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Increasing resource efficiency in the Swedish flooring industry through floor refinishing

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About this report

This report is a deliverable of a research project co-funded by Bona AB and SIVL. The outcome of this study is mainly intended for stakeholders in the flooring industry in Sweden but can also be used by parties engaged in circular economy development.

We would like to thank the project teams at Bona AB and IVL, the Swedish Environmental Research Institute, for their commitment and engagement throughout the project.

Fredrik Tegstedt and Maria Ahlm, May 2020

Bona AB is a family-owned company that supplies products for installing, renovating, maintaining and restoring premium floors. Founded in 1919, Bona was the first in the industry to offer a full system of waterborne hardwood floor finishing and floor care products. Today, Bona offers products for most premium floor surfaces including wood, tile, vinyl, resilient, rubber and laminate. The head office is in Malmö, Sweden, and the company is represented globally by its 17 subsidiaries, 70 distributors, 600 employees and 5 factories. For more visit www.bona.com.

Table of contents

Summary ... 5

Sammanfattning ... 7

1 Background ... 9

2 Purpose, goal and scope ... 11

2.1 Purpose ... 11
2.2 Goal ... 11
2.3 Scope ... 11

3 Life cycle assessment of floor refinishing including an impact comparison with new flooring ... 13

3.1 What did we include in the assessment? ... 13
3.2 How did we perform the assessment? ... 14
3.3 What were the conclusions? ... 15

3.3.1 What is the impact of floor refinishing? ... 15
3.3.2 Can floor refinishing reduce emissions of greenhouse gases and resource use? ... 16

4 Roadmap for increased resource efficiency in the flooring industry ... 17

4.1 How was the roadmap developed? ... 17
4.2 What is the current situation for floor refinishing? ... 18
4.3 Increased resource efficiency through floor refinishing ... 20
4.4 What are the barriers for floor refinishing? ... 21
4.5 Actions to overcome the barriers ... 22
4.6 Final roadmap for increased resource efficiency in the flooring industry ... 24

5 Final conclusions and future recommendations ... 26

Annex A: LCA of floor refinishing – including an impact comparison with new flooring ... 27

Summary

Lengthening the service lifetime of products before being disposed could be an effective solution in achieving reduced impact on climate change and improved resource use. In the flooring industry, floor refinishing has been part of the business model for a long time. But floor owners and other stakeholders in the industry do not always recognize that floor refinishing is a viable alternative to installing new flooring. This results in that flooring which technically can be refinished for continued use is often disposed and replaced by new flooring. If the share of refinished flooring is increased, the impact on climate change and resource use is expected to be significantly improved. The Swedish flooring market has great potential for refinishing services with millions of square meters of installed flooring.

The purpose of this project was primarily to generate information for stakeholders in the flooring industry about resource efficiency and the impact on climate change as a result of floor refinishing in Sweden. In addition, the aim was to identify barriers which prevent floor refinishing and propose potential actions for the industry to overcome these barriers. The project further aims to increase the knowledge base among stakeholders in the industry regarding the environmental impact of floor refinishing and whether it can lead to greenhouse gas emissions savings and reduced resource use compared to installation of new flooring. The scope of the project was the Swedish flooring market with specific focuses on commercial properties.

Life cycle assessment

The project has been divided in two parts. In the first part the environmental impact from refinishing hardwood and resilient flooring has been investigated through performing a life cycle assessment. The outcome has been compared to the impact from producing and installing new flooring in terms of climate change and resource use. In addition, the result was used as proof of concept that floor refinishing can reduce the impact on climate change and minimize resource use compared to producing and installing new flooring.

The result of the first part of this project shows the following:

- The main impact on the environment as a result of floor refinishing in commercial properties is caused by production of raw materials used to produce products used for refinishing (primer and varnish) and its end of life treatment. Sanding, application of refinishing products, consumables, and other activities related to refinishing has a comparably low impact.
- Floor refinishing in commercial properties can significantly reduce the impact on climate change and improve resource use compared to production and installation of new flooring. The study shows that floor refinishing in most cases can reduce greenhouse gas emissions by more than 75% compared to new flooring. The main reason is that refinishing enables continued use of existing flooring by using a relatively small amount of product as well as it needs limited processing compared to the requirements for new flooring.

Roadmap

In the second part of this project a roadmap was developed. A roadmap is a strategic plan that defines desired outcome and outlines important actions to overcome the barriers that separates the current state from the desired outcome. The roadmap in this project has been developed together

with stakeholders from the flooring industry such as material suppliers, property owners, architects and contractors through interviews and workshops following the workflow described below:

Current position includes a description of the decision-making process among the stakeholders that decide whether to refinish or install new flooring. From this study we can conclude that today the material suppliers have insufficient contact with the decision-makers which includes the property owner, tenant, and architect.

Desired position in the future is, given by the LCA-comparison, that floor refinishing should be considered a desired alternative. For this, new contact paths and new information needs to be established between stakeholders such as the material suppliers and the decisionmakers.

Barriers identified that stand between the current and desired position are:

- Lack of technical, economic, and environmental information about refinishing within the industry
- The prevailing business model in the construction industry enables contractors to earn more money from selling new products than selling refinishing as a service.
- The social norm demands new installations of products such as kitchen, bathrooms and new flooring and it impacts pricing in negotiations.
- Technical know-how such as what criteria to evaluate the potential of floor refinishing. Currently this relies on the craftsman's experience which takes years to acquire.
- Environmental requirements compete with one another, for example acoustic requirement in open office landscapes makes it difficult to retain hardwood and resilient flooring.
- Environmental assessment systems today focus on new products rather than reusing and refinishing existing products.

Actions to overcome the identified barriers can be summarized in three main categories:

1. Enhanced knowledge and information sharing. Several barriers can be overcome through information and enhanced understanding of which floorings can be refinished, what the cost and time for that would be and the climate benefits. Communicating results from life cycle assessments via guidebooks, via industry associations, or via the environmental assessment systems that are operating in Sweden are important actions.

2. New business models that support circular economy. The current business model in the construction industry is a barrier where selling building materials is a good source of income that contradicts refinishing services. One way of changing this behavior would be to develop policy instruments targeting professionals in the refinishing business and other labor-intensive fields.

3. Further development of maintenance services. The floor owner lacks information and knowledge about floor maintenance. This may affect future opportunities for refinishing since a poorly maintained floor may not be possible to save and refinish. Actions that provide digital solutions such as maintenance plans with reminders for the floor owner could help overcoming these barriers. Other action would be to offer maintenance as a service or to offer flooring on a lease agreement.

The final roadmap with all details can be found on page 25.

Sammanfattning

Att förlänga livslängden och användandet av produkter innan de kasseras och slängs är i många fall ett effektivt sätt att spara naturresurser och minska dess påverkan på klimatförändringarna. I golvbranschen och för golv är renovering sedan länge ett sätt att göra just detta. Men det är inte i alla lägen så att renovering anses vara ett konkret alternativ då ett golv är utslitet. Detta leder i många fall till att golv som skulle kunna renoveras istället byts ut. Om andelen golv som renoveras skulle öka i Sverige finns det stora möjligheter att förbättra branschens resurseffektivitet och minska dess koldioxidutsläpp. Det installeras och byts ut miljontals kvadratmeter golv i Sverige varje år, vilket innebär att potentialen för renovering är stor.

Syftet och målet med det här projektet har varit att bidra till ökad kunskap om resurseffektivitet och koldioxidemissioner inom den svenska golvbranschen och med ett speciellt fokus på renovering av golv. Ett annat mål med arbetet har varit att identifiera hinder inom golvbranschen, som bidrar till att en relativt liten del av svenska golv renoveras, samt att presentera förslag på en handlingsplan med potential att öka den andelen. Projektet omfattar golv på den svenska marknaden för kommersiella fastigheter och offentlig miljö.

Livscykelanalys

Projektet har genomförts i två delar. I den första delen har en livscykelanalys utförts där miljöpåverkan från renovering av trä- och halvhårda golv (PVC) undersökts. Resultatet har därefter jämförts utifrån ett klimat- och resurseffektivitets perspektiv mot att nya golv tillverkas och installeras. Jämförelsen har använts som underlag till att få svar på huruvida renovering kan bidra till besparingar av koldioxidutsläpp och till minskad resursanvändning i jämförelse med att installera ett nytt golv.

Resultatet av projektets första del visar att

- Den största delen av den miljöpåverkan som uppstår då golv i kommersiella fastigheter renoveras kommer från lackerna och de råmaterial som används för att tillverka dessa. Slipning, applicering av renoveringsprodukter, renoveringsutrustning och andra renoveringsaktiviteter har relativt lite påverkan.
- I jämförelse med att producera och installera nya golv kan renovering bidra till kraftigt minskade utsläpp av koldioxid och rejält förbättrad användning av både förnyelsebara och icke förnyelsebara naturresurser. Resultaten visar att det i många fall går att minska koldioxidemissionerna med mer än 75% genom att renovera golv istället för att byta ut dem. Huvudanledningen till resultatet är att renovering av golv möjliggör att man kan förlänga användandet av de resurser golven består av. Dessutom kan det göras genom användandet av en relativt liten mängd produkt (lack) i jämförelse med åtgången av resurser och material då hela golven byts ut.

Roadmap

I den andra delen av projektet arbetades en roadmap fram. En roadmap är en strategisk plan som innehåller nödvändiga åtgärder för att uppnå ett önskat resultat. I arbetet med roadmapen undersöker man vilka de hinder som skiljer nuläget från det önskade läget. I det här projektet har roadmapen utvecklats i dialog med aktörer inom den svenska golvbranschen. Till exempel har leverantörer av golvmaterial, fastighetsägare, arkitekter och entreprenörer deltagit i intervjuer och workshops i enlighet med nedan beskrivet arbetsflöde:

Nuläget innefattar en beskrivning av beslutsprocessen om huruvida ett golv skall renoveras eller om det skall bytas ut mot ett nytt och besluten involverar ett flertal branschaktörer. Slutsatsen är att de som tillverkar och levererar golvmaterial har begränsad kontakt med de aktörer som faktiskt tar beslutet så som fastighetsägare, hyresgäster och arkitekter.

Önskat läge för framtiden innebär att renovering av golv skall anses vara ett alternativ att föredra med tanke på resultatet från livscykelanalysen och jämförelsen mellan att renovera och installera nya golv. Men för att uppnå det krävs ändringar i branschen då informationsutbytet mellan olika aktörer och dess kontaktytor behöver förändras. Till exempel bör leverantörer av golvmaterial och beslutsfattare i branschen kommunicera och byta information med varandra.

