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Method for the whole life carbon assessment of buildings

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Method for the whole life carbon assessment of buildings

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Abstract

In 2017 the Ministry of the Environment published a roadmap to low-carbon construction. It stated that the whole life carbon assessment of buildings must be incorporated in the building regulations by the mid-2020s. The low-carbon factor is also part of the complete reform of the Land Use and Building Act now in progress.

This publication describes the first version of a method employed in Finland for the whole life carbon assessment of buildings. The method is based on the European Commission's Level(s) method and European Standards.

A low-carbon building has a low carbon footprint and a big carbon handprint. A carbon footprint analysis covers a building's entire life cycle. It includes the manufacture and transportation of the products used in a construction project, the worksite, the use and maintenance of the building, its demolition, and recycling.

The carbon handprint analysis incorporates the net benefits of climate impact that would not arise if there were no construction project. These might be the building's carbon storages and sinks, the extra renewable energy produced during the building's life cycle, and the benefits gained from the reuse and recycling of the construction products.

The method is intended to be used for the assessment of the carbon footprint and carbon handprint of new buildings and buildings undergoing extensive repairs. After it is tested, the method will be updated.

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Tiivistelmä

Ympäristöministeriö julkaisi vuonna 2017 vähähiilisen rakentamisen tiekartan. Sen mukaan rakennusten elinkaaren vähähiilisyys tulee osaksi rakennusmääräyksiä 2020-luvun puoliväliin mennessä. Vähähiilisyys on myös osana maankäyttö- ja rakennuslain käynnissä olevaa kokonaisuudistusta.

Tässä julkaisussa kuvataan rakennusten vähähiilisyyden arviointiin Suomessa käytettävän menetelmän ensimmäinen versio. Menetelmän pohjana ovat Euroopan komission Level(s)-menetelmä sekä EN-standardit.

Vähähiilisella rakennuksella on pieni hiilijalanjälki ja suuri hiilikädenjälki. Hiilijalanjäljen arviointi kattaa rakennuksen koko elinkaaren. Siihen kuuluvat rakennustuotteiden valmistus, kuljetus ja työmaa, rakennuksen käyttö ja huolto sekä rakennuksen purku ja kierrätys.

Hiilikädenjäljen arviointiin sisältyvät sellaisten ilmastovaikutusten nettohyödyt, joita ei syntyisi ilman rakennushanketta. Näitä voivat olla rakennuksen hiilivarastot ja hiilinielut, rakennuksen elinkaaren aikana tuotettu ylimääräinen uusiutuva energia sekä rakennustuotteiden uudelleenkäytön tai kierrätyksen myötä syntyvät hyödyt.

Menetelmä on tarkoitettu käytettäväksi uudisrakennusten ja laajamittaisten korjausten hiilijalanjäljen ja hiilikädenjäljen arviointiin vuonna 2019 alkavalla testausjaksolla. Testauksen jälkeen menetelmä päivitetään.

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Miljöministeriet gav år 2017 ut en färdplan för koldioxidsnålt byggande. Enligt färdplanen ska målet om låga koldioxidutsläpp under byggnadens hela livscykel tas in i byggbestämmelserna senast i mitten av 2020-talet. Klimatavtrycket beaktas också i den pågående totalreformen av markanvändnings- och bygglagen.

Den här publikationen redogör för den första versionen av den metod för beräkning av byggnaders klimatavtryck som ska användas i Finland. Metoden baserar sig på Europeiska kommissionens Level(s)-metod och på EN-standarder.

En koldioxidsnål byggnad har ett litet fotavtryck och ett stort handavtryck. Beräkningen av klimatavtrycket omfattar byggnadens hela livscykel. I beräkningen ingår framställning av byggprodukter, byggplats och transporter, användning och underhåll av byggnaden samt rivning av byggnaden och återvinning av rivningsavfall.

Beräkningen av handavtrycket innefattar sådana nettofördelar av klimatpåverkan som inte uppkommer om byggprojektet inte genomförs. Till dessa hör kollager och kolsänkor i anslutning till byggnaden, det överskott av förnybar energi som producerats under byggnadens hela livscykel samt fördelar som uppkommer i samband med att byggprodukter återanvänds eller återvinns.

Metoden är avsedd att tillämpas på beräkning av fotavtrycket och handavtrycket av nya byggnader och omfattande reparationer under en testperiod som inleds under 2019. Efter testningen kommer metoden att uppdateras.

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FOREWORD

Finland aims to achieve carbon neutrality by 2035. This will require significant emissions reductions in all sectors of society. This target will also have an impact on the construction industry.

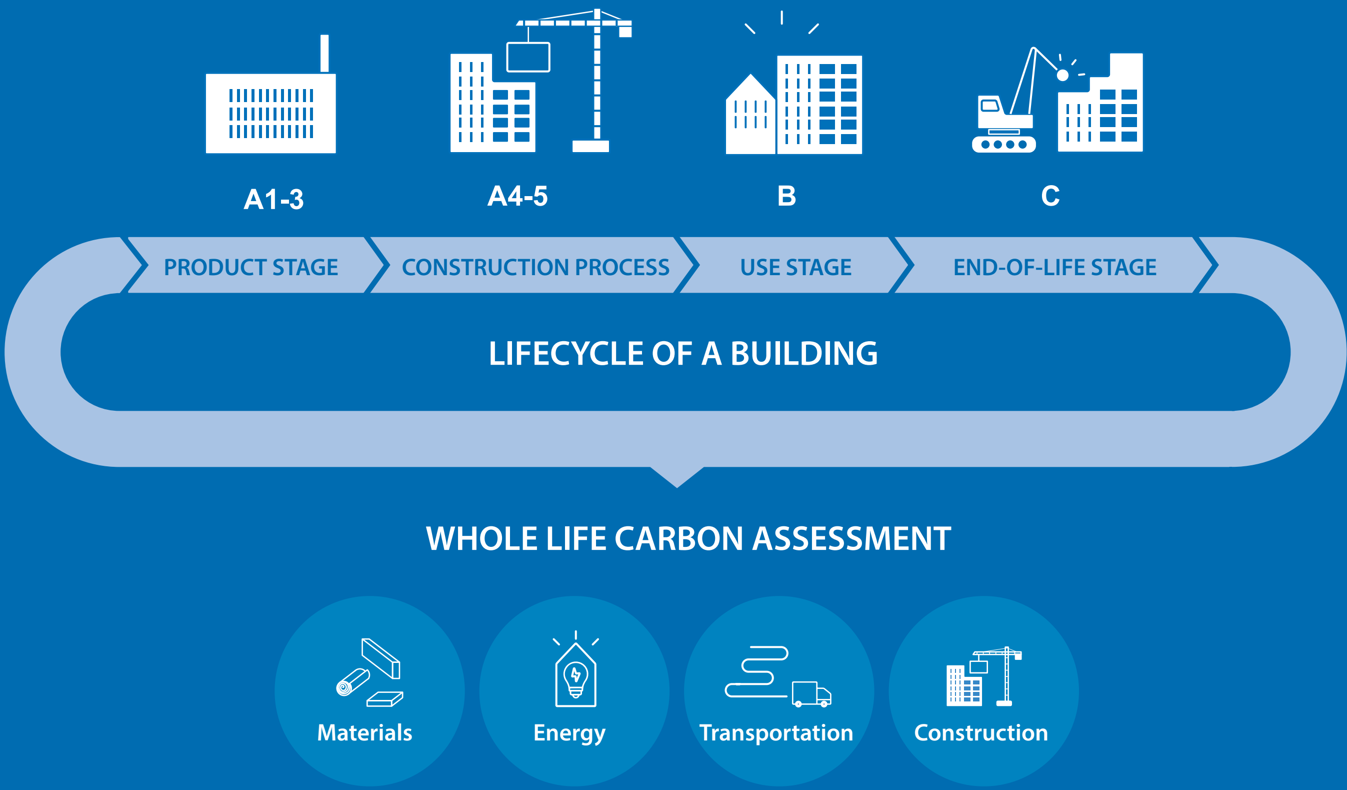
It is difficult to reduce something if we cannot measure it. This guide describes the assessment method developed for the conditions in Finland. It is based on evaluation methodology developed in 2018 together with experts in the field and further refined based on feedback obtained through a consultation round.

