

Background report – demolition processes

Update 16.10.2025 (R01.04): New emission factor was calculated for demolition of the building site (C1)
Update 19.12.2024 (R01.03): Accessibility update
Update 2.4.2024 (R01.02): Updated demolition (C1) emission factor for all buildings
Update 4.3.2022 (R01.01): Completed with additional information (C3 for bricks, gypsum, glass, and plastics added and new background data for timber added)
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1 Building lifecycle phase C

In accordance with EN 15804, the after-use phase is divided to the following four sub-phases:

- C1 Deconstruction demolition
- C2 Transport
- C3 Waste processing
- C4 Disposal

2 Amounts and types of demolition waste

In each demolition process, the volume and type of demolition waste naturally depends on the quality of the building in question. The main shares of waste come from those building parts – such as load bearing slabs, walls, columns, and beams - that also dominate in building process from the viewpoint of weight.

The service life of a building is normally several decades, and the quantities and types of waste fractions base on the types of building materials and ways of building applied in the period on construction.

Typically, the share of different fractions in new-building, renovation and demolition are as follows (%) according to Perälä and Nippala (1998)¹:

process	mineral materials	wood	cardboard	metal	other
new building	44	25	2	4	25
renovation	40	26	1	12	22
demolition	70	23	0	2	4

Perälä and Nippala also assess that the quantities of wastes are as follows:

- repair 0,5–2 kg/rm³
- medium renovation 2 – 15 kg/rm³
- heavy renovation 15 – 100 kg/rm³
- demolition 200 – 500 kg/rm³ (600 – 1500 kg/m² for a residential building when using the value 3 as the ratio between gross area and volume).

The following conversion values for gross volume and building area can be used for different types of buildings ²:

- detached, attached, and terraced buildings 3,5
- blocks of flats 3
- office buildings 7

¹ (<https://www.vttresearch.com/sites/default/files/pdf/tiedotteet/1998/T1936.pdf>)

² https://www.theseus.fi/bitstream/handle/10024/42428/1/Korteoja_Otto.pdf mukaan suhde rm³/brm²

- school buildings 5
- kindergartens 4.

When a whole building is demolished, the amount of waste should include all structures of the building. Regarding the assessed values by Perälä and Nippala, the higher of the estimated values are probably more relevant for concrete buildings considering that for example alone the weight of typical hollow core slab is 485 kg/m² (Parma EPD 2019)³.

The case study by Ruuska and Häkkinen (2013) assessed the overall weight of a typical concrete residential building. The results are based on a real building, which was considered as a typical solution, and the values were calculated based on the building design.

structure	weight, kg/gross m ²
exterior walls	217
interior walls	204
floors	374
roofs	67
balconies	151
flue structures	26
stairs	2
non-load bearing interior walls	16
fixed furniture	32
Total	1088
of which concrete	1010

3 GWP value of deconstruction demolition (C1)

Perälä and Koski (2010) have assessed the consumption of energy in the demolition of five storey concrete residential building. The assessment focused on the fuel consumption of working machines used for the demolition of the building frame. Sirje Vares (2020) summarises the results as follows:

The mechanical demolition of the Kuopio concrete apartment building frame took 80 h and the fuel consumption of the demolition machine was 35 l / h. In addition, an excavator was used for 8 h and had a fuel consumption of 20 l / h. Calculated according to this, the total fuel consumption was 2960 liters / building. The building volume was 5700 m³; thus, the fuel consumption per m³ was 0.520 l / m³. Using the value 0.566 kgCO₂ / liter for the procurement of fuel oil and the value 2.4 kgCO₂ / liter for use, the carbon emissions from mechanical demolitions is $(0.520 \text{ l/m}^3) \cdot (0.566 + 2.4) (\text{kg CO}_2\text{e/l}) = 1,54 \text{ kg CO}_2\text{e/m}^3$. By using the ratio of three for building volume and floor area, it can be calculated that the emissions per m² are $3 \cdot 1.54 \text{ kg CO}_2\text{e/m}^2 = 4,62 \text{ kg CO}_2\text{e/m}^2$.

The case study by Bozdağ and Seçer⁴ presents that the average energy consumption for demolition is 10 kWh/m². The study investigated the life cycle of three buildings, which were 5,6 or 10 storey residential buildings; the main building material was concrete. Assuming that the energy source is fuel oil, the net calorific value is 42.5 MJ/kg (11.8 kWh/kg), density 845 kg/m³, and using the above mentioned emission

³ https://cer.rts.fi/wp-content/uploads/rtsepd_28-19_parmaoy_ontelolaatta-1.pdf

⁴ Energy consumption of RC buildings during their life cycle Ö. Bozdağ & M. Seçer Dokuz Eylül University, Izmir, Turkey. sb08. https://www.irbnet.de/daten/iconda/CIB_DC24603.pdf

values considering both combustion and procurement, we can calculate that the emission value is 3 kg CO₂e/m².

The theoretical study by Coelho and Brito (2012)⁵ proposes a value of 2.62 kg CO₂/m² for mere demolition without considering any other processes.

