Study for the application of assessment principles for the carbon footprint of construction works in Estonia

FINAL REPORT

31.12.2021

Kalamees, Targo

Kertsmik, Kadri-Ann

Kurnitski, Jarek

Lylykangas, Kimmo

Oviir, Anni

Pasanen, Panu

Tikka, Sara

Euroopa Liit
Euroopa
Regionaalarengu Fond

Eesti
tuleviku heaks

ABSTRACT

This report summarizes the results of the project „Study for the application of assessment principles for the carbon footprint of construction works in Estonia“ („Uuring ehituse süsinikujalajälje hindamisprintsiipide rakendamiseks Eestis“) in 2021. The project was commissioned by the Estonian Ministry of Economic Affairs and Communications and co-financed by the RITA programme. The project was carried out by the researchers of TalTech and the experts of the Finnish company One Click LCA.

Carbon footprint of a building quantifies the global warming potential (GWP) over the life of the building through life cycle assessment (LCA). The purpose of the report and the nine annexes is to establish an initial Estonian methodology that can be introduced to the Estonian construction sector, tested and developed further. The proposed calculation methods are straight-forward and apply simplified default values.

The proposed calculation method is based on the European standards EN 15804 and EN 15978, the European Level(s) framework and the international best practise on carbon footprint assessment. Furthermore, the methodological approach takes into consideration the European Taxonomy regulation which entered into force on 12 July 2020. Despite the European standardization, there are differences between the carbon footprint methodologies of the EU member states. The report includes a comparative analysis of the carbon footprint regulation in six European forerunner countries. In the proposed methodology, the significant exceptions from the relevant European standards are 1) the method applies a scenario for the CO_2e emissions for energy carriers; and 2) tenant electricity (plug-in electricity) is included in delivered energy.

According to the proposed method, the carbon footprint of a building is the sum of the results from modules A1–A5, B4, B6, and C1–C4. The module D is calculated and reported, but not included in the carbon footprint. The reason for excluding some modules at the initial phase of the method development is the lack of data and their minor impact on the calculation result.

This report also provides the necessary default values and a dataset with CO_2e emission factors for 47 construction materials manufactured in Estonia, which form a basis for the Estonian database on the CO_2e emission factors of construction materials. It applies the most relevant scenario (Mändmets & Štõkov 2021) for the CO_2e emission factors of the energy carriers in Estonia.

The proposed assessment scope covers the most important CO_2e emissions. The rationale behind including an extensive number of modules already in the initial version of the method is to provide a complete picture of the emission sources and the climate impacts of Estonian buildings. Moreover, adding modules later in the assessment framework would cause confusion and change the results as well as the possible limit values set by the regulation.

The method was tested by calculating the carbon footprint for five case study buildings. The project also created a simple MS Excel calculator for demonstrating the proposed methodology.

The project also outlines the implementation of the carbon footprint assessment in regulation. The scope of the assessment is proposed to be specified as a new section in MKM's regulation/act No 58. The report includes a proposal for the wording of the extension.

The new regulation is expected to have the following impacts: a) Estonian material manufacturers develop their processes towards lower CO_2e emissions intensity; b) Low-carbon materials and solutions are preferred in building design and construction processes; c) the practise of carbon footprint assessment is expected to raise the general awareness of the climate impact of construction works within the Estonian construction sector.

The needs for further development include a.o. 1) revision of the scenarios for the CO_2e emission factors of the carriers of energy in Estonia; 2) development of the data and the calculation principles for category D (impacts beyond system boundary) emissions to include also biogenic carbon storage; and 3) study on benchmarks and possible limit values based on a sufficient number of calculation results. According to the proposal, the Estonian methodology could maintain the proposed scope but later develop further the calculation methods, the default values as well as the Estonian database on the construction materials. Before collecting calculation results, the CO_2e emission factors of the energy carriers need to be updated, as operational energy has a major impact on calculation result. The initiatives aiming at harmonization among the Nordic countries and within the EU member states, such as the Level(s) framework, the Taxonomy regulation and the Energy Performance of Buildings directive should be followed and, if necessary, responded to in the method development.

Authors

Kalamees, Targo	TalTech
Kertsmik, Kadri-Ann	TalTech
Kurnitski, Jarek	TalTech
Lylykangas, Kimmo	TalTech
Oviir, Anni	TalTech
Pasanen, Panu	One Click LCA Ltd (Bionova)
Tikka, Sara	One Click LCA Ltd (Bionova)

Steering group

Jaanisoo, Ivo	MKM
Rass, Jüri	MKM
Seinre, Erkki	MKM
Talve, Siret	MKM
Vahtraorg, Julia	MKM

Tallinn, Estonia, January 2022.

ABBREVIATIONS

AR5	IPCC Fifth Assessment Report
CCI-EE	The Estonian construction classification system
CO_2	Carbon dioxide
CO2data.fi	Finnish database maintained by the Finnish Environment Institute (SYKE).
CO_2e	Carbon dioxide equivalent of greenhouse gases
ecoinvent	A life cycle inventory database maintained by a Swiss-based non-profit organization ecoinvent
GaBi	A life cycle assessment tool and a life cycle inventory database developed and maintained by the US-based software provider Sphera
EN 15804+A2:2019	Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products
EN 15978:2011	Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method
EN 16258:2012	Methodology for calculation and declaration of energy consumption and GHG emissions of transport services (freight and passengers)
EPBD	Energy Performance of Buildings Directive
EPD	Environmental product declaration
GHG	Greenhouse gas
GLA	Greater London area
GWP	Global warming potential; a relative measure of how much heat a greenhouse gas traps in the atmosphere. The global warming potential is calculated in carbon dioxide equivalents meaning that the greenhouse potential of emission is given in relation to CO2. Since the residence time of gases in the atmosphere is incorporated into the calculation, a time range for the assessment is defined to be 100 years.
HBEFA	Handbook Emission Factors for Road Transport
IEA	International Energy Agency
IPCC	Intergovernmental panel on climate change
LCA	life cycle assessment
LCI	life cycle inventory
MKM	Ministry of Economic Affairs and Communications
NECP 2030	Estonian national energy and climate plan
RQ	research question
WP	work package
RITA	A programme supported by the European Regional Development Fund
RT	*Riigi Teataja*, publication issued by the Estonian Ministry of Justice
SI	Système International D'Unités, International System of Units
VBA	Visual Basic for Applications, the programming language of Excel

TABLES

FIGURES

CONTENTS

1. INTRODUCTION

This report summarizes the results of the project „Study for the application of assessment principles for the carbon footprint of construction works in Estonia“ („Uuring ehituse süsinikujalajälje hindamisprintsiipide rakendamiseks Eestis“) in 2021. The project was commissioned by the Estonian Ministry of Economic Affairs and Communications and carried out by the researchers of TalTech and the experts of the Finnish concultancy One Click LCA.

Carbon footprint of a building quantifies the global warming potential (GWP) over the life of the building through life cycle assessment (LCA). The purpose of the report and the nine annexes is to establish an initial Estonian methodology that can be introduced to the Estonian construction sector, tested and developed further. The proposed calculation methods are straight-forward and apply simplified default values.

1.1 THE OBJECTIVES OF THE PROJECT

The objectives of the project were:

- To develop the Estonian method to assess the carbon footprint of construction works, based on the standard ISO 14040, the European standards on the assessment of environmental sustainability (EN 15978, EN 15804), and the Level(s) framework. The method is demonstrated in a simple calculator which provides an estimate of the life cycle CO_2e emissions of construction works.
- To create a structure for the Estonian database on the CO_2e emissions of construction materials and define generic emission factors for the main construction material categories.
- To define the details of the regulatory framework for the implementation of the national requirements on the carbon footprint of construction works, and
- To outline the policies needed to improve the competitiveness of the Estonian construction sector in their key export market area.

1.2 RESEARCH QUESTIONS

The project focused on the following research questions:

RQ1.1: What are the similarities and the differences (country-specific features) of the carbon footprint regulation in other countries that have already applied or prepared a national regulation?