Life cycle assessment of buildings has been carried out in Finland for a long time. This work is largely based on European standards, which provide a common framework for calculations. The assessment method of the Ministry of the Environment continues this tradition. A new feature of the method is its focus on the goal of introducing a standard-based life cycle assessment that will be monitored as part of Finland's overall energy and climate strategy.

The assessment method contributes to the development of legislation. Low-carbon construction is part of the ongoing comprehensive reform of the Land Use and Building Act. The Ministry began developing a roadmap for low-carbon construction in 2016. The 2019 Government Programme calls for accelerating the implementation of this roadmap.

The evaluation method will be further developed through a piloting period and industry cooperation. We are also discussing the topic actively with other EU countries. We hope to achieve constructive dialogue with the entire sector so that we can develop a well-functioning evaluation method for Finland.

Teppo Lehtinen
Head of unit, Buildings and Construction
Ministry of the Environment



A1-3
A4-5
B
C
PRODUCT STAGE
CONSTRUCTION PROCESS
USE STAGE
END-OF-LIFE STAGE
LIFECYCLE OF A BUILDING
WHOLE LIFE CARBON ASSESSMENT
Materials
Energy
Transportation
Construction

1 The whole life carbon assessment of buildings

1.1 Why conduct an assessment?

The whole life carbon assessment of a building represents the endeavour to reduce greenhouse gases during the building's life cycle by means of some careful advance planning.

According to the Climate Change Act,[1] Finland aims to accomplish an 80% cut in greenhouse gas emissions by 2050, compared to the benchmark figure for 1990. This target also applies to the construction industry.

A building's life cycle impacts and low-carbon factor are part of the complete reform of the Land Use and Building Act now in progress. The Ministry of the Environment produced a roadmap to low-carbon construction in 2017[2]. According to that, the assessment of the carbon footprint of buildings and building-type-specific emission limits are planned to be included in Finland's building regulations in the 2020s. Under the 2019 Government Programme, the roadmap to low-carbon construction must be expedited.

1.2 What is the assessment method based on?

The Ministry of the Environment assessment method is based on the Level(s) framework developed by the European Commission[3]. It has as its background on the European

1 Climate Change Act (609/2015)

2 http://www.ym.fi/vahahiilinenrakentaminen

3 http://ec.europa.eu/environment/eussd/buildings.htm

standards on sustainable construction (including EN 15643 series, EN 15978 and EN 15804) and scientific research on the subject.

1.3 What sort of buildings is the assessment method suited to?

A whole life carbon assessment may be undertaken on all buildings and it can be applied to both new buildings and refurbishment projects. The assessment is intended to be undertaken in parallel with estimates of the energy efficiency of the building. The assessment method is not directly suited to the evaluation of infrastructure projects.

1.4 At what stage of a project can the assessment be undertaken?

The assessment is best conducted when a building is being designed. At this stage there is enough detailed information on the building's materials and energy needs.

Whole life carbon assessments may also be conducted prior to the building's design; for example, when setting goals in public procurement. In this way, statistical data on the carbon footprint of similar construction projects may be made use of. These method instructions do not include such statistics-based comparisons or the setting of goals.

1.5 What does an assessment of a building consist of?

The analysis considers the entire building, the structures on the site, and the main building service systems. The analysis does not cover the vegetation, soil or temporary scaffolding and protective covers at the site during construction.

It is conducted for the entire life cycle of the building. The manufacture of construction products, transportation and worksite operations, usage, repairs, demolition and recycling are all included in the life cycle. The stages of the life cycle, i.e. the modules, are defined in European Standard EN 15643-2 and shown in Figure 2.

1.6 What tools and information are needed?

To conduct a whole life carbon assessment of a building you will need the method described in these instructions, but also the emissions data for the construction projects and processes and a tool for calculating emissions.

The emissions database for construction products and processes used in Finland is currently being developed. Before the database is finalised, you can use the emissions data and scenarios included in the tools for the whole life carbon assessment of buildings.

To conduct the assessment you may either use the simple evaluation table developed by the Ministry of the Environment or you can choose another suitable tool. Note that assessments carried out using different emission data or tools do not ensure comparability.

1.7 How is the assessment method being developed?

This method version is only meant for the pilot phase, and should not be used as a condition for granting planning permission. During the pilot phase, feedback will be collected on the use of the method. The method will be updated with reference to the feedback received and on the basis of the experience gained.

Send feedback to www.elinkaarilaskenta.fi

Life cycle stages of a building

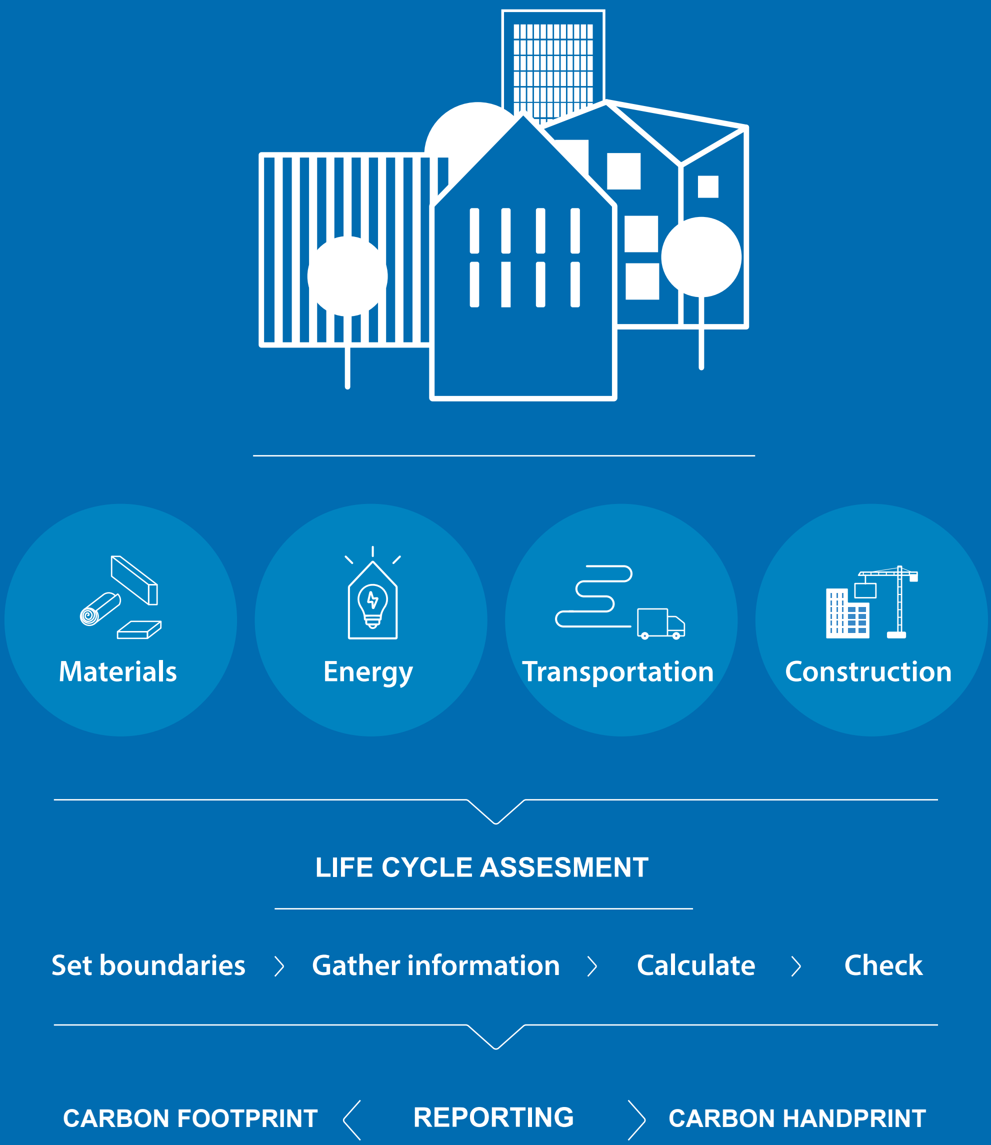
A1–3	A4–5	B		C
PRODUCT STAGE	CONSTRUCTION PROCESS	USE STAGE		END-OF-LIFE STAGE
A1 Raw material supply	A4 Transport	B1 Use of products	B5 Refurbishment	C1 Deconstruction
A2 Transport	A5 Construction work	B2 Maintenance	B6 Operational energy use	C2 Transport
A3 Manufacturing		B3 Repair	B7 Operational water use	C3 Waste processing
		B4 Replacement		C4 Disposal

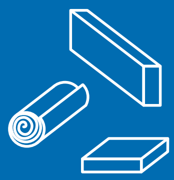
D

SUPPLEMENTARY INFORMATION

Benefits and loads beyond the system boundary

Stages of the whole life analysis

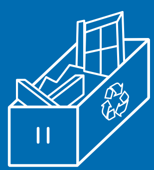




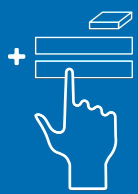
Materials

Compile a bill of quantities. Based on that, make a bill of materials used in each product.

