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Climate impact screening analysis

A climate impact screening analysis of a bathroom wall system covered with Fibo waterproof wall solutions versus walls that has been waterproofed and covered with Italian ceramic tiles for different markets

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Summary

This report documents a climate impact screening analysis of a bathroom wall system covered with Fibo waterproof wall panels versus walls that have been waterproofed and covered with ceramic tiles for different markets.

The scope of the analysis is limited to the materials, including transportation, required to construct walls for a bathroom of identical size and base. For both alternatives, we have assumed that we start off with wood panelling covering the framing.

The climate impact potential for all alternatives are shown per life-cycle stage; material usage, transportation to market, and end-of-life.

Given the assumptions in the analysis, we find that a bathroom wall system with a Fibo waterproof wall solution has a total lifetime CO_2 footprint that is lower than fully tiled walls.

Furthermore, whereas most of the CO_2 footprint from a tiled bathroom wall system occurs prior to bathroom installation, the full CO_2 impact of a Fibo wall system will only be seen when all the wall panels are naturally degraded or burned for energy recovery after the useful lifetime of the bathroom. Re-use or recycling of Fibo wall panels, thus mitigating or avoiding entirely the release of embedded biogenic carbon, provide significant opportunities to lower Fibo wall panel emissions even further.

Introduction

Asplan Viak AS has been engaged by Fibo AS to carry out a climate impact screening analysis of a bathroom walls covered with Fibo waterproof wall solutions versus a bathroom that has been waterproofed and covered with Italian ceramic tiles. The analysis was based on data input provided by Fibo AS, available litterateur and Environmental declarations (EPDs), and additional data were taken from LCA databases.

The results of this assessment are intended to be disclosed as documentation of, specifically, the potential climate impacts from a bathroom wall system installed with a Fibo wall system, or tiled walls

The use of the results presented in this analysis must be based on an understanding of the assumptions, limitations, variations and uncertainties within the method and data.

The intended audience are, in addition to Fibo AS, all interested parties and stakeholders.

Comparisons made in the assessment are not intended as environmental claims regarding superiority or equivalence versus other products.

The analysis and report have been developed by Asplan Viak for Fibo As, and Elise Almås has been the contact person.

This report is structured as follows. Chapter 1 explains the methodology applied in this study. Chapter 2 presents the data. Chapter 3 presents the results, and Chapter 4 offers a short discussion of the findings. Finally, chapter 5 concludes the study.

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1. Methodology in this study

1.1. Goal and scope

This report presents a climate impact screening analysis of bathroom walls covered with Fibo waterproof wall solutions versus a walls that has been waterproofed and covered with Italian ceramic tiles for different global markets.

The scope of the analysis is to compare "identical" bathroom walls, for several markets, where either Fibo panels or tiles are used. For a Norwegian and EU bathroom we have assumed a wall covering area of 29.4 m^2. For a UK bathroom we have assumed a wall area of 11.5 m^2. While for a North American bathroom, we have assumed a dimension of 60" x 36", which corresponds to a wall area of 93 sq. fl. (8,6 m^2). For all bathroom walls alternatives, we have assumed that we start off with wood panelling covering the framing.

The purpose of this report is to find the potential environmental impacts from a bathroom wall system with Fibo wall panels, and similarly for tiled walls. The aim is to show the climate impact throughout the value chain for all alternatives, and provide results per i) material usage, ii) transportation of the materials, and iii) treatment of the materials at the end of the bathroom lifetime.

The assessment is based on a life cycle inventory analysis (LCI-study) which is based on available environmental declarations (EPDs). The screening analysis follows but is not according to the standard ISO14044. The use of the results presented in this analysis must be based on an understanding of the assumptions, limitations, variations and uncertainties within the methodology and data.

1.2. System boundary

There are different standards for water proofing, a typical Norwegian and EU bathroom is fully waterproofed, while a UK and North American bathroom only waterproofs the shower or similar. Therefore, several types of bathroom walls have been defined.

This analysis intends to reveal the climate footprint caused by the material consumption when made in Fibo wet room panel and Italian ceramic tiles, respectively. Timber framing, coarse panel, and other factors that are common to both material alternatives are therefore not included. Joints, screws, latches, and other fastening materials (with the exception of glue) are not included as they are not expected to significantly affect the result.

The analysis covers life-cycle stages A1-A3, and C1-C4 as declared in selected environmental declarations (EPDs). An EPD is a document which transparently communicates the environmental performance or impact of any product or material over its lifetime. It is assumed that the declared life-cycle stages follow the modularity principle as given in EN15804. Life-cycle stage A4 is model according to own assumptions, as described in Chapter 3.

Reference service life (RSL) is 20 years for the bathroom walls.

Boundaries to nature, into the system is placed at the extraction of raw materials and energy carriers from nature. Boundaries to nature from the system are considered at those activities performed in the system leading to emissions to air, water, and soil. Waste flows are assumed to stay within the Technosphere for waste treatment until end-of-waste and are included in the system.

1.3. Product description

1.3.1. A Fibo bathroom

A Fibo bathroom contain Fibo wall panels which are mainly wood-based; the core in birch plywood accounts for 80% of the panel weight. As the wood is harvested from renewable forests (FSC or PEFC certified wood), carbon is captured and contained in the material during the use phase. After the useful life of a bathroom, the wood-based materials will either be recycled, degraded or incinerated for energy recovery. Assuming that no part of a Fibo bathroom is recycled or re-used, the carbon that has been captured will be released once the wood is degraded.

Due to the system design, Fibo's wall covering solution consists of only a few components, implying that the waterproof wall panels account for the vast majority of the emissions.

Fibo wall panels may be combined with a Vinyl or tiled floor, but this is not included in the analysis.

1.3.2. A tiled bathroom

A typical Norwegian tiled bathroom is described by the Norwegian tile forum (Norsk byggkeramiskforening, 2018), and it contain several components such as ceramic tiles, cement products (as glue, sealants, or other coating materials), membrane and polystyrene boards. The component list was adjusted and compared to a component list with calculations provided by Fibo. As there is no bound carbon in ceramic tiles, impacts from end-of-life waste treatment are limited to waste handling infrastructural emissions.

The following bathroom wall system components are considered in this analysis:

- *Ceramic tiles*: Made of clay and glaze, and the chosen production location is Italy, with specific EPDs collected for all tile alternatives in the analysis. Best-case results and average results are used in this study.
- *Adhesives*: There are mainly three types of adhesives that are used with tiles; cement-based glue, dispersion glue and hardened plastic glue. Cement-based glue is considered very common and is used in this study.
- *Sealant and elastic sealant*: cement-based sealant is used along with silicon.
- *Wallmembrane:* Necessary to protect the underlying constructions from humidity. Several types of membranes exist, and a coating membrane is used in this analysis.
- *Primer*: Pre-treatment which is necessary for some coating membranes. It is assumes that this is used in the EU market alternative, but not in the UK and North American.
- *Wet room plaster board*: Plaster boards are often is often used in wet rooms under the tiles. This analysis uses two types of paster boards, as a best-case result and an average result are used in this study.

1.4. Functional units

For the study, the functional unit is bathroom walls with a specific size relevant for the intended market. Therefore, three functional units are used:

1. Bathroom walls for a Norwegian and EU bathroom with a wall area of 29.4 m^2.
2. Bathroom walls for a UK bathroom with eight Fibo wall panels, resulting in a wall area of 11.5 m^2.
3. Bathroom walls for a North American bathroom with six Fibo wall panels, resulting in a wall area of 93 sq. fl. (8.6m^2).

1.5. Data sources

The analysis is based a material list from Fibo describing the components in a bathroom with Fibo wall panels. The corresponding tiled bathroom is based on a component list for a 5.5 m^2 tiled bathroom given in a report from the national tiles forum in Norway (Norsk byggkeramiskforening, 2018), which were adjusted and compared to a component list with calculations provided by Fibo. The inventory data used in the analysis is further described in Chapter 2. The emissions data is based on component specific environmental declarations collected in 2021 and 2022 from EPD databases. To find emissions data for all components several types of EPDs have been used both average EPDs, and product specific EPDs.

1.6. Assessment tool

The inventory analysis modelling and impact calculation in this screening LCA was done using MS Excel and the LCA software SimaPro (version 9).

1.7. Impact assessment

Impact results are presented per Global Warming Potential (climate change), which consists of the aggregated impacts from life-cycle greenhouse gas emissions expressed per kg CO_2-equivalents (kg CO_2e).

1.8. Perspective and allocation

This study is based on an attributional LCA perspective for the value chain up to end-of-life as used in the EPD system.

Allocation is not used in the study due to the system boundaries where the processes do not have co-products.

2. Data

This chapter describes the inventory of the analysis and the data sources.

2.1. An EU bathroom wall system

The comparison of bathroom walls for a Norwegian and EU bathroom is based on a wet room with a wall surface of 29.4 m^2, and it is intended to reveal the climate footprint caused by the material consumption when made in Fibo wet room panel and Italian ceramic tiles, respectively.

Table 1 summarizes the assumptions for an EU bathroom, which is further described in the following sections.

Table 1 Overview of the assumptions for a Norwegian and EU bathroom

Assumption	Tiles	Fibo
Wall area (m2)	29,4	29,4
Timber framing	Similar – excluded	Similar – excluded
Coarse panel	Similar – excluded	Similar – excluded
Joints, screws, latches and similar	Different – excluded	Different – excluded

2.1.1. Fibo – A Fibo waterproof wall solution

The first alternative, a Norwegian or EU bathroom with Fibo wall solution, is summarized in Table 2. All components and material usage are included with a reference to the EPD used to find the climate impact.

Table 2 Overview of the components and material used in a Fibo bathroom wall solution

Building component	Component	Product	Consumption per bathroom (kg)	Data source	Comment
	Fibo panel	Fibo wall panel, 10.2 mm thick	223,9	EPD (NEPD-2105-950-NO)	Specific lifetime values from producer. 7,58kg/m2
	Glue	Fibo seal	1,25	EPD (Secret)	Specific lifetime values from producer. 1,25 kg/m2
	Aluminium frame		0,53	EPD from Alumeco[1]	Anodized Aluminium profile. 0,018kg/m2
Wall	Screws and fasteners	Not estimated	Not estimated	Not estimated	Not estimated

2.1.2. Ceramic tiles – A fully tiles bathroom

Overview of the technical characteristics of a fully tiled bathroom according to amounts from a Norsk byggkeramiskforening (2018), which were adjusted and compared to a component list with calculations provided by Fibo. Two types of tiled bathroom are analysed, based on different climate performance level of the Italian tiles, one average Italian tile and the “best available” tile. Table 4 gives an overview of the components, material usage and EPDs for a tiled bathroom in Europe, while Table 4 provides an overview of all Italian tiles used in the study.

[1],[2] Based on the report “Environmental Product Declaration Aluminium Profiles” by Alumeco, provided by Fibo AS

Table 3 Overview of the technical characteristics of a tiled bathroom wall system.

Building component	Component	Product	Consumption per bathroom (kg)	Data source	Comment
	Tiles	Ceramic tiles, Italy	695,1 (typical) 513,6 (best case)	EPD (varies)	Avg. of Italian producers. 24 kg /m2 (typical) Specific Italian tile, 17 kg /m2 (best case)
	Glue	Cement based glue	73,5	EPD (NEPD-1787-753-EN)	Proxy: Weber Supra Rapid Light Fix 2,5 kg/m2.
	Sealant	Cement based sealant	14,7	EPD (NEPD-2152-976-EN)	Weber Rapid Grout, light, 0,5kg/m2
	Elastic sealant	Silicon based sealant	1,6	EPD (EPD-FEI-20150323-IBG1-EN)	European industrial average, 0,1kg/m2
	Wall membrane	Coating membrane	33,8	EPD (S-P-01109)	Proxy Mapelastic Aqua defense, 1,15kg/m2
	Wall membrane	Primer*	8,8	EPD (proxy) (NEPD-1456-485-EN)	Proxy Jotun epoxy primer (for more robust coatings), 0,3kg/m2
	Wall membrane	Sleeves, sealing tape	Not calculated		
Wall	Wet room plasterboard	Standard plasterboard	273,4 (typical) 264,6 (best case)	EPD typical: NEPD-2141-967-EN) Best: NEPD-1260-406-EN	Norgips moisture resistant plasterboard, 9,3kg/m2 Gyproc standard 12,5 mm board (best case), 9,0kg/m2

Table 4 Overview of the EPD data from the selected Italian tiles used in the study to find the "average" Italian tile. A "best case" and "worst case" tile have also been defined.

Producer	GWP "cradle-to-gate" per m²	GWP for "end-of-life" per m²	Material usage kg/m2	Declaration number in EPD Italy
Marazzi	15,50	0,34	28,0	MAR_CAS_17_0001

Gresmalt (best case)	8,69	0,18	17,5	EPD-GRESMALT-0001-20
Marazzi	11,70	0,28	22,6	MAR_EMI_18_0001
Emilgroup	11,70	0,28	22,6	EMI_FIO_18_000
Marazzi (worst case)	17,90	0,37	30,4	MAR_SAS_18_0001
Marazzi	9,47	0,27	20,8	MAR_FIN_18_0001
Tiles (avg)	12,49	0,29	23,64	-

2.2. A UK bathroom wall system

An average UK bathroom not a fully waterproofed bathroom, but only the shower area. For this reason, the UK bathroom in this analysis has a wall area of eight Fibo wall panels[2] which equals 11.5 m^2. It is assumed that a UK bathroom contain almost the same components as the EU bathroom, only scaled to the relevant size. Primer is also excluded in the tiled bathroom as this is not used in this market[3]. Table 5 shows the assumptions for a UK bathroom wall solution.

Timber framing, coarse panel and other factors that are common to both material alternatives are therefore not included. Joints, screws, latches, and other fastening materials (with the exception of glue) are not included as they are not expected to significantly affect the result.

Table 5 Overview of the assumptions for the UK bathroom

Assumption	Tiles	Fibo
Wall area (m2)	11,5	11,5
Timber framing	Similar – excluded	Similar – excluded
Coarse panel	Similar – excluded	Similar – excluded
Joints, screws, latches and similar	Different – excluded	Different – excluded

2.2.1. Fibo – A Fibo waterproof wall solution

An overview of the components, material usage and EPDs for a Fibo wall solution for bathrooms in the UK market is given in Table 7.

[2] Based on average orders of Fibo wall panels in the UK, according to Fibo AS.

[3] According to Fibo AS.

Table 6 Overview of the components, material usage and EPD used for the UK bathroom walls

Building component	Component	Product	Consumption per bathroom (kg)	Data	Comment
	Fibo panel	Fibo wall panel, 10.2 mm thick	87,3	EPD (NEPD-2105-950-NO)	Specific lifetime values from producer. 7,58kg/m2
	Glue	Fibo seal	0,7	EPD (Secret)	Specific lifetime values from producer. 1,25 kg/m2
	Aluminium frame		0,21	EPD from Alumeco[4]	Anodized Aluminium profile. 0,018kg/m2
Wall	Screws and fasteners	Not estimated	Not estimated	Not estimated	Not estimated

2.2.2. Ceramic tiles – fully tiled bathroom walls

An overview of the technical characteristics of a bathroom with tiled walls in UK is given in Table 9. It is based on the components from Norsk byggkeramiskforening (2018), which were adjusted and compared to a component list with calculations provided by Fibo. Two types of tiled walls are analysed, based on different climate performance level of the Italian tiles. This has the same components, but the amounts are scaled based on consumption per m^2 compared to the EU bathroom walls, and the primer is excluded.

Table 7 Overview of the components, material usage and EPDs for a UK bathroom

Building component	Component	Product	Consumption per bathroom (kg)	Data	Comment
Wall	Tiles	Ceramic tiles, Italy	272,4 (typical) 201,3 (best case)	EPD (varies)	Avg. of Italian producers. 24 kg /m2 (typical) Specific Italian tile, 17 kg /m2 (best case)

[4] Based on the report "Environmental Product Declaration Aluminium Profiles" by Alumeco, provided by Fibo AS

	Glue	Cement based glue	28,8	EPD (NEPD-1787-753-EN)	Proxy: Weber Supra Rapid Light Fix 2,5 kg/m2.
	Sealant	Cement based sealant	5,8	EPD (NEPD-2152-976-EN)	Weber Rapid Grout, light, 0,5kg/m2
	Elastic sealant	Silicon based sealant	0,6	EPD (EPD-FEI-20150323-IBG1-EN)	European industrial average, 0,1kg/m2
	Wall membrane	Coating membrane	13,2	EPD (S-P-01109)	Proxy Mapelastic Aqua defense, 1,15kg/m2
	Wall membrane	Sleeves, sealing tape	Not calculated		
	Wet room plasterboard	Standard plasterboard	107,1 (typical) 103,7 (best case)	EPD typical: NEPD-2141-967-EN) Best: NEPD-1260-406-EN	Norgips moisture resistant plasterboard, 9,3kg/m2 Gyproc standard 12,5 mm board (best case), 9,0kg/m2

2.3. A North American bathroom wall system

The comparison for a North American bathroom wall solution is based on a wet room with a wall surface of six Fibo wall panels. This results in 93 sq. fl. wall area. The bathroom walls in this study is imported from Europe and the production sites of the selected components, resulting in long transport phase.

Timber framing, coarse panel and other factors that are common to both material alternatives are therefore not included. Joints, screws, latches, and other fastening materials (with the exception of glue) are not included as they are not expected to significantly affect the result. Table 10 shows an overview of the assumptions for North American bathroom walls.

Table 8 Overview of the assumptions for a North American bathroom wall system.

Assumption	**Tiles**	**Fibo**
Wall area (sq. fl.)	93	93
Timber framing	Similar – excluded	Similar – excluded
Coarse panel	Similar – excluded	Similar – excluded
Joints, screws, latches and similar	Different – excluded	Different – excluded

2.3.1. Fibo – A Fibo waterproof wall solution

Table 11 gives an overview of the components, material usage and EPDs for a Fibo wall system in a North American market.

Table 9 Overview of the components, material usage and EPDs for a Fibo bathroom wall system.

Building component	Component	Product	Consumption per bathroom (lbs)	Data source	Comment
Wall	Fibo panel	Fibo wall panel, 10.2 mm thick	144,4	EPD (NEPD-2105-950-NO)	Specific lifetime values from producer. 7,58kg/m2
	Glue	Fibo seal	1,3	EPD (Secret)	Specific lifetime values from producer. 1,25 kg/m2
	Aluminium frame		0,16	EPD from Alumeco[5]	Anodized Aluminium profile. 0,018kg/m2
	Screws and fasteners	Not estimated	Not estimated	Not estimated	Not estimated

2.3.2. Ceramic tiles – A fully tiled wall solution

Overview of the technical characteristics of a fully tiled bathroom wall solution in North America is given in Table 13. It is based on the components from Norsk byggkeramiskforening (2018), which were adjusted and compared to a component list with calculations provided by Fibo. Two types of tiled bathroom are analysed, based on different climate performance level of the Italian tiles. This has the same components, but the amounts are scaled based on consumption per m^2 compared to the EU bathroom, and the primer is excluded.

[5] Based on the report "Environmental Product Declaration Aluminium Profiles" by Alumeco, provided by Fibo AS

Table 10 Overview of the components, material usage and EPDs used for North American bathroom walls

Building component	Component	Product	Consumption per bathroom (lbs)	Data source	Comment
	Tiles	Ceramic tiles, Italy	450,3 (typical) 332,8 (best case)	EPD (varies)	Avg. of Italian producers. 24 kg /m2 (typical). Specific Italian tile, 17 kg /m2 (best case)
	Glue	Cement based glue	47,6	EPD (NEPD-1787-753-EN)	Proxy: Weber Supra Rapid Light Fix 2,5 kg/m2.
	Sealant	Cement based sealant	9,5	EPD (NEPD-2152-976-EN)	Weber Rapid Grout, light, 0,5kg/m2
	Elastic sealant	Silicon based sealant	1,0	EPD (EPD-FEI-20150323-IBG1-EN)	European industrial average, 0,1kg/m2
	Wall membrane	Coating membrane	21,9	EPD (S-P-01109)	Proxy Mapelastic Aqua defense, 1,15kg/m2
	Wall membrane	Sleeves, sealing tape	Not calculated		
Wall	Wet room plasterboard	Standard plasterboard	177,1 (typical) 171,4 (best case)	EPD NEPD-2141-967-EN (typical) NEPD-1260-406-EN (best case)	Norgips moisture resistant plasterboard, 9,3kg/m2. Gyproc standard 12,5 mm board (best case), 9,0kg/m2

2.4. Transportation to the specific market

The same transport scenarios were chosen for all alternatives to provide a common basis for comparison. Table 15 summarises the background data used for modelling the transportation. Appendix 1 and Appendix 2 provides information about the specific route for each component and the distance used in the modelling.

To calculate the transportation, TKM was first established based on the distance*mass. Key trailer size parameters were loaded into a proprietary, parameterized, transportation dataset developed by Asplan Viak. In this process, fuel use for different load factors is calculated based on a regression analysis based on data from the Agri-Footprint database for lorries with a load capacity from 3,6 tons to 24 tons. Fuel consumption is therefore the only value that is changed by the use of the parameters. Emissions from brakes, road wear and so on are assumed the same per TKM. The Agrifootprint database was used for ship transport.

Parameters for truck capacity were adjusted and based on the following assumptions. First, the load capacity is assumed to be 75 %, and the total vehicle weight capacity was assumed to be 32 tones based on available information from Fibo. The same assumptions were used for a tiled bathroom wall system.

Table 11 Transport data for transportation to market.