Assessed values for demolition have also been reported in environmental product declarations, though these values are reported product specifically. For example, a Swedish EPD⁶ for concrete structures, Parma's EPDs for concrete structures and ÖkobauDat generic data define estimated values for demolition:

Case	GWP(C1) kg CO ₂ e/kg
Prefabricated reinforced massive wall (Sweden)	0,0073
Prefabricated reinforced massive slab (Sweden)	0,0073
Prefabricated reinforced balcony (Sweden)	0,0052
Concrete column (Finland) ⁷	0,0041
Hollow core slab (Finland) ⁸	0,0100
Precast slab ⁹ (German)	0,0007
Precast wall ¹⁰ (German)	0,0007
Ready mixed concrete ¹¹ (German)	0,0090

By assuming that the amount of concrete waste for a residential building is 1000 kg/gross m² and the GWP value of C1 phase is (the average of above values) 0,006 kg CO₂e/kg, the overall result for a concrete residential building when only concrete is considered is as follows:

$$1000 \text{ kg/m}^2 * 0,006 \text{ kg CO}_2\text{e/kg} = 6 \text{ kg CO}_2\text{e/gross m}^2$$

This value should be close to the building-scale value because the share of concrete of demolition waste is typically high. The value is close to the values based on literature and described above (same order of magnitude).

However, for office buildings the average value is probably significantly bigger and for schools and kindergartens somewhat bigger.

An alternative approach is to utilize EPD-based C1 phase data for different types of main building materials and calculate the building-scale value with the help material specific emission data and data about waste volumes. However, the quality and reliability of material specific data for demolition is probably significantly weaker than for example the data related to A3 phase.

⁵ Influence of construction and demolition waste management on the environmental impact of buildings André Coelho, Jorge de Brito Universidade Técnica de Lisboa, Portugal. Waste management 32(2012) 532-541
<http://dx.doi.org/10.1016/j.wasman.2011.11.011>

⁶ https://www.epd-norge.no/getfile.php/1312712-1583419315/EPDer/Byggevarer/Betongvarer/NEPD-2062-930_Precast-Concrete-One-Layer-Elements--.pdf

⁷ https://cer.rts.fi/wp-content/uploads/rtsepd_30-19_parma_tb-suorakaidepilari-1.pdf

⁸ https://cer.rts.fi/wp-content/uploads/rtsepd_28-19_parmaoy_ontelolaatta-1.pdf

⁹ https://oekobaudat.de/OEKObAU.DAT/datasetdetail/process.xhtml?uuid=9357b7fc-cf0a-45fc-8299-e794e3889a40&version=20.19.120&stock=OBD_2020_II&lang=en

¹⁰ https://oekobaudat.de/OEKObAU.DAT/datasetdetail/process.xhtml?uuid=b342696e-2ebb-4fe1-a71d-f3520db0cee9&version=20.19.120&stock=OBD_2020_II&lang=en

¹¹ https://oekobaudat.de/OEKObAU.DAT/datasetdetail/process.xhtml?uuid=a758fb6a-7fb1-4cdc-b652-c42cf2f7632c&version=20.20.020&stock=OBD_2020_II&lang=en

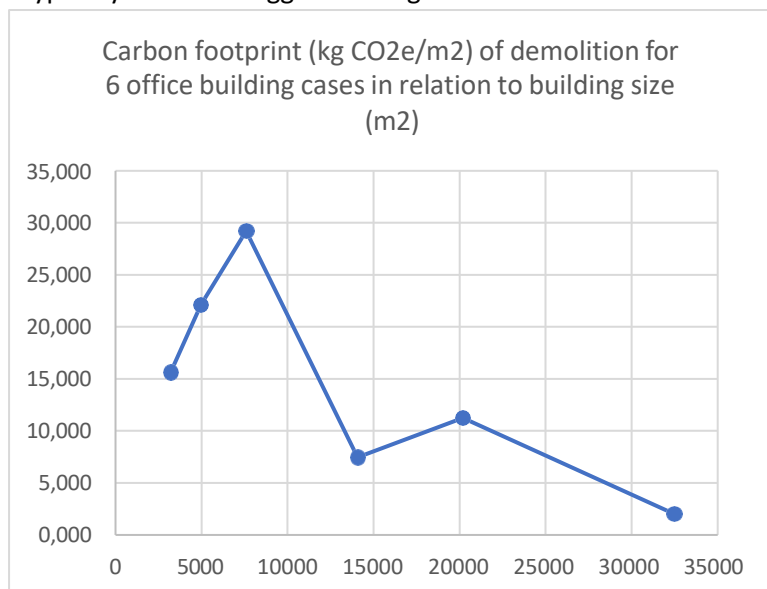
Norwegian EPD reports for standard glued laminated timber structures and for CLT systems and other Nordic EPDs for steel structures estimate the following values for phase C1:

Case	GWP(C1) kg CO ₂ e/kg
Glued laminated timbe structure (Norway) ¹²	0,00002
Cross laminated timber system (Latvia) ¹³	0,00002
Prefabricated steel structure Contiga (Sweden) ¹⁴	0,00060
Load bearing steel structures Aulis Lundel (Finland) ¹⁵	0,00040
Steel beams Stene Stål produkter (Norway) ¹⁶	0,05700
Steel structures Nordec (Finland) ¹⁷	0,02800
Steel strucutres Peikko (Lithuania) ¹⁸	0,06000

The values for wood structures are few and very low, and the values for steel structures vary a lot.