Estimate the amount of materials that will need replacing during the life cycle of the building.



Estimate the amount of materials for reuse, recycling or disposal at the end of the life cycle.



Calculate the carbon footprint of the life cycle stages of products.

2 Carbon footprint of materials

2.1 Manufacture of construction products (modules A1–3)

2.1.1 Content of the analysis

Make a materials list for the products planned for the building, site and main building service systems. The parts of the building to be included in the calculation are set out generally in Table 1 and in greater detail with their nomenclature in Appendix 1. Include any surplus or waste generated on the worksite.

Exclude vegetation on the site or in the building, the climate impacts of the soil, vegetation or bodies of water on the site, and temporary scaffolding, protective covers and worksite facilities used during construction. Exclude too soil restoration work on the site and the buildings or structures that are demolished or taken down on the site.

2.1.2 Volume calculations in refurbishment projects

If you are assessing the carbon footprint associated with a refurbishment project, restrict the assessment to the new building parts and products needed for the refurbishment work or those to be repaired. Do not include in the carbon footprint analysis the life cycle stages prior to refurbishment (i.e. retroactively).

2.1.3 Reuse of products

If at the building implementation stage old building parts or other products left over from other worksites are being reused, exclude these from the carbon footprint assessment for the manufacture of these products or preparations for reuse. You can only arrive at an assumption regarding the reuse of products when the products for reuse have been a part of the overall building design. The same assumption can no longer be made later when the building is being repaired and replacements are being made (modules B3-4).

2.1.4 Complete table of values for building systems

If you are assessing the carbon footprint at an early stage of a project, the planning of certain building service systems may be incomplete and the data on volumes imperfect. In such a case use the table of values in Appendix 2 to assess the carbon footprint of building service systems. Having made the building system plans more specific, you can estimate material volumes for the systems with reference to the delimitation in Appendix 1.

Table 1. Assessed parts of building.

	Included in the analysis	Not included in the analysis
Site	+ Ground elements + Soil stabilisation and reinforcement elements– + Paved areas + Site structures	- Site equipment - Vegetation - Climate impacts of vegetation, soil or bodies of water
Load-bearing structures	+ Foundations + Ground floors + Structural frame + Façades, doors and windows + External decks + Roof structures	- Separate nails, screws, adhesives, seals, caulks and other fasteners, brackets, etc. that do not come with the products.
Supplementary structures	+ Interior walls and doors + Stairs + Surfaces + Normal fittings + Ducts and fireplaces + Prefabricated units	- Surface materials and mouldings - Surface treatment and paintwork - Separate nails, screws, adhesives, seals, caulks and other fasteners, brackets, etc. that do not come with the products.
Building systems	+ Heating systems + Water and drainage systems + Air conditioning systems + Cooling systems + Sprinklers + Electrical systems + Lifts	- Information systems - Building automation - Emergency power systems - Escalators - Separate machinery and equipment
Construction site	+ Energy consumed on the construction site	- Scaffolding and protective covers - Temporary structures, moulds and technical equipment - Life cycle of construction site facilities - Site personnel traffic

2.2 Replacements of construction products during a building's life cycle (module B4)

2.2.1 Content of the analysis

Estimate the amount of construction products that will need replacing during the time the building is being used. Take into account all products whose technical service life is shorter than the building's target lifetime. If the technical service life of a product is longer than the building's target lifetime, assess the possible low-carbon benefits achieved as a result of reuse, in accordance with section 6.2.

2.2.2 Estimated replacements

You can make an assessment of the construction products that will need replacing either with reference to the table of values in Appendix 3 or by calculating them in accordance with Formula 1. The construction products for a building in connection with repairs and replacements are always assumed to be new.

Estimates of construction product replacements should not take account of refurbishment (module B5) that might be undertaken during the building's life cycle.

2.2.3 Conditions of use

In deciding the technical lifetime of building elements and products also pay attention to the conditions of use for the products, climatic stress categories, load combination categories, the submersible load category, abrasion load and abrasion resistance categories and other factors affecting the functional resistance of products, such as the importance of maintenance (EN ISO 12944, SFS-EN 1990, ISO 9223, SFS-EN 335-1, EN 15804).

Formula 1. Calculating the product replacement interval.

$$\text{Replacement interval} = \left[\left(\frac{\text{Building´s service life}}{\text{Product´s service life}}\right) - 1\right]$$

Example 1. *The building's target lifetime is 80 years. The planned service life of a construction product is 25 years. According to calculations, the product would be replaced 2.2 times (80/25 – 1 = 2.2). The replacement interval is rounded off to the integral number 2. The third time for replacing the product would occur at year 75, but the product would probably not be replaced for the remaining five operating years. In the whole life analysis, the product is considered to be replaced twice during the building's operating lifetime.*

Example 2. *The building's target lifetime is 80 years. The planned service life of a construction product is 45 years. According to calculations, the product would be replaced 0.78 times (80/45 – 1 = 0.78). The replacement interval is rounded off to the integral number 1. If the product was not replaced at year 45, it should endure nearly twice longer than planned, and taking such a risk is not likely. In the whole life analysis, the product is considered to be replaced once during the building's operating lifetime.*

Example 3. *The building product may also be partly replaced. In this case, the calculation of the environmental impacts caused by the replacement is contributed to the part of the product that is replaced. The ventilation engine of a ventilation machine may be replaced instead of replacing the entire machine. However, replacing the engine is not part of general maintenance (module B2) in the way that replacing the filter would be, for instance.*

2.3 Waste processing and disposal (modules C3–4)

2.3.1 Alternative assessment methods

Conduct the assessment of the carbon footprint of waste management and disposal using the table of values given in Appendix 3. Alternatively, you can calculate the carbon footprint of waste management and disposal for each material fraction in accordance with sections 2.3.2 and 2.3.3.

2.3.2 Content of the analysis

Estimate the amount of waste material generated at the building demolition stage. Assume that the amount of materials is the same as when the building was being constructed, regardless of any replacements and repairs made during its life cycle.

If you are conducting an assessment for a refurbishment project, take into account all the materials in the building and on the site before the project started.

If you are conducting an assessment for a temporary building planned for removal, distinguish between the waste resulting from the move and the building parts for reuse. In the carbon footprint assessment, only consider the waste resulting from the move. State the benefits obtained from reuse as part of the carbon handprint, reflecting the principles outlined in Appendix 5.

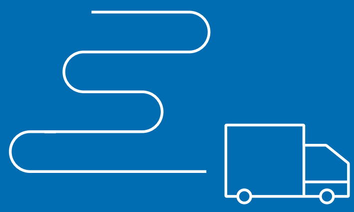
2.3.3 Scenarios

Use the different scenarios for each material category in the emissions database for construction products to assess the carbon footprint of residual streams[4].

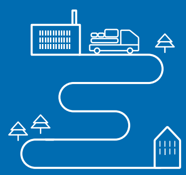
If the materials are to be used for energy, indicate the environmental impacts of using them this way as those beyond the building's life cycle (module D) and the corresponding benefits as part of the carbon handprint. This also applies to hazardous waste.

The principle for assessing the low-carbon benefits beyond the building's life cycle is described in Appendix 5.

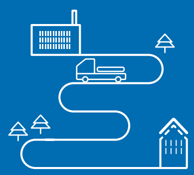
4 The scenarios will be ready for use later as part of the national emissions database. They will include assumptions as regards whether the products can be used again and how much of each material could be used or, alternatively, will be disposed of. Before that, you could devise scenarios with reference to modules C33-4 for each project as applied to conditions in Finland.



Transport

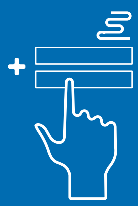


Estimate the distances products travel when transported to the construction site.



Estimate the transport distances relating to repairs while the building is used.

Estimate the transport distances at the end of the building's life cycle.



