[28] Suomen virallinen tilasto (SVT): Energian hankinta ja kulutus [verkkojulkaisu]. ISSN=1799-795X. Helsinki: Tilastokeskus. http://www.stat.fi/til/ehk/index.html

calculation principles based sustainability criteria of the EU directive on the promotion of renewable energy sources [29], [30].

The emissions because of procurement of fuels are based on the 4th version of "Well to tank" report by JRC[31]. As the 5th version has already been published, the recommendation is to recalculate precombustion values in the next update of the CO2DATA-base.

The benefit allocation method was applied to allocate the consumption of fuels for power and heat in combined heat and power (CHP) generation. In this method the consumption of fuels is allocated for heat and power based on the same assumed efficiencies as in separate production. The efficiency of 39% was used for electricity and 90% for heat.

The CO2DATA-base provides emission values for energy services also for coming decades considering the targeted decarbonization of energy services. The applied assumptions are based on the basic scenario (the so-called WEM scenario) for 2020 – 2050 presented by VTT and SYKE in PITKO project (Long-term emission trends) documentation[32].

The WEM scenario does not specify district cooling. The specific emissions from district cooling have been defined by assessing the required electricity and district heat for production and delivery of district cooling and by applying for these the specific emissions of heat.

The GHG emissions of fossil fuels for building heating in decentralized systems were assessed for light heating oil considering the emissions caused by procurement and construction of infra in addition to combustion. The precombustion emissions and the CH_4 and N_2O emissions of combustion were assumed to be the same as those assumed for heavy fuel oil in the connection of emission-assessment of electricity and district heat. The specific emissions for biofuels (wood briquettes, pellets, and bio-oils) were formulated by using the same factors as was used for chips for in the connection of emission-assessment of electricity and district heat. The assessed emissions because of transportation and manufacturing were added following the principles of EU REDII Directive (EU 2018). The specific emission factors for fossil fuels and biofuels for decentralized heating of buildings were assumed to remain unchanged throughout the period considered.

[29] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. Official Journal of the European Union 5.6. 2009

[30] Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources - Analysis of the final compromise text with a view to agreement. Interinstitutional File: 2016/0382 (COD), Council of the European Union , Brussels, 21 June 2018.

[31] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/well-tank-report-version-4a-jec-well-wheels-analysis

[32] Koljonen, T., Soimakallio, S., Asikainen, A., Lanki, T., Anttila, P., Hildén, M., Honkatukia, J., Karvosenoja, N., Lehtilä, A., Lehtonen, H., Lindroos, T.J., Regina, K., Salminen, O., Savolahti, M., Siljander, R., Tiittanen, P. Energia- ja ilmastostrategian vaikutusarviot: Yhteenvetoraportti. Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 21/2017.
Koljonen, T., Soimakallio, S., Ollikainen, M., Lanki, T., Asikainen, A., Ekholm, T., Hildén, M., Honkatukia, J., Lehtilä, A., Saarinen, M., Seppälä, J., Similä, L., Tiittanen, P. Keskipitkän aikavälin ilmastopolitiikan suunnitelman vaikutusarviot. Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 57/2017.
Koljonen, T., Soimakallio, S., Lehtilä, A., Similä, L., Honkatukia, J., Hildén, M., Rehunen, A., Saikku, L., Salo, M., Savolahti, M., Tuominen, P., Vainio, T. Pitkän aikavälin kokonaispäästökehitys. Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 24/2019.

8 GWP values of building products on building level assessment

The CO2DATA-base provides typical GWP values for building products and services.

For building products, conservative GWP values are given in addition to the typical values:

CONSERVATIVE GWP VALUE = 1.2 X TYPICAL GWP VALUE

The conservative factor was chosen with the help of information about the range of GWP values of similar product types. Information was searched for by comparing GWP results given in relevant environmental product declarations. The factor of 1.2 was chosen though the range varies significantly, and the difference may be much bigger for some products.