For the time being the approach that utilizes material specific data is not recommended.

Delete Oy has collected emission values based on recent demolition cases. The average emission value of 6 office building cases was 14,6 kg/m². The differences between cases are significant and the emissions are typically lower for bigger building sizes:



¹² https://www.epd-norge.no/getfile.php/139068-1530528866/EPDer/Byggevarer/Heltreprodukter/NEPD-1576-605_Standard-limtrebjelke.pdf

¹³ https://www.epd-norge.no/getfile.php/137187-1489474635/EPDer/Byggevarer/Heltreprodukter/NEPD-1269-410_Cross-laminated-timber-panels.pdf

¹⁴ https://www.epd-norge.no/getfile.php/1311591-1573811642/EPDer/Byggevarer/St%C3%A5lkonstruksjoner/NEPD-1928-851_Prefabricerade-stalkonstruktioner.pdf

¹⁵ https://www.epd-norge.no/getfile.php/1311428-1571737380/EPDer/Byggevarer/St%C3%A5lkonstruksjoner/NEPD-1905-832_Load-bearing-steel-profiles-S350-Z.pdf

¹⁶ https://www.epd-norge.no/getfile.php/1315253-1602677477/EPDer/Byggevarer/St%C3%A5lkonstruksjoner/NEPD-2409-1210_Stalbjelker-og-kanaler-S355J2---S460M-ML.pdf

¹⁷ https://cer.rts.fi/wp-content/uploads/rts-epd_67-20_nordecoy_welded-and-painted-structural-steel-products_european-steel-material.pdf

¹⁸ https://cer.rts.fi/wp-content/uploads/peikko-steel-structures-epd_bionova-ltd_allekirjoitettu-2.pdf

The energy consumption because of deconstruction depends on several issues including the type of the construction system and building material, number of floors and floor height. All collected emission values for the deconstruction phase are of the same order of magnitude (around 10 kg CO₂e/m²). As the ratio between building volume and area is typically bigger in other building types than in residential buildings, the emission value may also be typically bigger for example for offices than for blocks of flats.

However, there is lack of adequate data that would enable the formulation of justified specific values for different building types, and value 10 kg CO₂e/m² was selected for all building types.

According to case study of Ruuska and Häkkinen (2013)¹ the mass of foundation for a typical concrete apartment flat building is 292 tons. As previously stated, an average emission factor of concrete demolition is 0,006 kg co₂e/kg. Now, total GWP of foundation demolition is calculated as 1752 kg co₂e. Gross floor area of the building is 2455 m² and net floor area is 2332 m² (when multiplied by 0,95). Now, a default value 0,75 kg co₂e/m² of net floor area is calculated for demolition of building site.

Moreover, any demolition work in life-cycle phase B4 (construction product replacements) is considered so minor in overall picture that they are calculated as zero.

Following default values are selected for demolition (C1) of building and building site:

- Demolition, building = 10 kg CO₂e/m² (of net floor area)
- Demolition, building site = 0,75 kg CO₂e/m² (of net floor area)

4 GWP value of waste transportation (C2)

GWP of phase C2 depends on quantities of waste, transportation distances, load sizes, means of transportation and types of fuels. Demolition wastes are transported by lorries. The load sizes and load factors vary and those can be small for some waste fractions.

Sirje Vares (2020) has assessed typical emissions by using the following assumptions:

- waste volume 1200 kg/m²,
- transportation distance 50 – 100 km road driving by lorry,
- the load capacity 19 tons,
- load size 50% - 100%,
- use of LIPASTO¹⁹ for emission data

She assesses that the emission could be 6 – 8 kgCO₂/gross m² regarding local transportation or 12 – 16 kg CO₂/gross m² when part of transportation distances is longer (100 km) and load sizes smaller (<50%).

In building specific assessment, the approach is

- 1) to apply default values for emissions of transportation (given in the database),
- 2) to either apply given default values transportation distances (50 – 100 km) and load sizes (50 – 100%) or define case-specific values if known
- 3) to assess the quantities of waste always on building scale (considering the overall weight of the building).

5 GWP value of waste processing (C3)

Waste processing may partly happen already at demolition site. The environmental impact of waste processing depends on the type and quantity of demolition waste and on the aimed use of the processed

¹ [Rakennusmateriaalien ympäristövaikutukset : Selvitys rakennusmateriaalien vaikutuksesta rakentamisen kasvihuonekaasupäästöihin, tiivistelmäraportti - Valto](#)

waste. The effect of the aimed use purpose on the carbon footprint of C3 phase can be significant; thus, the definition of a representative value for generic C3 data per product may be problematic.