Calculate the carbon footprint of transportation.

3 The carbon footprint of transportation

3.1 Alternative assessment methods

You can assess the carbon footprint of transportation using the table of values in Appendix 3. Alternatively, you can calculate the carbon footprint of transportation in connection with the construction work, repairs, demolition or waste management activities required during the building's life cycle as described in sections 3.2–3.5.

3.2 Transportation during construction (module A4)

The analysis of the carbon footprint of transportation to the construction site includes all transportation of construction products, materials and large quantities of soil to the construction site, and covers possible temporary storage and prefabrication sites. Transportation also includes that of the construction waste generated at the construction site for waste management or temporary storage.

Omit the transport of construction machinery and the journeys made by the construction workers to the worksite from the transportation assessment.

Calculate traffic emissions separately for each journey. Employ the emission coefficients typical of each mode of transport and fuel.

Calculate the journeys in both directions in such a way that the load filling rate is assumed to be 80% on the outward journey and 0% on the return journey. The load filling rate for soils taken away from the site is assumed to be 100%.

Estimate the carbon footprint for the transportation of waste generated during construction as well as for the journeys made at the end of the life cycle (section 3.5).

3.3 Transportation during repairs (modules B3–4)

Calculate the carbon footprint for the transportation of the new construction products required for the repairs as well as for the journeys made during construction (section 3.2).

Estimate the carbon footprint for the transportation of waste generated while repairs are being carried out as well as for the journeys made at the end of the life cycle (section 3.5).

3.4 Transportation during refurbishment projects

If you are conducting a carbon footprint assessment for a refurbishment project, only assess the journeys made necessary by the project (section 3.2) and those journeys made during the life cycle following the project (sections 3.3 and 3.5). Do not include the journeys made in the earlier stages of construction in the carbon footprint (i.e. retroactively).

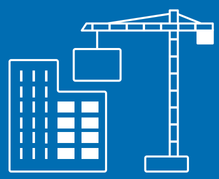
3.5 Transportation at the end of the life cycle (module C2)

Transportation at the end of the life cycle includes all journeys from the demolition site for reuse, recycling and waste management, including possible temporary storage and further processing sites.

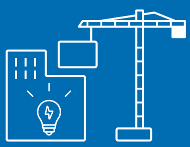
Calculate the carbon footprint for transportation for each mode of transport separately. Employ the emission coefficients typical of each mode of transport and fuel.

Estimate the transportation distances based on the locations of waste processing, recycling or reprocessing facilities available at the time of calculation. Note that the demolition waste transport stage may include several consecutive journeys.

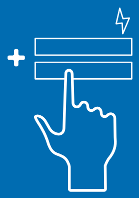
Calculate the distances in both directions in such a way that the load filling rate is assumed to be 0 % on the outward journey and 80% on the return journey.



Construction



Estimate the amount of energy consumed on the construction site.



Calculate the carbon footprint of energy.

4 The carbon footprint of the construction site

4.1 Alternative assessment methods

You can use the table of values in Appendix 3 to assess the carbon footprint of the construction site. Alternatively, you could estimate the carbon footprint resulting from construction, repairs and demolition on the worksite in accordance with section 4.2.

4.2 The calculation of the carbon footprint of the construction site

4.2.1 The worksite during construction (module A5)

Calculate the carbon footprint with reference to the emissions from purchased energy and fuel consumed on the construction site. Include in the estimate for energy the need for energy arising from lighting, drying, heating, the use of temporary construction site facilities, and anything else required on the worksite. Use in the calculation the emission coefficients for different forms of energy and fuels.

Calculate the carbon footprint resulting from temporary construction site facilities or operations even if it does not originate on the building site in question. If the construction site facilities or auxiliary services are also there for buildings other than the one subject to the analysis, apportion the carbon footprint of these facilities and services in relation to the gross area of the construction projects they are there for.

If at the construction stage some construction products are not used, calculate the emissions from their manufacture as part of the carbon footprint of the building in accordance with section 2.1.

Estimate the quantity of waste and recyclable and reusable construction products resulting on the worksite in accordance with sections 2.1–2.3.

4.2.2 The construction site during repairs (modules B3-5)

Calculate the carbon footprint with reference to the emissions from purchased energy and fuel consumed on the site where repair work is being carried out along the same guidelines as those stated in section 4.2.1. Use in the calculation the emission coefficients for different forms of energy and fuels. Take account of the future emission reductions given for these coefficients in Appendix 4.

4.2.3 The construction site for refurbishment projects

If you are making a carbon footprint calculation for a refurbishment project, only assess the carbon footprint for the worksite used for the project (section 4.2.1) and that for the sites in the life cycle following the project (sections 4.2.2 and 4.2.4). Do not include the carbon footprint of the worksites in the earlier stages of construction retroactively.

4.2.4 Demolition site (module C1)

Calculate the carbon footprint with reference to the emissions from purchased energy and fuel consumed on the demolition site along the same guidelines as those stated in section 4.2.1. Use in the calculation the emission coefficients for different forms of energy and fuels. Take account of the future emission reductions given for these coefficients in Appendix 4.

5 The carbon footprint of energy

5.1 The calculation of the carbon footprint of energy

Calculate the carbon footprint of energy by multiplying the estimated consumption of purchased energy supplied to the building by the emission coefficients for the different forms of energy.

Specify the estimated consumption of energy supplied to the building with reference to the Decree on the Energy Performance of New Buildings[5]. If no energy report has been produced for the building in accordance with the Decree, assess the consumption of delivered energy using the calculation method given in the Decree.

Do not include the electricity consumed by appliances or technical systems not identified in the Decree on the Energy Performance of a New Building in the energy carbon footprint calculation.

5.2 The emission coefficients for different forms of energy

Calculate the carbon footprint of energy using the standardised emission coefficients in Appendix 4. These take account of the fact that, during the reference study period, energy emissions are expected to decrease as a result of the measures under Finland's National Energy and Climate Strategy.

For district heating you could also state separately the carbon footprint calculations for energy arrived at using the emission coefficients for each producer. The national emission coefficients for electricity include a share for renewable production.

5 Ministry of the Environment Decree on the Energy Performance of a New Building 1010/2017.

6 Carbon handprint

6.1 Components of the carbon handprint

Carbon handprint means the climatic benefits that can be achieved during a building's life cycle and which would not arise if there were no construction project. Examples include:

- Greenhouse gas emissions avoided through the reuse of building parts and components or the recycling of materials (module D).
- The surplus renewable energy produced in a building or on a site (module B).
- The biogenic carbon stored in construction materials and the carbon dioxide from the atmosphere that may be bound to them during the building's life cycle (modules A–C).

The carbon handprint is not deducted from the carbon footprint.

6.2 Benefits obtained from reuse and recycling

6.2.1 Assessment provisos

Reusable building parts or recyclable materials must have net benefits that impact a low carbon footprint and that would not arise if they were not used.

You can only assess the benefits derived from reuse and recycling[6] through calculation or by using the data given in the environmental declaration for the product.

6 The possibility of drawing up tables of values to speed up the assessment for the net benefits of reuse and recycling should be looked into during the pilot phase.

You can only include in the analysis the building parts and construction products that themselves were included in the calculation of the carbon footprint of the building's materials.

6.2.2 Calculation of the benefits of reuse and recycling

Estimate the volume of reusable building parts and recyclable materials. Calculate the net greenhouse gas emissions of the reusable building parts and components removed beyond the system boundaries of the building and of recycled materials and those used for energy based on their net material and energy flows. Give these results in the form of separate additional information. Use the method shown in Appendix 5 in the calculation.

6.3 Surplus renewable energy

6.3.1 Assessment provisos

You can include the excess renewable energy supplied to the electricity grid or district heating network in the carbon handprint. You can include the renewable energy produced by a system for the building, for the site or outside the site for the building.

If you are calculating the handprint for surplus renewable energy, the carbon footprint for the life cycle of equipment needed to produce the energy must also be included in the carbon footprint analysis for the building. This also applies to any production and transmission systems off-site if they are there for the building being assessed.

6.3.2 Calculation of surplus energy

Estimate the amount of surplus renewable energy produced yearly (kWh/year). Multiply the amount of energy by the emission coefficients in Appendix 4. Remember that the emission coefficients will change in the decades to come. Give the results of the calculation in kilos of carbon dioxide (kgCO_2).