Transport	Comment and data
Truck	EURO 6, load factor 75%. Weight capacity 32 ton. Same load for return trip. Based on Asplan Viak process.
Ferry	Based on ecoinvent process.
Small container ship	Agri-footprint process for transport distances between 5 000-10 000km. Transport, sea ship, 5000 DWT, 80%LF.
Large container ship	Agri-footprint processes for transport distances 5000km, 5000km-10 000 and >10 000km. 50000 DWT and 80% LF

3. Results

This chapter presents the results for a Fibo bathroom wall system and an average ceramic tiles wall system to all relevant markets. We describe the impact stemming from i) material usage, ii) transportation of the materials to the different markets, and iii) treatment of the materials at the end of the bathroom lifetime.

The results per m^2 is given in Appendix 3, and can be used to scale the impact to the desired wall system size.

There is a significant variation between the selected Italian ceramic tiles used in the study, and the total climate impact will vary perpending on the selected product. To illustrate this the result including "best case tiles" and "worst case tiles" are included Appendix 4.

3.1. A Norwegian and EU bathroom wall system (29.4m^2)

3.1.1. Material usage

The total material usage for an EU bathroom is illustrated in Figure 1. The Fibo wall system, with its Aqualock feature, is instantly sealed when mounted, whereas tiles require an underlying layer of membrane covered plasterboards or other waterproofing solutions. The total amount of materials required to build a waterproof bathroom is therefore significantly higher when using tiles than for a Fibo based system.

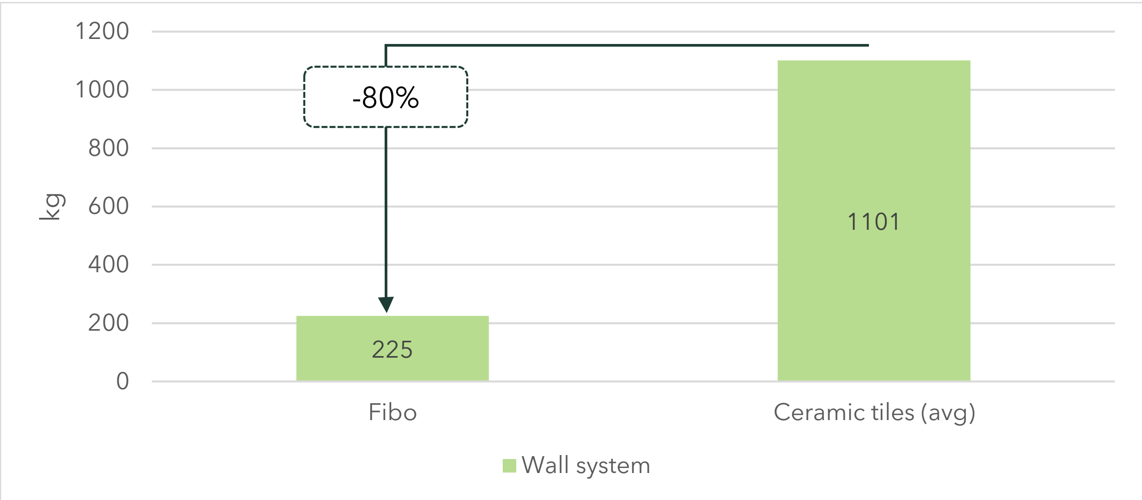

Figure 1 Material usage in kg for the Norwegian and EU bathroom walls.

3.1.2. "Cradle-to-gate" emissions

The total amount of materials required to build waterproof bathroom walls is significantly higher when using tiles than for a Fibo based system, which also causes a higher climate impact for tiles as illustrated in Figure 2. As Fibo wall panels are mainly wood based; the core in birch plywood accounts for 80% of the panel weight. As the wood is harvested from renewable forests (FSC or PEFC certified wood), carbon is captured and contained in the material. In a life-cycle perspective, the production and use of Fibo panels have a significantly lower CO_2 footprint compared to other materials in this analysis.

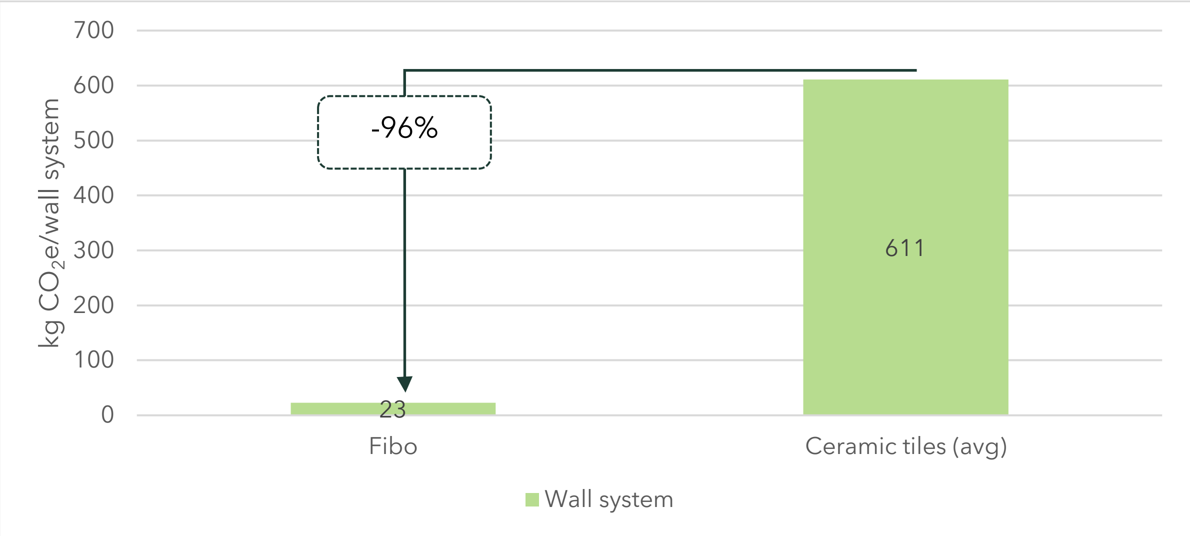

Figure 2 Climate impact in a "cradle-to-gate" perspective for the different EU bathrooms, excluding the end-of-life emissions.

After the useful life of a bathroom, the wood-based materials will either be recycled, degraded, or incinerated for energy recovery. Assuming that no part of a Fibo wall system is recycled or re-used, the carbon that has been captured will be released once the wood is degraded. As there is no bound carbon in ceramic tiles, impacts from end-of-life waste treatment are limited to waste handling infrastructural emissions. The climate impact including end-of-life is included in Figure 3, showing that in a life cycle perspective the climate impact from a Fibo bathroom is significantly increased.

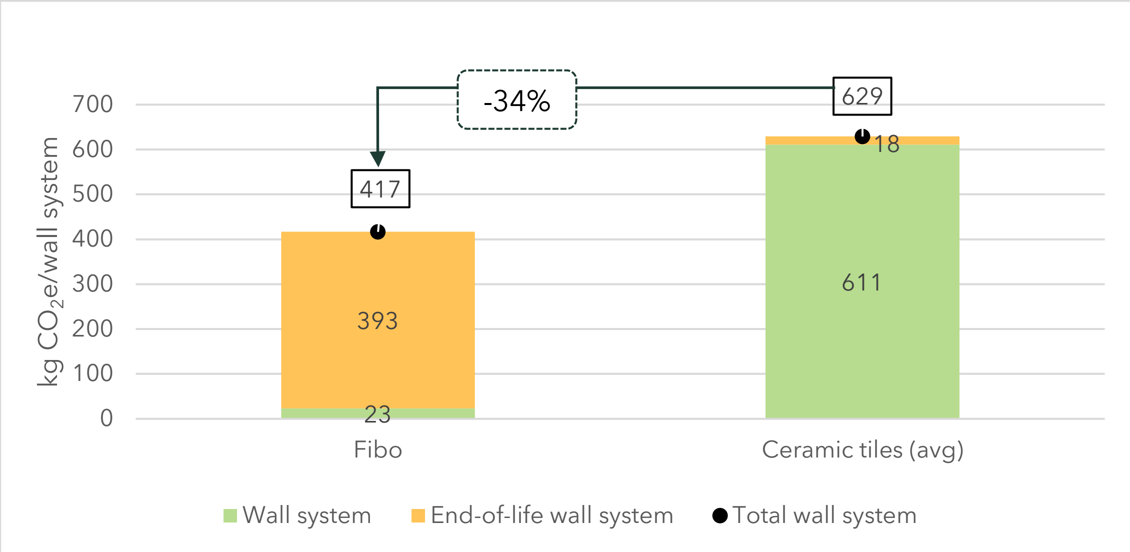

Figure 3 Climate impact in a "cradle-to-gate" perspective for the different bathroom walls for EU or Norway, including the end-of-life emissions.

3.1.2.1 Contribution of the wall components

Figure 4 illustrates the climate impact of all components in a Fibo wall system. Due to the system design, Fibo's wall covering solution consists of only a few components, implying that the waterproof wall panels accounts for the vast majority of the emissions. End-of-life treatment of the wall panels are the largest components of the Fibo system's climate impact.

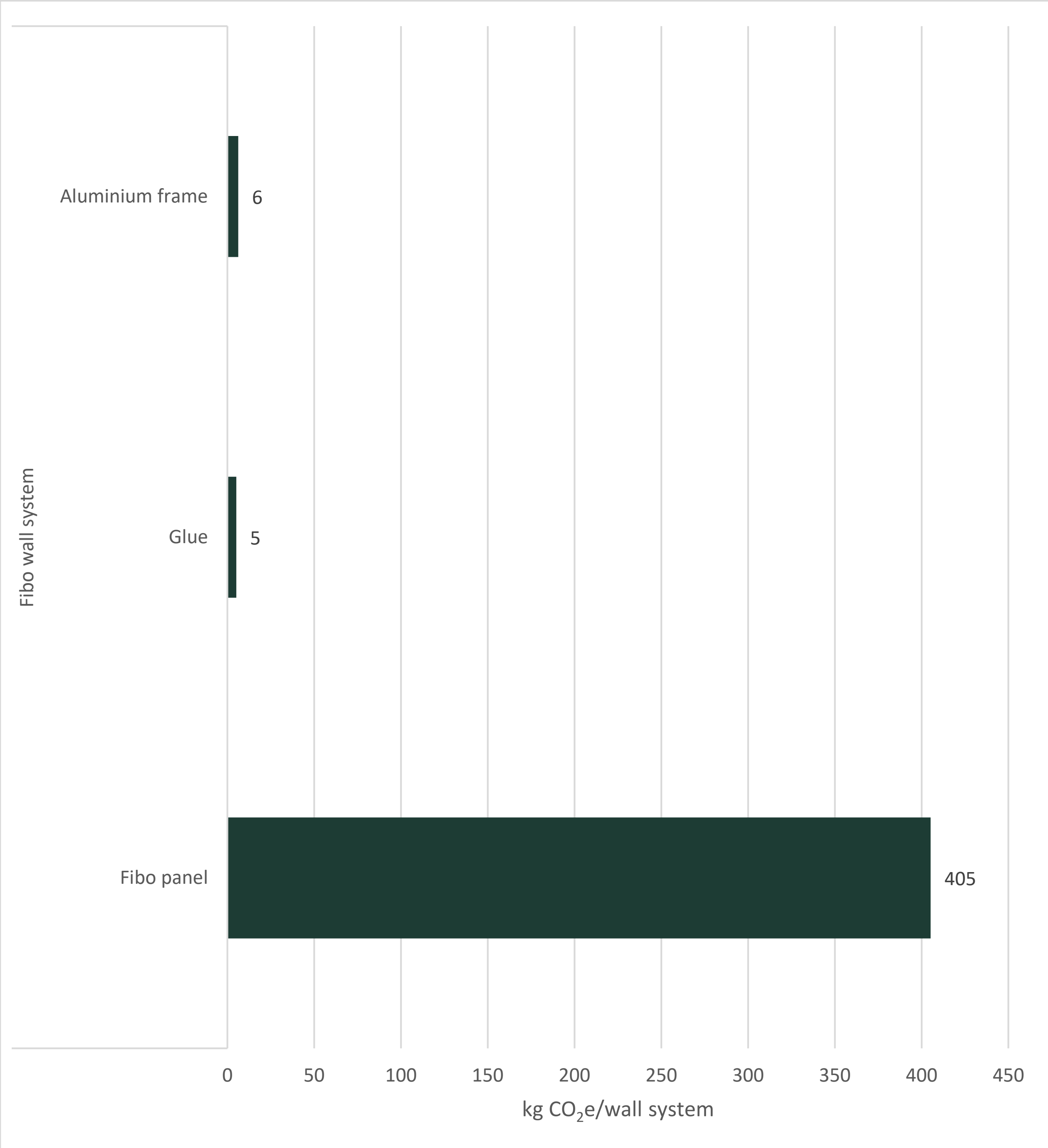

Figure 4 Climate impact of all components in a Fibo wall system in a "cradle-to-gate" perspective including end-of-life.

Figure 5 illustrates the climate impact of all components in bathroom walls system based on Italian tiles. The results shows that ceramic tiles and wet room plaster board are the components with the largest carbon footprint, and these components also have different footprint in the best and average scenario.

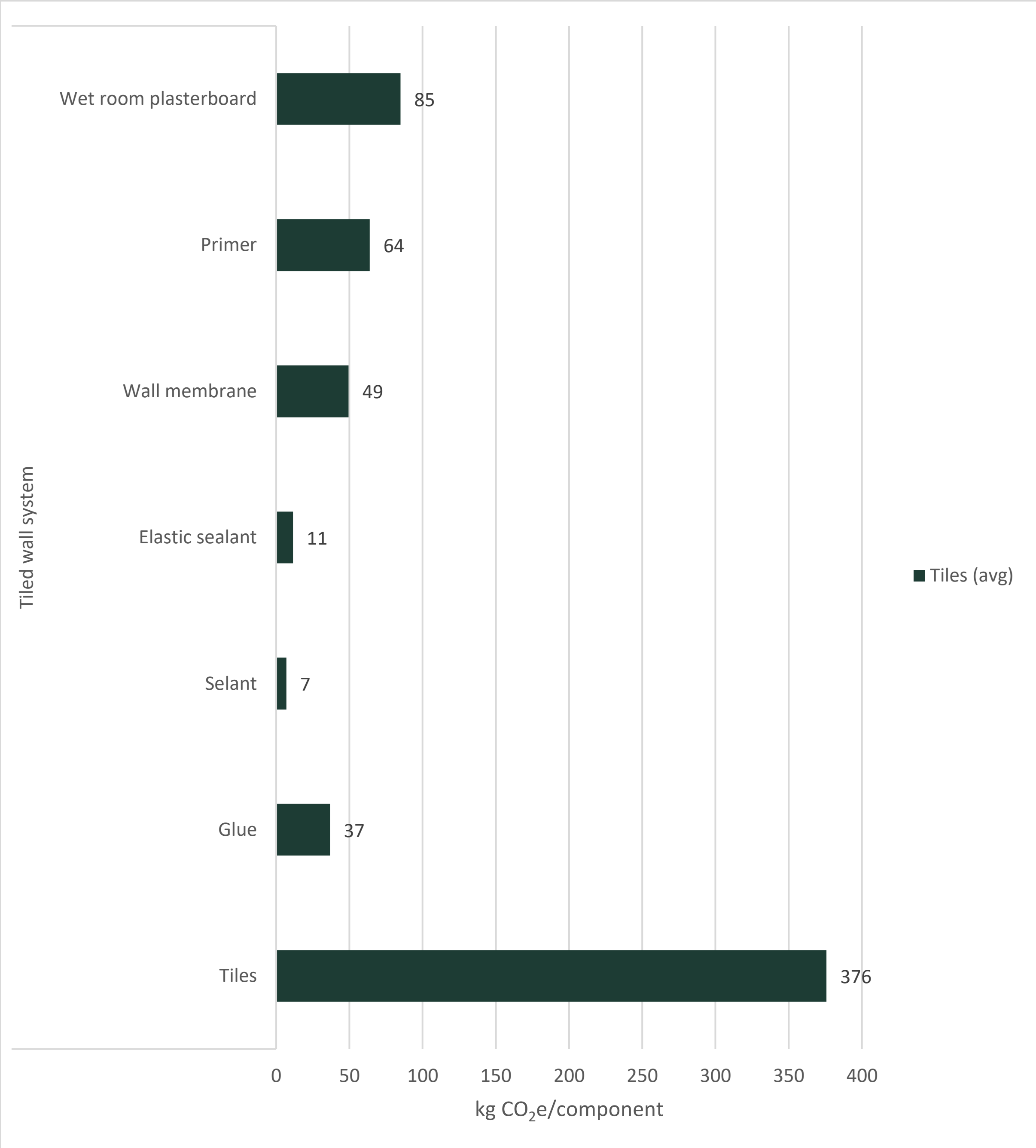

Figure 5 Climate impact of all components in a tiled bathroom wall system in a "cradle-to-gate" perspective including end-of-life.

3.1.3. Transportation to different markets

The emissions for the transportation of the materials to the different markets in Noorway or Europe highly depends on the transport distance and the weight of the materials. Figure 6 illustrates the emissions from transportation to Helsingfors, Stockholm, Berlin, and Holland.

As the tiled bathroom have higher material usage, this highly affect the transportation phase. These results are highly sensitive to the assumption about production location and the transport distance, but also the choice of components and their weight.

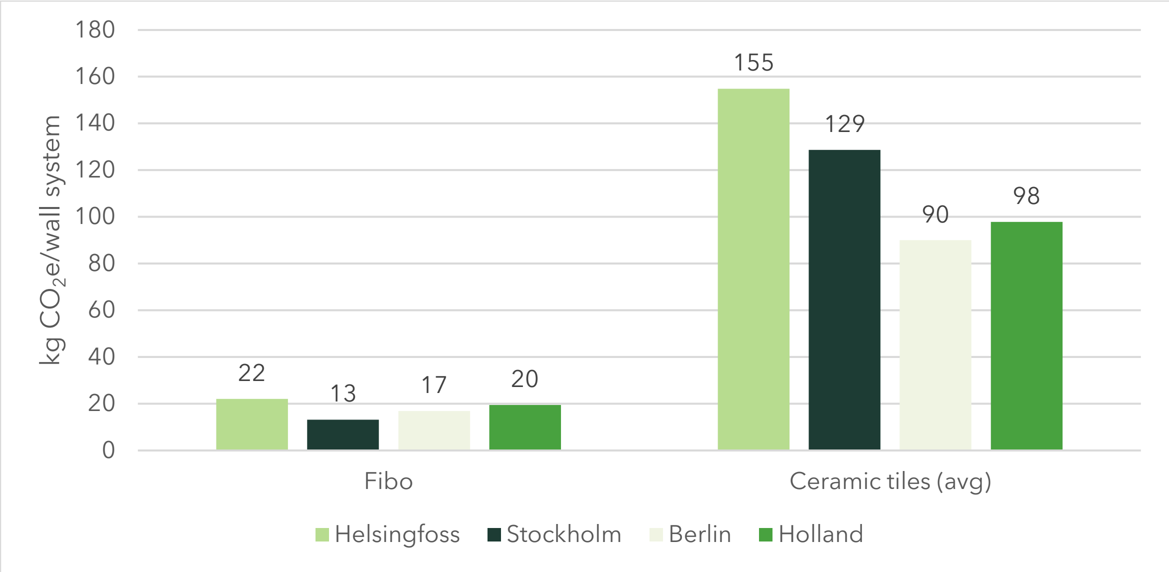

Figure 6 The climate impacts steeming from the transportation to the specific market in Europe.

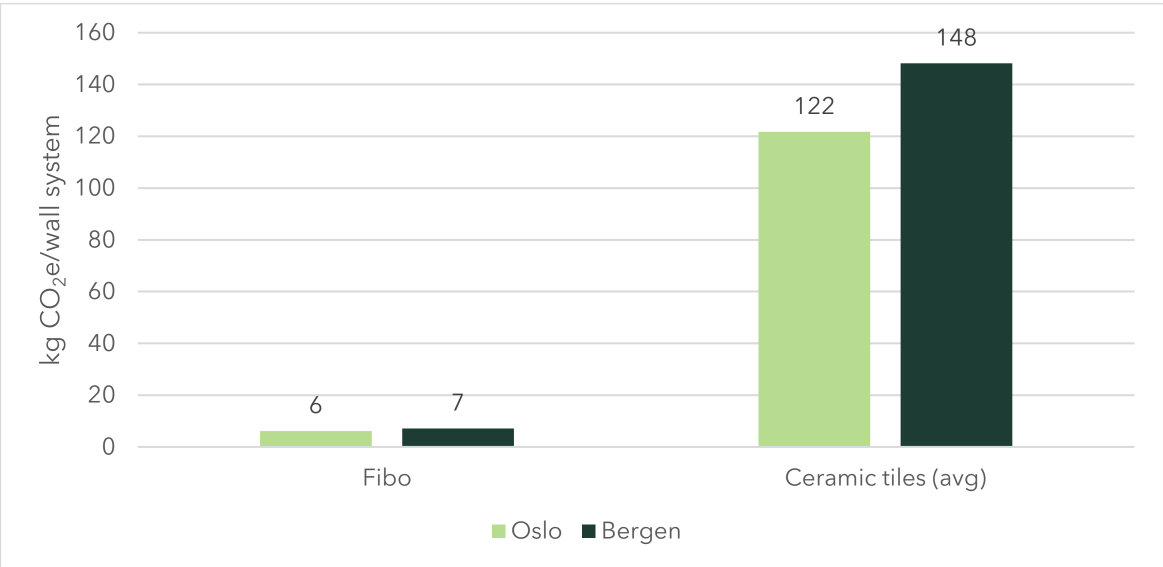

Figure 7 The climate impacts steeming from the transportation to the specific market in Norway.

3.1.4. "Cradle-to-grave" emissions

The climate impact including the whole value chain for all alternatives in the Norwegian and EU market are illustrated in the figures bellow. The emissions for the material usage and end-of-life are the same for all markets, but the transport distances are different, resulting in different total climate impact depending on the market location.