Hinder som identifierats i projektet och som bidrar till att det önskade läget inte uppnås:

- Brist på information om fördelarna av att renovera golv inom branschen (teknisk, ekonomisk och miljömässig information).
- Affärsmodellen i dagens byggbransch som bland annat bygger på att entreprenörer har goda incitament att sälja byggmaterial istället för att sälja renovering.
- Samhällets norm påverkar aktörer till att bygga nytt och som i sin tur tillåts påverka hyressättning.
- Tekniskt kunnande om huruvida ett golv kan renoveras till ett tillfredställande resultat är svårtillgänglig. I dagsläget finns kunnandet hos golventreprenörer med långa erfarenheter.
- Olika miljökrav konkurrerar med varandra. Till exempel kan krav kring akustik i öppna kontorslandskap bidra till att befintliga golv byts ut mot textilgolv, oavsett om de går att renovera.
- Miljöcertifieringssystem fokuserar ofta på värdering av nya produkter och inkluderar inte alltid aspekter såsom återbruk och renovering av redan installerade produkter.

Åtgärder för att överkomma de identifierade hindren kan sammanfattas i tre kategorier:

1. Förbättrad kunskaps- och informationsspridning. Flera hinder skulle kunna överbryggas genom förbättrad kunskaps- och informationsspridning. Till exempel skulle ökad information om golvs renoveringspotential, kostnad och tidsåtgång underlätta för beslutsfattarna. Även information om hur renovering bidrar till minskade klimatutsläpp skulle vara till hjälp. Att sprida resultatet från det här projektets LCA genom exempelvis branschorganisationer eller genom svenska miljöcertifieringssystem är åtgärder som skulle kunna bidra till detta.

2. Nya cirkulära affärsmodeller. Byggbranschens affärsmodell, där försäljning av byggmaterial ekonomiskt premieras i jämförelse med renoveringstjänster, är ett stort hinder. Ett alternativ för att förändra affärsmodellen vore att erbjuda ekonomiska incitament för olika typer av renoveringstjänster.

3. **Utveckling av nya underhållstjänster.** Golvägare saknar i många fall tillräcklig kunskap om hur golv bäst underhålls. Detta kan i sin tur leda till att golv slits mer än nödvändigt och på grund av det inte kan renoveras. För att underlätta för golvägaren skulle digitala tjänster kunna påminna golvägaren om när och hur golven bäst bör underhållas. Andra alternativ skulle kunna vara att erbjuda underhållprogram som en tjänst eller att golvägaren hyr golven av lämplig aktör.

Projektets roadmap finns i sin helhet på sidan 25.

1 Background

Climate change and circular economy

Climate change is already affecting people and ecosystems worldwide and there are clear societal benefits to limit the warming to 1,5 degrees C. Current emission levels are leading us toward warming well above two degrees and urgent mitigation actions in coming years are required to stay below 1,5 degrees C[1]. To reach these targets, several global and national initiatives are underway which impacts society and industry. The Paris Agreement is one initiative that brings nations together to combat climate change and the United Nations sustainable development goals is another[2].

The EU taxonomy for green financial change[3], presented by the European Commission in March 2018, also urges the need for change. In order to drive the work for a more circular economy, major changes have already been incorporated into six different EU directives, so that the value of products, materials and resources is retained in the economy for as long as possible and waste generation is minimized. The EU project "BAMB" (Buildings as Material Banks), which started in 2015 with the goal of establishing a system change for increased circularity in the construction sector, is another example of how EU teams are taking steps to change existing standards. "Materials Passports" and "Reversible Building Design", which are supported by new business models, policies and data for decision making, are examples of results from BAMB that will drive the development for an increased share of circular material flows.

In Sweden "delegationen för cikulär ekonomi"[4] (the "Circular Economy Delegation)" was established by the Swedish government in 2018. It aims to strengthening society's transition to a resource-efficient, circular and bio-based economy, both nationally and regionally, an is another example of initiatives that drives the change towards more sustainable and circular product flows.

The construction sector in Sweden

The construction and civil engineering sector, including the real estate sector, accounts for one fifth of Sweden's climate impact. A large proportion of the climate emissions comes from building material production.[5] As this is of major impact the sector has gathered key players around a common roadmap for a climate-neutral and competitive construction and civil engineering sector[6]. Many challenges and possibilities have been identified in this common roadmap and it is now up to all stakeholders of the sector to do their part and decrease their climate impact and increase their resource efficiency. Being able to measure and report on the climate impact from all parts of the building process and the materials used to complete the property is therefore becoming increasingly central. This report will investigate if floor refinishing is one possible solution which could develop the flooring industry towards becoming more circular.

The flooring industry in Sweden

The Swedish market is a traditional flooring market, which drives and develops by well established companies that often also are global players. They develop new and innovative

[1] https://www.ipcc.ch/sr15/, visited 2020-03-17
[2] https://sustainabledevelopment.un.org/sdg13, visited 2020-03-17
[3] https://ec.europa.eu/info/files/200309-sustainable-finance-teg-final-report-taxonomy_en, visited 2020-03-19
[4] https://tillvaxtverket.se/amnesomraden/affarsutveckli-ng/delegationen-for-cirkular-ekonomi.html, visited 2020-03-19
[5] http://fossilfritt-sverige.se/wp-content/uploads/2018/04/ffs_bygg_anlaggningssektorn.pdf, visited 2020-03-19
[6] http://fossilfritt-sverige.se/wp-content/uploads/2018/04/ffs_bygg_anlaggningssektorn.pdf, visited 2020-03-19

products and solutions and often try to take a wider responsibility. One example is the initiative to recycle PVC flooring installation residues in Sweden project[7].

Every year, 25 million square meters of hardwood and resilient flooring is sold in Sweden. Vinyl floors increase on behalf of other flooring materials such as wood, laminate linoleum[8]. The market for coatings for wood floors are decreasing, indicating that fewer wood floors are being renovated. One reason for this is probably that the retail price for one square meter three strip engineered oak floor has the same installation price today as 15 years ago. This has decreased the financial incentives for maintaining and refinish installed floorings. Also, many floor owners don't know about the possibility to change the look of their old floor and for that reason they choose a new one. The floor refinishing industry has an important task, not only to inform about the possibility to refinish an old floor, but also to educate that refinishing can transform old flooring into a completely new look which can extend the use of the flooring.

Hundreds of million square meter of floorings are installed in commercial properties in Sweden and the conditions of these floors differ from recently installed up to flooring that has been used for more than 30 years. The knowledge in the industry is in general low about the possibilities of refinishing and how best flooring should be maintained to enable refinishing as a viable alternative to new flooring.

By floor refinishing this project refer to a process where worn varnish and dirt is removed through sanding and where new layers of varnish is applied to the floor being refinished. The process is performed by an entrepreneur on the premises where the floor is installed.

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[7] https://www.ivl.se/download/18.14d7b12e16e3c5c3627a3a/1574324705745/C453.pdf, visited 2020-03-25

[8] https://www.golvbranschen.se/press-media#/pressreleases/golvet-i-siffror-2019-3002043, visited 2020-03-25

2 Purpose, goal and scope

2.1 Purpose

The purpose of this project is primarily to contribute to the development toward a circular economy in the Swedish flooring industry. It aims to provide guidance to stakeholders and decision makers on existing barriers within the industry that limits this development. In addition, the purpose of this project is to offer input to a potential action plan for how some of the identified barriers could be dissolved by the industry.

More specifically, the project aims to explore potential benefits of floor refinishing and increase the knowledge base among stakeholders and decision makers on the environmental impact of floor refinishing. It also aims to provide evidence for whether refinishing is a better alternative compared to installing new flooring considering natural resource use and greenhouse gas emissions and whether it could enhance the transition towards a circular economy in the flooring industry.

The aim of this project is further to create awareness about circular economy thinking among various stakeholders in the flooring industry. Our intention is that the project can act as a catalyst to start dialogues and that it leads to knowledge sharing, collaborations and partnering within the industry aiming to drive the development towards a circular economy.

2.2 Goal

There are primarily five objectives of this project:

1. to assess the environmental impact of refinishing hardwood and resilient flooring used in commercial properties in Sweden.
2. to identify environmental impact benefits/disadvantages of maintaining existing flooring through refinishing compared to production and installation of new floors.
3. to identify present and potentially upcoming barriers that oppose a sustainable development in the flooring industry.
4. to propose actions that may enhance the industry to overcome identified barriers.
5. to disclose the project outcome and thus contribute to knowledge that may stimulate long-term circular economy behavior in the flooring industry.

2.3 Scope

The scope of the project focuses on the Swedish flooring market and the national construction industry in Sweden. The study focuses specifically on flooring used in commercial properties in Sweden such as hospitals, schools, offices, stores, malls etc.

Two types of flooring are considered in the project - hardwood and resilient flooring. These are floorings which are commonly used in commercial properties in Sweden and are found in older as well as recently built buildings. In specific project activities where an even narrower scope is needed, hardwood and resilient flooring is represented by prefabricated parquet and homogenous PVC respectively.

The project does not consider any other markets than Sweden and the result should therefore primarily be used for the Swedish market and industry.

The project has been carried out through two main areas of work; a life cycle assessment (LCA) for assessment and comparison and a roadmap (strategic plan) to implement the findings of the LCA. More information about the specific methodologies used can be found in chapter 3 (LCA) and chapter 4 (Roadmap).

3 Life cycle assessment of floor refinishing including an impact comparison with new flooring

One of the objectives of this project is to assess the environmental impact of floor refinishing and identify stages in the lifecycle that have a significant impact on the result. Additionally, the project provides guidance on whether floor refinishing might offer less of an environmental impact compared to production and installation of new flooring.

To assess the environmental impact from floor refinishing a Life Cycle Assessment (LCA) was carried out to assess the impact of refinishing hardwood and resilient flooring. Additionally, the result from the LCA was used to compare the impact from refinishing to the impact of producing and installing new flooring. The findings serve as input for the development of the Roadmap and the outcome is intended for stakeholders in the flooring industry.

This section focuses primarily on the key findings and conclusions from the LCA. It further summarizes the findings from the comparative analysis in which the impact from floor refinishing has been compared to the impact of installing new flooring. Chapter 3 also provides a brief description of the goal and scope of the LCA, the methodology used, and the data applied to conduct the analysis. This paragraph does not intend to provide information on detailed assumptions and results from the study. Instead the reader is directed to the extended LCA report (Annex A) which describes the analysis and the outcome in details.