6.4 Carbon storages

6.4.1 Assessment provisos

You can only calculate carbon storage for biogenic materials such as wood. Fossil materials, such as the carbon found in oil-based plastics, do not count as carbon storage.

The proviso is that the material is of sustainably managed origin and that when it was harvested the natural carbon sink in the ecosystem was not permanently impaired.

You can only include in the analysis the building parts and construction products that themselves were included in the calculation of the carbon footprint of the building's materials.

You can only count as a carbon storage that part of a biogenic material that forms part of the final construction product. Exclude the side streams of production or production waste from the analysis. Omit too the biogenic materials used in packaging, on-site scaffolding, moulds and protective covers.

6.4.2 Calculation of carbon storage

Calculate the carbon storage of biogenic products by multiplying the dry weight of the biogenic material by the amount of carbon (C) it contains. With wood-based products, the assumption is that the volume of biogenic carbon is 50% of the dry weight of the wood. Give the results of the calculation in kilos of carbon dioxide ($kgCO_2$).

6.5 The carbon sinks of cement-based products

6.5.1 Assessment provisos

You can only include the carbon sink of cement in the carbon handprint if possible repairs due to carbonation carried out during the life cycle of products containing cement are taken account of in the calculation for the carbon footprint.

You can only include in the analysis the building parts and construction products that themselves were included in the calculation of the carbon footprint of the building's materials. The carbonation analysis must employ the same cement types as those used to calculate the carbon footprint.

You can only count as a carbon storage those parts of cement-based materials that form part of the final construction product. Exclude the side streams of production or production waste from the analysis. Omit from the analysis the cement-based products that might be used temporarily on the worksite.

6.5.2 Calculation of carbonation

Calculate the carbon in the atmosphere bound to cement-based products in accordance with standard EN 16757, Annex BB.

Calculate carbonation according to the following schedule:

- Carbonation prior to use (module A): Depending on the scenario, but not more than one year.
- Carbonation during use (module B): Length of the reference study period used (50 years or the design service life of the building).
- Carbonation after use (module C): Depending on the scenario, but not more than three years.
- Carbonation beyond the building's life cycle (module D): Depending on the scenario and in line with Finnish law in effect at the time of the analysis.

Use typical Finnish conditions in terms of temperature, humidity and exposure to the weather to calculate carbonation. When calculating carbonation during use (module B), take account of the exposure to the weather of a building component and any surface treatments that could affect carbonation.

Give the results of the calculation in kilos of carbon dioxide (kgCO_2).

7 Summary and reports

7.1 Whole life carbon assessment summary

7.1.1 Calculating the carbon footprint

Calculate the carbon footprint for the entire life cycle of a building by adding together the greenhouse gas emissions for the different life cycle modules. Give the climate warming potential as a total figure that includes fossil emissions. Exclude biogenic emissions if the biogenic raw materials of the products are of sustainably managed origin[7].

Give the results of the calculation as a carbon dioxide equivalent weight divided by the building's heated net area and the length of the reference study period ($kgCO_2e/m^2/year$). Give the carbon footprint as a positive whole number.

7.1.2 Calculating the carbon handprint

Calculate the carbon handprint by adding together the values for life cycle biogenic carbon storage, carbon sinks, and the emissions avoided through the reuse and recycling of materials or energy recovery beyond the building life cycle. Employ the conventional production, recycling or energy technology available at the time of the calculation.

Do not subtract the carbon handprint value from that for the carbon footprint: show it separately. Give the carbon footprint as a carbon dioxide equivalent weight divided by the building's heated net area and the length of the reference study period ($kgCO_2e/m^2/year$). Give the carbon handprint as a negative whole number.

7 Sustainable origin means, for example, that they have been issued with forest certificates guaranteed by a third party. The manufacturer's or producer's own declaration is not sufficient.

7.1.3 Other impacts

In addition to the life cycle carbon footprint and handprint you could also show other environmental or social impacts separately.

In evaluating these effects, observe the limitations to the whole life analysis in these instructions and, if necessary, follow the European Commission Level(s) guidelines and applicable EN or ISO standards. Report on the other effects separately for each life cycle phase as described in section 7.2. Attach a description of the data and methods used in the analysis.

7.2 Presenting the results of calculations

7.2.1 Results for new buildings

Show the results in accordance with the principle given in Appendix 6a separately for the following modules of the life cycle.

- Prior to use (A1–5)
- During use (modules B3-–4, B6)
- After use (C1–4)
- Impacts beyond the life cycle (module D)

7.2.2 Results for refurbishments

Show the results in accordance with the principle given in Appendix 6b separately for the following modules of the life cycle.

- Prior to refurbishment (A1–5)
- During use following the refurbishment (modules B3-–4, B6)
- After use (C1–4)
- Impacts beyond the life cycle (module D)

If you are making an assessment for a refurbishment project, do not include with the results of the calculation the carbon footprint or handprint from the building's earlier life cycle phases. Begin the check from the time of the stages of the refurbishment project.

7.2.3 Quality of the input data in the calculation

Report on the quality of the input data in the calculation. The instructions for reporting the quality of data and the minimum quality requirements for the data can be found in Appendix 7.

There is no need to evaluate the quality for modules A1–3 or B6 if you use the table of values in Appendices 2 and 3 in these instructions.

7.2.4 Reliability of the analysis

The results of the analysis will be judged reliable if you have carried it out observing the limitations set out in these instructions and Appendix 1, if you have calculated the volume of delivered energy in accordance with the Decree on the Energy Performance of New Buildings,[8] and if you have otherwise used the tables of values in the appendices and the national emissions database produced for the whole life analysis[9].

8 Ministry of the Environment Decree on the Energy Performance of a New Building 1010/2017.

9 The emissions database is currently being developed. At the testing stage, existing emissions data, which is applicable to conditions in Finland, can be used.

Table 2. Method for the whole life carbon assessment and restrictions summarised.

Projects assessed	New buildings, extensive repairs	
Types of building assessed	1–2 Residential building 3 Office and health centre 4 Business premises, theatre, library, museum 5 Accommodation establishment, hotel, hostel, sheltered accommodation building, nursing home, care facility 6 Educational establishment and crèche 7 Sports centre (excluding swimming pools and ice rinks) 8 Hospital 9 Other	
Parts of a building assessed	*Assessed*	*Not assessed*
Site	Earth works, soil stabilisation and reinforcement elements, paved areas, site structures	Site equipment, vegetation, soil and bodies of water
Load-bearing structures	Foundations, ground floors, structural frame, façades, doors and windows, external decks, roofs	Separate fasteners
Supplementary structures	Interior walls, doors, stairs, surfaces, fittings, ducts and fireplaces, box units	Mouldings, surface materials and surface treatments, separate fasteners
Building systems	Energy systems, water and drainage systems, air conditioning systems, power distribution and operating systems, solar panels and collectors, lifts	Information systems, emergency power, escalators, separate machinery and equipment
Construction site	Energy consumed	Scaffolding and protective covers, temporary structures, moulds, life cycle of worksite facilities, site personnel traffic
Analysis period	Fifty years or design service life (if used as a basis for the design)	
Reference unit	1 m^2 of the building's heated net space / year	

Assessed life cycle phases and the input data in the analysis

Prior to use	Evaluation	Data used
A1-3 Product manufacture	+ Assessed	Only project-specific data
A4 Transportation to construction site	+ Assessed	Project-specific data or table of values
A5 Construction	+ Assessed	Project-specific data or table of values
During use	**Evaluation**	**Data used**
B1 Use of products	- Not assessed	
B2 Maintenance	- Not assessed	
B3-4 Repairs and replacements	+ Assessed	Project-specific data or table of values
B5 Refurbishment	Independent, separate analysis	
B6 Operational energy use	+ Assessed	Only project-specific data
B7 Water consumption	- Not assessed	
After use	**Evaluation**	**Data used**
C1 Demolition work	+ Assessed	Project-specific data or table of values
C2 Transportation for processing	+ Assessed	Project-specific data or table of values
C3 Waste processing	+ Assessed	Project-specific data or table of values
C4 Disposal	+ Assessed	Project-specific data or table of values
The implementation and review of the analysis		
Database	Not specified. National emissions database forthcoming.	
Tool	Not specified. Must be compatible with the assessment method.	
Competency requirements	Not specified. Requirements still under way.	
Revision of results	Not specified. Requirements still under way.	