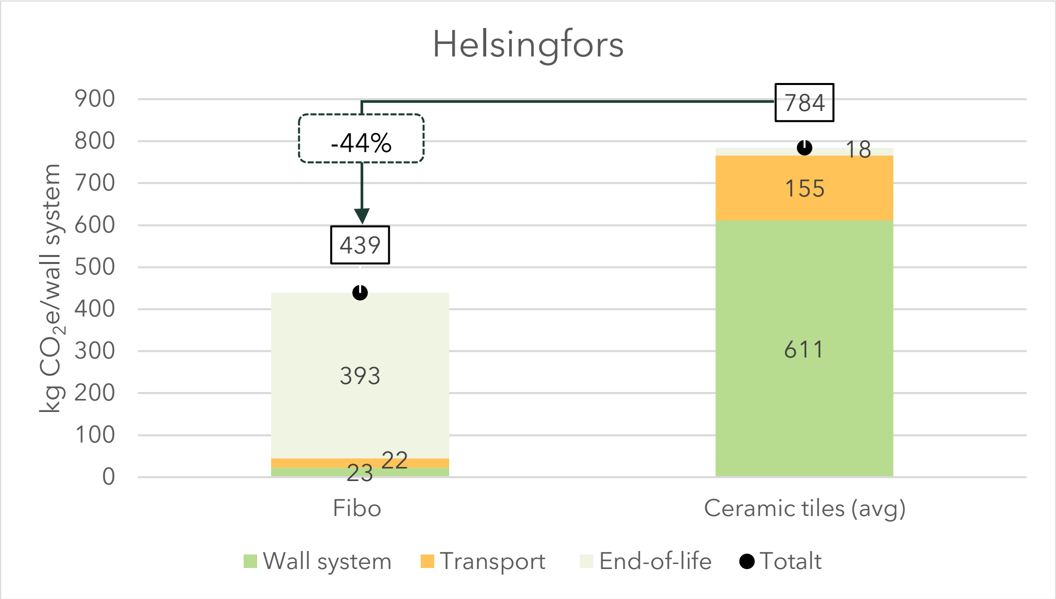

Figure 8 The «cradle-to-grave" emissions a bathroom wall system (29.4m²) in Helsingfors.

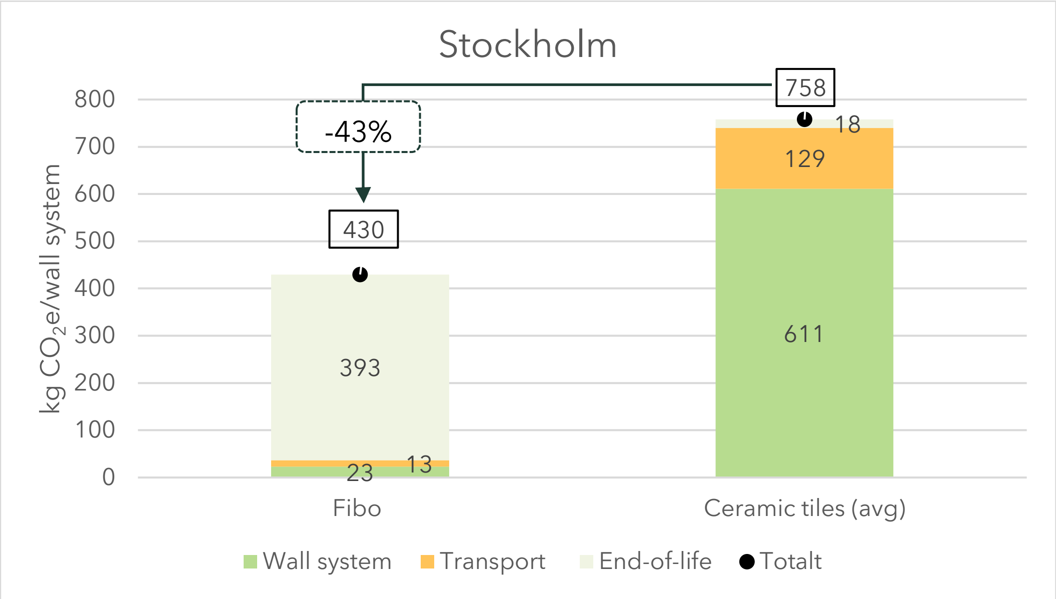

Figure 9 The «cradle-to-grave" emissions a bathroom wall system (29.4m²) in Stockholm.

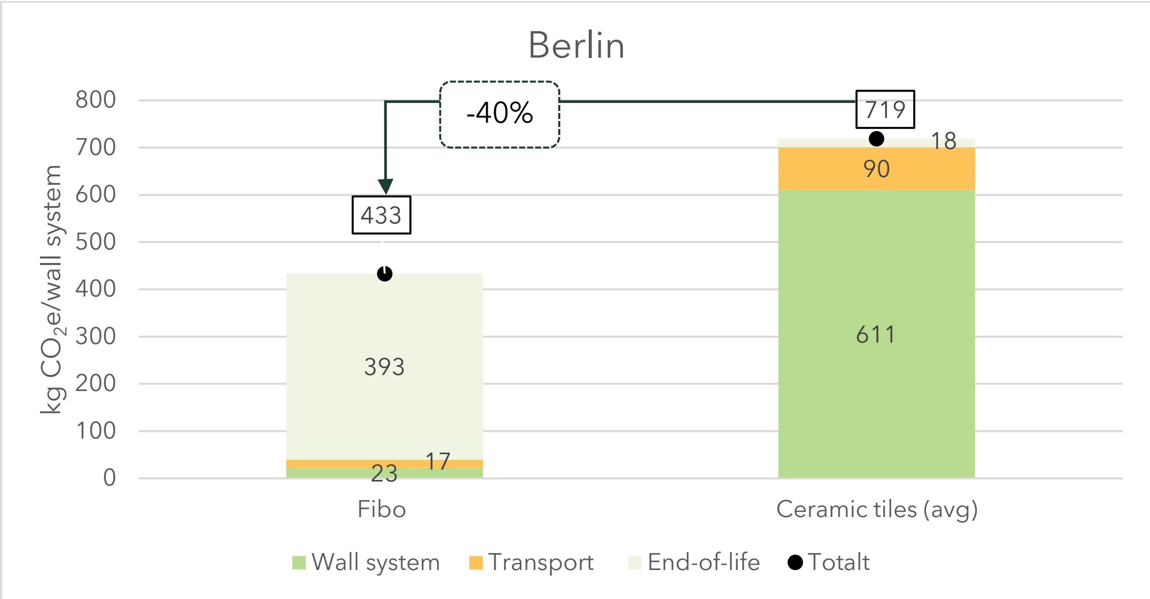

Figure 10 The «cradle-to-grave" emissions a bathroom wall system (29.4m²) in Berlin.

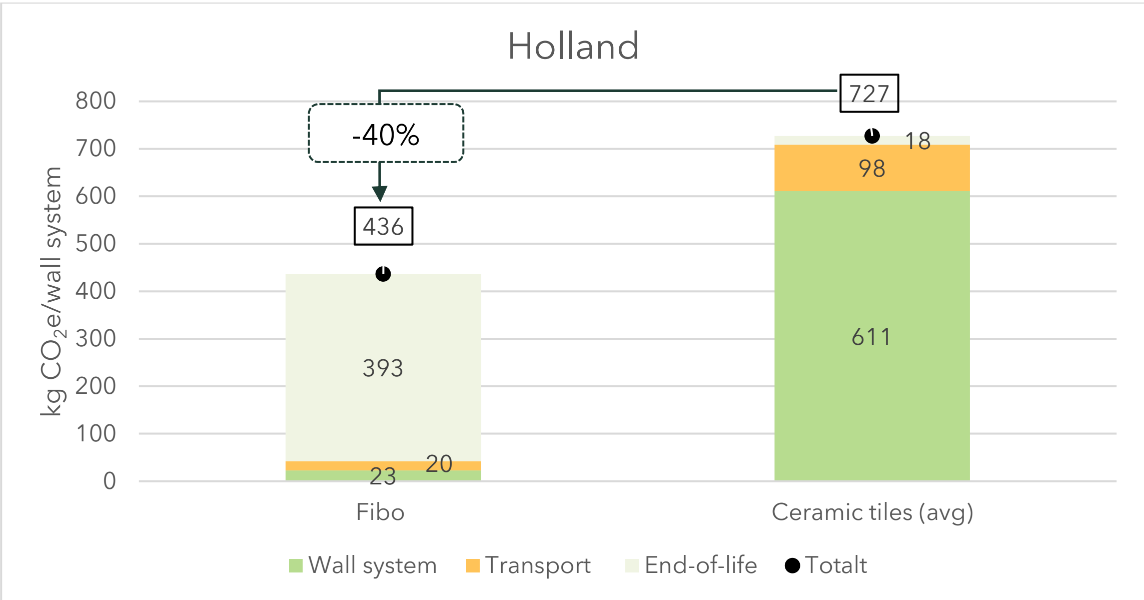

Figure 11 The «cradle-to-grave" emissions a bathroom wall system (29.4m²) in Holland.

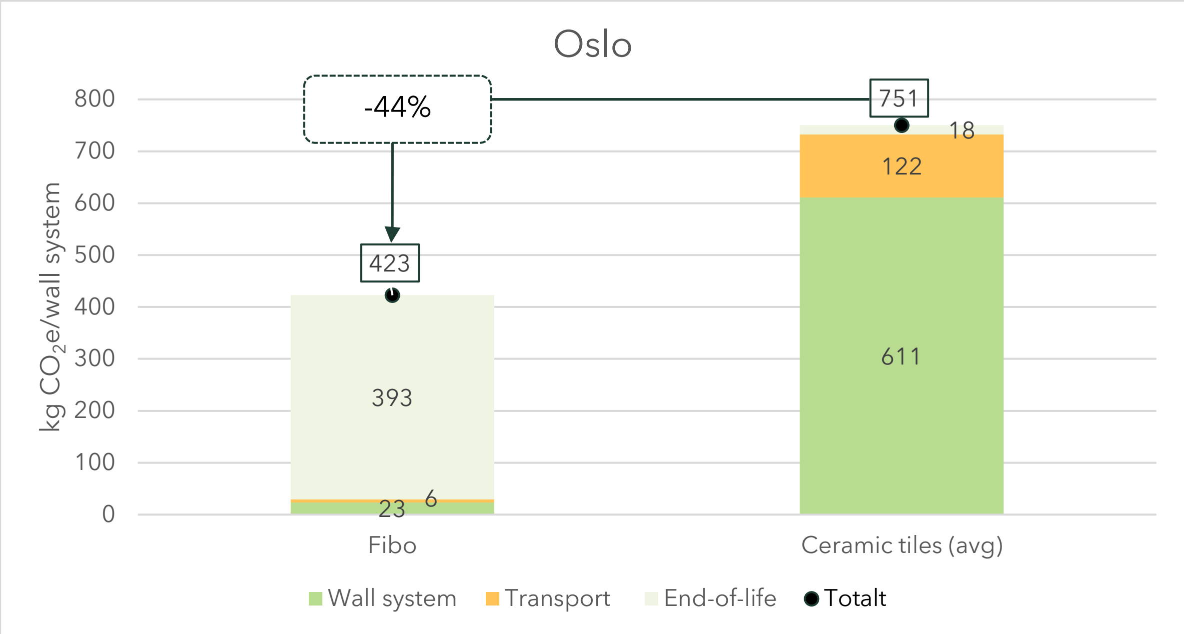

Figure 12 The «cradle-to-grave" emissions a bathroom wall system (29.4m2) in Oslo.

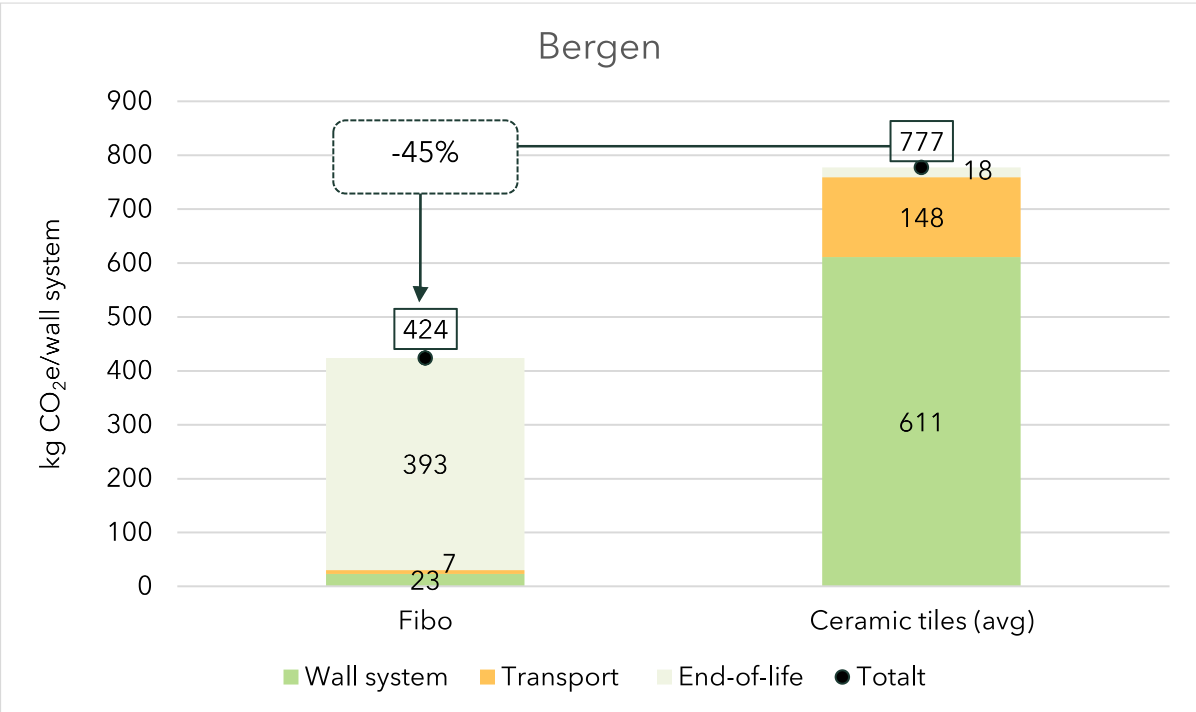

Figure 13 The «cradle-to-grave" emissions a bathroom wall system (29.4m2) in Bergen.

3.2. A UK bathroom wall system (11.5m^2)

The results for a "typical" UK bathroom wall system, which is smaller than a Norwegian or EU bathroom, is presented in this section. The walls for a UK bathroom are assumed to have a wall area of 11,5 m^2.

3.2.1. Material usage

The total material usage for a UK bathroom wall system is illustrated in Figure 14. The Fibo wall system, with its Aqualock feature, is instantly sealed when mounted, whereas tiles require an underlying layer of membrane covered plasterboards or other waterproofing solutions. The total amount of materials required to build a waterproof bathroom wall is therefore significantly higher when using tiles compared to a Fibo based system.

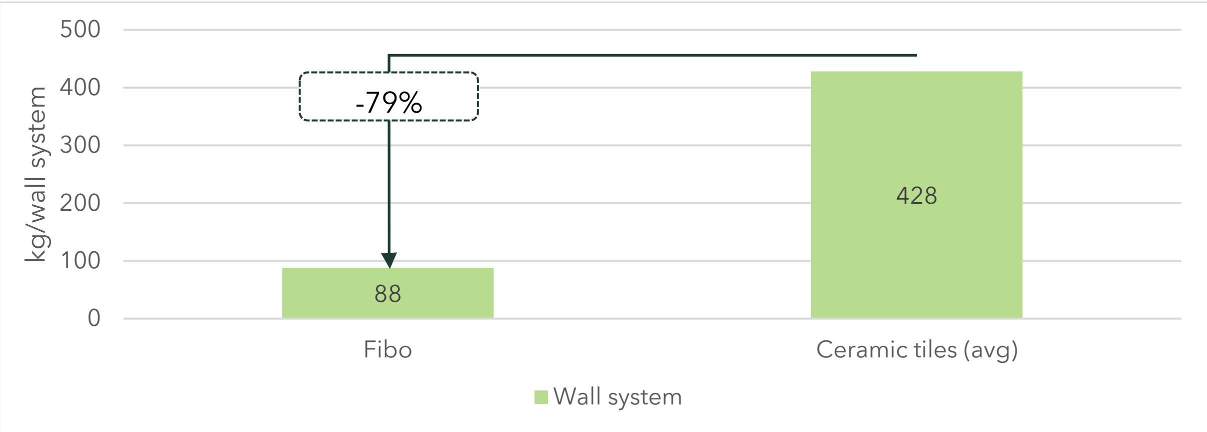

Figure 14 Material usage in kg for a wall system in the UK market.

3.2.2. "Cradle-to-gate" emissions

The total amount of materials required to build a waterproof bathroom wall system is significantly higher when using tiles than for a Fibo based system, which also causes a higher climate impact for tiles as illustrated in Figure 15. As Fibo wall panels are mainly wood based; the core in birch plywood accounts for 80% of the panel weight. As the wood is harvested from renewable forests (FSC or PEFC certified wood), carbon is captured and contained in the material. In a life-cycle perspective, the production and use of Fibo panels have a significantly lower CO_2 footprint compared to other materials in this analysis.

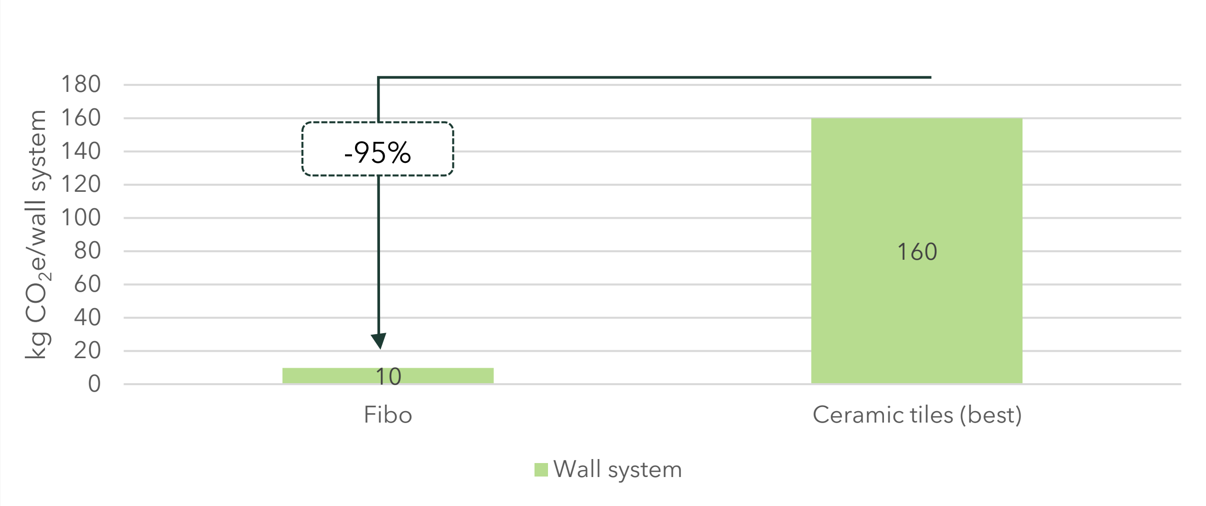

Figure 15 Climate impact in a "cradle-to-gate" perspective for the UK market, excluding the end-of-life emissions.

After the useful life of a bathroom wall system, the wood-based materials will either be recycled, degraded, or incinerated for energy recovery. Assuming that no part of a Fibo wall system is recycled or re-used, the carbon that has been captured will be released once the wood is degraded. As there is no bound carbon in ceramic tiles, impacts from end-of-life waste treatment are limited to waste handling infrastructural emissions. The climate impact including end-of-life is included in Figure 16, showing that in a life cycle perspective the climate impact from a Fibo wall system is significantly increased, while the tiled wall system has very low emissions at end-of-life.

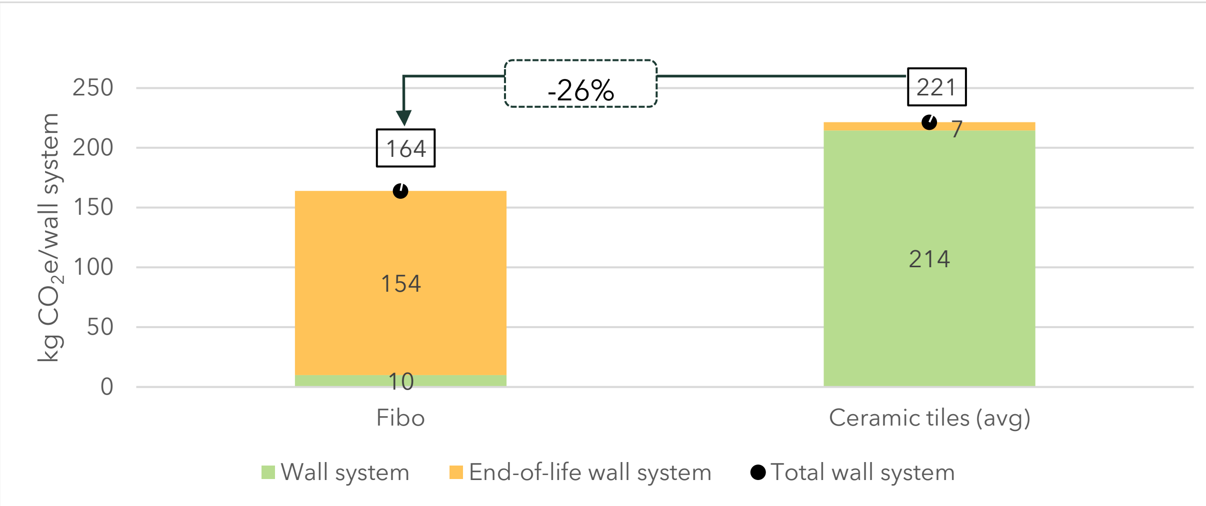

Figure 16 Climate impact in a "cradle-to-gate" perspective for the UK market, including the end-of-life emissions

3.2.2.1 Contribution of the wall components

Figure 17 illustrates the climate impact of all components in a Fibo wall system. Due to the system design, Fibo's wall covering solution consists of only a few components, implying that the waterproof wall panels accounts for the vast majority of the emissions. End-of-life treatment of the wall panels is the largest component of the Fibo system's climate impact.