RQ2.1: How should the international standards and frameworks on LCA and carbon footprint be applied in Estonia, in order 1) to ensure frictionless implementation and adoption in the construction sector; 2) to comply with the existing regulation, and 3) to have a significant impact on the reduction of CO_2e emissions of the building stock and on the competitiveness of Estonian manufacturers in export?

RQ3.1: What are the appropriate methods, taxonomies and structures for creating a national database for the CO_2e emission factors of construction materials? To what extent can the database be harmonized with the best practices from other countries?

RQ4.1: What is the expected impact of applying the proposed requirements on new and existing buildings and products?

RQ4.2: What are the limits and boundaries of the methodology?

RQ5.1: What are the appropriate pre-requisites and starting points for the environmental impact assessment of construction works in Estonia?

RQ5.2: What are the political and administrative steps and measures that should be taken to ensure the adoption of the new methods and procedures, and to improve the environmental performance of Estonian products and services to make them more competitive in their key export market areas?

RQ5.3: What are the necessary policy steps to ensure the compliance of Estonian construction material producers with neighboring countries?

Table 1 below shows the chapters and annexes of the report that respond to the research questions above.

Table 1. The report chapters and annexes that respond to the research questions.

RQ1.1: What are the similarities and the differences (country-specific features) of the carbon footprint regulation in other countries that have already applied or prepared a national regulation?	Chapter 2, Annex 1
• Which life cycle based environmental impact assessment tools are used in the reference countries (Finland, Sweden, Norway, Denmark, France and the Greater London Area)?	Chapter 2, Annex 1
• What are the proposed practices and requirements of the main export markets (Nordic countries) for the environmental impact of construction works?	Chapter 2, Annex 1
• How widely have the relevant requirements been implemented (% of the construction volume)?	Chapter 2, Annex 1
• What are the performance requirements and the possible requirements for the tool validation / for the competence of the expert who carries out the assessment?	Chapter 2, Annex 1
• Which databases are applied?	Chapter 2, Annex 1
• How do the quantitative requirements differ between building types?	Chapter 2, Annex 1
• How does the Level(s) framework for assessment and reporting relate to the export market practices?	Chapter 2, Annex 1
RQ2.1: How should the international standards and frameworks on LCA and carbon footprint be applied in Estonia, in order to	Chapter 3.1, Annex 2, Annex 8
1) ensure frictionless implementation and adoption in the construction sector;	Chapter 5.4
2) comply with the existing regulation	Chapter 5.2, Annex 8
3) have a significant impact on the reduction of CO_2e emissions of the building stock and on the competitiveness of Estonian manufacturers in export?	Chapter 5.3
RQ3.1: What are the appropriate methods, taxonomies and structures for creating a national database for the CO_2e emission factors of construction materials?	Chapter 4.1
To what extent can the database be harmonized with the best practices from other countries?	Chapter 2, Chapter 4.1, Chapter 4.2
RQ4.1: What is the expected impact of applying the proposed requirements on new and existing buildings and products, including:	Chapter 5.4
• The scope of implementation of the new requirements	Chapter 3.1, Annex 2, Annex 8
• Implementation in public procurement	Chapter 5.2
• Process integration	Chapter 5.4
• Incentives	Chapter 5.5
• Restricting competition and enhancing innovation	Chapter 5.5
• The role of environmental product declarations (EPDs)	Chapter 4.3, Chapter 5.5
• Financial incentives based on the interview of at least three banks (LHV, Swedbank, SEB).	Chapter 5.5
RQ4.2: What are the limits and boundaries of the methodology, including:	Chapter 3.1, Annex 2, Annex 8
• Stages of life to be included	Chapter 3.1, Annex 2, Annex 8
• Impacts to be regulated	Chapter 3.1, Annex 2, Annex 8
• Implementation of the future prognoses (primarily on the grid electricity emission factor)	Chapter 3.1, Annex 2

• Service life to be applied	Chapter 3.1, Annex 2, Annex 8
• Possible reflections to the site, context and location.	Chapter 5.2
RQ5.1: What are the appropriate pre-requisites and starting points for the environmental impact assessment of construction works in Estonia, including:	
• Process integration	Chapter 5.4
• Creation and management of materials databases	Chapter 4.1, Chapter 6
• Access to EPDs (Estonian database or foreign databases)	Chapter 4,3, Chapter 5.5
• Mechanisms to promote low carbon solutions	Chapter 5.5, Chapter 6
• Other environmental impacts (other than CO_2e)	Chapter 6
• Circular economy considerations.	Chapter 6
RQ5.2: What are the political and administrative steps and measures that should be taken to ensure the adoption of the new methods and procedures, and to improve the environmental performance of Estonian products and services to make them more competitive in their key export market areas?	Chapter 6
• Expected impact of the new regulation and practices	Chapter 5.3
• Scope of implementation	Chapter 3.1, Annex 2, Annex 8
• Implementation in public procurement	Chapter 5.2
• Integration into the building permission procedure	Chapter 5.2, Annex 8
• Incentives for better performance	Chapter 5.5, Chapter 6
• Restricting competition and encouraging innovation	
• The role of EPDs	Chapter 4.3, Chapter 5.5
• Financial incentives, including an interview with at least three banks (LHV, Swedbank, SEB).	Chapter 5.5
RQ5.3: What are the necessary policy steps to ensure the compliance of Estonian construction material producers with neighboring countries?	Chapter 6
• Relation of carbon footprint to EPDs	Chapter 4.3
• Access to EPDs	Chapter 4.3
• Creation and management of the EPD database	Chapter 4.3
• Support mechanisms to enhance EPDs.	Chapter 4.3, Chapter 5.5

2. COMPARATIVE ANALYSIS

The comparative analysis of six European carbon footprint regulation systems is Annex 1 of this report. The results are summarized in Table 2.

Table 2. The key findings of the comparative analysis of carbon footprint regulation in six European countries.

	DENMARK	FINLAND	FRANCE	GLA, UK	NORWAY	SWEDEN
Status of Regulation	Test phase	Awaiting legislation	In force	In force	Awaiting legislation	In force
Regulation timing	2023	Estimated 2024	January 2021	March 2021	January 2022, 1 year transition	January 2022
New or revision	New	New	Revision of energy code	Revision of London Plan	Revision of energy code	New
LCA Methodology	Sustainability class	Climate declaration	RE2020	WLC Assessment	Simplified NS 3720: 2018	Klimat-deklaration 2022
Methodological Standard Alignment	EN 15978	EN 15978	EN 15978 w/ deviations	EN 15978	EN 15978 / NS 3720	EN 15978
Limit values	2023 for >1000 m², 2025 for all	Expected 2025	Yes	No	No	Expected in 2027
Enforcing time	Construction permit and completion	Construction permit	Construction permit	Pre-application, planning submission & post-construction	Upon completion	Before completion
Life-cycle stages included in assessment	A1–A5 B4 B6 C3–C4 D	A1–A5 B4 B6 C1–C4 D	A1–A5 B1–B5 B6–B7 C1–C4 D	A1–A5 B1–B5 B6–B7 C1–C4 D	A1–A3 B4–B5	A1–A5
Assessment period	50 years	50 years	50 years	60 years	60 years	Completion only – 0 yrs
Unit for reporting	$kgCO_2e$/(m²a)	$kgCO_2e$ /(m²a)	$kgCO_2e$, kg CO_2e/m² & $kgCO_2e$/occupant	$kgCO_2e$ & $kgCO_2e$/m²	Undefined	$kgCO_2e$/m²
Biogenic carbon storage	Yes	Yes	Yes	Yes	Yes	No
Carbon handprint	No	Yes	No	No	No	No

Product standard alignment	Version undefined	EN 15804 +A2	EN 15804 +A1	EN 15804 +A1 & +A2	EN 15804	EN 15804 +A1 & +A2
Government generic data	No	Yes	Yes	No	No	Yes
Market data allowed	Yes	Yes	Restricted	Yes	Yes	Yes
Market data requirements	EN 15804	EN 15804 +A2	EN 15804, EN 50693	EN 15804, ISO 21930, ISO 14067, ISO 14025, ISO 14040, ISO104044 PAS 2050	EN 15804	EN 15804 +A1 & +A2
Source of energy data	National scenarios	National scenarios	Inies, Ministry of environment scenarios	National Building regulation, Future energy gov	Not relevant	Not relevant

There are multiple differences between the regulatory frameworks, national methodologies, and their current development stages. National regulations aim towards clarifying and facilitating life cycle assessments in national markets. They have also increased the amount of data disclosed and the knowledge on life-cycle accounting and emissions of built environment in the market. They have also altered material procurement and thus increased demand for transparency on environmental performance of construction products as well as increased demand for low-carbon construction products. The limit values set in some national regulations have not been widely implemented yet.