8 Terms and abbreviations

Terms

Reference study period	The period for which a life cycle calculation is made. The service life of a building may be longer than the period for the life cycle calculation.
Module	The life cycle stage of a building as in EN 15643–2.
Biogenic carbon	Carbon bound to biogenic materials as a result of photosynthesis.
Fossil carbon	Carbon from fossil sources.
Carbon dioxide equivalent	The global warming effect of different greenhouse gases converted to a level that corresponds to the impact of carbon dioxide.
Carbon footprint	The total for greenhouse gases produced during the life cycle of a product or service.
Carbon handprint	The total for the absolute climate benefits produced during the life cycle of a product or service converted to carbon dioxide equivalents.
Carbon sink	A function for removing carbon dioxide from the atmosphere. Carbon sinks can either be natural (such as a growing forest), chemical (such as the carbonation of cement) or artificial (developed technologies).
Carbon storage	Carbon from the atmosphere stored in a product or material. For example, about half of the dry weight of wood is atmospheric carbon.
Scenario	An assumption arrived at for future life cycle stages and their environmental impact. The assumption must be based on existing legislation, typical technology or a client's requirements.
Functional equivalence	The technical or functional requirement of a building or product that allows its comparison with another building or product.
Functional unit	The unit referred to when stating the environmental impact of a building or product for the purposes of comparison.

Abbreviations

CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
EPD	Environmental Product Declaration
kWh	Kilowatt-hour

Appendix 1. Assessed parts of buildings and their nomenclature

Assessed parts of building	Building 2000 classification system equivalence
Site	
Earth works	1111 Clearing elements 1112 Trenches 1113 Channels 1114 Filling on site 1115 Embankments 1116 Draining elements
Soil stabilisation and reinforcement elements	1121 Piles 1122 Permanent soil stabilisation 1123 Reinforcement elements
Paved areas on the site	1131 Traffic area pavings 1132 Parking area pavings 1133 Leisure and play area pavings
External structures and their foundations on the site	1151 Outdoor storage 1152 Yard sheds and pergolas 1154 Stairs, ramps/embankments and terraces
Load-bearing structures	
Building foundations and dewatering	1211 Footings 1212 Enclosure walls, and foundation columns and beams
Ground floors	1221 Ground floor slabs 1222 Ground floor channels/ducts
Structural frame	1231 Civil defence shelters 1232 Bearing walls 1233 Columns 1234 Beams 1235 Intermediate floors 1236 Structural frame stairs
Façades	1241 External walls 1242 Windows 1243 External doors
External decks	1251 Balconies 1252 Shelters and pergolas 1253 Special external decks
Roofs	1261 Roof substructures 1262 Eaves 1263 Roofings 1265 Glass roof structures 1266 Skylights and hatches
Light structures	
Interior walls	1311 Partitions 1312 Glass partitions 1315 Internal doors 1316 Special doors 1317 Space stairs
Surface elements	1321 Floor surface elements 1323 Ceiling surface elements 1325 Wall surface elements
Fixtures	1331 Standard fittings

Assessed parts of building	Building 2000 classification system equivalence
Light structures	
Flues and fireplaces	134 Flues and fireplaces
Box units	1351 Box unit bathrooms 1353 Box unit saunas 1354 Box units for building service systems 1355 Flue and duct components
Heating, ventilation and air conditioning systems and their corresponding LVI2010 nomenclature	
Heating systems	2111 Central units: boiler installations, burner systems, flues, geo-thermal and aerothermal heat pumps, solar thermal equipment 2112 Transmission components: exchange systems, heat transfer fluids, air ducts 2113 Terminal parts: radiators, radiant heaters, underfloor heating pipes, supply air heaters 2114 Local area parts: networks, thermal power stations, pipes, fuel stores, equipment for solar, heat pump and combined heating systems, heat storage equipment, pipework
Water and drainage systems	2122 Transmission components: tanks and storage appliances 2123 Terminal parts: mixers, taps, lavatory pans, urinals, baths, shower trays and cabins 2124 Local area parts, building pipework, site conduits, sewers, inspection chambers, runoff gullies, storm drains
Air conditioning systems	2131 Central units: appliances and their parts, air extractors, air recirculation systems, supply ventilation systems, waste air purification equipment 2132 Transmission components: pipes and ducts 2133 Terminal parts: exhaust air windows 2134 Local area parts: external and waste air gaps and ducts, heat recovery systems, filter units, outdoor air and exhaust equipment
Cooling systems	2141 Central units: appliances, equipment, pumps, steam gene-ra-tors, heat exchange units, condensers, tanks 2142 Transmission components: pipes 2143 Terminal parts radiators, air-conditioners, chilled beams 2144 Local area parts: network, central units, pipework
Fire-fighting systems	2152 Transmission components: Conduits, sprinkler pipes
Electricity systems and their corresponding S2010 nomenclature	
Production and connection	S212 Electricity generation systems and equipment
Main distribution	S221 Medium voltage power distribution system S222 Main distribution system
Electrification	S231 Electrification of a property's equipment and appliances S231 Electrification of heating, ventilation and air conditioning equipment and appliances S231 Electrification of a user's equipment and appliances
Lighting systems	S251 Internal lighting S252 External lighting S253 Local area lighting system
Electrical heating systems	S261 Building's electrical heating system S262 Underfloor heating
Mechanical elements	
Transporters	2511 Lifts

Appendix 2. Emissions data for building service systems

Conventional systems (surface area indicated for each room area of the building)	
Lift	7 585.00 kg CO_2/each
Electrical installations and wiring	5.28 kg CO_2/m^2
Sprinkler system	5.85 kg CO_2/m^2
Water supply and sewage (surface area indicated for each room of the building)	
Water supply	2.70 kg CO_2/m^2
Piping	0.52 kg CO_2/m^2
Heating system (surface area indicated for each room of the building)	
Radiators	6.67 kg CO_2/m^2
District heating substation	0.53 kg CO_2/m^2
Ventilation system[10]	6.97 kg CO_2/m^2
Solar panels (surface area indicated for each solar panel collector)	
Crystalline silicon solar panel	242.00 kg CO_2/m^2
Thin-film solar panel	67.00 kg CO_2/m^2
Network inverter	22,00 kg CO_2/each

The data per square metre is given per heated room area. If the floor area is required in the calculation, these figures should be divided by 1.18. The earlier account pro-duced by Technical Research Centre of Finland (VTT) has been used for the mass estimates[11]. The emission values for different materials are the temporary values for construction materials and products provided by the Technical Research Centre of Finland (VTT).

10 Includes the heat recovery ventilation appliances for each property, ductwork and insulation, vents and dampers.

11 Ruuska & Häkkinen (2013). Rakennusmateriaalien merkitys rakentamisen ympäristövaikutusten kentässä (The Relevance of Construction Materials to the Environmental Impacts of a Building): Background report. Technical Research Centre of Finland (VTT): Available at https://www.vtt.fi/inf/julkaisut/muut/2013/YM_Taustaraportti.pdf

Appendix 3. Table of values for emissions at different stages of the life cycle

The carbon footprint is given in kg CO_2e/m^2 units (net heated area). Tables of values are not available for the carbon footprint of building products when they are being manufactured (A1–-3) or for the energy use of the building (B6) but are always calculated separately for each project.

Typical emissions (kgCO_2e/m^2)		
A1–3 Manufacture		*(calculated only with project-specific data)*
A4 Transportation to site	10.20	Average transportation distance in Finland
A5 Functions at new construction site	27.30	Consumption of energy and fuel on the worksite
B3–4 Energy consumption of repairs[12]	2.16	The production of materials must be assessed separately
B6 Operational energy use		*(calculated only with project-specific data)*
C1 Functions at a demolition site	7.80	Consumption of energy and fuel on the worksite
C2 Transportation to further processing	10.20	Average transportation distance in Finland
C3–4 Waste processing and final disposal	15.60	
Total	73.26	kgCO_2e/m^2

The table of values shows the mean values for the carbon footprint calculations for building life cycles previously made in Finland. A 20% uncertainty factor has been added to the averages. The report must take account of the fact that the results need to be distributed across the service life of the building (kgCO_2e/m^2/year).

12 The carbon footprint is calculated for the entire surface area of the assessed building. The emissions at the manufacturing stage (A1–3) of replaceable construction products must be separately assessed and added to the carbon footprint for energy consumption at the repair stage given here. If the technical service life of building materials and products has not been separately calculated, it is assessed with reference to RT card 18–10922.