Figure 18 illustrates the climate impact of all components in a bathroom wall system based on Italian tiles, for both the "best case" and average scenario. As the bathroom has high material usage and high climate impact, the choice of tiles highly affects the total climate impact of the bathroom.

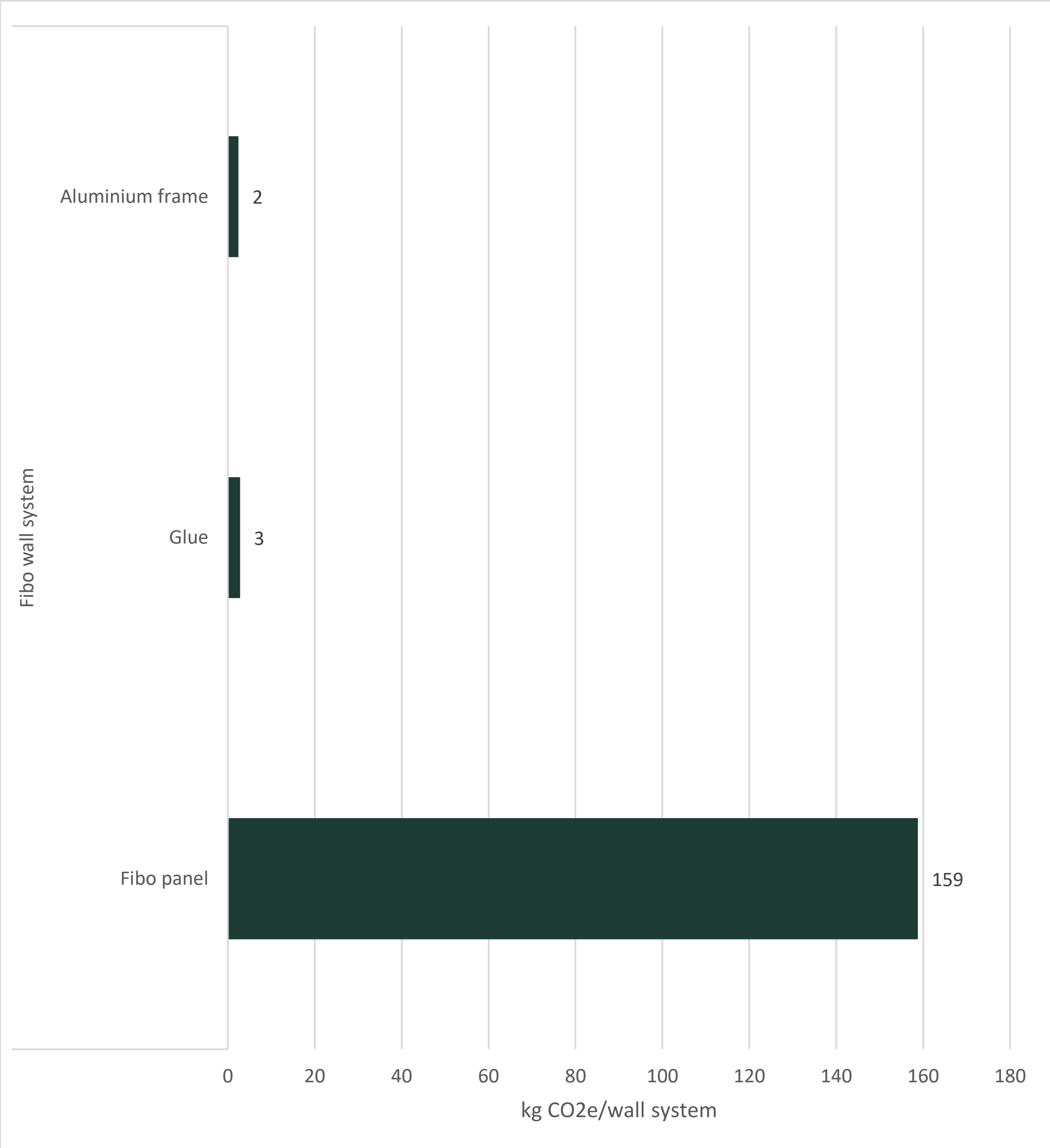

Figure 17 Climate impact of all components in a Fibo wall system in a "cradle-to-gate" perspective including end-of-life.

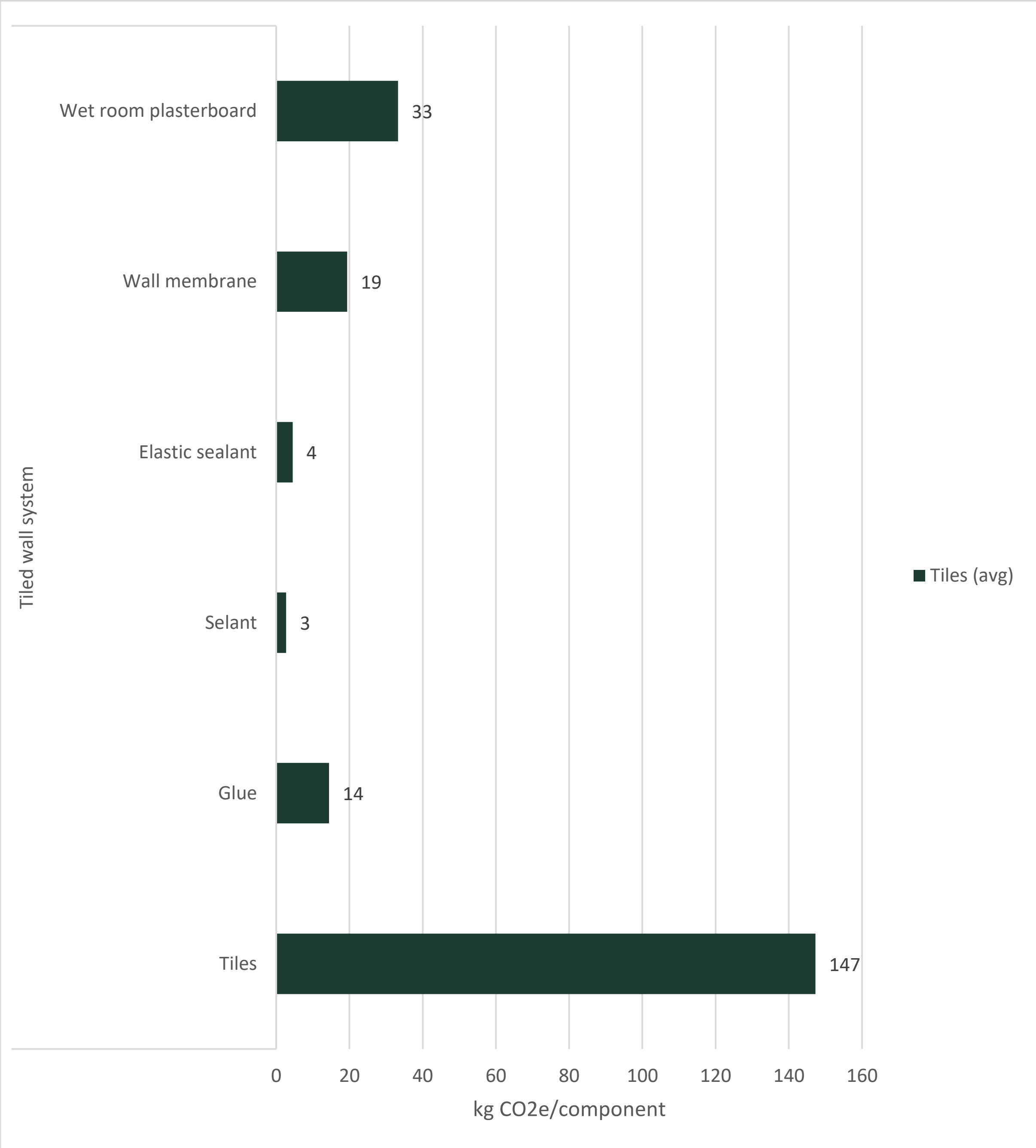

Figure 18 Climate impact of all components in a tiled wall system in a "cradle-to-gate" perspective including end-of-life.

3.2.3. Transportation to different markets

The emissions for the transportation of the materials to the different markets in the UK highly depends on the transport distance and the weight of the materials. Figure 19 illustrates the emissions from transportation to Bradford and Stirlingshire. As the tiled wall system have higher material usage, this highly affect the transportation phase. These results are highly sensitive to the assumption about production location and the transport distance, but also the choice of components and their weight.

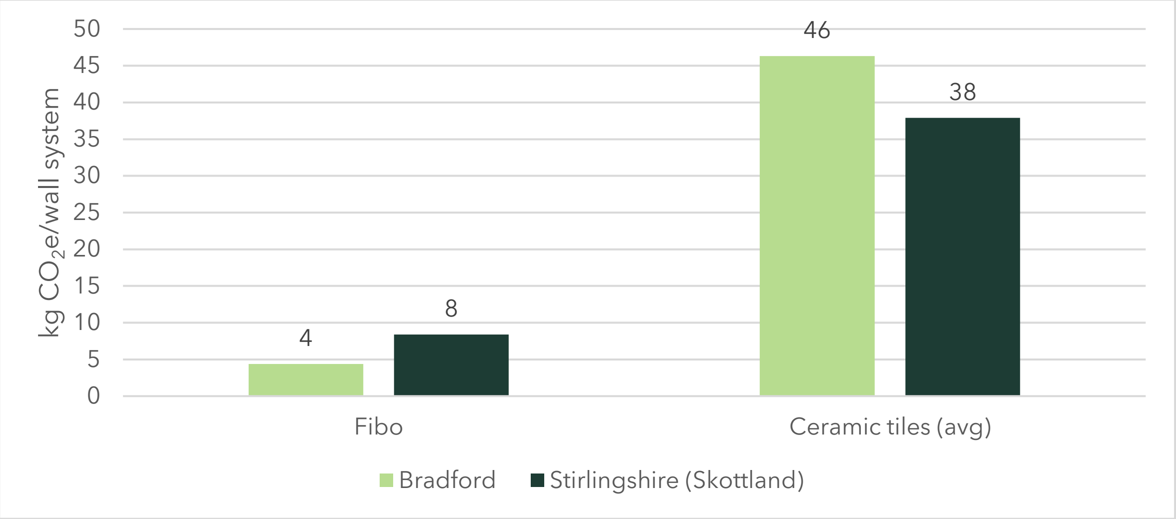

Figure 19 The climate impacts teeming from the transportation to the specific market in the UK.

3.2.4. “Cradle-to-gate” emissions

The climate impact including the whole value chain for all alternatives in the UK market are illustrated in the figures bellow. The emissions for the material usage and end-of-life are the same for all markets, but the transport distances are different, resulting in different total climate impact depending on the market location.

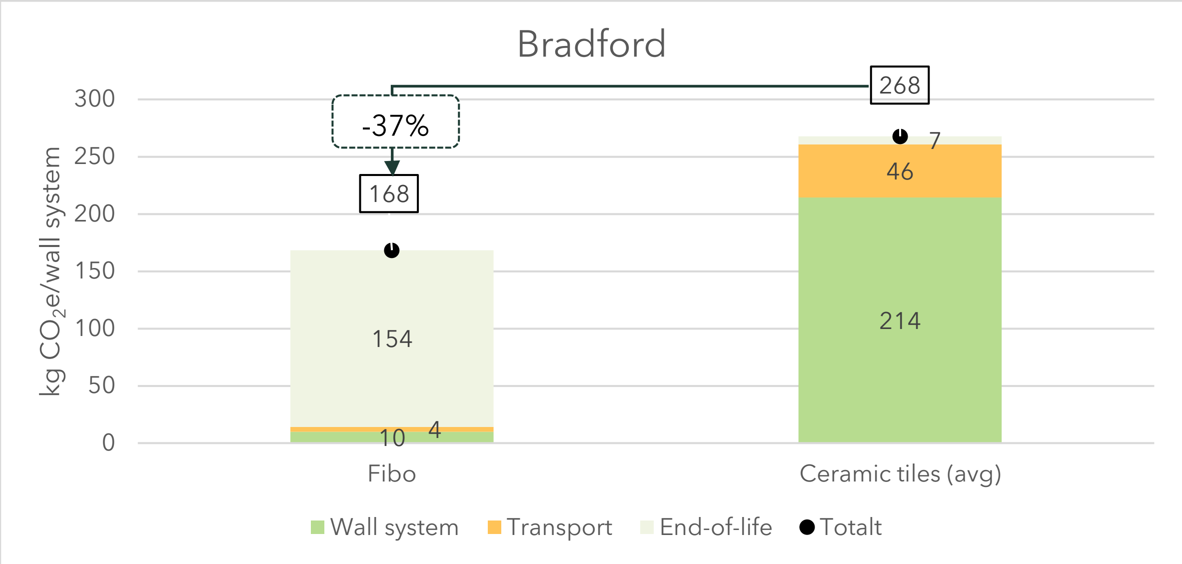

Figure 20 The «cradle-to-grave" emissions for a 11,5 m² wall system in Bradford.

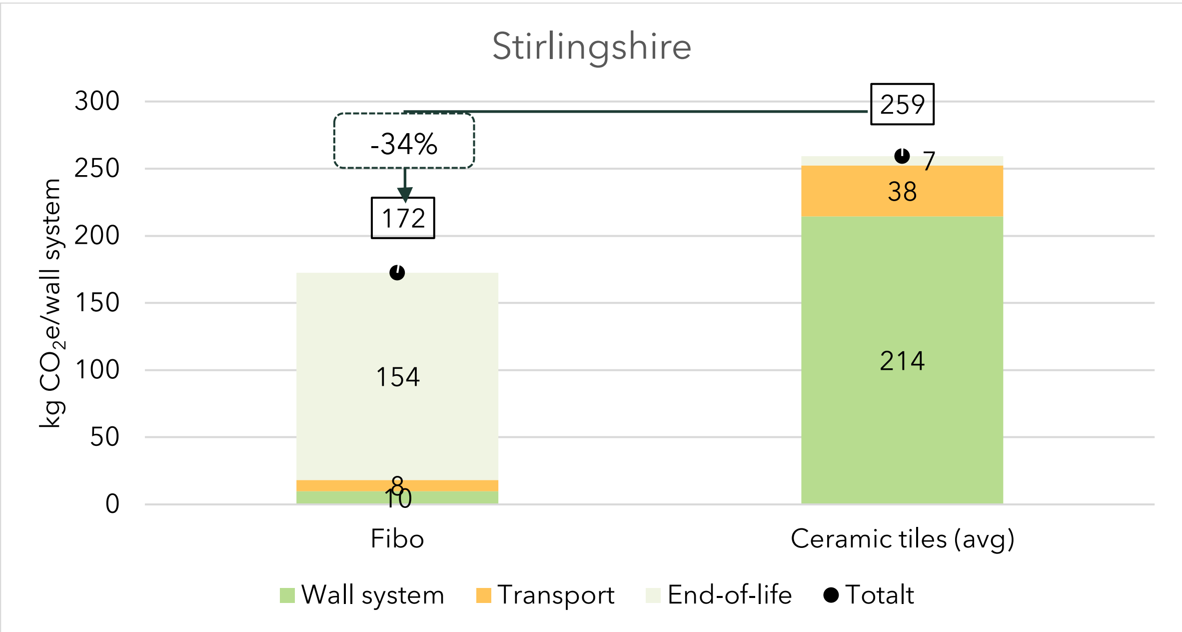

Figure 21 The «cradle-to-grave" emissions for a 11,5 m² wall system in Stirlingshire.

3.3. A North American bathroom wall system (8,6m²)

3.3.1. Material usage

The total material usage for a North American bathroom wall system is illustrated in Figure 22. The Fibo wall system, with its Aqualock feature, is instantly sealed when mounted, whereas tiles require an underlying layer of membrane covered plasterboards or other waterproofing solutions. The total amount of materials required to build a waterproof bathroom wall system is therefore significantly higher when using tiles than for a Fibo based system.

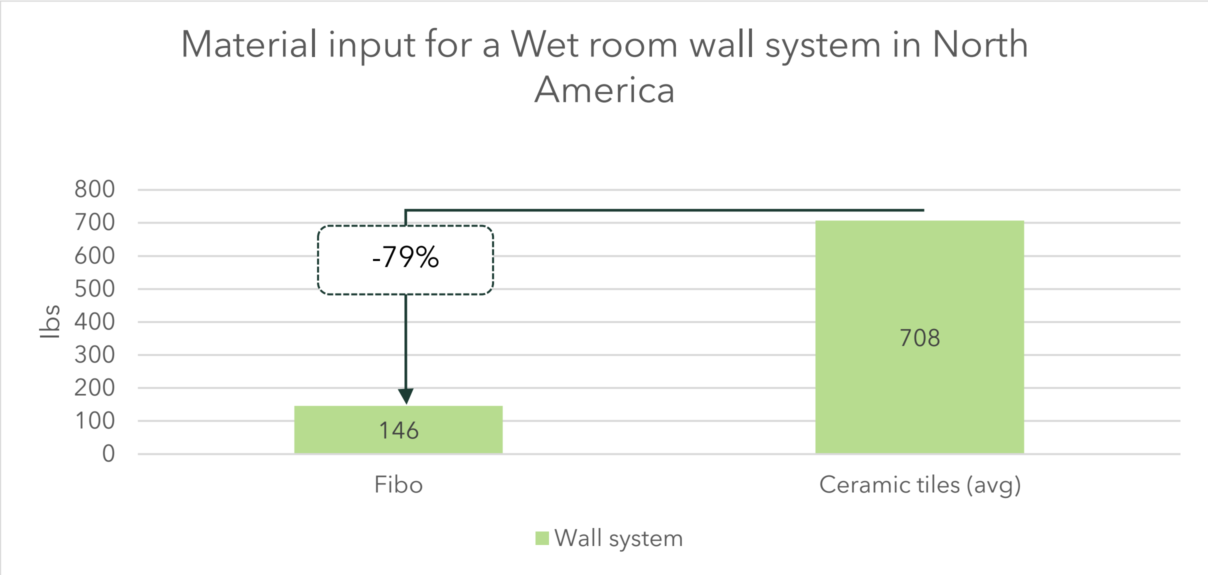

Figure 22 Material usage in Ibs for a bathroom wall system in the North American market

3.3.2. "Cradle-to-gate"

The total amount of materials required to build a waterproof bathroom wall system is significantly higher when using tiles than for a Fibo based system, which also causes a higher climate impact for tiles as illustrated in Figure 23. As Fibo wall panels are mainly wood based; the core in birch plywood accounts for 80% of the panel weight. As the wood is harvested from renewable forests (FSC or PEFC certified wood), carbon is captured and contained in the material. In a life-cycle perspective, the production and use of Fibo panels have a significantly lower CO_2 footprint compared to other materials in this analysis.

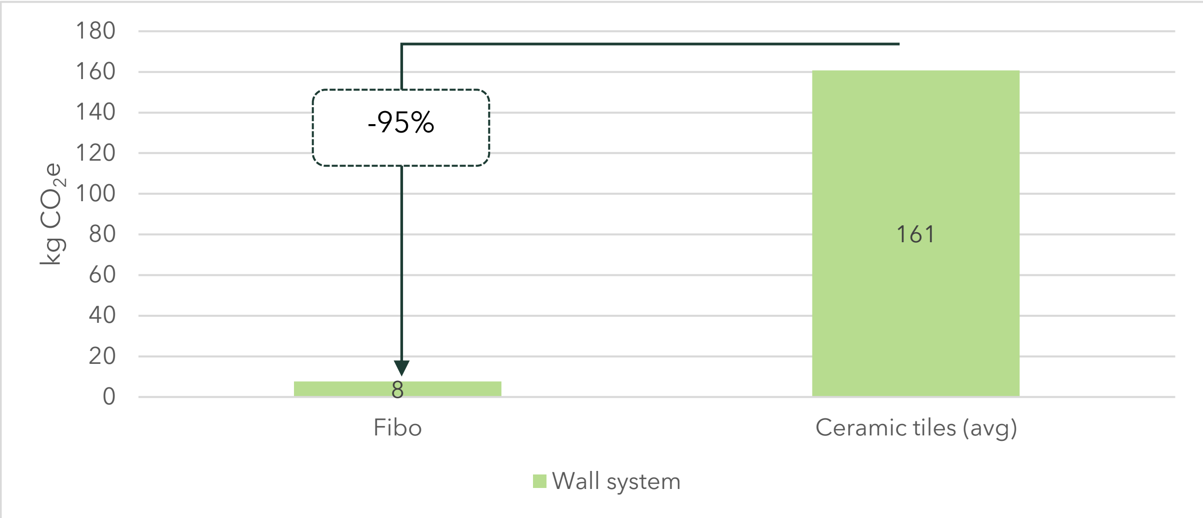

Figure 23 Climate impact in a "cradle-to-gate" perspective for the North American bathroom wall system, excluding the end-of-life emissions.

After the useful life of a bathroom, the wood-based materials will either be recycled, degraded, or incinerated for energy recovery. Assuming that no part of a Fibo bathroom is recycled or re-used, the carbon that has been captured will be released once the wood is degraded. As there is no bound carbon in ceramic tiles, impacts from end-of-life waste treatment are limited to waste handling infrastructural emissions. The climate impact including end-of-life is included in Figure 24, showing that in a life cycle perspective the climate impact from a Fibo bathroom is significantly increased.