3.1 What did we include in the assessment?

The goal of the LCA and the comparative analysis was to:

- assess the environmental impact resulting from refinishing hardwood and resilient flooring used in commercial properties in Sweden.
- identify environmental impact benefits/disadvantages of maintaining hardwood and resilient floors through refinishing compared to installing new flooring.

In order to align the scope of the analysis to the overall scope of the project two types of floorings have been considered:

- Floating prefabricated parquet (hardwood), also referred to as multilayer parquet and
- Homogenous PVC (resilient)

These are typically flooring which are found in commercial properties in Sweden.

The functional unit of the LCA and the comparative assessment was **1m^2 of flooring.** This is a commonly used reference within the flooring industry and a pedagogic measurement for communication with relevant industry stakeholders.

Further on, the study was a cradle –to-grave assessment, which means that the whole life cycle for refinished and new flooring was considered. The system boundaries include extraction, production, and transportation of raw materials and products, installation of flooring and refinish as well as end of life management of products and waste streams. The study did not include the impact from maintenance and cleaning of flooring while in use.

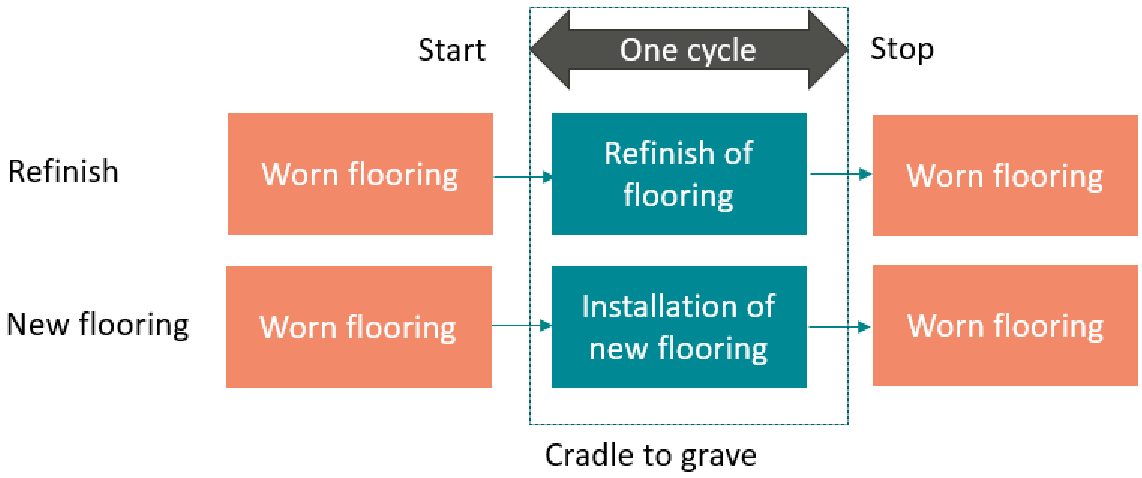

Figure 1: This figure illustrates the start and stop (system boundaries) of the analysis. It shows that environmental impact (cradle to grave) from one cycle of refinish and new flooring was considered and compared.

The number of times flooring can be refinished was not considered in this study. Nonetheless, it is expected that the flooring within the scope of this project can be recoated two to four times before it must be replaced by new flooring. The analysis and result represent one cycle but can be used for comparing the impact for several cycles as well, simply by multiplying the impact difference by the number of recoats the floor is expected to go through.

Further on, the lifetime of flooring is not a considered parameter since new and refinished flooring is expected to last equally long before it is worn and in need of maintenance (new flooring or refinish). This assumption is based on the technical lifetime provided by flooring manufacturers and companies supplying refinishing products and services. It is assumed that worn flooring, which is the starting point of the assessment, can be refinished.

3.2 How did we perform the assessment?

The environmental impact from floor refinishing was assessed by using LCA of refinishing systems (products and processes) developed and supplied by Bona. These systems are specifically developed for flooring used in commercial properties. Information about products and product formulations, production processes and the refinishing processes was collected from Bona and used as input to the LCA. The assumptions and data used in the LCA represents conditions for the Swedish market.

Next to the LCA, the comparative assessment was performed, in which the environmental impact as a result of floor refinishing was compared to the alternative of removing the old floor and install a new floor. The system boundaries of the analysis are illustrated in Figure 1. The comparison starts and ends with flooring that is worn and either needs to be replaced by new flooring or refinished. Besides inventory data from the LCA of floor refinishing, environmental impact data of parquet and homogenous PVC flooring was needed to conduct this analysis. This information was collected from publicly available Environmental Product Declaration (EPD) published by the flooring industry and used for the comparison. Consequently, this project does not include any LCAs of flooring. Instead the impact from flooring is based on the data found in EPDs representing flooring within the scope of this project. The workflow of the analysis is shown in Figure 2 and which is explained further in Annex A.

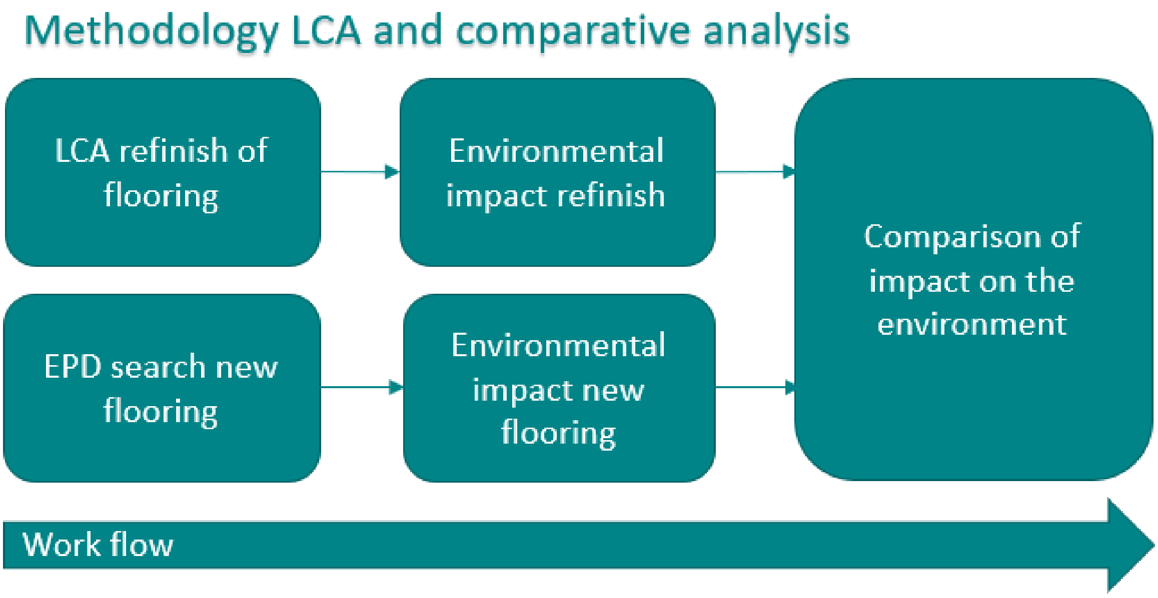

Figure 2: This figure summarizes the workflow of the analysis.

3.3 What were the conclusions?

The result from the study was divided into two parts. The first part includes the findings from the LCA of floor refinishing and the second part comprises the outcome of the comparative assessment. The result considers a set of environmental impact categories, but this summary includes the impact on climate change and resource use.

3.3.1 What is the impact of floor refinishing?

The LCA shows that the refinish system studied on multilayer parquet generates a climate change impact equal to 1,4 kg carbon dioxide equivalents per m^2 of flooring. For homogenous PVC this number is instead 1,1 kg carbon dioxide equivalents per m^2. For both types of flooring, it is the production of the raw materials used to formulate refinishing products (primer and varnish) and the treatment at their end of life that influences the outcome significantly.

Another aspect identified that contributes significantly to the studied systems' greenhouse gas emissions is the return travels the craftsman must do to reach the premises where the floor is being refinished. The result indicates that longer distances could increase the impact on climate change from floor refinishing significantly.

The outcome of the LCA also shows that the production of product used for refinishing has a relatively low impact on climate change. Also sanding and consumables used for refinishing contributes little to the total climate change impact. This is valid for both parquet and PVC flooring.

The outcome of the LCA further shows that predominantly primary energy from non-renewable resources is consumed by the two product systems studied. A small part of the primary energy is of renewable origin. The main part of the energy resources is used in the extraction and production of the raw materials used for primers and varnishes. Less than 10% of the primary energy is consumed by activities related to refinishing, such as sanding, consumables and travels made by the craftsman.

3.3.2 Can floor refinishing reduce emissions of greenhouse gases and resource use?

The overall result in the comparative assessment of this study shows that significant environmental impact benefits are likely obtained if existing flooring is refinished instead of being replaced by new flooring. Refinishing offers the possibility of utilizing already available flooring material (resources) and consequently reduces the need for resources and emissions associated to the production of new flooring material. The outcome further shows that the impact from refinishing is not expected to become greater in any of the cases studied compared to the impact from installing new flooring.

For multilayer parquet, the impact on climate change is equal or significantly reduced by refinishing instead of installation of new flooring, this study shows. In most of the studied cases refinishing contributes to reduced greenhouse gas emissions by more than 75%. The use of primary energy resources, especially renewable energy resources, can be significantly decreased since refinishing allows continued use by already available flooring material.

The conclusion for PVC flooring is that refinishing is clearly the preferred alternative considering emissions of greenhouse gases. It reduces the emissions by more than 85% compared to installation of new flooring. The result further shows that large amount of non-renewable primary energy resources can be saved in cases where refinishing is selected. This is because the amount of product required to recoat flooring is considerably less than the material needed to produce a new flooring system.

One aspect that has been shown to have a significant effect on the impact on climate change is the travels the craftsman makes as part of floor refinishing. It is shown in this study that long travels could lead to that the clear benefits of refinishing are significantly cut compared to installing new flooring.

4 Roadmap for increased resource efficiency in the flooring industry

A roadmap is a strategic plan that defines a goal or desired outcome and outlines important milestones. It captures the major steps needed to overcome the obstacles that separates the current state from the desired outcome. It also serves, at a high level, as a communication tool that helps articulate strategic thinking behind both the goal and the plan for getting there. When it comes to understanding the role of the roadmap, perhaps the most important concept to remember is that it is a strategic document, not a document that captures all the details of the strategic plan. The method is considered to come from the company Motorola in the 1980´s who defined roadmap as "an extended look at the future."