Appendix 4. The emission coefficients for different forms of energy (g CO_2/kWh)

	2020	2030	2040	2050	2060	2070	2080	2090	2100	2110	2120
Electricity	121	57	30	18	14	7	4	2	1	1	0
District heating	130	93	63	37	33	22	15	10	7	4	3
District cooling	130	93	63	37	33	22	15	10	7	4	3
Fossil fuels	260	260	260	260	260	260	260	260	260	260	260
Renewable fuels	0	0	0	0	0	0	0	0	0	0	0

Specific fossil CO_2 emissions from the electric power consumed in buildings, district heating and district cooling for the period 2020–2120 were determined with reference to the CO_2 emissions from fuel consumption in Finnish production and the energy transferred for consumption. The specific CO_2 emissions correspond to the annual average production of electricity, district heating and district cooling. The calculation takes account of the CO_2 emissions caused by the combustion of fossil fuels and peat. The CO_2 emissions from the combustion of biomass have been estimated as zero in accordance with principle governing the calculation of sustainability criteria in the EU Directive on the promotion of the use of energy from renewable sources[13],[14]. The CO_2 emissions resulting from fuel production or the establishment of infrastructure are ignored.

The assumptions employed in the calculation regarding the supply of electricity and district heating are based on the 2020–2050 'with existing measures' scenario in the PITKO project ('Long-term Development of Total Emissions') created by the Technical Research Centre of Finland (VTT) and the Finnish Environment[15] Institute ('WEM' scenario). The assumptions associated with the WEM scenario until 2030 are also described in Finland's National Energy and Climate Strategy 2016[16] and its Medium-term Climate Policy Plan

13 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.

14 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.

15 Koljonen, Soimakallio, Lehtilä et al. (2019). Pitkän aikavälin kokonaispäästökehitys (Long-term Development of Total Emissions'). Publications of the Government's analysis, assessment and research activities 24/2019.

16 Ministry of Economic Affairs and Employment (2017). Valtioneuvoston selonteko kansallisesta energia- ja ilmastostrategiasta vuoteen 2030 (Government report on the National Energy and Climate Strategy for 2030) Ministry of Economic Affairs and Employment Publications - Energy - 4/2017.

(KAISU)[17] reports and in the summary reports on the assessment of their impacts[18],[19]. District cooling is not dealt with separately in the WEM scenario, so the specific CO_2 emissions for district cooling were assumed to correspond to the figure for the specific CO_2 emissions for the consumption of district heating. The emission coefficients for the period 2051–2120 were arrived at by extrapolating the exponential curve for the specific CO_2 emission coefficients calculated for 2020–2050.

The supply of electrical power by means of coal, peat, gas and oil in CHP production was determined with reference to the data on electrical energy supply and condensing production. The efficiency of condensing production was assumed to be 39%. The efficiency rating for CHP production and district heating produced in stand-alone heating only plants was assumed to be 90% and the power to heat ratio in CHP production was assumed to be 50% for all production technologies. The efficiency rating for the production of district heating and the power to heat ratio in CHP production were used to calculate district heating production in the CHP boilers. The stand-alone production of district heating was calculated by subtracting the CHP production of district heating from its supply. The total, the electrical and the heat energy produced by combined heat and power plants producing district heating was calculated with reference to the consumption of district heating CHP plant fuels, their total efficiency (90%) and the power to heat ratio (50%). Transmission losses were assumed to be 3 TWh for electricity and 4 TWh for district heating, in accordance with the Energy and Climate Strategy 2016.

Allocation of fuel consumption and the related CO_2 emissions between electricity and heat in combined heat and power production was based on an assumed situation for both, where electricity and heat would have been produced separately in stand-alone plants using similar fuels. For this 'benefit-sharing' method, the efficiency rating for stand-alone production used was 39% for electricity and 90% for heat.

The specific CO_2 emissions for the combustion of fuels were taken from the Statistics Finland fuel classification[20]. For the specific emissions from peat, a mean average of 105.4 g CO_2/MJ for sod peat and milled peat was used. For coal and peat an average value

17 Ministry of the Environment (2017). Valtioneuvoston selonteko keskipitkän aikavälin ilmastopolitiikan suunnitelmasta vuoteen 2030. (Government Report on Medium-term Climate Change Plan for 2030). Kohti ilmastoviisasta arkea (Towards a Climate-wise Everyday Existence). Reports of the Ministry of the Environment 21/2017.

18 Koljonen, Soimakallio, Asikainen et al. (2017). Energia- ja ilmastostrategian vaikutusarviot (Impact Assessments of the Energy and Climate Strategy): Summary report. Publications of the Government's analysis, assessment and research activities 21/2017.

19 Koljonen, Soimakallio, Ollikainen et al. (2017). Keskipitkän aikavälin ilmastopolitiikan suunnitelman vaikutusarviot (Impact Assessments of the Medium-term Climate Policy Plan). Publications of the Government's analysis, assessment and research activities 57/2017.

20 Statistics Finland 2018. Fuel classification 2018.

of 99.3 g CO_2/MJ for the specific emission for coal and that for peat as mentioned above was used. For gas and oil an average of 67.3 g CO_2/MJ for the specific emissions from natural gas and heavy fuel was used. For waste incineration the specific emission value for mixed/municipal waste of 40 g CO_2/MJ was used.

The specific CO_2 emissions from electricity transmitted for consumption was calculated by dividing the CO_2 emissions from the combustion of fossil fuels and peat in the generation of electricity in Finland by the amount of Finnish electricity transmitted for consumption. The specific CO_{2c} emissions from district heating transferred for consumption with respect to fossil fuels and peat was calculated by dividing the CO_2 emissions from the supply of district heating by the amount of district heating consumed.

Appendix 5. The rules for calculating environmental impacts beyond the building life cycle of the assessment site (module D)

As a rule, all of the building products and materials removed from and dismantled in a building during its life cycle are considered waste from the viewpoint of the whole life analysis described in these instructions.

When building and demolition waste is prepared and further processed for recovered products and materials, the resulting greenhouse gas emissions are allocated as follows:

- The utilisation of waste generated at the construction stage: module A5
- The utilisation of waste generated in repairing and replacing elements during operation: modules B3––4
- The utilisation of waste occurring at the end of the building life cycle: module C3

Categorisation of products and materials as waste ends with the following conditions:

- The criteria of section 5 of the Waste Act 646/2011 are met with measures in accordance with Government Decree 179/2012.
- The recovered materials fulfil the criteria for end-of-waste status laid down for different waste categories (for example, Government Decree 843/2017 for crushed concrete).
- The recovered materials have undergone recovery measures in a body with valid environmental permits.

Once the recycled building products and materials are no longer perceived as waste, they are presumed to be suitable for reuse, material recycling or energy recovery from the perspective of the whole life analysis. In this case, they are retired from the system limits of the analysis site. These impacts beyond the life cycle of the assessed site are allocated to life cycle module D.

The indicative table of values for greenhouse gas emissions given in the emissions database for construction products is based on the default values for each material and product group in the database and the calculation norms given in this appendix.

The reuse of building elements and products

In the context of building elements and products, the net greenhouse gas emissions are the benefits brought by reuse when the element or product is used to replace elements or products produced with average technology available in Finland at the time of analysis. The greenhouse gas emissions generated in processing (e.g. corrosion or fire-retardant treatment of parts) and transportation possibly occurring after the categorisation as waste are allocated to module D as stress factors until the technical or functional characteristics required of them reflect the equivalent characteristics required of the replaced products.

Recycling of materials

In the context of the recycling of materials, the net greenhouse gas emissions consist of greenhouse gas emissions avoided or caused in theory as a result of recycling. The greenhouse gas emissions arising from the possible further processing and transport of recycled materials after their categorisation as waste are allocated to module D as stress factors until the characteristics required of these materials reflect the technical or functional properties required for the purpose determined for them. If the recycled material fails to fulfil the technical or functional quality standards for the replaced material, the greenhouse gas emissions of the recycled material are added as stress factors in module D based on a 'quality difference factor'. The net greenhouse gas emissions notified in module D may be 'caused emissions' rather than 'avoided emissions'.

Recycling of materials, open loop (open loop: 'down-cycling' or 'up-cycling')

In the context of the 'open loop' of the recycling of materials (typically e.g. plastic, wood, glazing pane, bitumen, concrete), net greenhouse gas emissions are calculated by using recycling to compensate for the greenhouse gas emissions that would be caused if an amount of technically equivalent material corresponding to the amount of the recycled material was produced in Finland using the average technology available in Finland at the time of the analysis.