Regarding multi-storey buildings, the main share of emissions in C3 phase comes from crushing and possible pulverizing of concrete, which is the main building material of these buildings.

Concrete

In accordance with Betoniteollisuus r.y.²⁰, crushed concrete can be used either as crushed stone in road construction or in the production of new concrete. If crushed concrete is used in the manufacture of concrete up to about 20% of the total amount of aggregate, the properties of the concrete will remain almost the same as in concrete made with normal aggregates. The largest area of use for crushed waste concrete is in soil construction. It is commonly used as filling in the construction of roads, streets, and courtyards and parking areas. It is also possible for use in pipe excavations, foundations, and other fillings in building

¹⁹ <http://lipasto.vtt.fi/yksikkopaastot/tavaraliikenne/tieliikenne/kamaanstie.htm>

²⁰ [https://www.elementtisuunnittelu.fi/fi/valmisosarakentaminen/ymparistoominaisuudet/purettavuus-ja- ...](https://www.elementtisuunnittelu.fi/fi/valmisosarakentaminen/ymparistoominaisuudet/purettavuus-ja-...)

construction. There are more than 20 collection points for waste concrete in different parts of Finland. The Government Decree on the Utilization of Certain Wastes in Civil Engineering allows the use of crushed concrete through a notification procedure without an environmental permit. Quality assurance has been arranged for the concrete crushed stone, in which the concentration and solubility of possible harmful substances in the environment are examined periodically.

Crushing is in practice the only option for the processing of ready mixed concrete structures for recycling. Regarding concrete elements, also the use elements would be possible in theory but is very rare in practice. However, there are experiences in other countries, for example in Germany²¹.

The GPW values for C3 of concrete products have also been presented in EPDs. For example, the EPDs published by Parma report the following values for phase C3:

- for concrete column GWP (C3) = 3,89 kg CO₂e/1 m³ or 0,002 kg CO₂e/kg (density 2400 kg/m³)²²
- for hollow core slab GWP(C3) = 0,271 kg CO₂e/m² or 0,0006 kg CO₂e/kg (weight 485 kg/m²)²³

A Norwegian EPD²⁴ gives the following values for phase and C3

Case	GWP(C3) kg CO ₂ e/kg
Prefabricated reinforced massive wall	0,0074
Prefabricated reinforced massive slab	0,0076
Prefabricated reinforced balcony	0,0076
Average	0,0075

Ökobaudat generic values for precast slab²⁵, precast wall²⁶ and ready mixed concrete²⁷ are as follows

Case	GWP(C3) kg CO ₂ e/kg
Precast slab	0,007
Precast wall	0,007
Ready mixed concrete	0,007

Assuming that the amount of concrete waste for a residential building is 1000 kg/gross m² and the GWP value in C3 phase is 0,006 kg CO₂e/kg (a rough average of the Finnish, Norwegian and German values), we can calculate the following result:

$$1000 \text{ kg/m}^2 * 0,006 \text{ kg CO}_2\text{e/kg} = 6 \text{ kg CO}_2\text{e/gross m}^2$$

²¹ <https://trepo.tuni.fi/bitstream/handle/123456789/21463/makela.pdf?sequence=4&isAllowed=y> TAMPEREEN TEKNILLINEN YLIOPISTO Rakennustekniikan koulutusohjelma MÄKELÄ, HANNES: Materiaalitehokas talonrakentamisprosessi Diplomityö, 76 sivua Helmikuu 2013

²² https://cer.rts.fi/wp-content/uploads/rtsepd_30-19_parma_tb-suorakaidepilari-1.pdf

²³ https://cer.rts.fi/wp-content/uploads/rtsepd_28-19_parmaoy_ontelolaatta-1.pdf

²⁴ https://www.epd-norge.no/getfile.php/1312712-1583419315/EPDer/Byggevarer/Betongvarer/NEPD-2062-930_Precast-Concrete-One-Layer-Elements-.pdf

²⁵ https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=9357b7fc-cf0a-45fc-8299-e794e3889a40&version=20.19.120&stock=OBD_2020_II&lang=en

²⁶ https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=b342696e-2ebb-4fe1-a71d-f3520db0cee9&version=20.19.120&stock=OBD_2020_II&lang=en

²⁷ https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=a758fb6a-7fb1-4cdc-b652-c42cf2f7632c&version=20.20.020&stock=OBD_2020_II&lang=en

Timber and engineered wood products

Many of the currently available EPDs of sawn timber and engineered wooden products are written following the earlier version of EN 15804 (A1). Thus, the calculation results are not applicable because of biogenic emissions and storage cannot be differentiated from the total values.

However, the recent RTS EPDs for sawn timber and cross laminated timber give the following values for C3 and C4 phase. The waste processing scenario is chipping according to the EPD for sawn timber. According to the RTS EPD for CLT, wood materials are finally sent to incineration (99 %).