However, there are some downsides to national regulations, especially if they differ greatly from the underlying European standards. This can be especially seen in the French regulation that can be seen to create barriers to global trade with its restrictions on market data used in life cycle assessment. As the French methodology only accepts EPDs published by the French Program Operator, they have excluded any company not publishing in French outside of their market scope.

Where the underlying standard is the same in all compared national methodologies, and the frameworks are similar with the European Commission's Level(s) framework, there are deviations between national methodologies and Level(s). As national methodologies are equally recognized, this does not pose significant problems. However, some scopes of assessments are relatively simpler than others, especially in terms of building elements and life cycle stages assessed. This may cause some distortion in knowledge.

3. METHOD AND TOOL DEVELOPMENT

3.1 METHOD DESCRIPTION

The introduction of the carbon footprint calculation methodology aims at reducing the greenhouse gas emissions of the Estonian building stock, increasing the awareness of the climate impacts of built environment and supporting the competitiveness of the Estonian construction industry by developing the environmental performance of products. The methodology can be applied to all types of buildings. It can also be applied to renovations and construction works with minor adjustments.

The purpose of this proposal is to establish an initial methodology that can be introduced to the Estonian construction sector, tested and developed further. The proposed calculation methods are straight-forward and apply simplified default values.

According to this proposal, life cycle carbon footprint is calculated as cradle to gate with options, modules A4, A5, B4, B6, C1–C4 and D according to EN 15804+A2:2019 standard. The assessment scope is provided in Table 3.

The rationale behind including an extensive number of modules already in the initial version of the method is to provide a complete picture of the emission sources and the climate impacts of Estonian buildings. Furthermore, adding modules later in the assessment framework might cause confusion. Therefore, the future development of this methodology could maintain the proposed scope but update the calculation methods and the default values as well as develop further the database on the construction materials. The first priority is to update the scenarios for the CO_2e emission factors of the energy carriers, especially grid electricity, as the scenarios have a major impact on the calculation result. The on-going initiatives aiming at harmonization among Nordic countries and among the EU member states, as well as the developments of the Level(s) framework, Taxonomy regulation and the Energy Performance of Buildings directive should be followed and, if necessary, reacted on in the method development.

Before considering any limit values, the method needs to be tested and a sufficient number of calculation results collected on all building types. All support mechanisms generating more environmental product declarations for Estonian products would be welcome, as they also provide more information to base the generic emission factors on.

The carbon footprint methodology is based on the life cycle assessment (LCA) in accordance with ISO 14040 as illustrated in the Figure 1. The method is aligned with the European Standards EN 15804+A2:2019 and EN 15978, the European Level(s) framework and with international best practice. Furthermore, the methodological approach takes into consideration the European Taxonomy regulation which entered into force on 12 July 2020 (EU 2020/852).

The significant exceptions from the relevant European standards are:

- The method applies a scenario for the CO_2e emissions for energy carriers[1].
- Tenant electricity (plug-in electricity) is included in delivered energy[2].

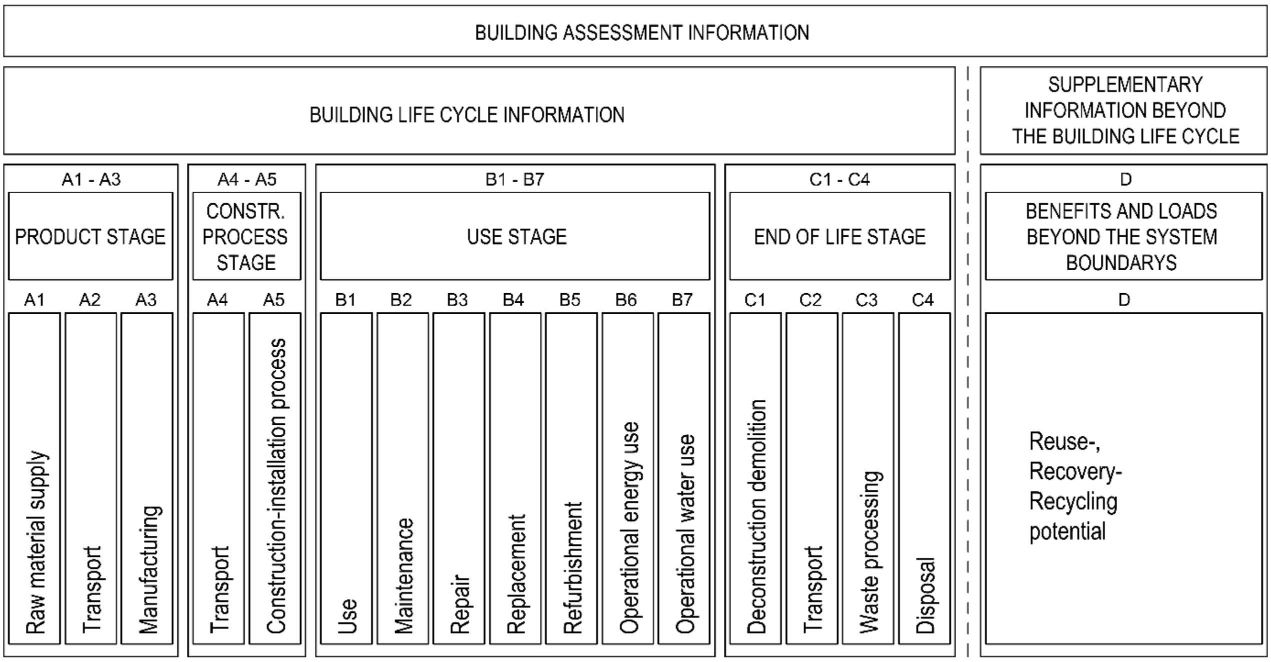

Figure 1. The LCA framework according to the standard EN 15804+A2:2019.

[1] According to Energy Performance of Buildings Directive and EN 15978, the CO_2e emission factor for a each energy carrier is constant over the assessment period.

[2] According to Energy Performance of Buildings Directive and EN 15978, tenant electricity is not included in delivered energy.

Table 3. The proposed scope of assessment.

Stage	Scope	Definition	Explanation
A1–A3 Product stage	X	'Cradle-to-gate' emissions from materials and services used in construction.	Key source of emissions
A4 Transport to construction site	X	Emissions from the transport of building materials to the building site.	Allows distinguishing source of supply
A5 Construction site	X	Material wastage on the construction site.	Wastage is relevant
B1 Use	-	Refrigerant leakages during use of the building	Data not available, minor impact
B2 Maintenance	-	The maintenance of construction products.	Data not available, minor impact
B3 Repair	-	The repair of construction products.	
B4 Replacements	X	Replacement of building materials	Default value
B5 Refurbishments	-	Planned refurbishments for the building.	Major renovations not expected during the assessment period (50 years)
B6 Operational energy	X	Operational delivered energy used by the building's technical systems	Key source of emissions
B7 Operational water	-	Water used and its treatment.	Very low impact
C1 Demolition	X	Demolition of a building	Default value
C2 Transport	X	Transportation of building waste to the waste processing facility or to landfilling	Default value
C3 Waste processing	X	Processing of construction waste to the end-of-waste state	Allows distinguishing between three material categories
C4 Final disposal	X	Final disposal, landfilling	Default value
D Benefits - Beyond system boundary	X	Net environmental benefits or loads from recycling, reuse and energy recovery.	Supports circularity strategies and reuse

The proposed method will consider only the Global Warming Potential (GWP) indicator measured in kgCO_2-equivalents.