4.1 How was the roadmap developed?

Most common is to develop a roadmap for companies, corporate functions or business units. In this project we have developed a roadmap for a sector within the flooring industry, namely refinishing of hardwood and resilient floors.

In this project the roadmap includes actions that lead to the goal – to reduce greenhouse gas emissions and improve resource use by increasing the number of floors that are refinished and reconditioned. The purpose of the roadmap is to concretizing actions for various stakeholders to make the case of refinishing and reconditioning the more common means for floor owners. The roadmap has been developed together with stakeholders from the flooring industry such as manufacturers, real estate owners, architects and contractors through interviews and workshops.

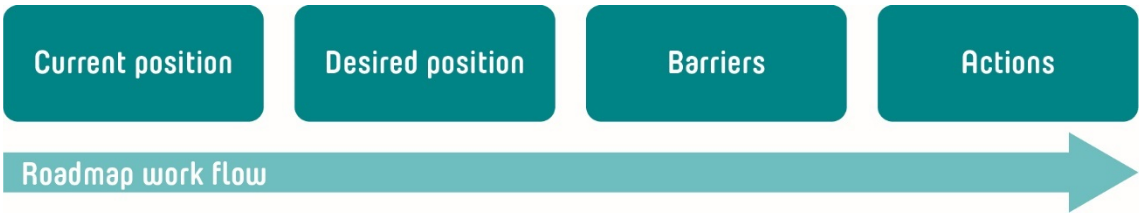

Figure 3. illustrates the workflow of developing a Roadmap.

The roadmap development process is divided into four phases. It starts with mapping the *current situation* to ensure that all stakeholders share the same view of the world around them. Next, the stakeholders define the *desired situation*. This is followed by the stakeholders identifying main *barriers* that impede the desired development. Finally, necessary *actions* to overcome the barriers are suggested. The outcome is compiled in a roadmap document which presents a summary of the findings.

4.2 What is the current situation for floor refinishing?

In chapter 1 it is mentioned that approximately 25,4 million square meters of new floors (wood, vinyl, textile and other) are installed each year in Sweden. At the same time, the market for coatings for wooden flooring are decreasing, indicating that fewer floors are being refinished.

The roadmap work started with an analysis of the current situation of the flooring industry and, in particular, hardwood and resilient floors. This was done through several interviews and workshops.

Sales, marketing, research and development representatives from Bona were interviewed to provide their view of the current situation. Additionally, stakeholders from the flooring value chain were invited to a workshop to discuss the current flooring industry status regarding floor refinishing relative to installation of new flooring. This was done in small groups and the following questions were addressed:

1. Who decides whether to refinish or install new flooring?
2. When is the decision made whether to refinish or install new flooring?
3. What decides whether to refinish or to install new flooring?
4. Why does the decision-making process look this way?

1. Who decides whether to refinish or install new flooring?

Despite different points of view, the various stakeholders had a consensus on who makes the decision whether to refinish the floor or to install new flooring, namely that it is decided by the property owner and the tenant. An architect or interior architect is often involved to guide the tenant of possible solutions. In some cases, the tenant can choose which flooring solution they want. In other cases, the property owner provides a choice (for example three floor colors/styles) that meets their long-term requirements. The tenant can then decide which floor they want to install based on the choices suggested.

2. When is this decision made whether to refinish or install new flooring?

The decision is often part of the rent negotiation where a new floor can be considered to increase the rent. Consequently, the discussion about floor refinishing and restoration needs to take place when a tenant terminates their lease agreement and a new tenant is considering renting the premises.

Depending on stakeholders, and at what point in time they get involved in the construction process, the time for decision making regarding flooring is considered being both "too late" and "too early." From a contractor's point of view, the decision is made too early, long before the floor is installed. Floors are installed late in the construction process and consequently purchased late. From a material suppliers' point of view the decision is made far too late, as they are in contact with the contractor who purchases flooring. This indicates that either the contractor or the material supplier thinks that they can influence the decision-making as the process looks today.

Material suppliers and contractors are in contact regarding prices and installations. Architect, tenants and property owners discuss different options and provide the contractor information via the blueprints. There is limited contact between material suppliers and architect, tenants, and property owners. This is probably the main reason why material suppliers think the decisions regarding flooring is made too late. Consequently, there is a gap between current stakeholder contacts and the required contacts which would facilitate sustainable flooring choices.

The figure below (Figure 4) describes the contact points material suppliers have today. It is clear that they miss out on decision making taking place when property owner, tenant, and architect re-design for a new tenant.

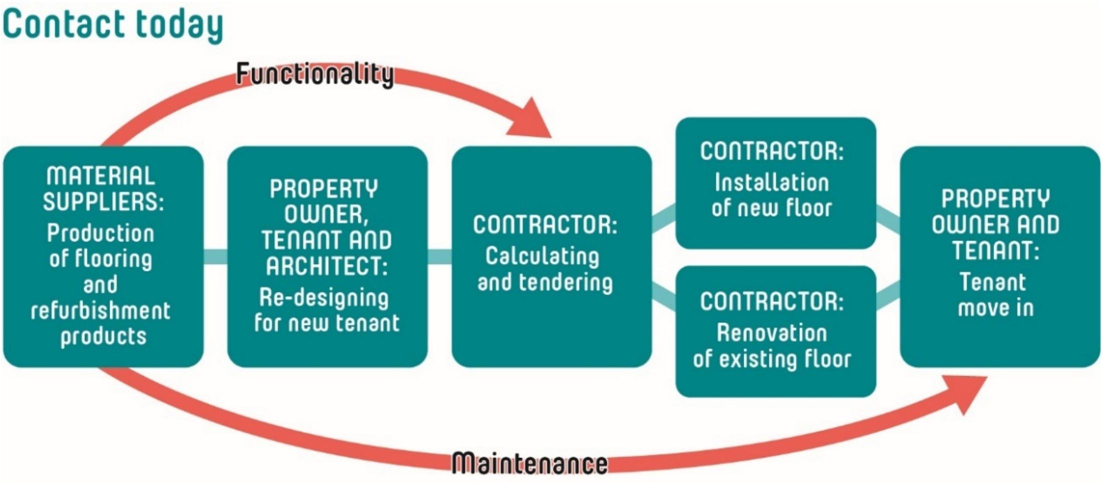

Figure 4 Communication between stakeholders today.

To be able to influence the decision makers to evaluate refinishing as an option, material suppliers need to communicate with property owners, tenants, architects, and contractors as described below (Figure 5). If the material supplier can discuss functionality and possibilities for refinishing with the property owner, tenant, and architect it is more likely that they can guide them to a more sustainable decision. To increase future possibilities for refinishing, it is also desired that the material supplier communicates with the property owner about maintenance plans and supports them with knowledge about how to keep the flooring in good shape.

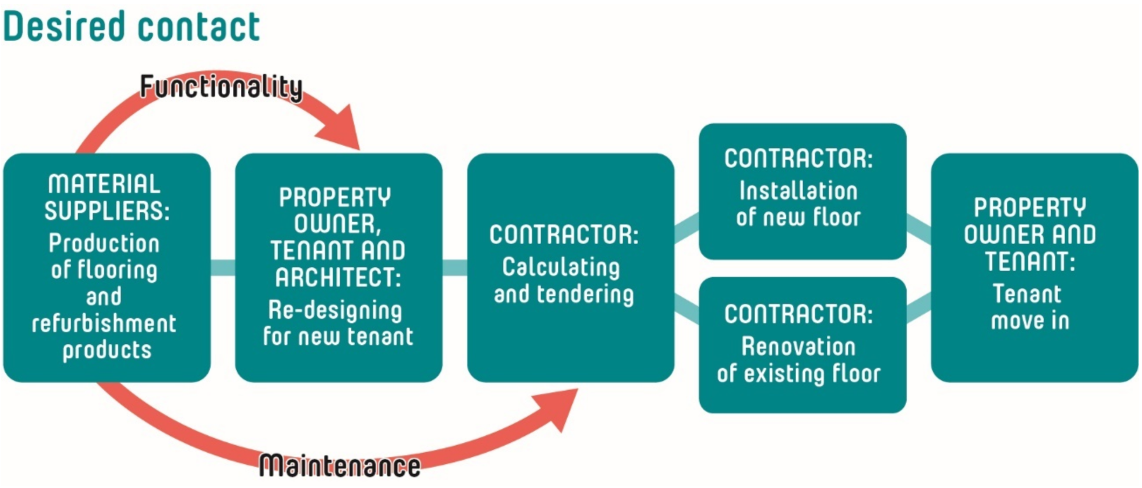

Figure 5 Desired communication between stakeholders in the future.

3. What decides whether to refinish or install new flooring?

All stakeholders agree that design, material purchasing, cost and installation time is the most important factors if technical and functional requirements such as acoustics and friction are met. Due to the prevailing business model in the construction sector, contractors make profit of material purchase. This is a more reliable source of income than income from renovation work, which entails uncertainties in terms of consumed hours and results. This is believed to be a driving force for installation of new floorings.

4. Why does the decision-making process look this way?

Stakeholders typically evaluate the purchasing cost of flooring as their main selection criteria, even though it only makes up 8% of the total cost for the floor over its lifetime[9]. Even though maintenance makes up over 90% of the cost, low maintenance cost is seldom a requirement for the selection of flooring. This is the case since the maintenance cost is often charged to the tenant at a later stage, which means that the maintenance costs are not included as a criterion for the selection of flooring.

The contractors and property owners lack information on how to calculate maintenance cost. They also pointed out that they have no other tools to evaluate floors than purchasing cost, design, and functionality. KPIs indicating a set of sustainability parameters would be helpful to achieve requirements in environmental assessment system.

4.3 Increased resource efficiency through floor refinishing

The outcome of the LCA for refinishing of hard wood flooring and PVC flooring forms the basis for the “desired position” in the roadmap as it shows that floor refinishing is likley to result in significant savings of greenhouse gas emissions and reduced use of natural resources compared to installing new hardwood or resilient flooring. Concequently, when feasable, refinishing should be the prefferred alternative compared to installation of new flooring.