Case	GWP (C3) fossil kg CO2e/kg	GWP (C3) biogenic kg CO2e/kg	GWP (C4) fossil kg CO2e/kg	GWP (C4) biogenic kg CO2e/kg
Sawn and planed timber ²⁸	0,005	1,53	0,0008	0,042
CLT ²⁹	0,027	1,46	0	0,184

A Norwegian EPD³⁰ (where also separate figures are given for fossil and biogenic emissions) reports for wooden cladding a value of $(4,73/513=)$ 0,009 kg CO2e/kg in phase C3. Other Norwegian EPD reports give values for standard glued laminated timber structures and for CLT systems in phase C3 as written in the following table. The EPD by Stora Enso for Classic Sawns reports roughly 4 kg CO2e/m3 for crushing in phase C3. The total C3 phase emission is 736 kgCO2e/m3 but this includes the carbon content of wood (732 kg/m3). The emission calculated per kg is 0,0087 (density 460 kg/m3).

Case	GWP(C3) kg CO2e/kg
Cross laminated timber ³¹	0,0087
Wooden cladding, sawn timber (footnote 30)	0,0090
Glued laminated timbe structure ³²	0,0250
Cross laminated timber system ³³	0,0360

The selection for GWP (C3) fossil for timber and engineered wooden products is 0,02 kg CO2e/kg (calculated as the average of the collected results).

By using an assumption that the amount of wood waste from demolition is 200 kg/m2 and by using the average of the EPDs for C3 (0,02 kg/kg), the following can be calculated:

$$200 \text{ kg/m}^2 * 0,02 \text{ kg/CO}_2\text{e/kg} = 4 \text{ kg CO}_2\text{e/gross m}^2.$$

²⁸ https://cer.rts.fi/wp-content/uploads/rts-epd_124-21_sahateollisuus_sahattu-ja-hyltty-puutavara.pdf

²⁹ https://cer.rts.fi/wp-content/uploads/rts-epd_110-21_crosslam-corrected.pdf

³⁰ https://www.epd-norge.no/getfile.php/139808-1548156954/EPDer/Byggevarer/Heltreprodukter/NEPD-1691-682_Malm100.pdf

³¹ <https://www.storaenso.com/-/media/documents/download-center/certificates/wood-products-approvals-and-certificates/epd/stora-enso-epd-classic-sawn-2020.pdf>

³² https://www.epd-norge.no/getfile.php/139068-1530528866/EPDer/Byggevarer/Heltreprodukter/NEPD-1576-605_Standard-limtreljelke.pdf

³³ https://www.epd-norge.no/getfile.php/137187-1489474635/EPDer/Byggevarer/Heltreprodukter/NEPD-1269-410_Cross-laminated-timber-panels.pdf

Steel (metals)

Nordic EPD published for steel structures in EPD Norge provide the following values for C3 phase:

Case	GWP(C3) kg CO ₂ e/kg
Prefabricated steel structure Contiga (Sweden) ³⁴	0,0010
Load bearing steel structures Aulis Lundel (Finland) ³⁵	0,0600
Steel beams Stene Stål produkter (Norway) ³⁶	0,0002
Steel structures Nordec (Finland) ³⁷	0,0024
Steel structures Peikko ³⁸	0,0028

The values vary very much. If the lowest and highest values are excluded, the average is 0,002 kg CO₂e/kg. The building-scale impact would be rather low as also the share of metals in demolition waste is typically low (see the text in Section Amounts and types of demolition waste).

Bricks

The RTS EPDs for light and red bricks^{39, 40} presents the following GWP values for the waste processing (C3) of bricks. The end-of-life process description says that 58% is collected with mixed construction waste and processed for final disposal and 42 % is collected separately for recycling:

- light and red bricks 0,00496 kg CO₂e/kg.

The ÖkobauDat database presents the following values for waste processing (C3) of clay-based facing bricks⁴¹. The results represent the country specific situation in Germany, focusing on the main technologies.

- bricks 0,00734 kg CO₂e/kg

IBU EPD⁴² for clay-based bricks defines separate values for C3 for recycling and landfilling:

- bricks for recycling 0,00263 kg CO₂e/kg
- bricks for landfilling 0 kg CO₂e/kg

The EPD for Weber KAHl bricks⁴³ presents the following C3 values. According to the applied scenario, the entire product is collected with excavation process in demolition of the building; material recycling (100 %), the entire product is recycled using waste brick treatment process (crushing); 50 % of waste is processed on-site and 50 % is transported to waste processing.