Carbon footprint is the sum of the results from modules A1–A5, B4, B6 and C1–C4. Additionally module D is reported.

In general, the global warming potential of the greenhouse gas emissions is calculated as activity data x emission factor. The carbon footprint assessment includes three main types of calculations:

- CO_2e emissions from materials: mass of the material (kg) x emission factor (kgCO_2e/kg)
- CO_2e emissions from energy use: delivered energy (kWh/m²a) x emission factor (kgCO_2e/kWh)
- CO_2e emissions from transportation: mass (kg) x transportation distance (km) x emission factor (kgCO_2e/tkm).

Material-related emission factors: this project has specified the CO_2e emission factors and the necessary default values for 47 construction materials manufactured in Estonia (see Chapter 4). These are presented in Annex 6. The methodology for defining the emission factors is presented in Annex 7.

A database on the CO_2e emission factors for Estonian construction materials is a crucial component for the method. As the number of environmental product declarations for Estonian products is still very limited, the generic CO_2e emission factors were at this stage localized from the foreign database values, mainly from the Finnish *CO2data.fi* database, as the range of products and construction materials is very similar in Estonian and Finnish buildings. The updates will be needed when the energy used in the processes decarbonizes and more information on the Estonian construction materials and products is available.

For imported construction materials, the values of the foreign databases, such as the Finnish *CO2data.fi* database, can be applied. Product-specific values from foreign and Estonian Environmental Product Declarations (EPDs) can also be applied when the specific product is known. The addition of A2 in the EN 15804 standard in 2019 introduced some changes for environmental product declarations. As most of the Estonian EPDs were created after 2019, this is not an issue for the collection of Estonian data. When using EPDs from foreign databases, EPDs in accordance with EN 15804+A2:2019 should be prioritized.

Energy-related emisson factors: the proposed method applies the Estonian scenario for CO_2e emission factors for energy carriers (Table 4, Figure 2). Revised scenarios for the energy carriers listed in MKM No 63 needs to be created, because the current data is not complete and the existing scenario is not in line with the climate neutrality commitment.

Energy scenarios tend to vary in their assumptions considering the future developments. The standard EN 15978 instructs to use no scenario at all. The Level(s) framework applies linear scenarios. Denmark applies so called WEM scenario (with existing measures) that shows a declining emission factor for the grid electricity until 2030, without any assumptions on the future decisions after that. The most recent Finnish and Estonian scenarios are so called WAM scenarios (with additional measures). WOM (or WM) refers to a future projection «without measures». (UNFCCC 2016)

Obviously, any future projection reaching further than 10 years includes high uncertainty. The European Commission applies the PRIMES model[3] in producing future scenarios.

The emission factor for grid electricity shall include the Estonian energy production that is constantly changing by the demand and pricing, as well as imported and exported electricity. Thus, the national scenario on the grid electricity will need to make assumptions also on the grid electricity developments in export countries.

Table 4. Estonia's electricity and district heating CO_2 equivalent emission factor scenario until 2070 (Mändmets & Štõkov 2021).

tCO_2e/MWh	2020	2025	2030	2035	2040	2045	2050	2055	2060	2065	2070
Grid electricity	0.717	0.637	0.509	0.425	0.359	0.344	0.32	0.27	0.22	0.17	0.11
District heating	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11

[3] The PRIMES model is an EU energy system model which simulates energy consumption and the energy supply system. Decision making behaviour is forward looking and grounded in micro economic theory. The model proceeds in five year steps and is for the years 2000 to 2015 calibrated to EUROSTAT data.(https://ec.europa.eu/clima/eu-action/climate-strategies-targets/economic-analysis/modelling-tools-eu-analysis_en)

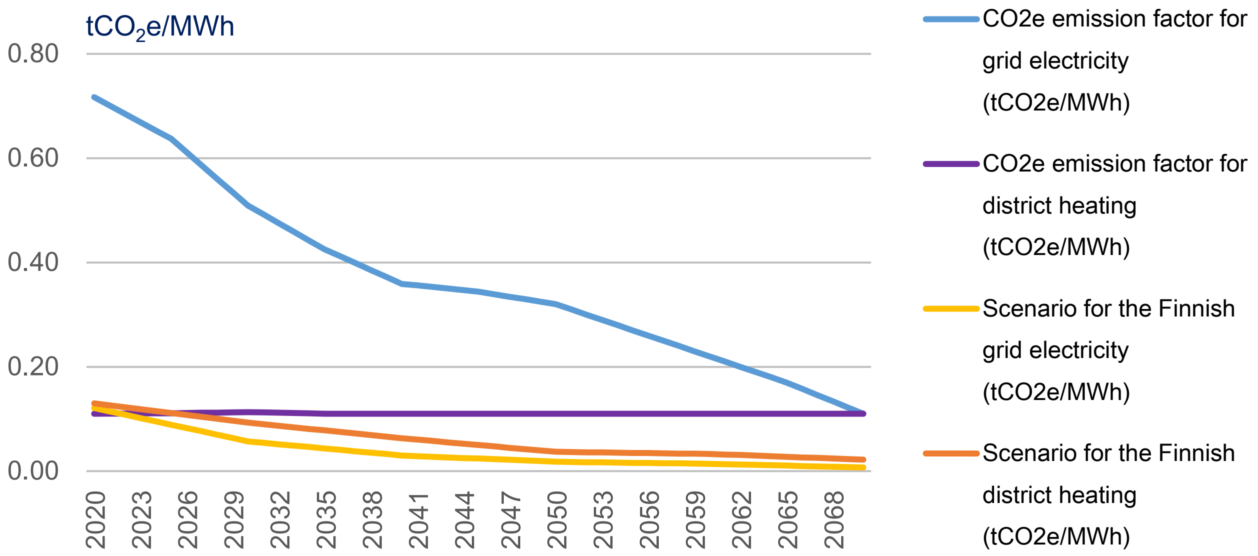

Figure 2. Scenarios for grid electricity (blue line) and district heating (purple line) in Estonia[4] (Mändmets & Štõkov 2021).

Transport-related emission factors: The GHG emissions for transportation are calculated as tank-to-wheel emissions (e.g. tailpipe emissions). As a default, the proposed method applies the road transport emission factors from the Finnish LIPASTO database[5]. This is justified, as the road transport vehicle fleet is dominated by diesel engines in both countries.[6] The LIPASTO emission factors were last updated in 2017, and VTT plans to close the database in 2022.

An alternative source for defining transport emission factors is for example *Handbook Emission Factors for Road Transport* (HBEFA) that provides emission factors for all current vehicle categories[7]. The CO_2e emission factors for the national car fleet can also be modelled with the COPERT[8] tool that is a globally used software for calculating air pollutant and greenhouse gas emissions produced by road transport. The scientific development of the COPERT tool is managed by the European Commission.

[4] The Finnish energy scenarios (2019) are displayed in yellow and orange for comparison.

[5] http://www.lipasto.vtt.fi/yksikkopaastot/indexe.htm

[6] The share of diesel engines in the medium and heavy commercial vehicles fleet is 97.7% in Finland and 85% in Estonia. 14.8% of the Estonian medium and heavy commercial vehicles have petrol engines. This share does not make a major difference in the average CO_2e emission factor. The average age of the medium and heavy commercial vehicles is 13.9 years in Finland and 18 years in Estonia. (ACEA 2021). The assumptions on the driving profiles (highway driving/street driving) cause much higher uncertainty than the differences in vehicle fleets.