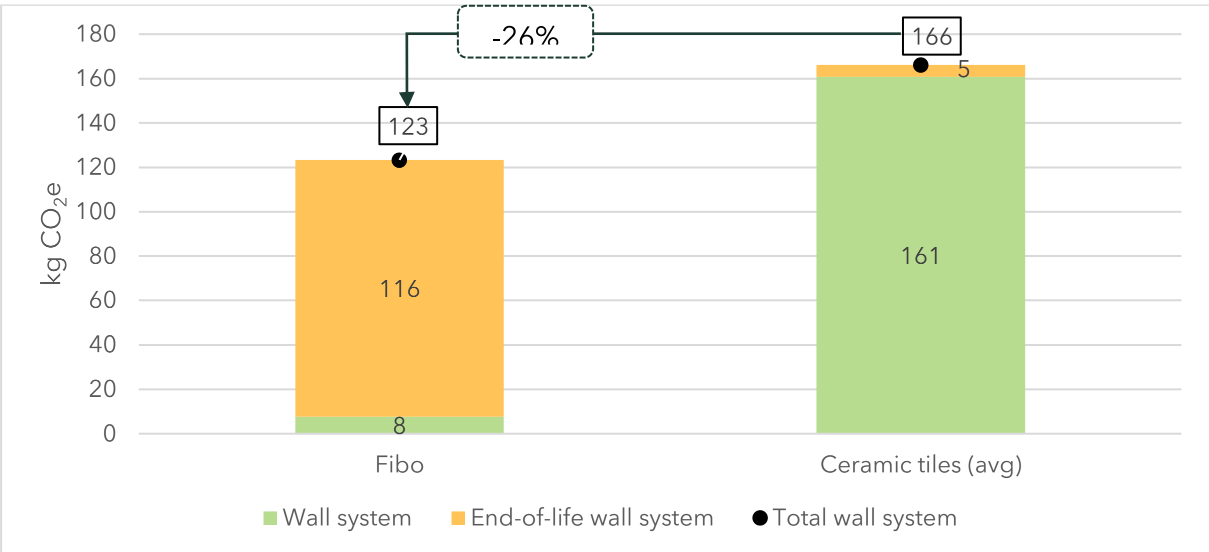

Figure 24 Climate impact in a "cradle-to-gate" perspective for the different North American bathrooms, including the end-of-life emissions

3.3.2.1 Contribution of the bathroom components

Figure 25 illustrates the climate impact of all components in a Fibo wall system. Due to the system design, Fibo's wall covering solution consists of only a few components, implying that the waterproof wall panels accounts for the vast majority of the emissions. End-of-life treatment of the wall panels is the largest components of the Fibo system's climate impact.

Figure 26 illustrates the climate impact of all components in a tiled bathroom wall system. As the tiled wall system has high material usage and high climate impact, the choice of tiles highly affects the total climate impact of the bathroom.

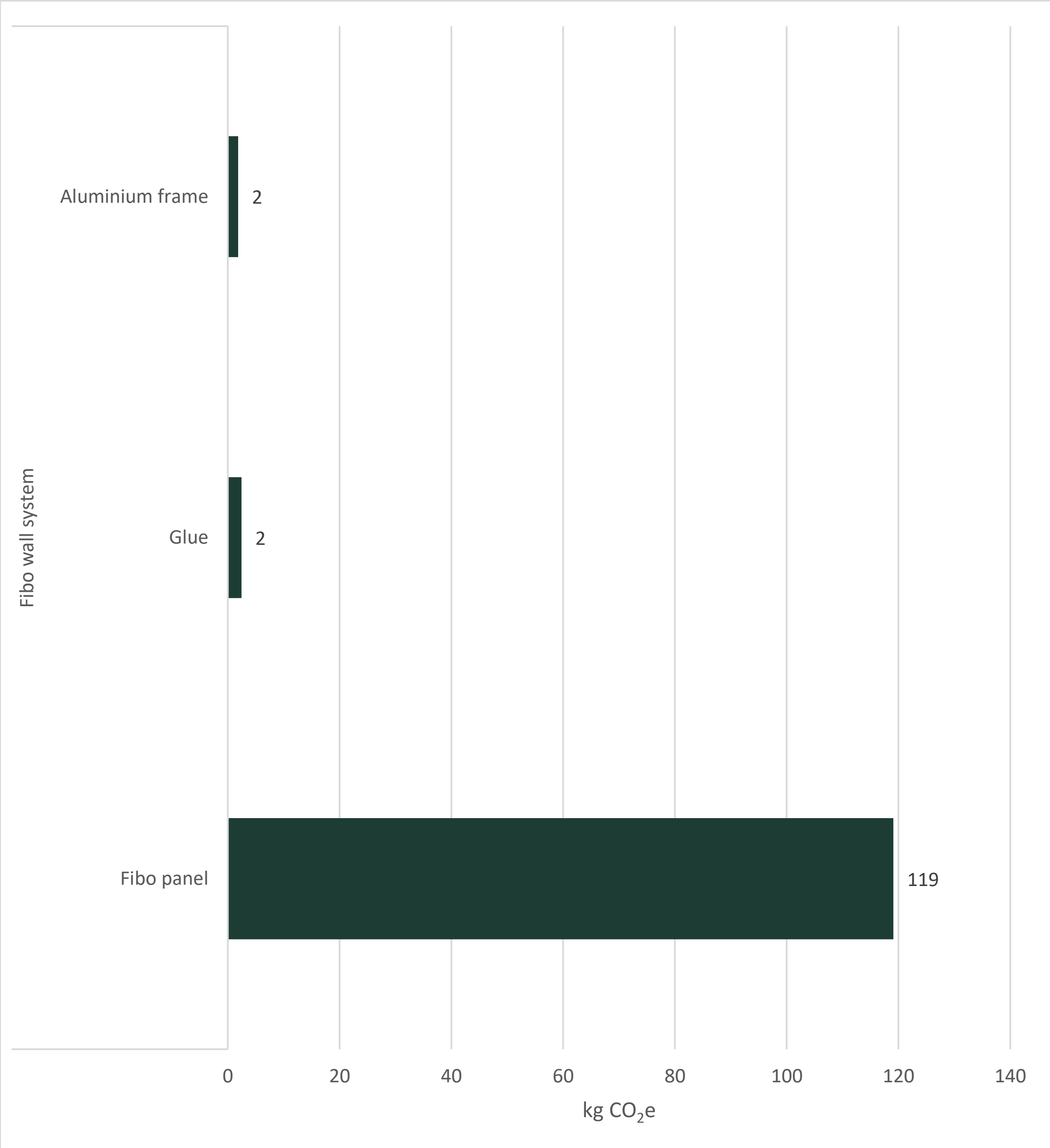

Figure 25 Climate impact of all components in a Fibo bathroom in a "cradle-to-gate" perspective including end-of-life.

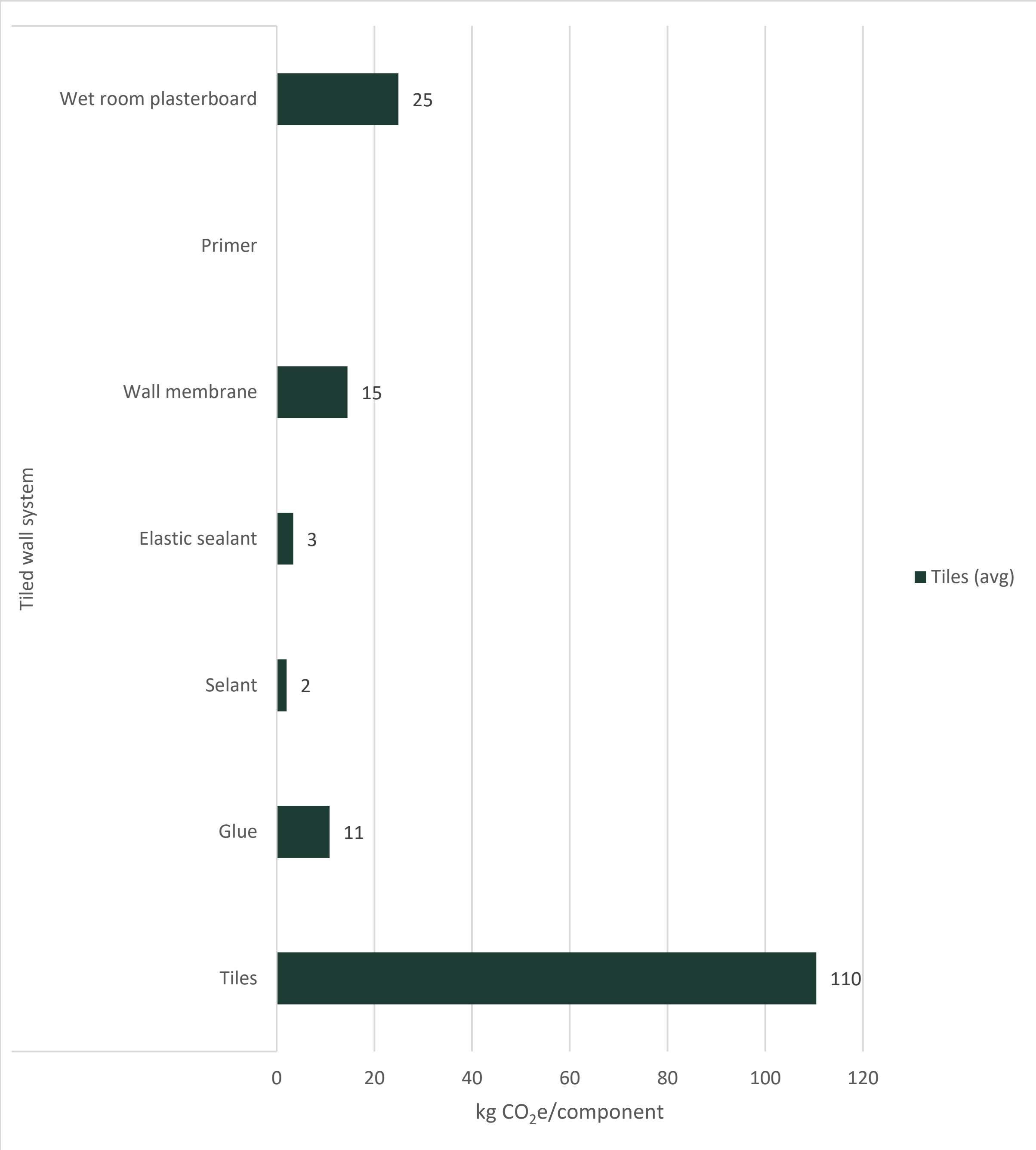

Figure 26 Climate impact of all components in a tiled bathroom in a "cradle-to-gate" perspective including end-of-life.

3.3.3. Transportation to different markets

The emissions for the transportation of the materials to the different markets in the North America highly depends on the transport distance and the weight of the materials. Figure

27 illustrates the emissions from transportation to Norfolk, Oakland, and Montréal (Canada). As the tiled bathroom have higher material usage, this highly affect the transportation phase. These results are highly sensitive to the assumption about production location and the transport distance, but also the choice of components and their weight. As the wall components are assumed produces in Europe or Asia, the transport distance is long.

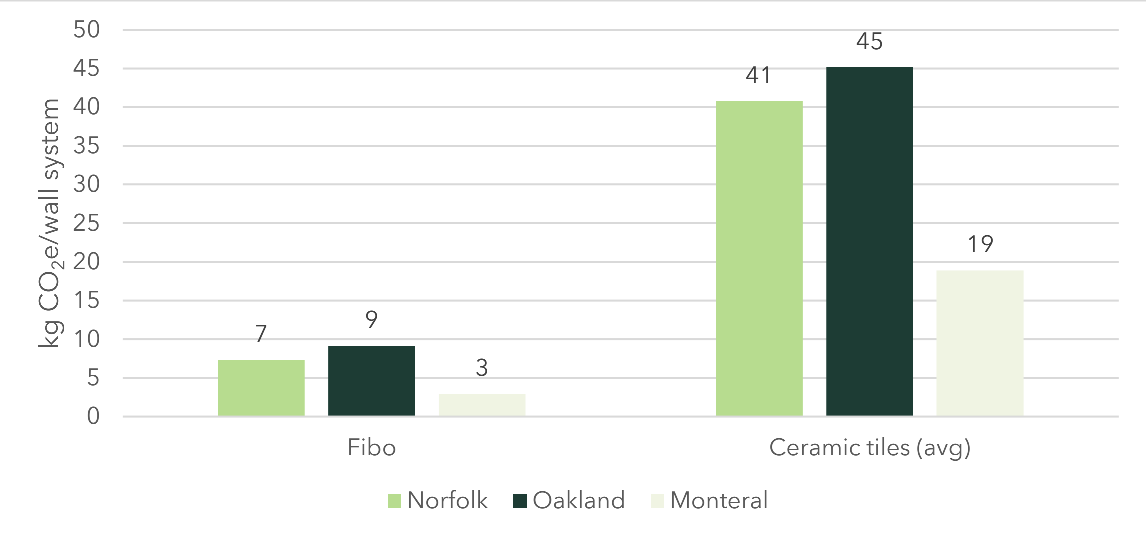

Figure 27 The climate impacts teeming from the transportation to the specific market in North America.

3.3.4. "Cradle-to-gate" emissions

The climate impact including the whole value chain for all alternatives in the North American market are illustrated in the figures bellow. The emissions for the material usage and end-of-life are the same for all markets, but the transport distances are different, resulting in different total climate impact depending on the market location.

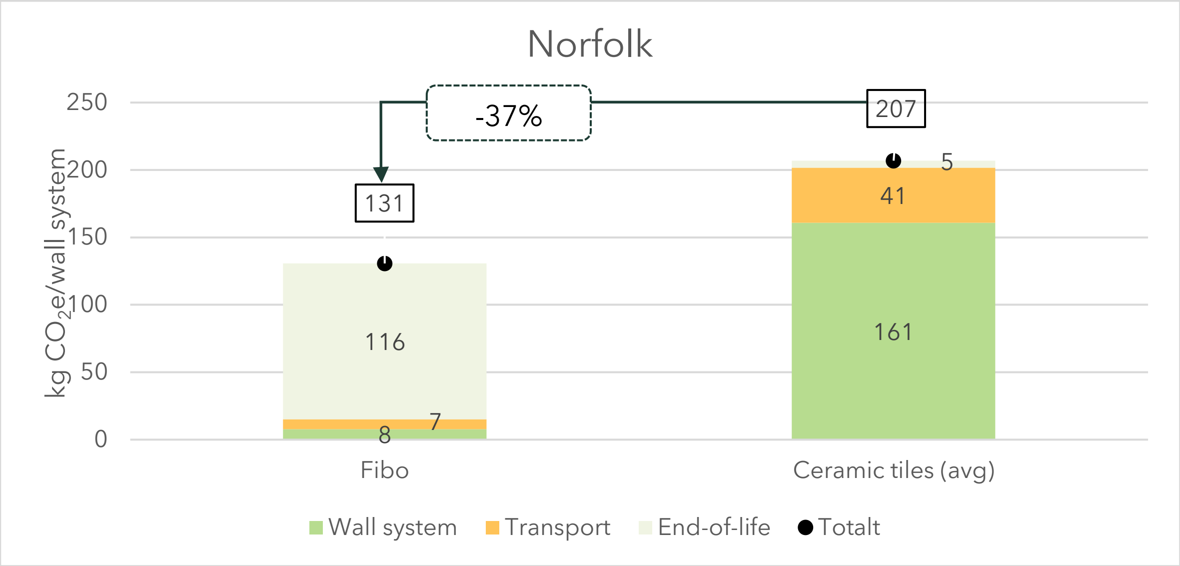

Figure 28 The «cradle-to-grave" emissions for a bathroom wall system in Norfolk.

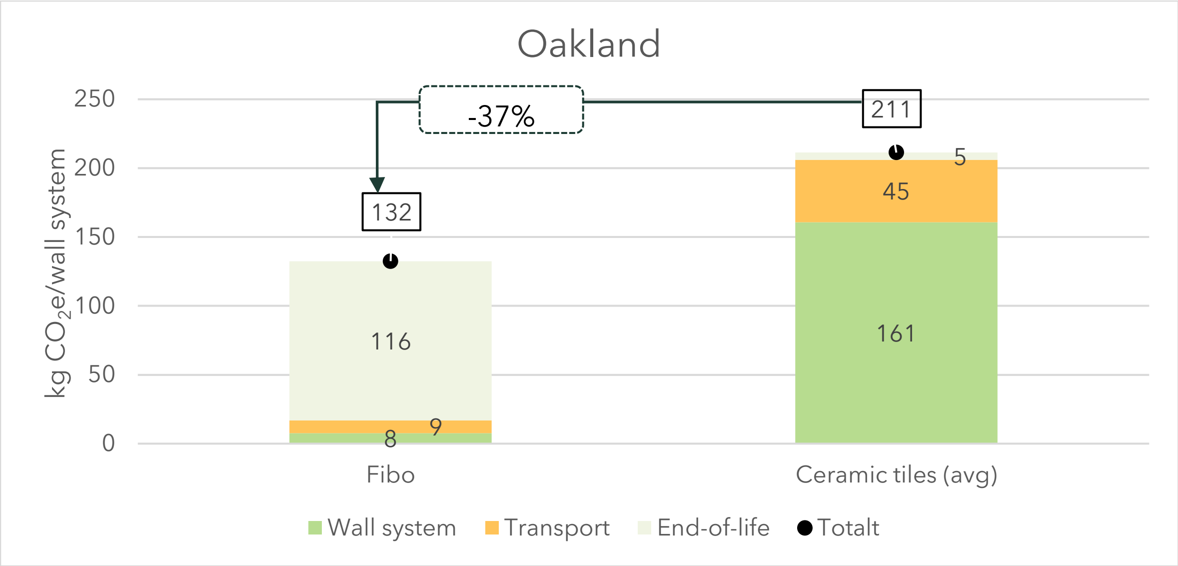

Figure 29 The «cradle-to-grave" emissions for a bathroom wall system in Oakland.

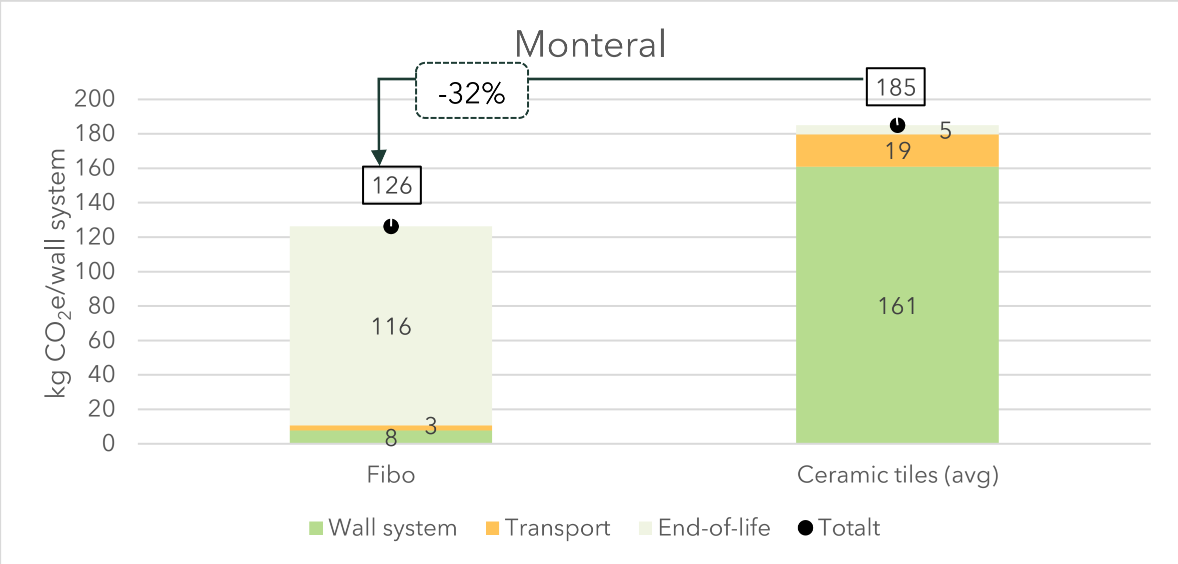

Figure 30 The «cradle-to-grave" emissions for a bathroom wall system in Montréal, Canada.

4. Discussion

4.1. Uncertainty

Life cycle assessments and carbon budgets always includes a significant uncertainty. This origin from several aspects, such as the variations in the analysed system, data quality, choices within the methodology, and the impact assessments methods which estimates the environmental impacts.

Several types of bathrooms are compared, and the comparison is based on the same functional unit and with the same methodical considerations. According to ISO 14044 comparisons between systems shall also have the same data quality and decision rules. The assumptions regarding the relevant bathroom dimensions for UK and North America are based on the assumption that it is possible to scale the material usage according to the material consumption per m^2.

Despite the uncertainty within the analysis, the results for the main activities which contributes to the climate footprint of bathrooms are satisfactory for a screening analysis.

4.2. Sensitivity of the results

Due to the total weight of tiles required to cover walls in a bathroom, tiles account for the highest amount of climate emissions in our analysis. The total weight also impacts the emissions from transportation, which also contributes significantly to total emissions.

The overall result is sensitive to assumptions made on the membrane, implying that small changes in the choice of representative technology or emission inventory for the material will have a significant impact on the overall result.

Due to emissions from transportation of the heavy materials required to furnish a bathroom walls with tiles, locally produced tiles will have significantly lower emissions than tiles imported from afar. Also, alternative solutions for waterproof membranes or sealings will also impact total climate emissions from a tiled bathroom.

4.3. Limitations

The impact assessment results in this analysis are limited to climate impacts for a bathroom wall system. The relative performance of the various bathroom wall covering solutions, transportation and geographic aspects may differ greatly for other impact assessment categories. A full LCA, which should include several impact categories in addition to climate change potential, is recommended to fully understand environmental impacts associated with the life cycle of a bathroom wall system.

Results of the study are limited to the data inventory obtained, the assumptions and considerations taken, and are in such not representative for other bathrooms and bathroom covering technologies. Further, there may be different regulations and demands for the included markets which are not considered in this study, causing the components in this study to differ from actual bathrooms for the included markets.