³⁴ https://www.epd-norge.no/getfile.php/1311591-1573811642/EPDer/Byggevarer/St%C3%A5lkonstruksjoner/NEPD-1928-851_Prefabricerade-stalkonstruktioner.pdf

³⁵ https://www.epd-norge.no/getfile.php/1311428-1571737380/EPDer/Byggevarer/St%C3%A5lkonstruksjoner/NEPD-1905-832_Load-bearing-steel-profiles-S350-Z.pdf

³⁶ https://www.epd-norge.no/getfile.php/1315253-1602677477/EPDer/Byggevarer/St%C3%A5lkonstruksjoner/NEPD-2409-1210_Stalbjelker-og-kanaler-S355J2--S460M-ML.pdf

³⁷ https://cer.rts.fi/wp-content/uploads/rtsepd_67-20_nordecoy_welded-and-painted-structural-steel-products_european-steel-material.pdf

³⁸ https://cer.rts.fi/wp-content/uploads/peikko-steel-structures-epd_bionova-ltd_allekirjoitettu-2.pdf

³⁹ https://cer.rts.fi/wp-content/uploads/rtsepd_47-19_wienerberger_lightclaybricks_en.pdf

⁴⁰ https://cer.rts.fi/wp-content/uploads/rtsepd_46-19_wienerberger_redclaybricks_en.pdf

⁴¹ https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=f74a19da-df9a-4462-a632-3b3dc83377b1&stock=OBD_2020_II&lang=en

⁴² https://www.gima-ziegel.de/wp-content/uploads/Facing-Bricks-Clay-Pavers-and-Brick-Slips_GIMA.pdf

⁴³ <https://www.fi.weber/files/fi/2019-04/Kahi-tiilet-ja-harkot-EPD-ymparistoseloste.pdf>

- lime sand bricks 0,00031 kg CO₂e/kg

The ÖkobauDat defines country specific values focusing on main technologies. The calculated GWP for waste processing (C3) of is ⁴⁴

- lime sand bricks 0,00627 kg CO₂e/kg.

Based on the collected results, a representative GWP value for the waste processing of clay-based bricks and lime sand bricks is 0,005 kg CO₂e/kg (order of magnitude). The selection is to apply this value for all mineral materials except concrete and gypsum.

Glass

According to the EPD by Euroglas⁴⁸ for flat glass 70 % of glass is landfilled and 30 % is recycled. The EPD presents the GWP value 0,017 kg CO₂e/kg for C3 for flat glass.

Ökobaudat⁴⁹ presents the value 0,074 kg CO₂e/kg for C3 phase of insulation glass unit. The result represents the country specific situation in Germany, focusing on the main technologies.

RTS EPD by Pihla⁵⁰ defines the GWP value 0,018 kg CO₂e/kg [1,43 kg CO₂e/77,5 kg (the weight of window)] for C3 for wood framed window unit with aluminium cladding (share of glass 56,5 %), (37 % for material recycling, 21 % for energy use, and 42 % for final disposal).

⁴⁴ https://oekobaudat.de/OEKODAT/datasetdetail/process.xhtml?uuid=29e6c6cf-0552-4e4b-85c7-26a68a625252&stock=OBD_2020_II&lang=en

⁴⁵ https://knauf.fi/fileadmin/user_upload/EPD-ymparistoselosteet/Knauf_EPDKN13KEK13KXT9KPS15.pdf

⁴⁶ https://www.gyproc.fi/sites/gypsum.nordic.master/files/gyproc-site/document-files/fi/EPD_FI_Gyproc_Habito.pdf

⁴⁷ <https://www.environdec.com/Detail/?Epd=8890> and

https://www.gyproc.fi/sites/gypsum.nordic.master/files/gyproc-site/document-files/fi/EPD_SE_Glasroc_H_Ocean.pdf

⁴⁸ https://www.euroglas.com/fileadmin/content/euroglas/Deutsch/Service/Zertifizierungen/EPD/2019-02-13_Euroglas_M-EPD_FG_ESG_VSG_efin.pdf

⁴⁹ https://oekobaudat.de/OEKODAT/datasetdetail/process.xhtml?uuid=d941f45e-1244-419c-a083-e4a49fb5498e&version=20.19.120&stock=OBD_2021_II&lang=en

⁵⁰ https://www.rttuotetieto.fi/pub/media/resources/68766_RTS_EPDPymprist_seloste-puualumiini-ikkuna-MSE1-A.pdf

Norgesvinduet Kompetanse AS / EPD Norge⁵¹ gives the GWP value 0,033 kg CO₂e/kg for C3 phase for wood framed window without aluminium cladding (share of glass 80 %).

The selection is to apply the GWP value 0,02 kg CO₂e/kg for C3 in accordance with the Finnish EPD for windows. The value is roughly the same order of magnitude with other collected examples.

Plastics

In accordance with the RTS EPD by Finnfoam for **PIR polyurethane** insulation boards, 100% of end-of-life product is assumed to be material recycled as it is easy to collect and qualified for recycling. The EPD⁵² defines GWP for C3 phase for three PIR products: 0,619, 0,618 and 0,624 kg CO₂e/kg. In each case, polyurethane is the main material of the product.

ÖkobauDat⁵³ presents the result 2,6 for waste processing (C3) of **PIR** high-density foam without information about the scenario. The result represents the country specific situation in Germany.

IBU EPD by UNLIN⁵⁴ defines the C4 value 2.0 kg CO₂e/kg for energy recovery scenario for **PIR** insulation boards. Correspondingly IBU EPD by IVPU⁵⁵ gives the value 2.1 kg CO₂e/kg for energy recovery scenario for **PU** thermal insulation boards with 50 µm aluminium facing

The RTS EPD by Finnfoam for **EPS insulation boards**⁵⁶ gives the value 2,4 kg CO₂e/kg for C3 phase with the assumption that all demolition waste goes to energy recovery.