[7] https://www.hbefa.net/e/index.html

[8] https://www.emisia.com/utilities/copert/

The proposed emission factor will turn conservative by the time, but is not likely to be outdated very soon. Based on the ALIISA2019 model, VTT's LIPASTO database file on the future projections assumes only a 18.8% reduction in the fuel consumption of diesel trucks in 2021–2050[9].

More radical changes in the average emission factor may occur if the share of electricity or alternative fuels increases in road transport fleet propulsion. The CO_2e emission factors of electric vehicles are dependent on the grid electricity emission factor.

Instructions for more detailed calculation are provided in the standard EN 16258:2012 and the guide "Calculating GHG emissions from freight forwarding and logistics services in accordance with EN 16258. Terms, Methods, Examples." (Schmied et al. 2012).

The assessment shall be carried out for a reference service life of 50 years for all building types.

The key inputs for carbon footprint calculation are

- Materials quantities (m^2, m^3)
- Delivered energy by energy carrier (kWh/m^2a[10]).

Materials quantities are collected as a bill of materials that includes also an assumption of material wastage, which is assessed as part of the A1–A3 life cycle stage. Delivered energy is calculated as for the energy certificate.

Annex 2 provides a detailed description of the calculation.

3.2 TOOL DEVELOPMENT

Following the task description of the assignment, the project created a simple MS Excel calculator to demonstrate the proposed methodology. The tool is not designed to compete with the commercial life cycle assessment (LCA) tools but rather to familiarize the users with the LCA approach and to demonstrate the Estonian carbon footprint calculation method for construction works. Therefore the tool is designed to make the calculation as transparent as possible. To make testing easy, the tool asks for a minimum number of inputs to get started. More project information will be asked step-by-step, as the user proceeds with the assessment.

[9] keskikulutus_avg_consumption_timeseries_2021_2050_ALIISA2019.xlsx (live.com)

[10] Unit refers to heated floor area.

The tool includes a separate worksheet with user guidance. All the calculation modules are equipped with a "+" button that opens a set of new rows explaining how each module is calculated.

The key inputs are:

- The quantities (m^3) of construction materials (bill of materials)
- The delivered energy by energy carrier.

Bill of materials is usually exported from the building information model in a design software. The list can be exported from the design software as an Excel spreadsheet. The Excel table including the material names and the quantities is copied and pasted into the calculator on the "Import" worksheet. The tool has also a sketching worksheet that can be used for comparing alternative solutions in an early stage of the design process.

Delivered energy is calculated as for the energy certificate. The delivered energy for heating of spaces and water as well as electricity needs to be simulated or estimated in another tool, as delivered energy cannot be calculated in this tool. The current Estonian scenario on energy is displayed on the worksheet "Energy". The current scenario reaches until 2070, after which the emission factor is assumed to remain on the same level.

The calculation period is selected in module B6. The Estonian method applies the calculation period of 50 years. With the tool it is possible to test the impact of various calculation periods.

The tool enables the comparison of five alternative versions. The tool has specific worksheets with a lay-out for printing results or comparisons on paper.

The tool can be used in Estonian, English or Finnish. The language is selected on the first page and it can be changed any time without any impact on the actual calculation.

The tool applies the standard functionalities of MS Excel. The version control and the action buttons apply macros with simple VBA scripts.

Carbon footprint calculator is Annex 3 of this report. Annex 4 is the user manual that explains the functionalities of the calculator. Annex 5 is a video guide on the use of the tool.

3.3 CASE STUDIES

The project conducted carbon footprint analyses of five Estonian case studies (Table 5). The purpose of the case study analysis is to test the proposed Estonian method (as defined in the Chapter 3.1, Annex 2 and

Annex 8) on real projects. For comparison, the calculation was carried out using the Estonian method, the Level(s) method and the method by the Finnish ministry of environment in the One Click LCA tool. The modules included in these methods are presented in Table 6. Table 7 shows the calculation results. The results are compared by each calculation module (based on EN 15978) to validate the method and the underlying database.

Table 5. Case studies.

Case-study	Building type	new or renovation	size m^2		load-bearing structure
			total floor area	heated floor area	
Maardu	day-care centre	new, 2018	1320	1060	timber
Sõpruse	apartment building	new, 2017	6800	6373	concrete, steel
Mäemaja	educational building	renovation 2021 built 1986	4068	3406	timber
Kuuma	apartment building	renovation 2021 built 1986	3260	1887	large panel
Pärnu	public building	new, 2021	12224	11761	concrete, steel

Table 6. Modules covered in three different methods.

<table>
<tr><th>Methodology comparison</th><th>Modules</th><th>Level(s)[11]</th><th>Low-carbon (FI)</th><th>Hoone süs kalk (EST)</th></tr>
<tr><td>Product stage</td><td>A1–A3</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Transport to site</td><td>A4</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Construction site</td><td>A5</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Repair</td><td>B3</td><td>✓</td><td>-</td><td>-</td></tr>
<tr><td>Replacements</td><td>B4</td><td rowspan="2">✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Refurbishments</td><td>B5</td><td>-</td><td>-</td></tr>
<tr><td>Operational energy</td><td>B6</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Operational water</td><td>B7</td><td>✓</td><td>-</td><td>-</td></tr>
<tr><td>Demolition</td><td>C1</td><td rowspan="4">✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Transport</td><td>C2</td><td>✓</td><td>✓</td></tr>
<tr><td>Waste processing</td><td>C3</td><td>✓</td><td>✓</td></tr>
<tr><td>Final disposal</td><td>C4</td><td>✓</td><td>✓</td></tr>
<tr><td>Benefits</td><td>D</td><td>✓</td><td>✓</td><td>✓</td></tr>
</table>

Table 7. Five case-study result comparison between three different methods.

$kgCO_2e/(m^2a)$[12]	Level(s)	Low-carbon (FI)	Hoone süs kalk (EST)
Maardu	28.0	27.2	26.5
Sõpruse	27.5	26.3	28.2
Mäemaja	22.2	21.7	23
Kuuma	17.3	17.2	17.3
Pärnu	30.4	29.9	31.7

[11] Some Level(s) modules are excluded due to lack of data.

[12] Unit applies heated floor area.

Table 8. Comparison of Maardu case study building by life cycle module.

$kgCO_2e/(m^2a)$	**Level(s)**	**FI**	**EST**
A1–A3	6.4	6.2	6.5
A4	0.1	0	0.3
A5	1.7	1.8	0.5
B4	2.8	2.5	2.4
B6	16.3	16.3	16.3
C1–C4	0.8	0.7	0.6

Table 8 shows the results for each life cycle module for Maardu case study. In A1–A3 module Estonian method demonstrates slightly higher impacts than FI or Level(s) methods. This is likely due to the limited database that was used to define the material manufacturing impacts, developed within this project (Annex 6). The results are likely to be more similar once the Estonian database expands.The A4 module impacts are not assessed with the FI method, since it's using a default value. Compared with the Level(s) method Estonian method has much higher impacts in A4. This is expected since the proposed method suggests using conservative transportation distances if no actual data is available. At the early stage of the assessment it is justified to slightly overestimate the impacts, but also A4 module does not have proportionally high impacts. A5 module compared to other methods demonstrates lower impacts. This is most probably due to the fact that the other methods also include impacts related with energy and material consumption on site, whereas the Estonian method (at this stage) includes impacts related to material wastage, it's transportation, and end of life processing. The site impacts related with energy and auxiliary material consumption can be added in the later stage, however, further studies are required to determine the average scenario for site impacts Estonia. The B4 impacts are rather similar for all the methods. Slight deviation is most probably to do with the limitations of the database. C1–C4 impacts are also similar for all methods. Estonian method indicates here slightly smaller impacts, which is again probably to do with the database limitation. Annex 9 provides more detailed information on the case studies.