If the future of flooring industry is in line with the results from the LCAs, refinishing should be evaluated as a viable option next to installing new flooring. From the current situation analysis, it is clear that decision making about flooring is made by the property owner and/or the tenant with the support from an architect. This could, for example, be when the property owner negotiates with a new tenant. In order to increase floor refinishing recommendations for property owners and tenants in the desired future could be to:

1. Include carbon footprint from installed materials in the negotiation.
2. Investigate if it is possible to refinish the floor.
3. If installation of new floors are necessairy, choose a floor designed for refinishing.

[9] https://proffs.tarkett.se/sv_SE/node/stadning-och-kostnader-aldreboende-6179, visited 2020-03-19

4.4 What are the barriers for floor refinishing?

Barriers are what separates the current situation from the desired situation. If the recommendations above were reality in a desired future situation, what barriers does the flooring industry have to overcome to get there?

The barriers have been identified using a PESTLE analysis[10]. PESTLE analysis is used by companies and industry sectors for strategic market analysis and planning in order to find factors in the surrounding macro environment that affect the business.

PESTLE is an abbreviation for political, economic, social, technological, legal, and environmental factors. The analysis method can be used to understand market growth or decline, business position and potential, and the direction of the business. The PESTLE acronym reflects every aspect to be considered in a strategic analysis of barriers.

Through a workshop several barriers were identified, and some were recurrent for the PESTEL categories analysed.

Political

One political barrier identified was that current market rents does not take carbon footprint into account. Today energy efficiency of the building, redecorated kitchen, toilets, walls and floorings have higher impact on negotiations than the climate impact of installed materials. Climate declarations is not yet an EU/national requirement for buildings, but it is being discussed and developed at the EU level and is likely to be implemented in the coming years.

Economic

When it comes to economic barriers the main barrier identified is that there is too little price difference between new and refinished floors. The prices of new flooring have dropped over time and new combinations of materials, such as Luxury Vinyl Tile (LVT) products, has gained market shares from wooden flooring. LVT is not suited for refurbishment. Most decisions on whether to install new flooring or to refinish existing ones are based on the purchasing cost of the flooring material. It does not include maintenance cost for the flooring over its lifetime.

There is also a barrier when it comes to the contractors that offer refinishing services. These contractors make money from both offering the refinishing services and by selling material. If the choice is to offer a customer a floor refinishing or to sell them new flooring, most contactors would probably suggest new flooring. This is the case since it is a quicker job for them, and they probably make more money from selling the flooring material compared to the refinishing services. Hence, there is a lack of economic incentive for contractors to sell refinishing services compared to new floorings and it has to do with the business model in the construction sector.

Lack of data for calculating cost and time for refinishing services was also pointed out as a barrier. When a contractor is offering a customer refinishing services there is a high uncertainty about the real cost and time needed for completing the job. If there were more data available and these were

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[10] https://pestleanalysis.com/what-is-pestle-analysis/, visited 2020-03-19

integrated and easily accessible in used calculation tools, it would facilitate and reduce risks for the contractor to offer refinishing services.

Social

Social barriers usually include factors such as prevailing norms and perceptions in the society. In this case it was identified as a barrier that installation of new flooring, new kitchen and newly painted walls is the norm for new tenants. Tenants expect to move in to a "new" building and refinished flooring is not considered to be as attractive as a new floor.

Another social barrier that was outlined is that no stakeholder in the construction process has refinishing of flooring on the top of their agenda. The choice of flooring is made by the property owner, tenant, contractor, and an assisting architect and takes design, acoustic requirements, and other functional requirements into account at the point of installation. When the flooring is installed, the property owner owns the flooring which the tenant is renting. Major maintenance is done by the property owner and daily cleaning is often purchased by the tenant. Future possibilities for renovating the floors are determined by how well they are maintained and how they have been cleaned. Consequently, none of the stakeholders drive the agenda for refinishing.

Technological

Technological barriers can be both that a technical solution for a certain problem is missing or that information about possible technical solutions are not shared with the right stakeholders.

One barrier that was pointed out as a technical barrier is that there are no technical criteria to evaluate which floors can be refinished. This is craftsman's know-how that takes years to acquire. Several stakeholders expressed the need for new criteria to guide them in the decision-making so that purchase cost would not be the only criteria. For example, it is not clear how to evaluate climate benefits and maintenance costs. The property owners expressed a need for more knowledge of flooring maintenance and would appreciate help to develop maintenance plans.

Legal

No legal barriers were found.

Environmental

In Sweden, it is common to assess products in environmental assessment systems to help customers choose the best suited product for the application. However, most environmental assessment systems focus on new products even though some of them also give credit for reused or recycled materials. None of the systems we have investigated specifically focus on floor refinishing and it is therefore considered a barrier. Also, other environmental requirements counteract refinish for example acoustic requirements.

The environmental benefits of floor refinishing are articulated in the life cycle assessment done in this project. However, availability of LCA data representing refinishing of products is in general lacking and this itself is a barrier, given that the environmental impact is reduced by refinishing.

4.5 Actions to overcome the barriers

One way of grouping stakeholders is to make a division between the stakeholders who are responsible for the implementation of a policy or a project and those who are affected by it. The actions stated below are directed towards specific stakeholders that are affected by the barriers and the actions. In the final roadmap we will also point out preferred implementors - the stakeholders suggested for implementing the actions.

Information to property owners, tenants and their architects

Several identified barriers can be overcome through information to property owners, tenants and architects to increase their knowledge and understanding of which flooring can be refinished, what the cost and time for that would be and the greenhouse gas emission benefits. By communicating results from life cycle assessments and by adding other factors to evaluate solutions such as time requirements and cost, more flooring would probably be refinished. A guidebook with good examples of possibilities could be one solution.

Another facilitator for communication is the environmental assessment systems that are operated in Sweden. Potentially their criteria can be updated and complemented to enhance reuse of flooring through refinishing.

Business models for contractors

When it comes to the barriers for the contractors, the current business model is a challenge. Selling building materials is a good source of income which counteracts refinishing services. This is the principal model for the whole construction sector and not only for the flooring industry to solve. It is difficult to suggest one specific action, but change will have to come if the current climate crisis and the overuse of resources shall be solved. Government on EU level and national level push for this change through programs for circular economy.

One possible action to create more circular businesses is to form policy instruments, such as tax-reduction, that enables a lower cost for refinishing services. This is already done for other sectors in Sweden and could maybe be applied for professionals in the building industry as well.

Another barrier that can be more easily solved is the lack of information about refinishing services that the contractors and property owners experience. This can be solved by adding data about cost and time needed for refinishing into calculation and purchasing tools commonly used.

New services for maintenance

The maintenance customer is often the property owner but could also be the cleaning company. For these stakeholders, information and knowledge about maintenance plans is critical. As a result, there is no agenda to review the condition of flooring. This can be solved through several actions.

One action would be a digital solution where maintenance plans are provided together with products and could include e.g. digital reminders for the floor owner. Another action would be to offer maintenance as a service. A third action could be to offer flooring on a lease agreement. In this case the floor would be owned by a third party that provides maintained floors as a service and who is responsible for maintaining its condition. This type of service can be found for facades in Sweden and could possibly be translated into the flooring market.

Challenges for government and industry associations

Some barriers found need to be addressed by the government for example barriers connected to the prevailing business models and price structure for new products versus reused products. One action could be to evaluate, develop and implement new policy instrument such as lower taxes to drive the change towards circular economy and improved resource efficiency.

Other barriers need to be addresses by the industry associations to reach the whole construction sector. These are barriers connected to lack of information or knowledge such as or by construction sector via industry associations.

These stakeholders, the government and industry associations, also play a main role when it comes to communicating the benefits of refinishing and adding other factors than purchase cost to choose products from by the construction sector.

4.6 Final roadmap for increased resource efficiency in the flooring industry

To start taking the industry from the current situation to the desired situation defined in this project, several barriers have been identified along with some suggested actions. All this is summarized in the roadmap below where the stakeholder (left column) is the one perceiving the barrier and the implementer (right column) is the one needed to do the actions so that the barriers can be solved.

The suggested barriers and actions are a selection of possible answers that came up during the workshops in this project. Other solutions are of course possible.

Stake-holder	Barriers	Actions	Actor
Material suppliers	• LCA for refinishing is unusual and not communicated	• Communicate results from refinishing LCA to property owners and architects	• Material supplier • Flooring Industry Association
Property owners	• Lack of maintenance knowledge	• Offer digital maintenance plans with reminders • Offer floors for lease • Offer maintenance service	• Material supplier
	• Cost for maintenance and refinishing not included in common calculation tools	• Add unit cost and time for refinishing in calculation tools	• Material supplier (unit costs) • Contractors (unit time)
		• Review floor condition periodically	• Property owners
	• Small price difference between new and refinished floors	• Add other criteria to evaluate, eg climate data, maintenance cost, installation time	• Architect • Material supplier • Contractor
	• Benefits of refinishing is not well known	• Communicate results from refinishing LCA to property owners and architects	• Flooring Industry Association
Architects	• Environmental assessment systems have different criterias and focus on new products	• Update criteria with refinishing data	• Environmental assessment systems
	• There are no criteria to evaluate refinishing when choosing products	• Add other criteria to evaluate new versus refinished floors, eg climate data, maintenance cost, installation time	• Material supplier • Contractors
Contractors	• Lack of incentive for contractors that supply new products	• New business model to support circular economy and resource efficiency	• Construction sector
	• Lack of data for refinishing when calculating time and cost	• Add unit cost and time for refinishing in calculation tools	• Material supplier (unit costs) • Contractor (unit time)
	• Lack of incentives for refinishing for contractors	• Develop and implement new policy instruments	• Government (national)
Tenants	• Installation of new floors for new tenants is common	• Guidebook with good refinishing examples	• Material supplier • Architect
	• Negotiations do not include carbon footprint of installed products	• Add other criteria to evaluate new versus refinished floors, eg climate data, maintenance cost, installation time	• Property owners
	• Small price difference between new and refinished floors	• Add other criteria to evaluate new versus refinished floors, eg climate data, maintenance cost, installation time	• Architect • Material supplier • Contractor

Figure 6 Roadmap for increased resource efficiency in the flooring industry

5 Final conclusions and future recommendations

As a first remark, it is imperative to clarify that floor refinishing is one of several possibilities to reduce greenhouse gas emissions and achieve better resource utilization in the flooring industry. The industry needs to work on several initiatives in parallel including design for reuse, product durability, renewable raw materials, and recyclability.