The EPD by EPS Gruppen⁵⁷ published by EPD Norge is calculated with the assumption that roughly half of demolition waste is recycled and the other half goes to energy recovery. The assessed GWP value for **EPS** for C3 phase is 1,88 kg CO₂e/kg. ÖkobauDat⁵⁸ gives the C3 value for energy recovery for **EPS** for walls and with the density of 18 kg/m². The defined value is 3,3 kg CO₂e/kg.

The IBU EPD for Expanded Polystyrene (**EPS**) Foam Insulation – densities 15, 20, and 30 kg/m³ - by EUMEPS⁵⁹ ⁶⁰ ⁶¹ define the following scenarios and emission values for waste processing:

⁵¹ https://www.epd-norge.no/getfile.php/1319825-1628847846/EPDer/Byggevarer/D%C3%B8r%20og%20vinduer/NEPD-2996-1653_Norgesvinduet-Fixed-Frame-Window-with-and-without-aluminum-cladding.pdf

⁵² <https://cer.rts.fi/wp-content/uploads/pir-epd-23082021.pdf>

⁵³ https://oekobaudat.de/OEKODAT.DAT/datasetdetail/process.xhtml?uuid=2c076ee7-3853-4f69-9bf5-8ec265fa43e0&stock=OBD_2020_II&lang=en

⁵⁴ <https://www.takcentrum.se/wp-content/uploads/2017/08/EPD-UTHERM-141001.pdf> EPD-UNI-20140123-IBA1-EN (valid to 2019)

⁵⁵ <https://www.bauder.co.uk/getmedia/58272cfd-5902-4d55-8603-b5453d1dc56c/EDP-Environmental-Product-Declaration-PU-thermal-insulation-boards-with-50-m-aluminium-facing.pdf> (valid to 2026)

⁵⁶ https://cer.rts.fi/wp-content/uploads/ff-eps_epd_bionovaoy_19-1-2017-allekirjoitettu-1.pdf

⁵⁷ https://www.epd-norge.no/getfile.php/136975-1484299209/EPDer/Byggevarer/Isolasjon/NEPD-1236-244_Lavlambda-EPS-isolasjon.pdf

⁵⁸ https://oekobaudat.de/OEKODAT.DAT/datasetdetail/process.xhtml?uuid=64564161-a587-47de-b195-b6b13b3bfb07&stock=OBD_2020_II&lang=de

⁵⁹ IBU Declaration number EPD-EUM-20160273-IBG1-EN ECO, EPD Ref. No. ECO-00000510, Issue date 20/04/2017 Expanded Polystyrene (EPS) Foam Insulation (with infra-red absorbers, density 15 kg/m³) EUMEPS.

⁶⁰ <https://www.bewi.com/wp-content/uploads/2021/02/EPD.pdf>

⁶¹ <https://styropor.at/wp-content/uploads/EPD-EUM-20160272-IBG1-EN.pdf>, EPD-EUM-20160272-IBG1-EN

Density	Recycling GWP (kg CO ₂ e/kg) given for C3 or C4	Landfilling GWP (kg CO ₂ e/kg) given for C3 or C4	Energy recovery / incineration GWP (kg CO ₂ e/kg) given for C3 or C4
15	0,725 (C3)	-	3,37 /C4*)
20 (region Scandinavia)	-	0,07	3,45 (C3)
30	0,725 (C3)	-	3,37 (C4)

*the value is given for C4 although the scenario is energy recovery

The EPD by The European Plastics Pipes and Fittings Association (TEPPFA) ⁶² presents the average end-of-life GWP value 0,07 kg CO₂e/kg for PVC pipes based on the scenario that 80 % goes for landfilling, 15 % for incineration, and 5 % for mechanical recycling. Correspondingly TEPPFA EPD⁶³ defines for PP pipes that the GWP for end-of-life is 0,02 if 80 % is left in ground, 15 % for incineration, and 5 % for mechanical recycling.

ÖkobauDat presents the following values for C3 for polymer-based pipes (representing the country specific situation in Germany):

- PP pipes 3,22 kg CO₂/kg ⁶⁴
- PEX water pipes 3,77 kg CO₂e/kg ⁶⁵
- Polybutadiene pipes 3,22 kg CO₂/kg ⁶⁶
- PVC rain drain pipes 3,01 kg CO₂/kg ⁶⁷.

The scenario-based study by Kinnunen and Kupiainen⁶⁸ assessed the emission related to two different waste processing scenarios for plastics. Regarding the incineration scenario, the assessed emission were 1,9 kg CO₂e/kg or 2,0 kg CO₂e/kg (two cases), and regarding the recycling scenario the assessed emissions were 1,32 kg CO₂e/kg (both cases).

In accordance with the VTT report ⁶⁹ (53), the GWP of incineration of mixed plastics waste is 2,2 CO₂e kg/kg.