The typical values are provided for use in the development and comparison of alternative design solutions for low carbon building. When best solutions are searched for considering both product and energy alternatives as options for low carbon building, it is reasonable to apply typical values in the overall calculation.

In the near future, GWP calculation of the building will be required for building permission. In the building permission tasks, the conservative values for products must be used when the specific products are not known and when these products do not have an EPD.

Table 15 The use of typical and conservative values of CO2DATA for building products.

Use case	Selection of the correct value type
The designer studies the preliminary options for low-carbon building	Typical value
Building permission application No information about specific products	Conservative value
Building permission application The origin of products to be used in building is known	Product specific value (based on an EPD)
Building permission application The origin of products to be used in building is known but these do not have EPDs	Conservative value

9 The use of GWP values in life-cycle assessment of buildings

One of the main ideas of the CO2DATA is to provide GWP information that enables the consideration of the entire life cycle of buildings in design process. The following table summarises the availability of data in CO2DATA suitable for different life cycle modules in accordance with EN 15804 and other standards prepared by CEN TC 350 *Sustainability of construction works*.

Table 16 Building life cycle modules and corresponding GWP data in CO2DATA

LIFE CYCLE MODULE	GWP DATA OF CO2DATA
Product stage (A1-A3)	**GWP for building products**
Transport to the building site (A4)	**GWP for transportation services**
Construction / Installation into the building (A5)	**GWP for construction services**
Operational energy use (B6)	**GWP for energy services (considering decarbonization in coming decades)**
Replacement (B4)	**GWP for building products + service life values for products (when <50years)**
Deconstruction (C1)	**GWP for demolition services**
Transport (C2)	**GWP for transportation services**
Waste processing (C3)	**GWP for waste processing**
Waste disposal (C4)	**GWP for waste disposal**

10 Terms and definitions

The following table defines or explains the most essential terns used in this report.

Table 17 Definitions and explanations for essential terms used in the report.

TERM	DEFINITION / EXPLANATION
Carbon footprint	Global warming potential (GWP) in kg CO2e/kg The value is given for products considering the life cycle modules A1 – A3 (as defined in EN 15804). The other phases (modules) of life cycle are cocnsidered with the help of carbon footprint values defined for transportation, construction, energy, deconstruction, waste processing, and disposal services.
Typical value	GWP (A1-A3) value that represents an average value for a product type when the most significant manufactures from the viewpoint of the Finnish construction market are considered NOTE: The typical data value is not mean a value or weighted mean value calculated on the basis of market shares.
Conservative value	GWP (A1- A3) value calculated by multiplying the typical value by a factor of 1.2
Product specific value	GWP (A1-A3) value of a specific product presented in its EPD
Mean value / Weighted mean value	GWP value calculated as an arithmetic mean considering all manufactures of the product type in the market / value calculated as an arithmetic mean and weighted by market shares of all manufactures of the product type in the market
Service life	Period of time after installation during which a facility or its component parts meet or exceed the performance requirements(ISO 15686-1, 2011) Service life value based on the general service life information given in environmental declarations. Does not take into account different environmental or use conditions but refer to technical service life in normal or easy conditions. NOTE: The calculation method provides a more specific table for service life values to be used in the calculations to be required in building permission process. These values consider the purpose of use and divides the values into two categories (short/normal expectancy).
Waste factor	Estimated value for typical amount of waste at building site. The factor is given as the ratio of the weight of procured product at site per weight of product in building. Regarding sawn and planed timber, the factor also covers waste at prefabrication site.
Carbon handprint	Assessed potential GWP benefit beyond the system boundary because of recycling, energy recovery, carbon storage, or carbonation
End of life scenario	Assumed way of utilization or disposal of the product after deconstruction. The values are given in assumed percentages broken down to reuse, recycling, energy recovery, disposal in earth construction, and hazardous waste to be removed from use