The outcome of the LCA demonstrates that refinishing of hardwood and resilient flooring is a viable alternative to improve resource efficiency and reduce greenhouse gas emissions compared to installation of new flooring. The result shows that greenhouse gas emissions can be significantly reduced and that the use of renewable and non-renewable resources can improve if the number of refinished floors increase. In most cases, refinishing can reduce greenhouse gas emissions by more than 75% compared to the emissions expected from installation of new flooring.

The final Roadmap for refinishing outlines some areas for further development which stakeholders in the flooring industry need to work on together to continue the journey towards a resource efficient and circular future.

1. Awareness and knowledge about the benefits of refinishing needs to increase. This includes more research to establish proof of concept and to disseminate the result. Relevant information needs to be addressed for different stakeholders so they understand how they can contribute. Stakeholders who have participated in this project emphasized that they need simple key figures or other criteria that guide them in the decision-making process. This can be done through guidelines and handbooks and through including data regarding refinishing tools used for designing, calculation, purchase, and maintenance of flooring.

2. The business model in the flooring industry, as well in the construction sector, needs to change to transfer into a circular economy model with improved resource use. Current business model supports linear product flows and promotes installation of new products instead of endorsing reuse, refinishing and recycling. New business models provide the opportunity to develop new services in the flooring industry and it is likely that new groups of stakeholders will be established.

3. To speed up the transition from a linear model towards a circular, policy instruments could be developed and implemented to accelerate the change towards a more resource efficient and circular product flow.

Annex A: LCA of floor refinishing – including an impact comparison with new flooring

March 2020

LCA of floor refinishing

Including an impact comparison with new flooring

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This report has been reviewed and approved in accordance with IVL's audited and approved management system.

Table of contents

1 Introduction 4

1.1 About this report 4
1.2 What is LCA? 4

2 Goal and scope 5

2.1 Goal 5
2.2 Scope 5

2.2.1 Type of LCA 6
2.2.2 Functional unit 6
2.2.3 Studied product systems 6
2.2.4 Scenario analysis 9
2.2.5 Sensitivity analysis 10
2.2.6 System boundaries 10
2.2.7 Critical review procedure 11
2.2.8 Limitations and key assumptions 11
2.2.9 Selected impact categories 12

3 Life cycle inventory 13

3.1 Refinishing products 13
3.2 Product manufacturing 13
3.3 Floor refinishing 14
3.4 End of life treatment 15
3.5 Environmental impact data for flooring 16

4 Results 19

4.1 Life cycle impact assessment (LCIA) 19

4.1.1 Part one – Floor refinishing 19
4.1.2 Part two – Impact comparison of floor refinishing and new flooring 27

5 Conclusions 31

5.1 Part one – Floor refinishing 31
5.2 Part two – Impact comparison of floor refinishing and new flooring 32

6 References 33

7 Appendix 34

Appendix A: Impact categories 34

Appendix B: EPD data 36

Appendix C: Refinishing products 39

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1 Introduction

1.1 About this report

This report is one of the deliverables of a research project funded by Bona AB, a global company that supplies products for installing, renovating, maintaining and restoring premium floors, and the SIVL foundation carried out by IVL Swedish Environmental Research Institute in 2019 and 2020. It comprises a Life Cycle Assessment (LCA) in which the environmental impact as a result of refinish of hardwood and resilient flooring is assessed. Next to that, the result from the LCA is used to compare the impact from refinish to the impact of installing new flooring.

The outcome of this study is intended for stakeholders in the flooring industry and the findings will serve as input for the main report of this project.

1.2 What is LCA?

Life cycle assessments (LCA) investigate the environmental impacts related to a product or a system during its whole life cycle. This includes evaluating energy and resource use as well as emissions, from all life cycle stages including; material production, manufacturing, use and maintenance, and end-of-life. A schematic overview of a life cycle is shown in Figure 1.

LCA is a widely used and accepted method for studies of environmental performance of various products and systems.

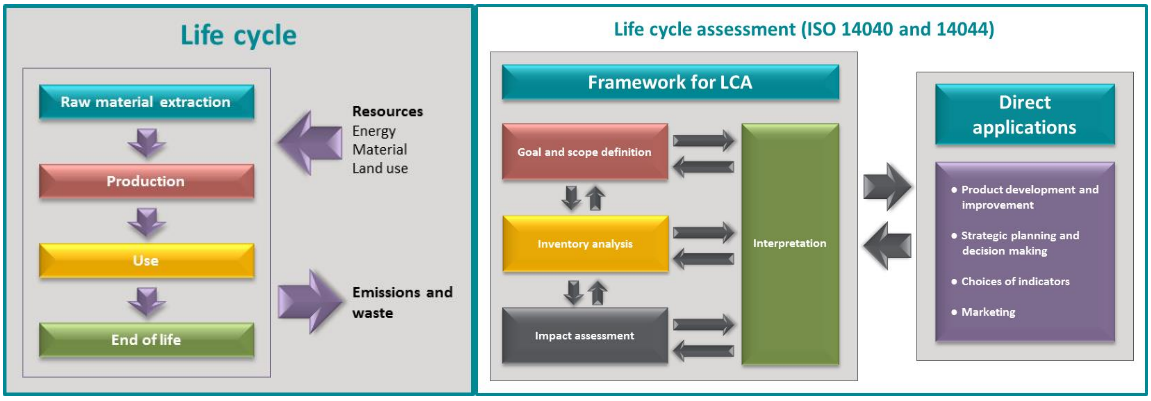

Figure 1: Illustration of the LCA system and the framework for life cycle assessment.

2 Goal and scope

In this chapter is the goal and scope of this LCA defined and explained. It is in this part of the report where the primary objectives of the study are listed and where the scope of the project is described. The goal and scope should act as guidelines to perform the assessment as well as helping the reader of the report to understand key assumptions, system boundaries, limitations and other aspects influencing the results. Another important element of the goal and scope is the definition of the functional unit which is the reference unit by which the inputs and outputs of the LCA is scaled.

2.1 Goal

The goal of this LCA is to:

- assess the environmental impact resulting from refinish of hardwood and resilient floors used in commercial properties in Sweden.
- identify environmental impact benefits/disadvantages of maintaining hardwood and resilient floors through floor refinishing compared to installing new floors.

The result is primarily intended to be used to inform stakeholders in the flooring industry about the environmental impact resulting from floor refinishing. Further on, the result should indicate whether refinish leads to any environmental impact benefits/disadvantages compared to the installation of new floors.

2.2 Scope

The study aims to investigate the environmental impact as a result of floor refinishing of two types of flooring:

- Floating prefabricated parquet (hardwood), also referred to as multilayer parquet
- Homogenous PVC (resilient)

The impact of floor refinishing is assessed by using refinishing systems (products and processes) supplied by Bona as reference.

The study further aims to compare the impact associated with refinishing to the alternative of installing a new flooring system. For this, publicly available Environmental Product Declarations (EPDs) for multilayer parquet and homogenous PVC published by floor manufacturers are used.

Both hardwood and resilient floors are assumed to be installed and refinished in commercial properties in Sweden.

2.2.1 Type of LCA

The LCA performed is an attributional LCA where the environmental impact from refinishing of two types of flooring systems is assessed and where the result is compared to the impact resulting from the installation of new floors.

2.2.2 Functional unit

A functional unit is used to relate the result to a fixed factor, to enable comparison of different cases based on the prerequisites of a certain function. This is important both when comparing results, but also to understand in which cases the LCA results are valid. While the result of the report is divided into two parts (see section *2.2.3*), the functional unit remains the same.

The functional unit of this study is **1 m² of flooring.** This is a commonly used reference within the flooring industry and a useful measurement for relevant industry stakeholders. The amount of material needed, weight, durability and use phase details all relate to this function. It is further a widely used functional unit applied for EPDs published by floor manufacturers and thus suitable for the comparison between refinishing and installation of new floors.

2.2.3 Studied product systems

The study is divided into two parts:

- In the first part a life cycle assessment is carried out. It aims to assess the environmental impact of Bona's refinishing processes for multilayer parquet and homogenous PVC flooring.
- In the second part of the study, the environmental impact as a result of floor refinishing and the impact from installing new flooring is compared. This part does not include an LCA of hardwood and resilient flooring, instead environmental data published in EPDs by the flooring industry are used.

The considered product systems are described in detail below.

2.2.3.1 Part one – Floor refinishing

Products

The products used for refinishing parquet and homogenous PVC flooring are shown in Table 1. These products have been selected for the study since they are typically used for hardwood and resilient floors in Sweden. The life cycle of the products is explained in this section, while the life cycle of the product system is described in the following two chapters below.

Table 1. Bona products included in the LCA

Product name	Type of product	For refinishing of	Relative density
Bona Prime Classic	Primer - Waterborne acrylic 1K	Parquet	1,04
Bona Traffic HD	Topcoat - Waterborne PUR 2K	Parquet	1,04
Bona Pure Color	Pigmented floor paint - Waterborne PUR 2K	Resilient PVC	1,04
Bona Pure	Topcoat - Waterborne PUR 2K	Resilient PVC	1,04
Bona PowerRemover R	Cleaner	Resilient PVC	1,025

Bona Prime Classic, Bona Traffic HD, Bona Pure Colour and Bona Pure are products produced by Bona in Malmö whereas Bona PowerRemover R is manufactured by a partner. The system studied related to the individual products includes (Figure 2):

1. Extraction, production and transportation of raw materials
2. Manufacturing of final products (raw material blending and processing as well as packaging and labelling)
3. Transportation of products to customers
4. Waste management and the end of life of products and packaging.

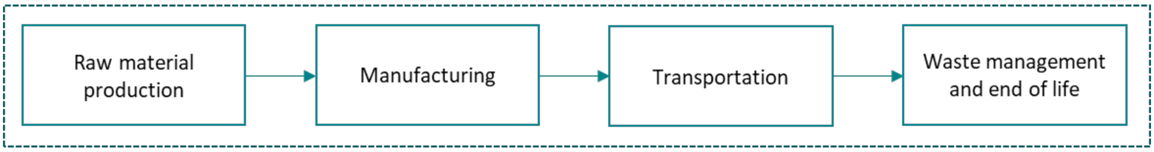

Figure 2: Overview of Bona's products life cycle - cradle to gate including end of life.

Refinishing of parquet

Bona's parquet refinishing process is applicable for floating multilayer parquet used in commercial properties. One cycle of the parquet refinishing process requires in general five visits to the premises by the craftsmen, see Figure 3. During the first visit, the craftsman visits the customer, examines the floor and prepares a quotation. On the second visit, the refinishing process is initiated, and the floor goes through dry sanding and the primer is applied. During the third and fourth visit, the first and second layer of the varnish is applied. Finally, during the last visit, the craftsman inspects the result.