3.4 REPORTING

An underlying requirement to enforce a regulation that requires building CO_2e assessment is to ensure the good quality and comparability of the assessments. In principle there are two main paths to secure that – either the building CO_2e-assessor is qualified; or the assessments are verified by a third party. In the early adoption stage it is recommended to assess the quality of the assessment reports, that is assessments are verified by a third party. In order to do that efficiently, it is crucial to have a reporting system that would easily allow detecting any possible major errors in the calculation. During the calculation of the case studies for this study, a proposal for such reporting was drafted.

Such reporting should include, for example: bill of materials, list of assessed elements and their respective impacts, various graphs and images to demonstrate where the major impacts occur.

The amount of new material and a CO_2e data table that combines input and output data should be added to MKM Regulation No 58 (RT I, 09.06.2015, 21). These will follow the logic of current Lisa2[13] and Lisa4[14] that report important data in condensed and easy to read format. This can be a max two page breakdown of the inputs and results of the modules A–D.

A new report (certificate) sheet should be added to MKM Regulation No 36 (RT I, 06.05.2015, 2). This sheet reports the results of the life cycle assessment for each life cycle stage included in the assessment. The results shall be presented as totals for the whole building life-time as tonnes (without decimals) and in $kgCO_2e/(m^2a)$[15] with one decimal precision, where the total result is annualized for one year of the assessment period.

Carbon footprint of building materials and products in the life cycle stage A1–A3 shall be reported for the main construction work categories in total and specific values **per heated area** as specified in Table 10. Additionally, a printout of at least 20 materials with highest carbon footprint shall be provided from the calculation software. The A1–A3 impact derives directly from material quantities. Therefore this practise enables fluent checking and makes the quantification process more transparent.

The report sheet shall also include the basic information on building, assessor, date and other necessary information considering the applicability of input data in the Estonian regulatory context[16]. The report shall include the results in a table format. A proposed format outline is provided below in Table 9 and Table 10.

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[13] https://www.riigiteataja.ee/aktilisa/1220/8201/9005/MKM_11012019_m3_lisa2.pdf#

[14] https://www.riigiteataja.ee/aktilisa/1220/8201/9005/MKM_11012019_m3_lisa4.pdf#

[15] Heated floor area.

[16] For example the origin of the values for delivered energy, design stage, use of foreign database values.

Table 9. Carbon footprint of building materials and products in the life cycle stage A1–A3.

Construction work	**Carbon footprint *C*, tCO_2e**	**Specific carbon footprint *c*, $kgCO_2e/(m^2a)$**
Foundation, sub-surface, basement and retaining walls		
Columns and load-bearing vertical structures		
Floor slabs, ceilings, roofing decks, beams and roof		
External walls and facade		
Windows and doors		
Internal walls and non-bearing structures		
Other structures and materials		
Finishes and coverings		
Building systems and installations		
Total emissions		
Date	*Name*	*/signed digitally/*

Table 10. Results of the life cycle GHG emissions of building.

Life cycle stage	**Carbon footprint *C*, tCO_2e**	**Specific carbon footprint *c*, $kgCO_2e/(m^2a)$**
A1–A3 Construction Materials	1 575	9.0
A4 Transport	53	0.3
A5 Construction Site	63	0.4
B4 Replacement	189	1.1
B6 Operating Energy	4 725	2.,0
C1–C4 End-of-life	0	0.0
Building total (A+B+C)	**6 605**	**37.8**
D Beyond system boundary	-284	-1.6

In accordance with the SI system[17] guidelines, the units are written without spaces, and the use parenthesis is recommended for clarity (SFS 2013): tCO_2e/building and $kgCO_2e/(m^2a)$.

[17] Système International D'Unités, International System of Units.

4. CO_2e EMISSIONS FACTOR DATABASE

4.1 STRUCTURE OF THE ESTONIAN DATABASE

Material classification system helps to search and find materials from the material database. Table 11 shows the material classification systems in the Finnish and Swedish databases.

However when subjected to closer scrutiny, the structure of the material database does not have any impact on the building CO_2e-calculation method or its application. After investigating the CCI classification system, it's been concluded that this system does not contain a material classification that could be utilized in defining material scope for the CO_2e-calculation of construction works. Therefore, the material scope is defined through generic descriptions of building elements in the method description, which is a clear and simple way to communicate the assessment scope.

Classifying the materials in the proposed Estonian material database is still helpful, especially once the database expands. Therefore, it is suggested to follow *CO2data.fi* database classes. The *CO2data.fi* database is also the basis for the material emission factor calculation, which is why using such classes is a consistent approach. The proposed classes are as follows:

PRODUCTS

Steel and metals

Concrete

Insulation and water proofing

Solid wood

Mineral materials and glass (excluding concrete)

Floorings and surface materials

Infra, yard, and foundations

Supplementary products

HVAC products and electrical installations

SYSTEMS

Building services

The material structure is delivered as part of the Estonian material database where each resource has an attribute of material structure class.

Table 11. The main categories of the Finnish database[18] and Swedish database[19].

SYKE database, Finland	Boverket database, Sweden
PRODUCTS	
	Blocks and tiles
Insulation and waterproofing	Insulation
	Water proofing
Building boards	Building boards
Concrete	Concrete
Steel and metals	Steel and other metals
Solid wood	Solid woods
Mineral materials and glass (exl. concrete)	Mineral materials
	Windows, doors and glass
Floorings and surface materials	Paints and sealants
HVAC products and electric installations	
Supplementary products	
Infra, yard and foundations	
SERVICES AND PROCESSES	
Energy	Energy and fuel
Transportation	
Construction process	
Demolition process	
SYSTEMS	
Building services	
Service life	

18 https://co2data.fi

19 https://www.boverket.se/sv/klimatdeklaration/klimatdatabas/klimatdatabas/

4.2 CO_2e EMISSION FACTORS FOR MATERIALS

The Estonian database for construction material carbon footprinting consists of emission factors provided for 47 construction materials, and 6 emission factors for building services based on building use type. The emission factor has been defined for the indicator Global warming potential (GWP) which is given in the unit kgCO_2-equivalents (kgCO_2e).

Each value for construction material represents its manufacturing impacts per kilogram (1 kg) of material and values for building services represent impacts per square meter (1 m²) of building net floor area. The manufacturing impacts cover A1–A3 modules based on the standards EN 15804+A2:2019 and EN 15978:2011.

The method for determining the emission factors for building materials has been designed considering following design factors:

- **Representativeness.** The database is required to represent the market for construction products as they are used in construction projects in Estonia.
- **Consistency.** The database is required to be consistent, so that competition between materials is not distorted.
- **Time efficiency.** The database is required to be delivered at very limited time and expense.
- **Comparability.** The database is required to be overall comparable with the national generic databases, especially Finnish, Swedish and German databases for similar products.

The emission factors for materials are defined using Finnish material database *CO2data.fi*[20] as the basis on top of which an Estonian localisation factor is applied.

In very limited cases a dataset from One Click LCA generic database was found to better represent the impacts. The reason for using One Click LCA generic database instead in those cases is that the *CO2data.fi* database relies on Finland's average assumptions, which in some cases include materials that have relatively

[20] https://co2data.fi/

high secondary material content. In the carbon footprint accounting this results in much smaller impacts, which is why as a conservative substitute for such cases from One Click LCA generic database was used.

The first case study calculation and comparison with locally developed EPDs has indicated that for the cement based materials (cement and any concrete resources) the uncertainty factor of 30% shall be used instead of 20%.

The material dataset for the Estonian database is Annex 6 of this report. The method description with the background information for defining the values in the database are provided in Annex 7. The following section summarizes the content of the database.