> ***An example of 'down-cycling':*** *Crushed concrete is used as substitute for extracted aggregate in road construction, which allows the greenhouse gas emissions generated in the quarrying and crushing of rock-based aggregate to be avoided (including the journeys).*

Recycling of materials, closed loop (closed loop: recycling)

In the context of the closed loop recycling of materials (e.g. usually metals), net greenhouse gas emissions are calculated by subtracting from the volume of recycled materials the amount for recyclable material in the manufacture of the product in ques-tion plus any losses. In this case, the information provided in module D includes an amount equivalent to the remaining portion of the calculated emissions 'avoided' for the total greenhouse gas emissions from the manufacture of the product, taking into account the possible additional burden in respect of greenhouse gas emissions caused by the quality difference factor.

> ***An example of 'caused' emissions in the closed loop:*** *A steel product is manufactured from 100% recycled material (e.g. 100% scrapped steel) and 5% of the amount of material in the manufactured product is 'removed' from the cycle and 95% ends up in material recycling after reaching end-of-waste status. In this case, 5% of the greenhouse gas emissions that would be caused if the product was manufactured using the average technology available at the time of analysis are reported in module D.*

Energy recovery

In the context of energy recovery, net greenhouse gas emissions refer to the green-house gas emissions theoretically avoided or caused in theory as a result of energy recovery if the energy material was used to replace an equivalent amount of energy produced with average technology available in Finland at the time of the analysis as fuel for energy production. The greenhouse gas emissions of material for energy re-covery (including transportation) are allocated to module D as stress factors, taking into account the technology available for the combustion unit using the material as fuel and the quality standards set for fuel. If the material does not fulfil the plant-specific 'quality requirements for fuel' set for a material suitable for energy recovery based on a universal rule (meeting the criteria for end-of-waste status), the greenhouse gas emissions for the material are included as stress factors in module D based on the 'quality difference factor'.

> ***An example of the use of the 'quality difference factor' in an energy production plant:*** *The dried, 'replaced' wood pulp of an energy production plant that uses wood pulp as fuel has the energy content of 19 MJ/kg and the wood-based construction material used in energy recovery has the energy content of 10 MJ/kg, making the 'quality dif-ference factor" 10/19.*

In some cases, the end-of-waste status can only be accomplished for material used in energy recovery during incineration (e.g. impregnated wood), in which case some of the greenhouse gas emissions generated by the incineration process and other emis-sions (e.g. heavy metals) are allocated to module C3.

Appendix 6. Minimum content of reports on the whole life carbon assessment of a building

6a. The minimum content of reports on the carbon assessment of a new building

Basic information of the analysis site	
Information about the construction site	- Building code - Address - Building type - Year of build (planned)
Technical details of the building	- Floor area - Number of floors - Number of cellar floors - Primary frame material - Energy class and estimated consumption of delivered energy.
Results of the whole life analysis	
Emission impacts prior to use (modules A1–-5)	+ xxx $kgCO_2e/m^2/year$
Emission impacts during use (modules B3–-4, B6)	+ xxx $kgCO_2e/m^2/year$
Emission impacts after use (module C)	+ xxx $kgCO_2e/m^2/year$
Emission impacts beyond the building life cycle (module D)	-/+ xxx $kgCO_2e/m^2/year$
Carbon footprint (life cycle modules A–C total)	+ xxx $kgCO_2e/m^2/year$
Carbon handprint (life cycle modules A–D total)	- yyy $kgCO_2e/m^2/year$
Analysis and input data	
Details of the person responsible for the analysis	- Name - Education - Date of preparing the analysis - Date of updating the analysis
Input data of the analysis	- Details of which parts of the calculation have made use of the tables of values and which are an exact calculation - Used environmental product declarations - Stage when preparing the analysis (building per-mit / implementation) - Calculation software used - Possible observations concerning the reliability of the data
Scenarios used in the analysis (no need to report on this if the tables of values in the appendices are used)	- Transportation distances (A4, C2) - A5 Construction work - B3-4 Repairs and replacements - B6 Operational energy use - C End of life cycle - D Impacts external to the life cycle

6b. Minimum content of reports on the whole life carbon assessment of refurbishments

Basic information on the analysis site	
Information about the construction site	- Building code - Address - Building type - Year of construction
Technical details of the building	- The available and changed floor area - Number of floors - Number of cellar floors - Primary frame material - Energy class before and after a renovation and estimated consumption of delivered energy.
Results of the whole life analysis	
The emission impacts of refurbishment (module B5, including the manufacture of building materials, transportation, construc-tion, demolition and waste management)	+ xxx $kgCO_2e/m^2/year$
Emission impacts during the operation of the refurbished build-ing (B6, future modules B3–-4)	+ xxx $kgCO_2e/m^2/year$
Emission impacts after the use of the refurbished building (module C)	+ xxx $kgCO_2e/m^2/year$
Emission impacts beyond the building life cycle (module D)	-/+ xxx $kgCO_2e/m^2/year$
Carbon footprint (life cycle modules A–C total)	+ xxx $kgCO_2e/m^2/year$
Carbon handprint (life cycle modules A–D total)	- yyy $kgCO_2e/m^2/year$
Analysis and used data	
Details of the person conducting the analysis	- Name - Education - Date of preparing the analysis - Date of updating the analysis
Input data of the analysis	- Details of which parts of the calculation have made use of the tables of values and which are an exact calculation - The used environmental product declarations - Stage when preparing the analysis (building permit / implementation) - Used calculation software - Possible observations concerning the reliability of the data
Scenarios used in the analysis (no need to report on this if the tables of values in the appendices are used)	- B3-4 Repairs and replacements, including transportation distances - B6 Operational energy use - C End of life cycle - D Impacts external to the life cycle

Appendix 7. Form for reporting the quality of the input data in the analysis

The quality of the data is assessed on a scale of 0-3 in accordance with the Level(s) system of the European Commission (see next page).

Life cycle modules	Technological representativeness	Geographical representativeness	Temporal representativeness	Uncertainty	Total	Minimum requirements
A1-3 Manufacture of products						Data at least on level 2.
A4 Transportation to site						Geographical representativeness must be at least at level 3.
A5 Construction site						Geographical representativeness must be at least at level 2.
B3-4 Repairs and replacements						Geographical representativeness must be at least at level 2.
B6 Operational energy use						Data at least at level 2.
C1 Demolition work						No minimum requirements
C2 Transportation to further processing						No minimum requirements
C3 Waste processing						No minimum requirements
C4 Final disposal						No minimum requirements
D Impacts external to the life cycle / carbon handprint						The data on products containing carbon storages or binding carbon at least at level 2. No other minimum requirements.
Total						

The classification of the input data in the calculation

	0	1	2	3
Technological representativeness	Not assessed	Data does not sufficiently correspond to the technical specifications of the product.	Data partly corresponds to the technical specifications of the product.	The used data corresponds well to the technical specifications of the product.
Geographical representativeness	Not assessed	The data refers to a completely different geographical context (e.g. Italy instead of Finland).	The data refers to a similar geographical context (e.g. Norway instead of Finland).	The used data refers to a specific geographical context.
Temporal representativeness	Not assessed	There is a period of more than six years between the validation and utilisation of data.	There is a period of two to four years between the validation and utilisation of data.	There is a period of less than 2 years between the validation and utilisation of data.
Uncertainty	Not assessed	Modelled or equivalent data are used. Accuracy and precision have been qualitatively assessed (e.g. an expert judgement by a supplier and process operator).	Modelled or equivalent data are used, whose accuracy and precision have been evaluated as satisfactory, and this is supported by a quantitative uncertainty analysis.	Project-specific and validated data are used, whose accuracy and precision have been evaluated as satisfactory (e.g. a completed and verified environmental product declaration has been issued).

This publication describes the first version of a method employed in Finland for the whole life carbon assessment of buildings. The method is based on the European Commission's Level(s) method and European Standards.

A low-carbon building has a low carbon footprint and a big carbon handprint. The whole life assessment covers a building's entire life cycle. It includes the manufacture and transportation of the products used in a construction project, the worksite, the use and maintenance of the building, its demolition, and recycling.

The method is intended to be used for the assessment of the carbon footprint and carbon handprint of new buildings and buildings undergoing extensive repairs.

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