Normally the treatment needs to be repeated every 15th year (technical lifetime of varnish) to maintain the quality of the floor and avoid it from being damaged by wear due to reduced protection by the varnish.

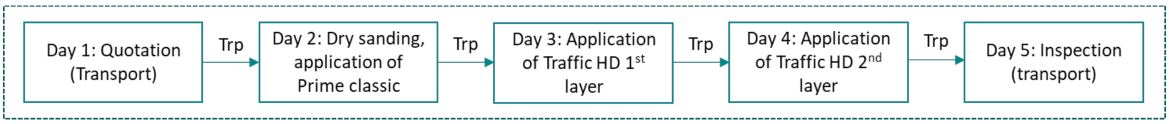

Figure 3: Overview of Bona's parquet refinishing process.

Refinishing of PVC flooring

Bona's refinishing process of PVC flooring is applicable for resilient homogenous PVC flooring used in commercial properties. One cycle of the refinishing process normally requires four visits to the premises by the craftsmen, see Figure 4. During the first visit, the craftsman visits the customer, examines the floor and prepares a quotation. On the second, the refinishing process is initiated, and the top layer of the floor is removed through applying the cleaner and performing wet sanding of the floor. Next, the floor is painted by applying the primer. On the third day, the varnish is applied. Finally, and during the fourth and last visit, the result is inspected.

As for parquet, the treatment needs to be repeated every 15^{th} year (technical lifetime of varnish). However, new PVC flooring does not always require refinishing as often as every 15^{th} year due to that varnishes last longer than their specified technical lifetime in this industry. In those cases, the flooring typically requires refinish every $20\text{-}25^{th}$ year instead. Still, the assumption in this assessment is that PVC flooring requires refinishing every 15^{th} year.

Figure 4: Overview of Bona's homogenous PVC floor refinishing process.

2.2.3.2 Part two – Impact comparison of floor refinishing and new flooring

The second part of the study aims at comparing floor refinishing to the alternative of removing the old floor and install a new floor. Besides inventory data for Bona's refinishing processes, environmental impact data of parquet and homogenous PVC flooring are needed to conduct this analysis. Information about the systems and environmental performance of the floors has been collected from publicly available Environmental Product Declarations (EPDs) published by floor manufacturers. The considered systems are described below, while the environmental impact categories studied, and related data are found in in chapter 3.

Multilayer parquet

The considered life cycle stages, from a cradle to grave perspective, for multilayer parquet, are shown in Figure 5. This is the supply chain which, from an environmental impact perspective, is compared with the impact of Bona's refinishing process.

Figure 5: Overview of the considered stages in the life cycle of a multilayer parquet.

Homogenous PVC flooring

The considered life cycle stages, from a cradle to grave perspective, for PVC flooring, are shown in *Figure 6*. As for parquet the environmental impact from this supply chain is compared with Bona's refinishing system.

Figure 6: Overview of the considered stages in the life cycle of a PVC flooring.

Systems compared – floor refinishing and new flooring

The systems considered for the comparative assessment (system 1 and system 2) are shown in Figure 7. The scenarios start and end with flooring that is worn out and either needs to be replaced by new flooring or needs refinishing. For system 1 it is assumed that the owner decides to keep the floor and refinish it. For system 2 the owner instead chooses to replace the flooring by installing a new floor. Both alternatives result in a comparable function - flooring suitable for commercial properties.

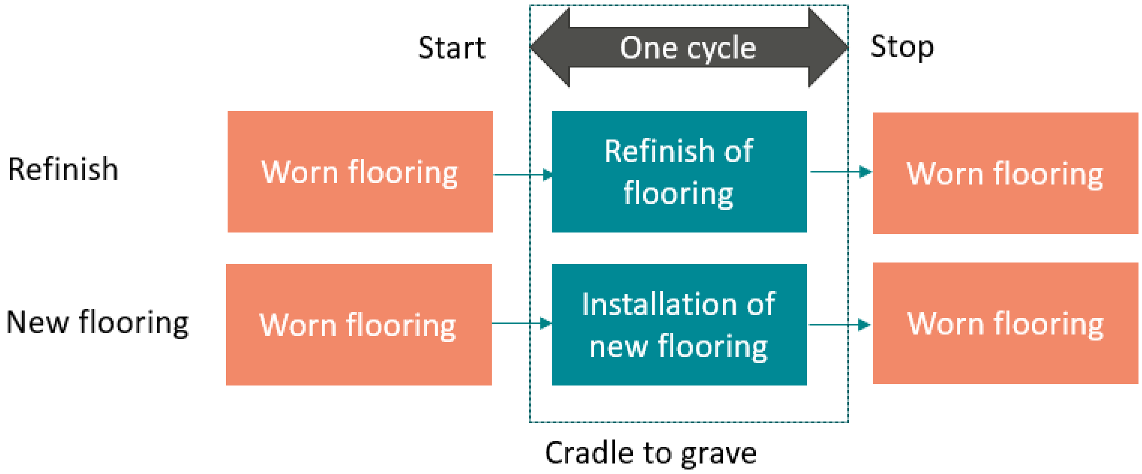

Figure 7: Overview of the system considered for the comparative assessment: Floor refinishing (system 1) and new floor (system 2). Green illustrates the part of the system within scope of the comparison.

The technical lifetime of hardwood and resilient floors may vary between products and producers, but typically a technical lifetime of at least 15 years is expected by floors intended for commercial properties. After this period the protective film (the varnish) is likely worn out and the flooring needs to be replaced or refinished. For the latter, the old varnish is removed together with a small part of the top layer of the flooring material and a new varnish is applied. The technical lifetime for refinished flooring is expected to be similar new flooring. The lifetime of flooring is not a considered parameter in this study since new and refinished flooring is expected to last equally long before it is worn out and in need of maintenance (new flooring or refinishing).

The number of times a floor can be refinished depends on several aspects such as the level of wear it is being exposed to, the thickness of the wear layer and how it is being maintained and cleaned. But for flooring within the scope of this study, it should be possible to refinish (multilayer parquet and homogenous PVC) between two to four times before the flooring must be removed and replaced by new flooring. For the purpose of the comparison of this study, the number of times a floor can be refinished is not considered. Still, the result can be used for comparing the impact for several cycles (Figure 7), simply by multiplying the impact difference by the number of refinishing cycles the floor is expected to go through.

2.2.4 Scenario analysis

The refinishing process for PVC flooring requires wet sanding in combination with stripping as an initial step before the varnishes can be applied. Bona is currently developing a process where dry sanding is used instead, which aims to replace wet sanding. As a result, wastewater from the wet sanding process containing polish and particles of plastics and varnish will be fully eliminated. To evaluate the difference in terms of environmental impact between the two sanding processes a scenario analysis is performed, where refinish of PVC flooring through wet and dry sanding is compared. Dry sanding does not generate any wastewater but generates sanding dust. The sanding dust is collected by the sanding machine, connected to an external vacuum cleaner in a closed loop system, and typically sent off to waste incineration.

2.2.5 Sensitivity analysis

In order to test the robustness of the results, two scenarios are added to the assessment. One concerns the distance the craftsman is assumed to travel to reach the customer and the other focuses on the impact of using different electricity sources for the sanding machine.

Craftsman trip scenario

One of the key assumptions in this study is the distance the craftsman is traveling to get to the premises. It is in the base case assumed that the distance is 20 km for one return trip, but since this can vary, a sensitivity analysis is carried out. It aims to show whether the impact from the craftsman's trips has a significant impact on the result. For this, two additional distances are evaluated, 40 and 80 km.

Power mix scenario

The sanding process used for refinishing of PVC and parquet floors consumes electricity. In Sweden and under Swedish power market conditions the impact from using electricity is relatively low compared to other European countries. This is the case since the average grid mix in Sweden has a low share of fossil fuels (mainly based on nuclear and hydro) which results in relatively low impact on e.g. climate change compared to countries like Germany and Poland. To evaluate the importance of the country grid mix for the sanding process a power mix sensitivity analysis is added to the assessment. In this analysis, the Swedish grid mix for the sanding process is replaced by a grid mix based on fossil fuels (50% coal and 50% natural gas).

2.2.6 System boundaries

In this section the applied system boundaries of the LCA are specified. Aspects such as boundaries towards nature and geographical boundaries, as well as methodology aspects concerning system expansion and allocation are defined and explained.

2.2.6.1 Boundaries towards nature

This study is a cradle to grave assessment, which means that the whole value chain has been covered i.e. that production of fuels, electricity and raw materials are followed from the cradle where the natural resources (e.g. crude oil or uranium) are extracted from the ground. The life cycle also covers all relevant transportation as well as the end of life management of the products i.e. the "grave" in terms of the soil (after human activity has ceased), the air (e.g. emissions from combustion of fuels) or water (e.g. water emissions from wastewater treatment).

2.2.6.2 Geographical boundaries

The LCA study mainly considers Swedish conditions and the Swedish flooring market regarding refinishing, while raw materials in Bona products are assumed to be produced in Europe.

The EPDs used to assess the environmental impact of producing and installing new floors are published for the European market and is based on European conditions.

2.2.6.3 System expansion

System expansion means that the systems are expanded to reflect the environmental benefit associated with for instance produced energy (electricity and heat produced in waste incineration of used products) and with the recycled materials (produced in material recycling).

System expansion is not applied in this study.

2.2.6.4 Allocations

Often allocations are required in LCA studies. This is, for instance, relevant for multioutput processes generating several products and co-products, where it is necessary to distribute (allocate) the environmental impact between these.

For this LCA, allocation is not applied (not needed) since the processes studied are not multioutput processes.

2.2.7 Critical review procedure

This study and report have been internally reviewed and approved in accordance with IVL's audited and approved management system. No third-party review has been performed.

2.2.8 Limitations and key assumptions

The LCA has to a large extent been aligned with the general methodology and common rules according to the requirements of ISO 14044:2006. The most important methodology choices are summarised below:

- The LCA performed is an attributional assessment.
- The environmental impact from the raw materials formulated into Bona refinishing products has been modelled using generic data from public databases such as thinkstep and EcoInvent. About 99% of the mass of the finished products has been covered.
- No system expansion has been applied, which means that no credits are considered for produced energy or materials in waste incineration or material recycling.
- No allocation of environmental impact has been carried out since not applicable.