For each row in the database are defined following attributes:

- **Material category:** defined for each material row based on the *CO2data.fi* database structure, as described in paragraph 4.1.
- **Material name:** in the first version of the database 47+6 material resource names are defined.
- **Sourcing region:** materials are sourced globally or locally.
- **Data source:** (an upstream) generic database where the emission factor is derived from (for the first version the *CO2data.fi* database or One Click LCA).
- **GWP in original database:** Global Warming Potential (unit $kgCO_2e$) of the resource in the Data source, after removing its uncertainty factor.
- **Uncertainty factor:** Uncertainty factor 20% is added to all locally sourced materials, except of cement based materials, where uncertainty factor 30% is used.
- **Estonian GWP:** Emission factor for Estonian material database, provided in $kgCO_2e$ per kg of material or per m² of building area for building technology. Any conversions shall be made in the calculator or manually.
- **Material wastage:** average material wastage at site, a value provided in percent (%)[21].
- **Service life:** The service life is derived from European databases on material longevity, expresses the interval for material replacement cycle.
- **End of life material class**: The C3 module impacts are assessed based on the material class. The Estonian material database is extended to include one of the following three classes for each material resource: mineral, wooden or metal materials.
- **End of life recycling rate:** the share of recycled material (based on End of life material class).
- **End of life disposal rate:** disposed material (based on End of life material class).

[21] Wastage percentages were defined for the material database in this project as an average from a large number of calculation cases collected by One Click LCA. Wastage percentages in the database need to be evaluated and, if necessary revised, when respective data from Estonia is available.

- **End of life benefits:** recycling or recovery benefits of the product after it's lifecycle considered in module D.
- **Mass conversion to m³**: conversion factor for materials into volume.
- **Mass conversion to m²**: conversion factor for materials into area (providing thickness in such case is mandatory).
- **Material thickness**: material thickness (in mm).
- **Material name in data source**: name of the original dataset in the upstream generic database (for the first version naming in the *CO2data.fi* database or One Click LCA).
- **Upstream database**: ecoinvent or GaBi, which are both LCI databases compliant with the standards used in Europe. In some impact indicators they may have some differences in the result, however, this is not impacting the GWP indicator where they are always comparable.
- **Plausibility analysis**: indicates if and how the resource has been analysed for plausibility.
- **Comment**: any additional comments or remarks relevant to the resource.

4.3 ENVIRONMENTAL PRODUCT DECLARATIONS

The research team proposes not to establish an Estonian register for Environmental Product Declarations (EPDs) at this stage. All EPDs created after 2012 are based on the standard EN15804 and despite the variation in scopes, the data provided by EPDs is applicable in any national carbon footprint framework. As it makes no difference if an EPD is collected from a foreign or a local database, and the maintenance of an EPD register requires resources and investments, it is difficult to see any added value in establishing a new Estonian EPD register. Most of the Estonian EPDs were created in recent years, thus following the standard EN 15804 update +A2:2019.

The publisher of an EPD has to pay a fee, but the use of EPDs is free of charge. According to a recent expert estimate, there are over 12000 verified environmental product declarations to EN 15804 for construction products registered globally at the start of January 2022. Globally, the number of EPDs totals over 80 000 (Anderson 2022).

Estonian product manufacturers can publish their EPDs in their export market area, for example in Finnish, Swedish and Norwegian EPD registers. ECO Platform[22] is an association of European construction product EPD Programmes that sets standards for verification and mutual recognition between programmes and

[22] https://www.eco-platform.org/list-of-all-eco-epd.html

provides member programmes with the opportunity to list EPDs on their website. The members of ECO Platform include the following European databases:

Austria: Bau EPD (https://www.bau-epd.at/epd/liste)
Belgium: B-EPD (FOD Volksgezondheid) (https://www.bau-epd.at/epd/liste)
Denmark: EPD Danmark (https://www.epddanmark.dk/uk/)
Finland: RT EPD (The Building Information Foundation RTS) (https://cer.rts.fi/en/rts-epd/)
France: FDES (Alliance HQE- GBC / Programme FDES INIES) (https://www.base-inies.fr/iniesV4/dist/consultation.html)
France: PEP EcoPassport (electronic items) (http://www.pep-ecopassport.org/find-a-pep/)
Germany: IBU (Institut Bau und Umwelt) (https://ibu-epd.com/en/published-epds/)
Ireland: EPD Ireland (IGBC) (https://www.igbc.ie/epd-search/)
Italy: EPD Italia (ICMQ) (https://www.epditaly.it/view-view-epd/)
Netherlands: MRPI (Milieurelevante Product informatie) (https://www.mrpi.nl/epd-certificaten/)
Norway: EPD Norge (Norwegian EPD Foundation) (https://www.epd-norge.no/?lang=en_GB)
Poland: ITB (https://www.itb.pl/epd.html)
Portugal: DAP Habitat (CentroHabitat) (https://daphabitat.pt/en_US/dap/dap-registadas/)
Slovenia: ZAG EPD (Zavod za gradbeništvo Slovenije) (http://www.zag.si/en/epd)
Spain (Catalonia): DAPconstrucción (CAATEEB)
Spain (national): Global EPD (Aenor)
Sweden: International EPD (EPD International) (https://www.environdec.com/library)
Switzerland: SÜGB (https://www.sugb.ch/dienstleistungen/umweltproduktedeklaration-epd/)
Turkey: EPD Turkey (https://epdturkey.org/en/urun-kategori/construction-materials/)
UK: BRE Verified EPD (BRE Global)

(Anderson 2020).

5. REGULATORY FRAMEWORK

5.1 COMPONENTS OF THE FRAMEWORK

A coherent practise for the assessment of the carbon footprint of construction works requires:

- Established LCA methodology with necessary guidance;
- Scenarios for energy carriers with updates every 5 years (if included in the method);
- Construction material database (with constant maintenance and development);
- Guidance and expertise on EPDs;
- Knowledge on benchmarks and limit values for the evaluation of results.

It is also necessary to have the Estonian method included in the tools applied for LCA analyses. Training activities are needed to ensure that the construction sector and experts can become acquainted with the method and to ensure that there are enough assessors and EPD experts available for the industry.

5.2 IMPLEMENTATION

The first steps of implementation should focus on promotion and testing of the proposed method as well as engaging Estonian construction industry in this work. Collection of calculation results from various kinds of projects and all building types should be arranged in a systematic way. However, the revision of the scenarios on the emission factors of energy carriers will change the range of results.

Public procurement can be a forerunner in the implementation of new practises and in the collection of results. Valuable datasets can be collected in architecture competitions, as the result displays the variation caused by the design solutions and material choices.

Implementation in the Estonian regulation can be done step-by-step. Public procurement could be a forerunner in the implementation. Including the carbon footprint assessment in architecture competitions would familiarize the architects with the method and generate benchmarks for results. A proposal to include carbon footprint assessment and the calculation method to existing regulation MKM nr 63, nr 58 and nr 36 is presented in Annex 8.

As a metrics, carbon footprint of a building typically omits the impact of location. Aspects of land use change and transportation emissions are usually included in the regional greenhouse gas analyses. Ideas of extending the scope of the evaluation or compatibility between building-scale GHG analyses and community-scale analyses should be further examined in research.

5.3 LIMIT VALUES

It is a good practise to estimate the carbon footprint of the whole life cycle, including all the modules with may have a significant impact on the result. This increases the understanding of the climate impacts caused by buildings and provides a proper understanding on the share of various parameters and design choices.

However, limit values can be set on some modules only. For example Sweden intends to apply limit values for the modules A1–A5, as this extends the regulation on construction materials. Operational energy use is already included in the regulation.

In their feedback on the Finnish carbon footprint regulation proposal, Finnish construction industry demonstrated with calculations that the possible limit values for the whole life cycle emissions would most likely cause changes in energy-related solutions, rather than material choices (Kemppainen 2021). This is a concern also in Estonia, where the module B6 on operational energy tends to dominate the results. Therefore, the Swedish model should be considered, when any decisions on the Estonian limit values are made.

Setting limit values requires a large number of calculation results from all types of buildings. Before collecting calculation results, the CO_2e emission factors of the energy carriers need to be updated, as operational energy has a major impact on calculation result. A practical solution for the systematic collection of reference results could be for example providing a free on-line calculator that collects anonymous reference data on the results. Another option is to first require a carbon footprint assessment in the building permission documentation without any limit values. Useful data can be also collected from architecture competitions, as it provides a range of results on one single building type.