As this study only includes a bathroom wall system, the results shall not be interpreted as the climate impact of a full bathroom. Such interpretations require assessments which also includes flooring and the excluded components.

Life cycle assessments and carbon footprint analyses where results are intended to inform consumers should follow the respective ISO standards. All requirements and relevant aspects of the standards must further be met when results are intended for comparative purposes. A screening analysis may follow, but does not adhere fully to, ISO 14044.

5. Conclusion

Given the assumptions in the analysis, we find that a bathroom wall system with a Fibo waterproof panel has a total lifetime CO_2 footprint that is lower than the CO_2 footprint of a fully tiled wall system. Furthermore, whereas most of the CO_2 footprint from a tiled bathroom wall occurs prior to the installation, the full CO_2 impact of a Fibo wall system will only be seen when all the wall panels are naturally degraded or burned for energy recovery after the useful lifetime of the bathroom. Re-use or recycling of Fibo wall panels, thus mitigating or avoiding entirely the release of embedded biogenic carbon, provide significant opportunities to further lower Fibo wall panel emissions.

References

Norsk byggkeramiskforening (2018). Bærekraftige konstruksjoner med keramiske fliser. Livsløpsvurdering og miljødokumentasjon. Available at https://sintef.brage.unit.no/sintef-xmlui/bitstream/handle/11250/2505923/B%25C3%25A6rekraftig-konstruksjoner-med-Keramiske-NBKF-ver-012018.pdf?sequence=2&isAllowed=y

Appendix 1

Transport distances for Fibo wall system to different markets

Table 12 Overview of the transport distance for a Fibo wall system to different markets.

Market	Route		Distance (km)	Technology
Norfolk	Part 1	Lyngdal - Kristiansand	76	Truck EURO 6, 32 ton
	Part 2	Kristiansand - USA (Norfolk port)	6678	Large container ship
	Part 3	Norfolk port - Cuyahoga Heights 44105 Cleveland	893	Truck EURO 6, 32 ton
Oakland	Part 1	Lyngdal - Kristiansand	76	Truck EURO 6, 32 ton
	Part 2	Kristiansand - USA (Oakland port)	20659	Large container ship
Montréal	Part 1	Lyngdal - Kristiansand	76	Truck EURO 6, 32 ton
	Part 2	Kristiansand - Canada (Montréal)	5989	Large container ship
Helsingfors	Part 1	Lyngdal - Kristiansand	76	Truck EURO 6, 32 ton
	Part 2a	Kristiansand - Helsingfors, u/ferry	1025	Truck EURO 6, 32 ton
	Part 2b	Horten-Moss, Åland-Kapellskar, Åbo-Åland	202	Ferry
Stockholm	Part 1	Lyngdal - Kristiansand	76	Truck EURO 6, 32 ton
	Part 2a	Kristiansand - Stockholm u/ferry	751	Truck EURO 6, 32 ton
	Part 2b	Horten-Moss	11	Ferry
Berlin	Part 1	Lyngdal - Kristiansand	76	Truck EURO 6, 32 ton
	Part 2a	Kristiansand - Berlin	790	Truck EURO 6, 32 ton
	Part 2b	Kristiansand-Hirshals	136	Ferry
Bradford	Part 1	Lyngdal - Kristiansand	76	Truck EURO 6, 32 ton
	Part 2a	Kristiansand - Berlin	790	Truck EURO 6, 32 ton
	Part 2b	Kristiansand-Hirshals	136	Ferry
Stirlingshire	Part 1	Lyngdal - Larvik	264	Truck EURO 6, 32 ton
	Part 2	Larvik - Immingham	917	Small container ship

	Part 3	Immingham-Stirlingshire	472	Truck EURO 6, 32 ton
Holland	Part 1	Lyngdal - Kristiansand	76	Truck EURO 6, 32 ton
	Part 2a	Kristiansand - Utrecht	960	Truck EURO 6, 32 ton
	Part 2b	Kristiansand-Hirshals	136	Ferry
Oslo	Part 1	Lyngdal - Oslo	394	Truck EURO 6, 32 ton
Bergen	Part 1	Lyngdal – Bergen	411,5	Truck EURO 6, 32 ton
	Part 2	Ferry	30,5	Ferry

Appendix 2

Transport distances for a tiled bathroom

Table 13 Overview of the transport distance for the different components in a tiled bathroom wall solution to different markets.

Market	Component	Assumed production location	Route		Distance (km)	Technology
Norfolk	Glue, sealant	Pargas, 21600, Finland	Part 1	Pargas, Finland - port Åbo, Finland	176	Truck EURO 6, 32 ton
			Part 2 boat	port Åbo, Finland - USA Norfolk	8027	Container ship
			Part 3	Norfolk port - Cuyahoga Heights 44105 Cleveland	893	Truck EURO 6, 32 ton
	Elastic sealant, Membrane	EU marked (Frankfurt Germany)	Part 1	Frankfurt - Rotterdam	454	Truck EURO 6, 32 ton
			Part 2 boat	Rotterdam - USA Norfolk	6569	Container ship
			Part 3	Norfolk port - Cuyahoga Heights 44105 Cleveland	893	Truck EURO 6, 32 ton
	Primer	Street 17A, Al Quoz Industrial Area 2 Dubai United Arab Emirates	Part 1a	Dubai(Port Rashid) - USA Norfolk	15123	Truck EURO 6, 32 ton
			Part 2 boat	Norfolk port - Cuyahoga Heights 44105 Cleveland	893	Container ship
	Tiles	Italia	Part 1	2013 Casalgrande (RE) Italy - porto di liverno	232	Truck EURO 6, 32 ton
			Part 2 boat	porto di liverno - USA Norfolk	8334	Container ship
			Part 3	Norfolk port - Cuyahoga Heights 44105 Cleveland	893	Truck EURO 6, 32 ton

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			Part 1	Fredrikstad port- Norfolk port	7728	Container ship
	Plaster boards	Fredrikstad, Norway	Part 2	Norfolk port - Cuyahoga Heights 44105 Cleveland	893	Truck EURO 6, 32 ton
			Part 1	Pargas, Finland - port Åbo, Finland	176	Truck EURO 6, 32 ton
	Glue, sealant	Pargas, 21600, Finland	Part 2 boat	port Åbo, Finland - USA Oakland	22209	Container ship
			Part 1	Frankfurt - Rotterdam	454	Truck EURO 6, 32 ton
	Elastic sealant, Membrane	EU marked (Frankfurt Germany)	Part 2 boat	Rotterdam - USA Oakland	19839	Container ship
	Primer	Street 17A, Al Quoz Industrial Area 2 Dubai United Arab Emirates	Part 1a	Dubai(Port Rashid) - USA Oakland	27191	Container ship
			Part 1	2013 Casalgrande (RE) Italy - Porto di Livorno	232	Truck EURO 6, 32 ton
	Tiles	Italy	Part 2 boat	Porto di Livorno- USA Oakland	19248	Container ship
Oakland	Plaster boards	Fredrikstad, Norway	Part 1	Fredrikstad port- Oakland port	20946	Container ship
			Part 1	Pargas, Finland - port Åbo, Finland	176	Truck EURO 6, 32 ton
	Glue, sealant	Pargas, 21600, Finland	Part 2 boat	port Åbo, Finland - Montréal	7338	Container ship
			Part 1	Frankfurt - Rotterdam	454	Truck EURO 6, 32 ton
	Elastic sealant, Membrane	EU marked (Frankfurt Germany)	Part 2 boat	Rotterdam - Montréal	6093	Container ship
	Primer	Street 17A, Al Quoz Industrial Area 2 Dubai United Arab Emirates	Part 1a	Dubai(Port Rashid) - Montréal port	14786,368	Container ship
Montréal	Tiles	Italia	Part 1	2013 Casalgrande	232	Truck EURO 6, 32 ton

				(RE) Italy - porto di liverno		
			Part 2 boat	Porto di liverno-Montréal	7488	Container ship
	Plaster boards	Fredrikstad, Norway	Part 1	Fredrikstad port- Monteral port	6432	Container ship

Market	Component	Assumed production location	Route		Distance (km)	Technology
Helsingfors	Glue, sealant	Pargas, 21600, Finland	Part 1	Pargas, Finland - Helsingfos, Finland	176	Truck EURO 6, 32 ton
	Elastic sealant, Membrane	EU marked (Frankfurt Germany)	Part 1a	Frankfurt - Tallin	2052	Truck EURO 6, 32 ton
			Part 1b	Tallin-Helsingfors	82	Ferry
	Primer	Street 17A, Al Quoz Industrial Area 2 Dubai United Arab Emirates	Part 1a	Dubai - Helsingfors	6342	Truck EURO 6, 32 ton
	Tiles	Italy	Part 1	2013 Casalgrande (RE) Italy - Helsingfors	2433	Truck EURO 6, 32 ton
			Part 2	Talinn - Helsingi	82	Ferry
	Plaster boards	Fredrikstad, Norway	Part 1	Fredrikstad port-Helsingfors	771	Truck EURO 6, 32 ton
			Part 2	Ferry Fredrikstad port-Helsingfors	206	Ferry
Stockholm	Glue, sealant	Pargas, 21600, Finland	Part 1a	Pargas, Finland - Stockholm	133	Truck EURO 6, 32 ton
			Part 1b	Ferry total	206	Ferry
	Elastic sealant, Membrane	EU marked (Frankfurt Germany)	Part 1a	Frankfurt - Stockholm (u/ferry)	1445	Truck EURO 6, 32 ton
			Part 1b	Ferry	19	Ferry
	Primer	Street 17A, Al Quoz Industrial Area 2 Dubai United Arab Emirates	Part 1a	Dubai - Stockholm	7163	Truck EURO 6, 32 ton
			Part 1b	Sassnitz-Ystad	113	Ferry
	Tiles	Italy	Part 1a	2013 Casalgrande (RE) Italy - Stockholm (U/ferry)	2055	Truck EURO 6, 32 ton
			Part 1b	Sassnitz-Ystad	113	Ferry

	Plaster boards	Fredrikstad, Norway	Part 1	Fredrikstad port-Stockholm	518	Truck EURO 6, 32 ton
Berlin	Glue, sealant	Pargas, 21600, Finland	Part 1a	Pargas, Finland - Berlin	1729,1	Truck EURO 6, 32 ton
			Part 1b	Ferry total	81,9	Ferry
	Elastic sealant, Membrane	EU marked (Frankfurt Germany)	Part 1a	Frankfurt - Berlin	551	Truck EURO 6, 32 ton
	Primer	Street 17A, Al Quoz Industrial Area 2 Dubai United Arab Emirates	Part 1a	Dubai - Berlin	6230	Truck EURO 6, 32 ton
	Primer	Italy	Part 1a	2013 Casalgrande (RE) Italy - Berlin	1116	Truck EURO 6, 32 ton
	Plaster boards	Fredrikstad, Norway	Part 1	Fredrikstad port- Berlin	847	Truck EURO 6, 32 ton
			Part 2	Ferry Fredrikstad port- Berlin	113	Ferry
Bradford	Glue, sealant	Pargas, 21600, Finland	Part 1a	Pargas, Finland - port Åbo	28,9	Truck EURO 6, 32 ton
			Part 2	Port Åbo-Hull	2043	containership
			Part 3	Kingston upon Hull- Bradford	115	Truck EURO 6, 32 ton
	Elastic sealant, Membrane	EU marked (Frankfurt Germany)	Part 1a	Frankfurt - Bradford (u/ferry)	1088	Truck EURO 6, 32 ton
			Part 1b	Ferry total		Ferry
	Primer	Street 17A, Al Quoz Industrial Area 2 Dubai United Arab Emirates	Part 1a	Dubai - Bradford	7401	Truck EURO 6, 32 ton
	Tiles	Italy	Part 1a	2013 Casalgrande (RE) Italy - Bradford (U/ferry)	1270	Truck EURO 6, 32 ton
	Plaster boards	Fredrikstad, Norway	Part 1	Fredrikstad port- Hull	115	Container ship
			Part 2	Hull port- Bradford	113	Ferry
Stirlingshire (Scotland)	Glue, sealant	Pargas, 21600, Finland	Part 1	Pargas, Finland - port Åbo	28,9	Truck EURO 6, 32 ton

			Part 2	Port Åbo-Immingham	2029,792	
			Part 3	Immingham-Stirlingshire	472	Ferry
	Elastic sealant, Membrane	EU marked (Frankfurt Germany)	Part 1a	Frankfurt - Stirlingshire (Scotland) (u/ferry)	1433	Truck EURO 6, 32 ton
	Primer	Street 17A, Al Quoz Industrial Area 2 Dubai United Arab Emirates	Part 1a	Dubai - Stirlingshire (Scotland)	7746	Truck EURO 6, 32 ton
	Tiles	Italy	Part 1a	2013 Casalgrande (RE) Italy - Stirlingshire (Scotland) (U/ferry)	2124	Truck EURO 6, 32 ton
	Plaster boards	Fredrikstad, Norway	Part 1	Fredrikstad port- Port Immingham	1422	Container ship
			Part 2	Immingham port- Stirlingshire	472	Truck EURO 6, 32 ton
Holland	Glue, sealant	Pargas, 21600, Finland	Part 1	Pargas, Finland - port Åbo	29	Truck EURO 6, 32 ton
			Part 2	Port Åbo-Rotterdam	2043	containership
			Part 3	Rotterdam-Holland	57	Truck EURO 6, 32 ton
	Elastic sealant, Membrane	EU marked (Frankfurt Germany)	Part 1a	Frankfurt - Holland (u/ferry)	409	Truck EURO 6, 32 ton
	Primer	Street 17A, Al Quoz Industrial Area 2 Dubai United Arab Emirates	Part 1a	Dubai - Holland	6722	Truck EURO 6, 32 ton
	Tiles	Italy	Part 1a	2013 Casalgrande (RE) Italy - Holland	1218	Truck EURO 6, 32 ton
	Plaster boards	Fredrikstad, Norway	Part 1	Fredrikstad - Holland	1268	Container ship
			Part 2	Ferry	18,7	Truck EURO 6, 32 ton
Oslo	Glue, sealant	Pargas, 21600, Finland	Part 1	Pargas, Finland - Oslo	631	Truck EURO 6, 32 ton
			Part 2	Ferry	206	ferry

	Elastic sealant, Membrane	EU marked (Frankfurt Germany)	Part 1	Frankfurt - Oslo (u/ferry)	1310	Truck EURO 6, 32 ton
			Part 2	Ferry	163	Ferry
	Primer	Street 17A, Al Quoz Industrial Area 2 Dubai United Arab Emirates	Part 1	Dubai - Oslo	7157	Truck EURO 6, 32 ton
			Part 2	Ferry	113	Ferry
	Tiles	Italy	Part 1	Casalgrande (RE) Italy - Oslo	1932	Truck EURO 6, 32 ton
			Part 2	Ferry Casalgrande (RE) Italy - Oslo	163	Ferry
	Plaster boards	Fredrikstad, Norway	Part 1	Fredrikstad - Oslo	94,1	Truck EURO 6, 32 ton
Bergen	Glue, sealant	Pargas, 21600, Finland	Part 1	Pargas, Finland - Bergen	1095	Truck EURO 6, 32 ton
			Part 2	Ferry	206	ferry
	Elastic sealant, Membrane	EU marked (Frankfurt Germany)	Part 1	Frankfurt - Bergen (u/ferry)	1442	Truck EURO 6, 32 ton
			Part 2	Ferry	163	Ferry
	Primer	Street 17A, Al Quoz Industrial Area 2 Dubai United Arab Emirates	Part 1	Dubai – Bergen	7459	Truck EURO 6, 32 ton
			Part 2	Ferry	168	Ferry
	Tiles	Italy	Part 1	Casalgrande (RE) Italy - Bergen	2227	Truck EURO 6, 32 ton
			Part 2	Ferry Casalgrande (RE) Italy - Bergen	163	Ferry
	Plaster boards	Fredrikstad, Norway	Part 1	Fredrikstad - Bergen	559	Truck EURO 6, 32 ton

Appendix 3

Results per m2 bathroom wall system

Figure 31 and Figure 32 presents the material usage and climate impact per m2 of bathroom wall system.

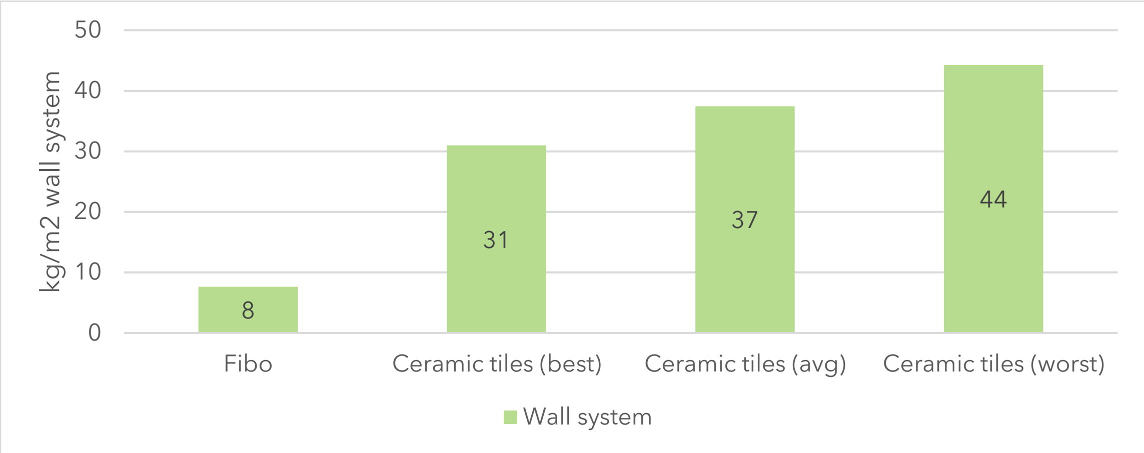

Figure 31 Material usage in kg per m2 of bathroom wall system

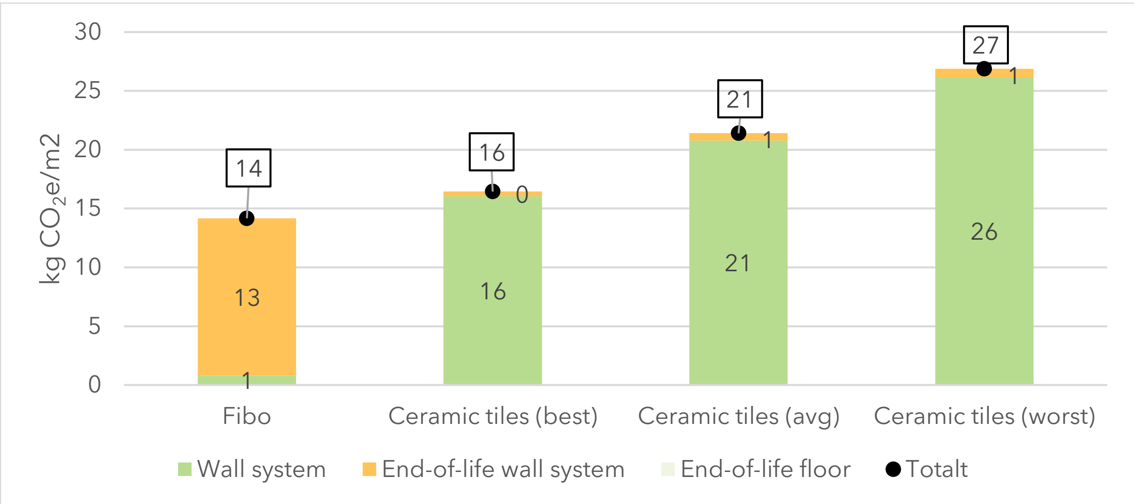

Figure 32 Climate impact in a "cradle-to-gate" perspective per m2 of wall system, including end-of-life emissions.

Appendix 4

Results including scenarios of "best" and "worst" tiles

The results presented for the tiled wall system are based on an average of several Italian tiles products, and there is a large variation in the carbon impact from the different Italian tiles. This section aims to provide information about this variation, and therefore the results are presented with "best", "average" and "worst" according to Table 4 in Chapter 2.

EU and Norwegian market

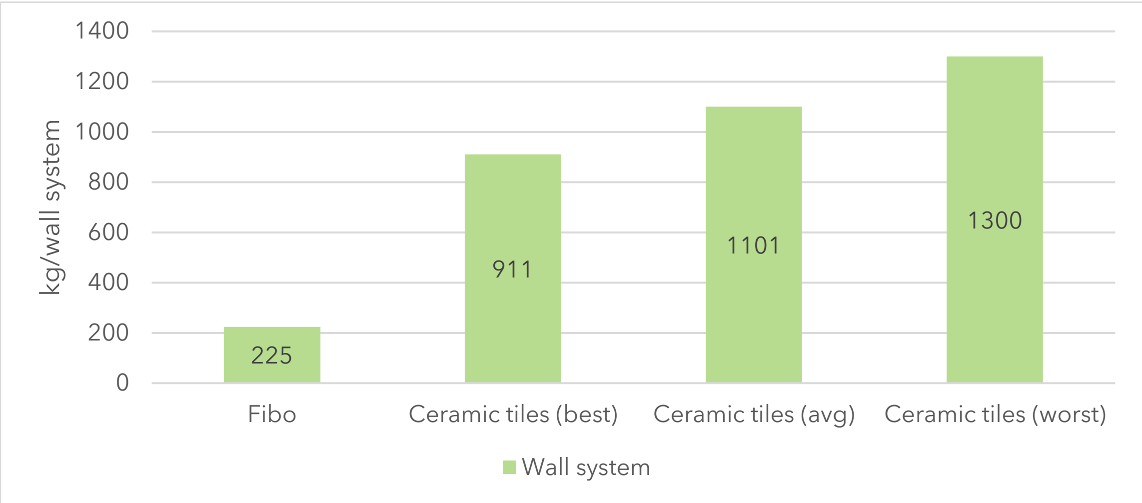

Figure 33 Material usage in kg for the Norwegian and EU bathroom walls.