⁶² <https://www.teppfa.eu/wp-content/uploads/SW02-PVC-U-soil-and-waste-EPD-2307.pdf> POLYVINYLCHLORIDE (PVC-U) PIPE SYSTEM FOR SOIL AND WASTE REMOVAL IN THE BUILDING.

⁶³ https://www.teppfa.eu/wp-content/uploads/SW01_PP_EPD_2020_final.pdf POLYPROPYLENE (PP) PIPE SYSTEM FOR SOIL AND WASTE REMOVAL IN THE BUILDING

⁶⁴ https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=94355965-8d24-4e78-a910-9f35b8ae1193&version=20.19.120&stock=OBD_2021_II&lang=en

⁶⁵ https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=9d623359-570b-40ca-8875-60dea3687846&version=20.19.120&stock=OBD_2021_II&lang=en

⁶⁶ https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=83a21998-b507-429e-bbe3-b5629e601138&version=20.19.120&stock=OBD_2021_II&lang=en

⁶⁷ https://oekobaudat.de/OEKOBAU.DAT/datasetdetail/process.xhtml?uuid=d9baa9f5-b9d2-4f8f-928d-2f4116b36662&version=20.19.120&stock=OBD_2021_II&lang=en

⁶⁸ Riikka Kinnunen ja Riina Kupiainen Rakennustyömaan muovijätevirrat ja lajittelun ympäristövaikutukset. KARELIA-AMMATTIKORKEAKOULU Energia- ja ympäristötekniikan koulutus. Opinnäytetyö Huhtikuu 2019.

https://www.theseus.fi/bitstream/handle/10024/167592/Opinn%C3%A4ytety%C3%B6_KinnunenKupiainen.pdf?sequence=2&isAllowed=y

⁶⁹ VTT working papers 176. Henna Punkkinen, Nea Teerioja, Elina Merta, Katja Moliis, Ulla-Maija Mroueh & Markku Ollikainen Pyrolyysin potentiaali jätemuovin käsittelymenetelmänä. 2011.

<https://www.vttresearch.com/sites/default/files/pdf/workingpapers/2011/W176.pdf> The report assesses the emissions from the incineration of wood and plastic waste. The assessed quantity is 83 340 t/a of which 42 590 t/a plastics and 40 750 t/a wood. As a result of the burning of plastic and wood, an estimated 122 700 t/a of CO₂ is released from the boiler of which 29 900 t/a is bio-based and therefore not taken into account. Thus, the emission from plastics is (122700-29900)/43590) 2.2 kg/kg (page 41).

Based on the collected data, the proposal is to apply the following rounded average GWP values for waste processing for polymer-based insulation boards and pipes:

- 3,0 for energy recovery scenario
- 0,7 for recycling scenario.

The same value is selected also for bitumen roofings regarding the recycling scenario. For example, Katepal (2022) gives GWP values for C3 module for bitumen roofings that are somewhat smaller but of the same order of magnitude, namely 0.4 kg CO₂e/kg.

Summary

The selection is to include generic values for waste processing in phase C3 for wood-based materials, mineral materials and metals and provide the following values based on collected EPDs for concrete, bricks, solid timber, and steel constructions:

- concrete materials 0,006 kgCO₂e/kg (mainly because of crushing)
- bricks, gypsum, and lime sand bricks (and other mineral materials excluding concrete) 0,005 kgCO₂e/kg (mainly because of crushing)
- glass 0,02 kg CO₂e/kg
- wooden materials (not impregnated) 0,02 kg CO₂e/kg
- metals 0,002 kg CO₂/kg
- plastics 3,0 kg CO₂e/kg for energy recovery scenario
- bitumen membrane 0,7 kg CO₂e/kg for recycling scenario.

The selection for the calculation method on building scale is to assess the amount of demolition waste divided to the above-mentioned groups and calculate the building scale value with using the generic values for these groups.

6 GWP value of disposal (C4)

Landfilling of organic material is restricted under the Government Decree on Landfills (331/2013). The aim is to steer biodegradable waste or other waste containing organic material away from landfills to be used as material or energy and to reduce the adverse impacts of waste management to the environment.

The main part of mixed waste assessed by weight - consists of concrete and other mineral materials. Mixed waste from building sites is not applicable for combustion. The different fractions need to be separated on buildings sites, or at latest on waste separation plants.

Statistics Finland has published emission values for different kinds of fuels. The value for recovered fuels is 0,57 kg CO₂/kg⁷⁰.

The selection for phase C4 is

- to provide a generic emission value with regard to the building-scale amount of combustible waste generated at demolition site
- to use a value given for recovered fuels by Statistics Finland (0,57 kg CO₂ / kg)
- When the share of combustible waste fraction cannot be assessed a default value of 10% can be used⁷¹ which leads to the emission value of 0,057 kg CO₂ / kg of all mixed waste.

⁷⁰ https://www.stat.fi/static/media/uploads/khkaasut_polttoaineluokitus_2020_v3.xlsx

⁷¹ as proposed by Tuuli Myllymaa SYKE