5.4 EXPECTED IMPACTS

The new regulation is expected to have the following impacts:

- Estonian material manufacturers develop their processes towards lower CO_2e emissions intensity, the industry will become accustomed to measuring the energy performance and thus will be more competitive in certain export markets thanks to better information
- Low-carbon materials and solutions are preferred in building design and construction processes as well as development and financing.
- the practise of carbon footprint assessment is expected to raise the awareness of the climate impact of construction works within the Estonian construction sector (see chapter 5.5).

The research team proposes to conduct a separate impact assessment at a later phase, when the time table for the implementation and the limit values for various building types are established.

For the financial sector, the clear guidelines from the government in the form of carefully considered carbon footprint regulations would boost sustainable development across the private sector, providing the banks and other funding organisations with reliable information on the sustainable investments they are already seeking. The viewpoints of financing organisations are presented in the following chapter, under section ”Financial incentives”.

5.5 PROCESS INTEGRATION

Carbon footprint assessment can steer the practises of building design both on a voluntary basis and through the regulation. When considering the limit values at a later stage, it is important to estimate the expected impact and weight the expected changes in practises against the expected impact on greenhouse gas emissions. At the early design stage, the data on materials is less accurate, but the opportunities to improve the results are better than at later stage of the process.

Follwing the Finnish example, a two-phase building permission process may be needed to verify that the solution complies with the regulation: the first assessment needs to be done for the building permission application, mainly based on generic material emission factors. The calculation needs to be updated with the data of purchased products before the use of building can commence. Respective practises are applied for the energy certificate.

In practice the assessment requires building information modelling that provides the bill of materials. There is great variation in the practices and the accuracy of modelling. Therefore, the activities that enhance more uniform modelling of buildings and more coherent practices also support the carbon footprint assessment. The competence requirements for assessors and/or validation of assessment tools should be a topic for a continuation project.

When low carbon footprint is an important voluntary target, the important decisions are done in an early stage of the process, when the information on the material quantities is very limited. Practises for early stage evaluation and optimisation could be further developed in collaboration with the Estonian forerunner companies.

5.6 INCENTIVES AND POLICIES

The role of the environmental product declarations (EPDs)

It would be beneficial to have Estonian material manufacturers publishing more EPDs. The information provided by EPDs can prove the environmental performance of a product in the export market. A higher number of EPDs would also help to evaluate the viability of the proposed generic emission factors for Estonian construction materials. The information gathered for an EPD helps to develop the manufacturing processes in order to reduce the greenhouse gas emissions. As the number of material manufacturers is limited in Estonia, it might be a viable long-term target to provide EPDs for all construction materials manufactured in Estonia.

Financial incentives

To provide an insight into banking services that can support the future adoption of the carbon footprint regulation in Estonia, three interviews were conducted with the largest banks operating in Estonia – Swedbank, SEB Bank, and LHV Bank. The interviews took place online on 09.08.2021 and 19.08.2021 (Oviir 2021).

The representatives of the banks were:

- Maris Riim, Head of Sustainability, Swedbank
- Priit Seeman, Head of Real Estate Financing, Deputy Head of Client Coverage, SEB Bank
- Aveli Auväärt, Head of Development, LHV Bank.

All banks do have available green products for several sectors, including real estate. Motivation is shared between internal goals and ambitions, market demand, and the international requirements and standards. International banks, SEB and Swedbank, have a slightly larger share of green products available at the moment. This is expected, as their larger markets are in Scandinavia or Western Europe and the clients in those regions are much more environmentally conscious than the clients operating in Estonia. The initiative and motivation for setting up a selection of green products originates from their parent undertakings, whereas Estonian bank LHV is primarily setting up their products based on local market demand.

All of the banks provide green loans for buildings that have been built following standards that exceed the local minimum requirements. Such products are available for companies as well as for individuals. Higher performance is most importantly expected in the overall quality and energy efficiency of the building. The loan offerings are also tied to the availability of internationally recognized green building certification schemes, such as BREEAM or LEED. The green building certification requirement may also be tied to reaching a certain ranking level (e.g. LEED Gold, BREEAM very good).

The newly published EU Taxonomy provides an excellent tool for the banks to better define, measure, and assess their client's activities, as well as for setting future goals. However, there is space for translating this document into the local context, which is a task that is expected to be solved by the public sector.

International banks are experiencing additional challenges in unifying the requirements for their markets. For example, in Estonia the minimum requirements for energy efficiency are much higher than in our neighboring countries. If a loan requirement is to reach 20% improvement from the local best practice, then it's nearly impossible to reach such a level here, whereas it is not very difficult in other countries.

Each of the bank representatives pointed out the issue with data availability for decision making. That is another topic where it was determined that the public sector could solve the problem through better data gathering and data sharing with the private sector. Locally, it has been very problematic to acquire info about building energy labels, especially for older buildings (which actually make up a very large share of the portfolio). Looking ahead, any sustainability related indicator about a construction project can help the banks in making a decision. Hence, each of the bank representatives very much welcomed the idea of establishing a CO_2e-regulation.

Regarding local building CO_2e-regulation it is important to the banks that it would follow international standards and would be comparable with other countries' requirements. Additionally a stakeholder engagement from the early development stage was considered an important factor, as the success of bringing green products to market is also dependent on the fact of how well the local market (the local client) understands what they are expected to do (Oviir 2021).

6. NEXT STEPS

The needs for further development include a.o. 1) revision of the scenarios on the CO_2e emission factors for the carriers of energy in Estonia; 2) development of the data and the calculation principles for category D (impacts beyond system boundary) emissions to include also biogenic carbon storage; and 3) study on benchmarks and possible limit values based on a sufficient number of calculation results. According to the proposal, the Estonian methodology could maintain the proposed scope but later develop further the calculation methods, the default values as well as the Estonian database on the construction materials. Before collecting calculation results, the CO_2e emission factors of the energy carriers need to be updated, as operational energy use has a major impact on the calculation result. The initiatives aiming at harmonization among the Nordic countries and among the EU member states, as well as the developments of the Level(s) framework, the Taxonomy regulation and the Energy Performance of Buildings directive should be followed and, if necessary, responded to in the method development.

Based on this study, the researchers propose the following steps in order to develop and implement the carbon footprint assessment in construction sector:

Immediate action

- Construction industry engagement
- Publishing and promotion of the method
- Establishing a national database on the CO_2e emission factors of construction materials
- Method testing and data collection on the results by building type
- Updating the Estonian scenarios for energy carriers
- Creating a collaboration forum for KeM and MKM to enhance the method development and implementation
- Development of the calculation method and default values (for example D category impact and carbon storage)
- Active engagement in the on-going harmonisation work in Nordic countries.

Short term activities

- Incentives for enterprises to create EPDs
- Development of educational material and training for the Estonian construction sector
- Preparations for the building code update
- Development of a roadmap for the policies and implementation
- Study on the limit values (based on the collection of calculation results)
- Establishing Estonian definition for a carbon neutral / zero-emission building

- Method and database development, for example
    - extension of material emission database
    - more accurate default values on transportation
    - further development of modules (to move away from default values at some point).

Long term activities

- Database development; inclusion of other environmental impacts (micro plastics etc.)
- Integration of data to building register and digital twins
- Research on the interoperability of data between building-level, regional and national GHG inventories
- Building permission process development and integration.

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ANNEX

Annex 1	Comparative analysis report, carbon footprint regulation in six European countries, One Click LCA
Annex 2	Method description, Estonian method for calculating the carbon footprint for construction works
Annex 3	Calculator ver 2.0
Annex 4	User manual for the calculator
Annex 5	Video guide for the calculator
Annex 6	Dataset on the CO_2e emission factors for the Estonian construction materials
Annex 7	Method description, CO_2e emission factors for Estonian construction materials, One Click LCA
Annex 8	Proposal to include carbon footprint requirements and calculation method to existing regulation MKM nr 63, nr 58 and nr 36
Annex 9	Pilot case study report