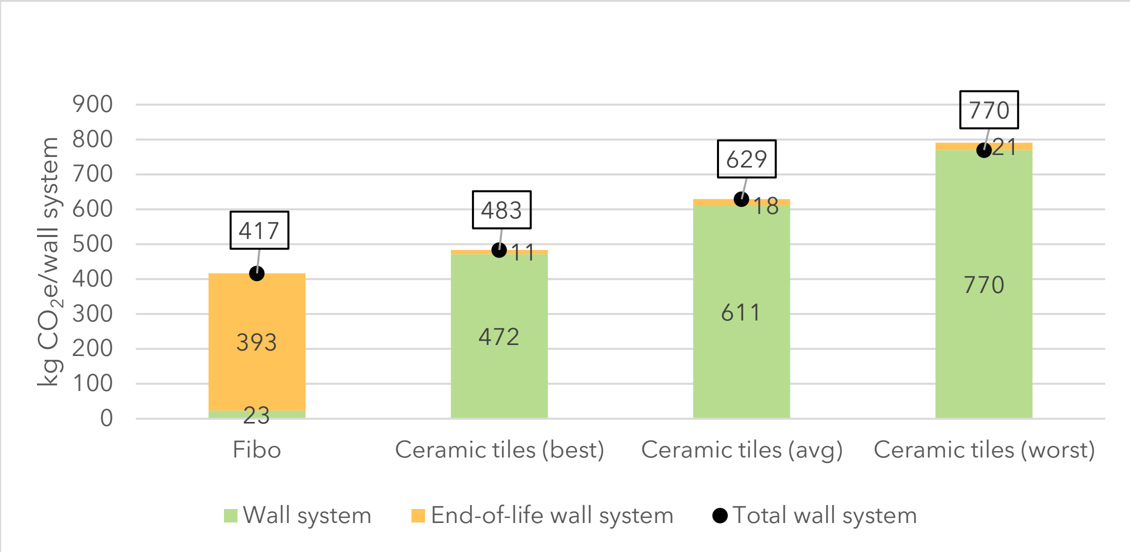

Figure 34 Climate impact in a "cradle-to-gate" perspective for the different bathroom walls for EU or Norway, including the end-of-life emissions.

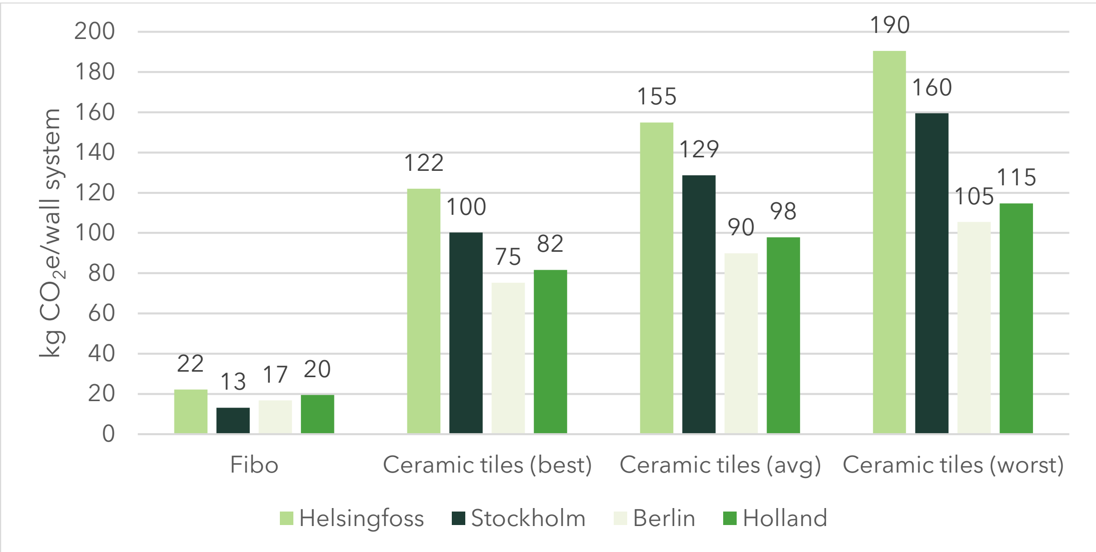

Figure 35 The climate impacts steeming from the transportation to the specific market in Europe.

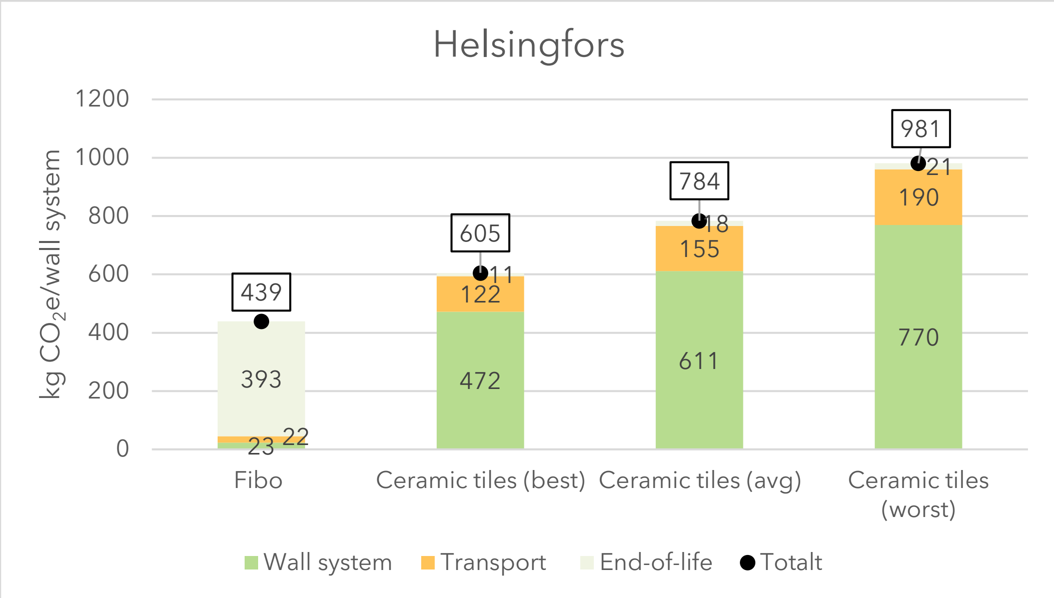

Figure 36 The «cradle-to-grave" emissions a bathroom wall system (29.4m²) in Helsingfors

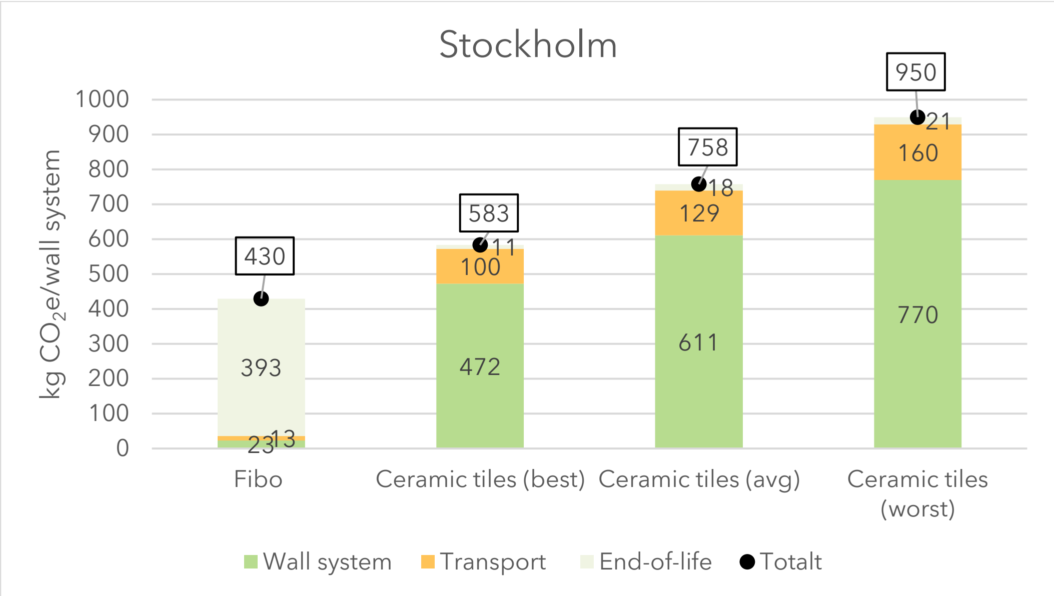

Figure 37 The «cradle-to-grave" emissions a bathroom wall system (29.4m²) in Stockholm

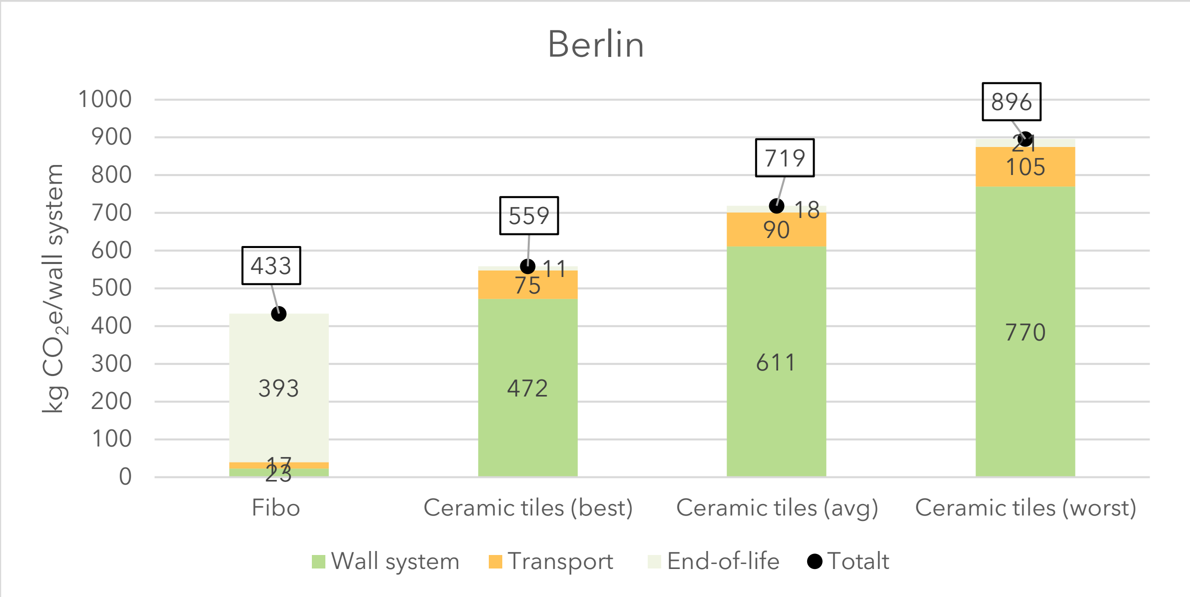

Figure 38 The «cradle-to-grave" emissions a bathroom wall system (29.4m²) in Berlin

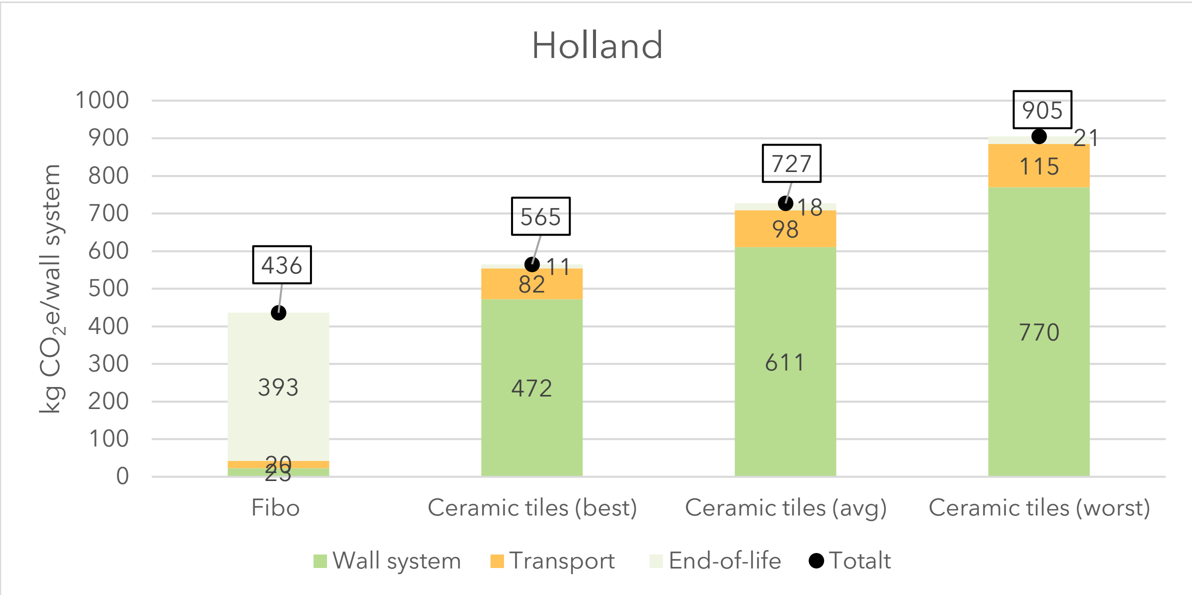

Figure 39 The «cradle-to-grave" emissions a bathroom wall system (29.4m²) in Holland

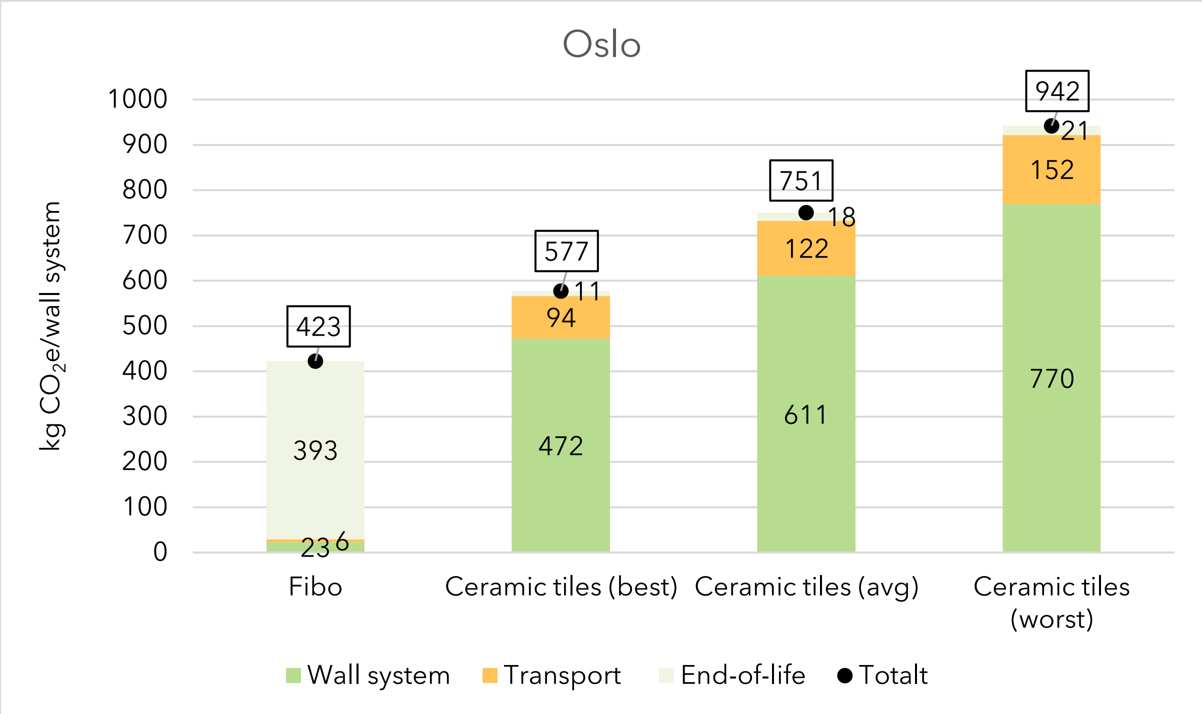

Figure 40 The «cradle-to-grave" emissions a bathroom wall system (29.4m2) in Oslo

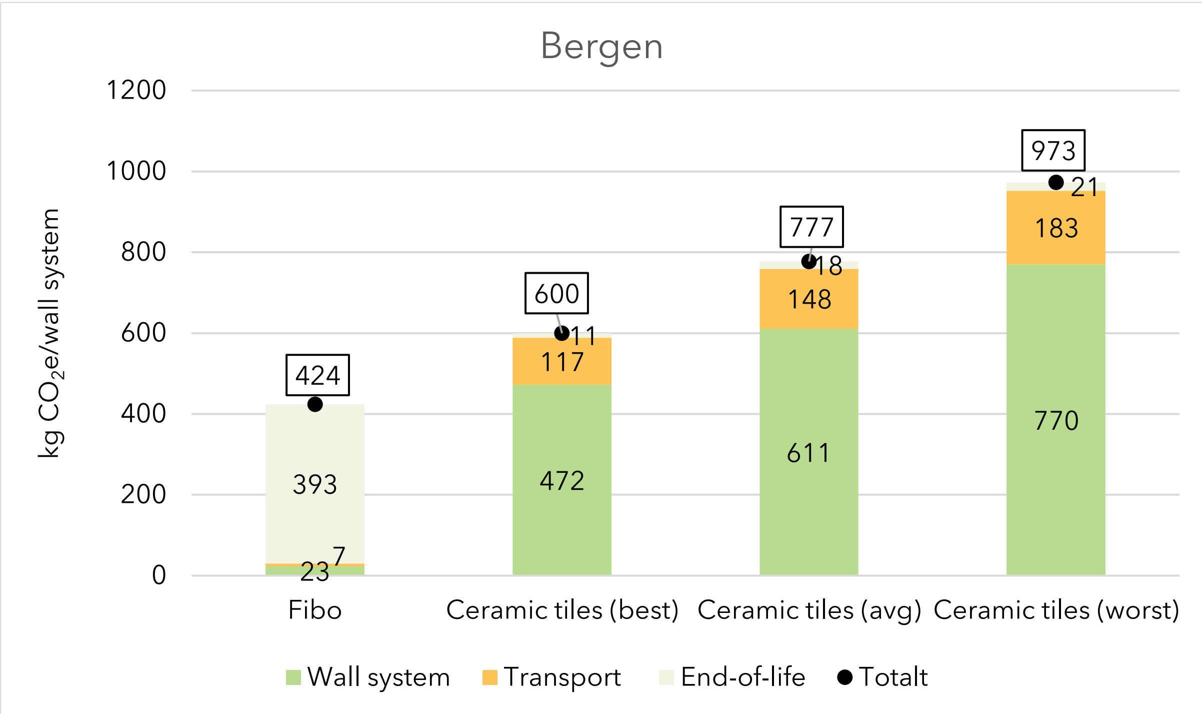

Figure 41 The «cradle-to-grave" emissions a bathroom wall system (29.4m2) in Bergen

UK market

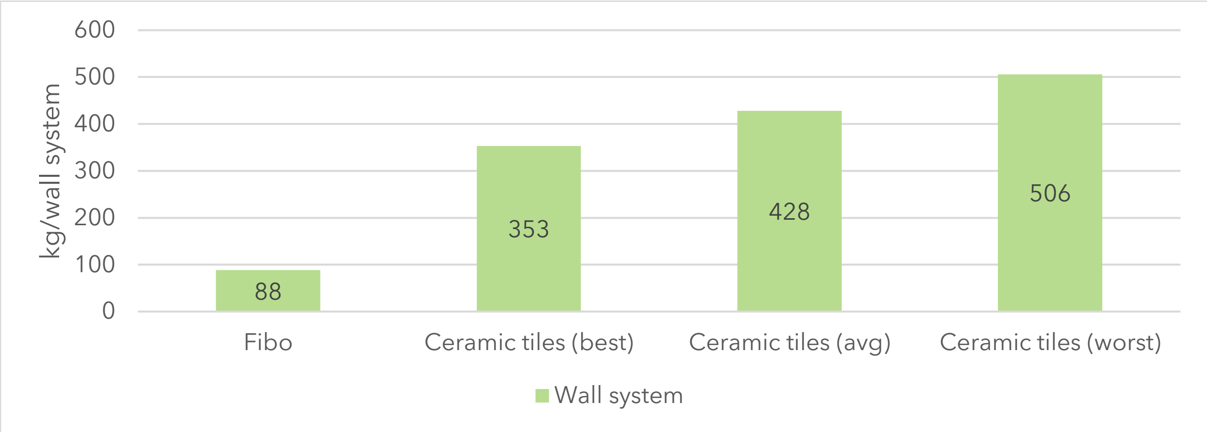

Figure 42 Material usage in kg for a wall system in the UK market

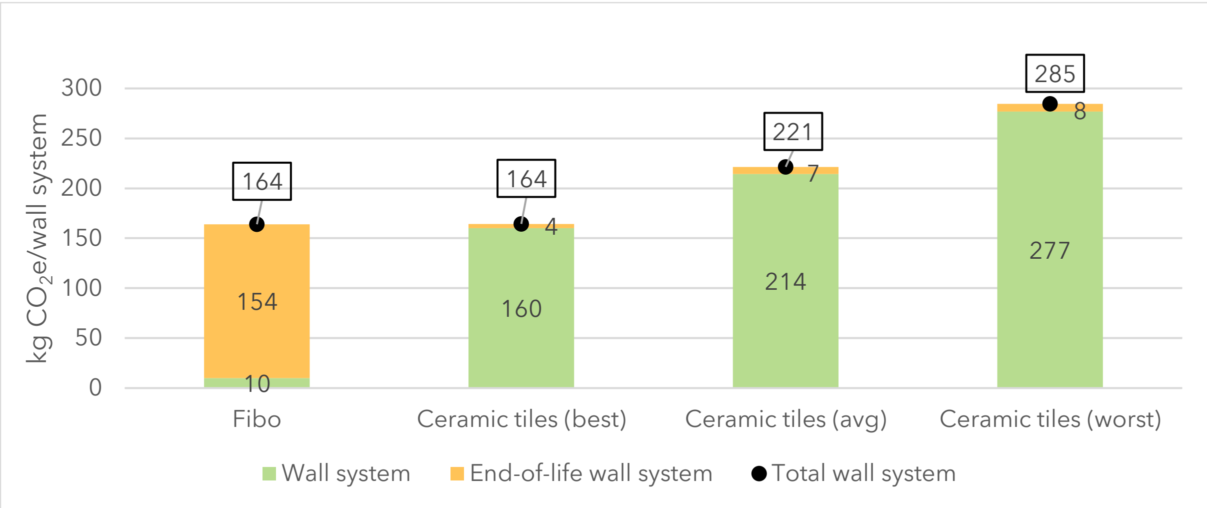

Figure 43 Climate impact in a "cradle-to-gate" perspective for the UK market, including the end-of-life emissions

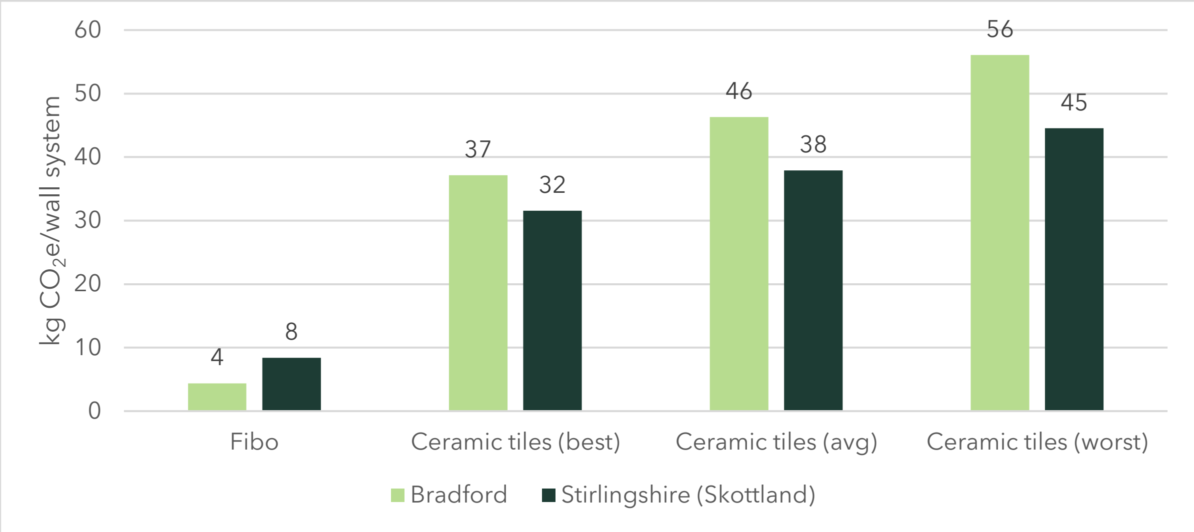

Figure 44 The climate impacts teeming from the transportation to the specific market in the UK

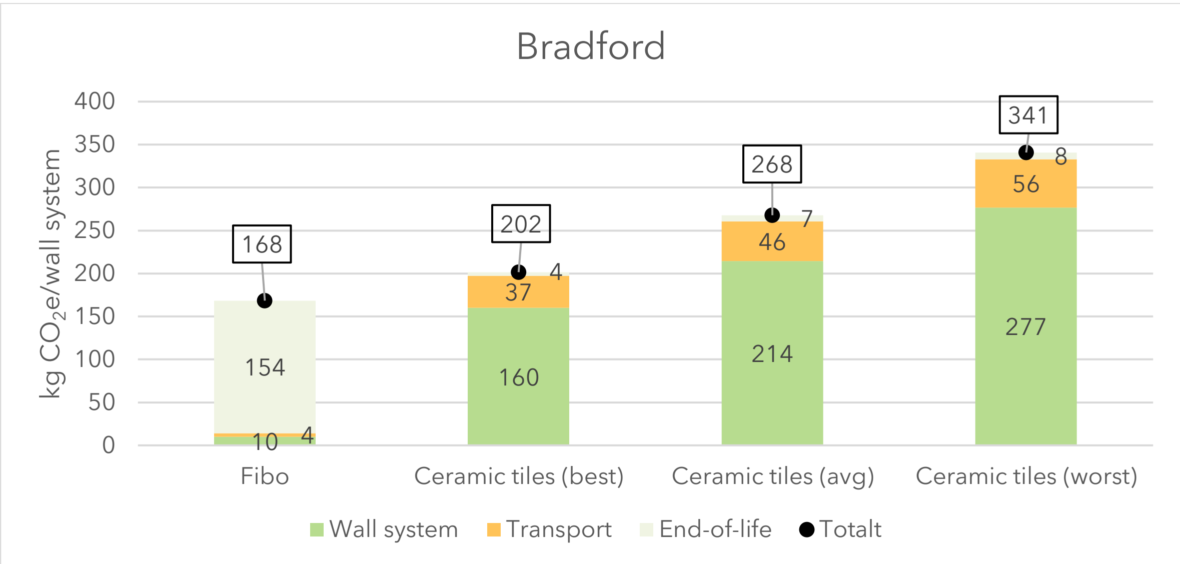

Figure 45 The «cradle-to-grave" emissions for a 11,5 m² wall system in Bradford

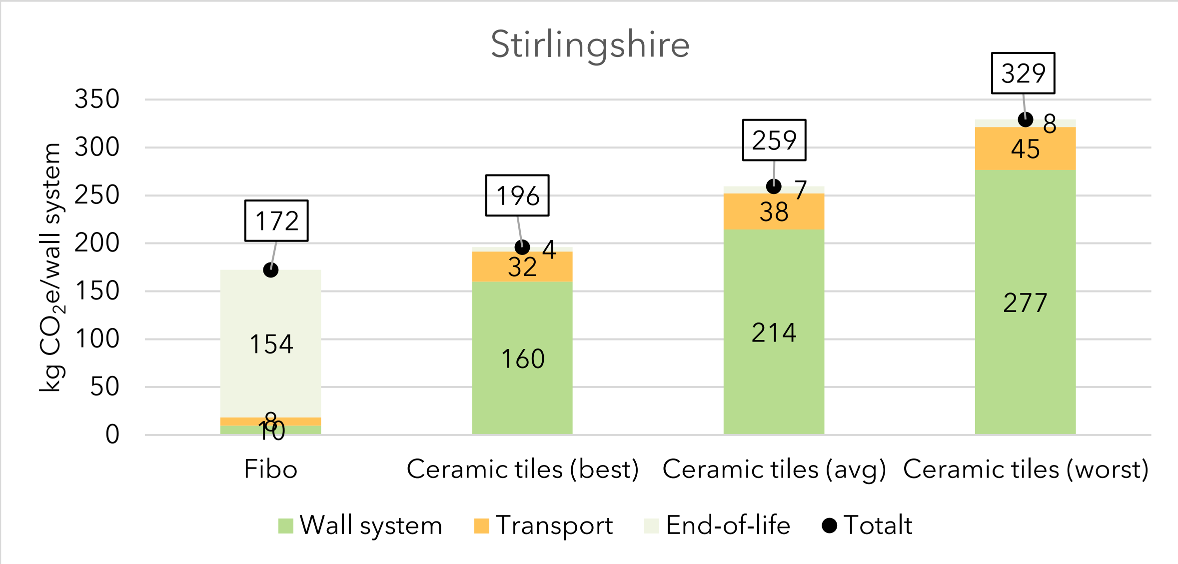

Figure 46 The «cradle-to-grave" emissions for a 11,5 m² wall system in Stirlingshire

North American market

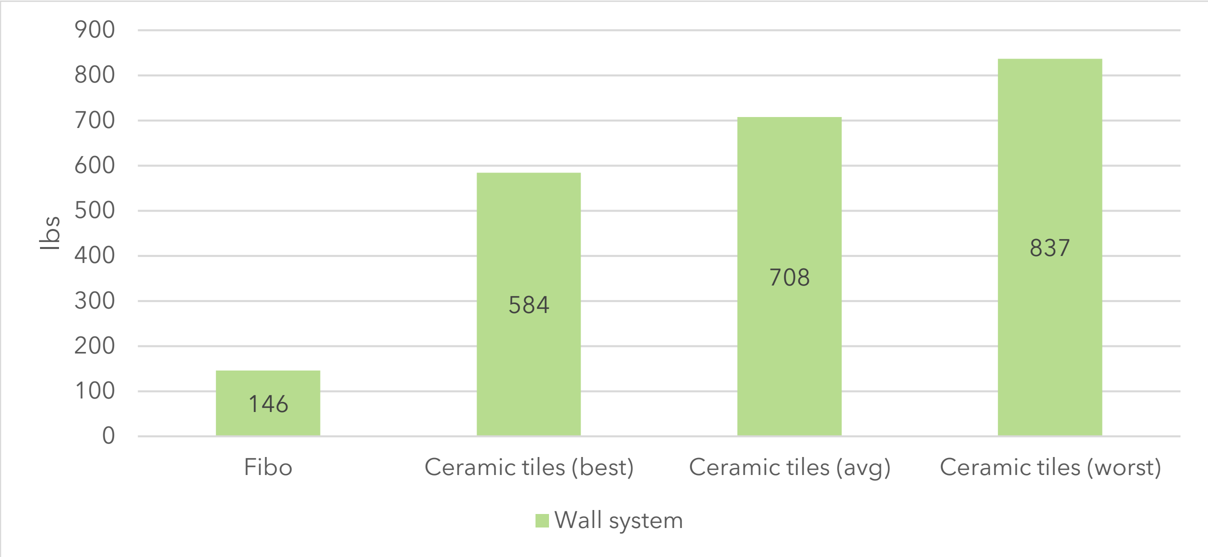

Figure 47 Material usage in lbs for a bathroom wall system in the North American market

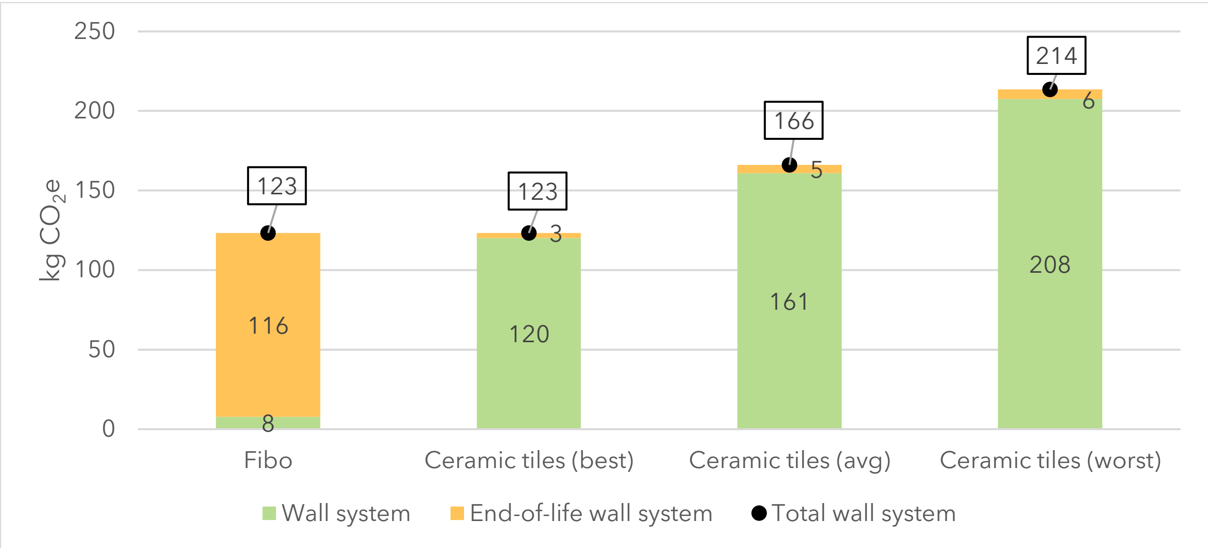

Figure 48 Climate impact in a "cradle-to-gate" perspective for the North American bathroom wall system, including the end-of-life emissions

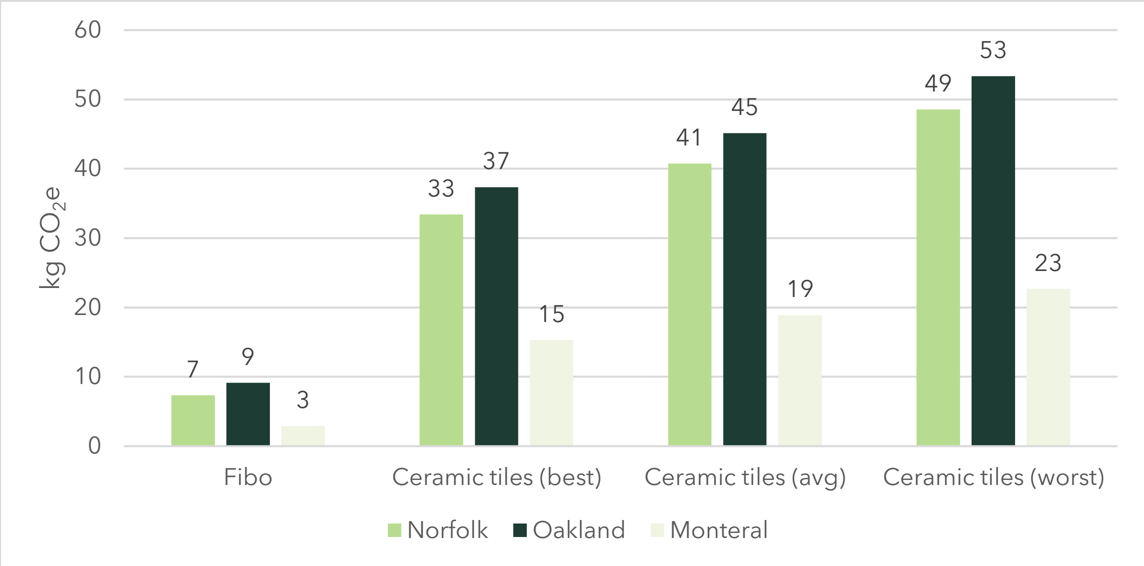

Figure 49 The climate impacts teeming from the transportation to the specific market in North America

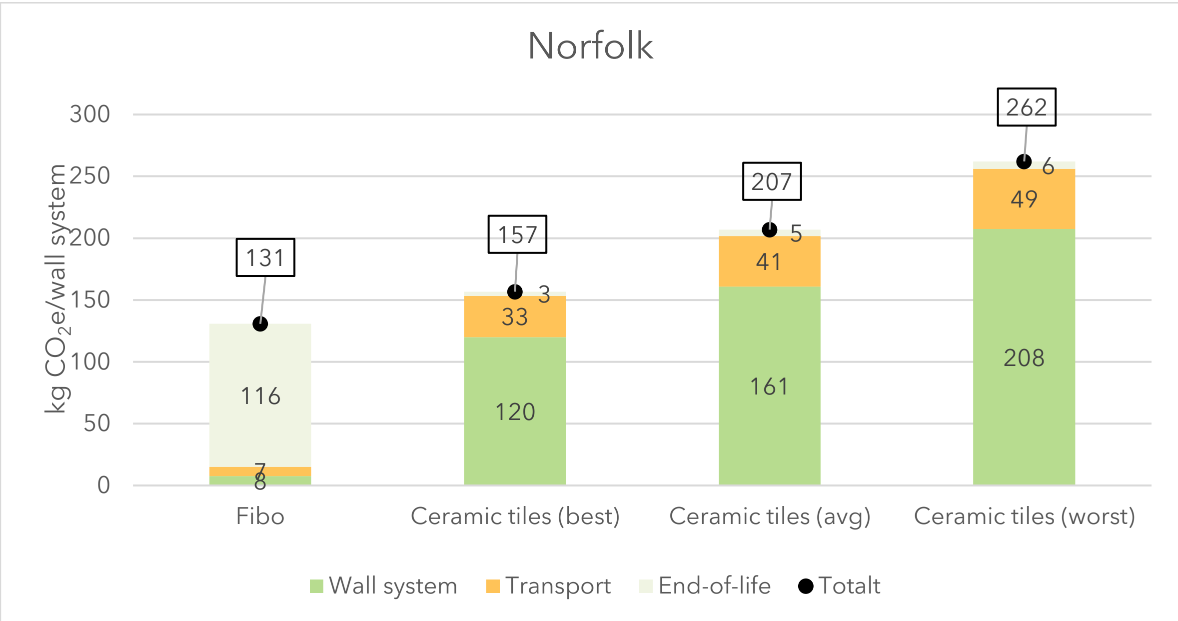

Figure 50 The «cradle-to-grave" emissions for a bathroom wall system in Norfolk

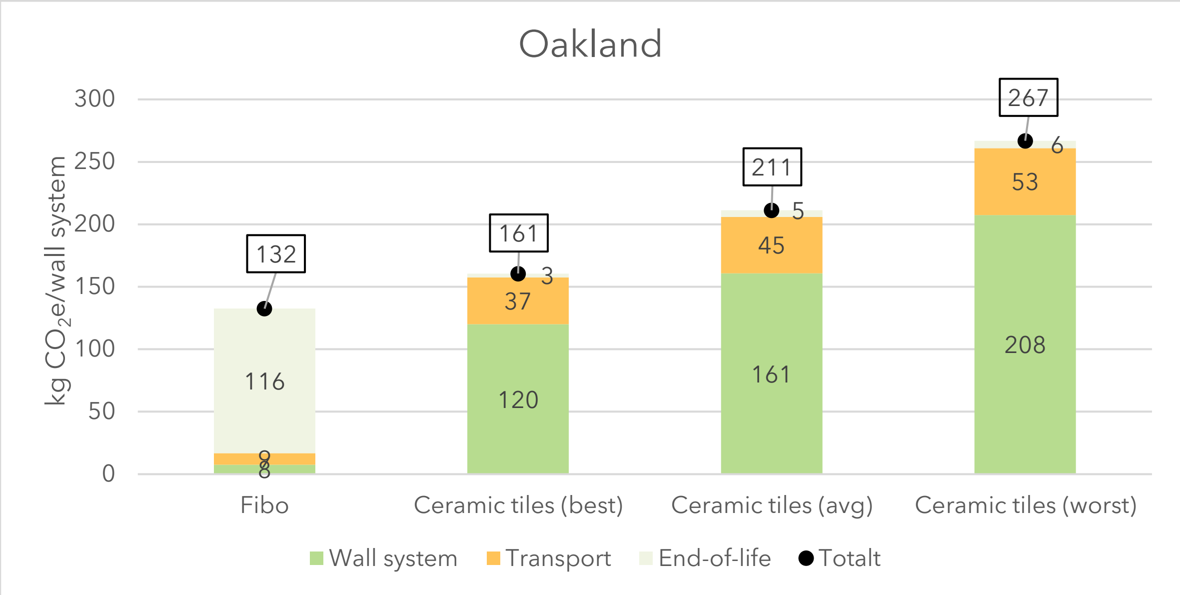

Figure 51 The «cradle-to-grave" emissions for a bathroom wall system in Oakland

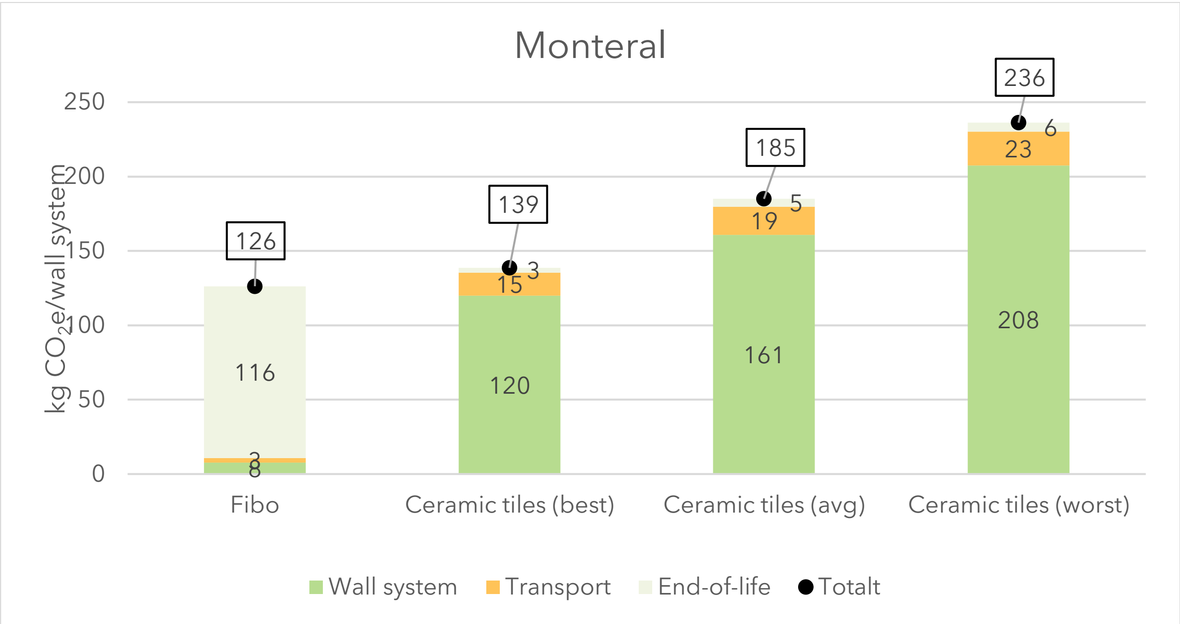

Figure 52 The «cradle-to-grave" emissions for a bathroom wall system in Montréal, Canada

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