The outcome of the study is influenced by limitations and assumptions made in the assessment. The main limitations and assumptions of the study are listed below:

- An LCA has been performed on Bona refinishing processes, while environmental impact data for flooring has been collected from EPDs published by the flooring industry.
- The main scope of the LCA is the Swedish market and the refinishing systems studied represent Swedish conditions.
- Daily transportation distance of craftsmen during refinish has been assumed to be 20 kilometres per 100 m^2 of flooring refinished in the base case. The impact of this assumption is assessed in the sensitivity analysis.
- The number of times a floor can be refinished is not considered.
- The lifetime of flooring is not a considered parameter since new and refinished flooring is expected to last equally long before it is worn and in need of maintenance.

2.2.9 Selected impact categories

The impact indicators used in the life cycle impact assessment are presented in Table 2. Other indicators describing resource use were also applied (Table 3). The indicators are based on the definition in the standard EN15804 (version 2012+A1:2013, Approved: 2013-11-24). Information and details about each impact category and the categories concerning resource usage are found in Appendix A. For global warming potential, the impact from biogenic carbon is out of scope. This includes carbon sequestration of the raw materials as well as the impact from emissions at the end of life. The reason for excluding biogenic carbon dioxide emissions is because they are considered to be net zero over a longer period and will not impact the result.

Table 2: Impact indicators - life cycle impact assessment.

Impact category	Category indicator	Reference: CML 2001 version
Climate change - Global warming potential (GWP) excluding biogenic carbon	kg CO_2 equivalents	January 2016
Eutrophication potential (EP)	kg PO_4 equivalents	January 2016
Acidification potential (AP)	kg SO_2 equivalents	January 2016
Photochemical Ozone Creation Potential (POCP)	kg Ethene equivalents	January 2016

Table 3: Indicators describing resource use.

Main category	Unit
Total use of renewable primary energy resources (PERT)	MJ
Total use of non-renewable primary energy resources (PENRT)	MJ

3 Life cycle inventory

This section gives an overview of the data collection process and the information collected and used in the analysis. In the first four sections is the data which is used to model the refinishing systems described. This is followed by an inventory of the flooring EPDs selected for the assessment and their specific impact on the environment.

3.1 Refinishing products

Information about the raw materials and products used in the refinishing process has been collected from Bona. Information about the products is presented in section 2.2.3.1.

Raw materials used in the products have been modelled using generic data from available databases such as thinkstep and EcoInvent. In cases when raw material data was not available estimations were done. About 99% of the mass, including water, of the finished products has been covered by database data. Transportation of raw materials from suppliers has been modelled using a 26-ton truck with a load factor of 85% and a transport distance of 500 km.

3.2 Product manufacturing

Information and data representing Bona's products has also been collected from Bona. Detailed process data used in the LCA is not disclosed in this report due to confidentiality. However, some information about data and datasets used in the LCA models is presented and reflects actual conditions at Bona.

Heat and electricity used at Bona are modelled by using data and datasets specified in Table 4. Site-specific emissions from the production originate mainly from the combustion of natural gas which is used to generate process heat. Gaseous nitrogen is used to create an incombustible atmosphere in the production processes and has been modelled by using a dataset from thinkstep, EU-28: Nitrogen (gaseous).

Table 4: Energy utilities used during manufacturing at Bona.

Energy utility	Production mix	Dataset
Electricity	Wind power	SE: Electricity from wind power, thinkstep
Heat	Natural gas boiler	Natural gas production (EU-28), thinkstep
Heat	District heating	District heat, SE, 2014, Data by IVL

The materials used for the packaging of the final products are presented in Table 5 and have been modelled accordingly.

Table 5: Packaging material used.

Packaging material	Dataset (1)
High density polyethylene (HDPE)	RER: Polyethylene high density granulate (PE-HD), PlasticsEurope 2014
Polypropylene (PP)	RER: Polypropylene granulate (PP), PlasticsEurope 2014
Corrugated board	Corrugated board box - Raw material consumption in Europe 2014, Fefco 2015
Paper	RER: Kraftliner, production Fefco 2015

(1) RER means Region Europe.

Transportation of natural gas, nitrogen and packaging material has been modelled using a 12-ton truck with a load factor of 85% and a transport distance of 500 km.

3.3 Floor refinishing

Information and data for floor refinishing has been collected from Bona. It represents Swedish conditions and reflects the activities required to refinish 100 m² of flooring. Due to confidentiality specific data is not disclosed in this report, but generic assumptions are presented below.

The LCA models developed for Bona products are used as input to the analysis. Electricity requirements for sanding the floor and vacuuming is modelled by using grid mix 1kV-60kV (SE) ts, a dataset for Swedish conditions and published by thinkstep. Consumables used during refinishing are presented in Table 6 and have been modelled by using the datasets specified.

Transportation of craftsmen and material has been modelled using a petrol car, euro 4, engine size up to 1,4 liters, with a travelling distance of 20 km per 100 m² refinished flooring (200 m per m²). For the fuel production data from the thinkstep database has been applied (EU-28: Gasoline mix (premium, 100% fossil) at filling station).

Table 6: Consumables used during floor refinishing.

Consumables	Material	Dataset (3)
Roller (1) (2)	Polyester	DE: Polyester Resin unsaturated (UP), thinkstep
Sanding belt (1)	Estimated with 100 % paper	RER: Kraftliner, production, Fefco 2015
Sanding disc (1)	Estimated with 100 % paper	RER: Kraftliner, production, Fefco 2015
BonaNet ceramic (2)	Estimated with 100 % paper	RER: Kraftliner, production, Fefco 2015
Cotton cloths (2)	Cotton	EU-28: Cotton raw conventional (EN15804 A1-A3), thinkstep
Mixing bucket (2)	Polypropylene	Polypropylene injection molding part (PP) (RER), PlasticsEurope

(1) Multilayer parquet flooring

(2) PVC flooring

(3) RER means Region Europe.

3.4 End of life treatment

Waste streams are created during the manufacturing of Bona's products and the refinishing process. The final disposal for the waste and the dataset used in the model are presented in the tables below (see Table 7, Table 8 and Table 9). Bona's products are packed in packaging that becomes waste and is treated (see Table 10 for information about disposal and dataset used). The data for end of life treatment was found in the thinkstep database.

Table 7: Waste streams from the production.

Waste	Final disposal	Dataset
Solid waste from production	Incineration	SE: Hazardous waste in waste incineration plant
Hazardous liquid waste from production		SE: Hazardous waste in waste incineration plant
Wastewater from production		SE: Hazardous waste in waste incineration plant

Table 8: Waste streams from refinish of parquet.

Waste	Final disposal	Dataset
Polyester roller	Incineration	SE: Plastics (unspecified) in waste incineration plant
Belt ceramic		SE: Paper and board (water 22%) in waste incineration plant
Disc ceramic		SE: Paper and board (water 22%) in waste incineration plant
Wastewater	Wastewater treatment	EU-28: Wastewater treatment ts
Wood dust	Incineration	SE: Processed wood in waste incineration plant
Varnish dust		SE: Plastics (unspecified) in waste incineration plant

Table 9: Waste streams from refinish of PVC flooring.

Waste	Final disposal	Dataset
Polyester roller	Incineration	SE: Plastics (unspecified) in waste incineration plant
Mixing bucket		SE: PP in waste incineration plant
BonaNet ceramic		SE: Paper and board (water 22%) in waste incineration plant
Cotton cloths		EU-28: Cotton in waste incineration plant (post-consumer waste 12% H_2O content)
Sludge of polish, PVC and PUR	Wastewater treatment or incineration	EU-28: Wastewater treatment ts or SE: Plastics (unspecified) in waste incineration plant

Table 10: Packaging waste.

Waste	Final disposal	Dataset
HDPE packaging waste	Incineration	SE: PE in waste incineration plant
PP packaging waste		SE: PP in waste incineration plant
Corrugated board packaging waste		SE: Paper and board (water 22%) in waste incineration plant
Paper packaging waste		SE: Paper and board (water 22%) in waste incineration plant

The end of life treatment of Bona´s products is not included in the refinishing process since the products are applied to the floor and not disposed of. However, when applying the products, the solvent in Bona´s products will evaporate. The solvent evaporation is modelled as an emission and accounted for as volatile organic carbon (VOC).

3.5 Environmental impact data for flooring

The life-cycle environmental impact of multilayer parquet and PVC flooring was collected from Environmental Product Declarations (EPDs). An EPD search was conducted by exploring different EPD programme operators. A list of found EPDs for both multilayer parquet and PVC flooring was compiled by IVL and reviewed by Bona. To capture the variety of floors on the market and make a consistent comparison, more than one floor was assessed for both parquet and PVC. The EPD search however showed that the availability of EPDs for the concerning floorings is somewhat limited. The EPDs used for estimating the life-cycle environmental impact for multilayer parquet and PVC flooring are presented below.

Multilayer parquet

The EPDs for a multilayer parquet collected through the EPD search are presented in Table 11 and represents typical flooring used in commercial properties.

Table 11: Environmental product declarations considered for multilayer parquet flooring.

Declaration holder	Programme operator	EPD No	Weight [kg/m²]	Thickness [mm]
Parador GmbH	IBU (1)	EPD-PAR-20170076-IBC1-EN	7,0	12,9
Weitzer Parkett GmbH & CoKG	IBU (1)	EPD-WEI-20150284-IBD1-DE	7,3	12,5
Verband der Deutschen Parkettindustrie e.V.	IBU (1)	EPD-VDP-20150263-IBG1-DE	4-20	8-21
Scheucher Holzindustrie GmbH	IBU (1)	EPD-SCP-20150324-IBC1-DE	7,0	14

(1) IBU – Institut Bauen und Umwelt e.V.

Data published by Parador GmbH and the Verband der Deuchen Parkettindustrie e.V. disclose the lowest and the highest impact on climate change of the four EPDs found and were specifically highlighted in the comparison for that reason. But also, an average of the four EPDs in Table 11 was compiled and included in the comparison.

The climate change impact and resource use for the three cases are presented in Table 12, Table 13 and Table 14. The environmental impact for the activities A4 (transport) and A5 (installation) were only declared in the EPD from the floor producer Parador GmbV and therefore used in all three cases.

Table 12: Climate change impact and resource use for the floor from Parador GmbH per m² of flooring.

Impact	Unit	A1-A3 (Parador)	A4 (Parador)	A5 (Parador)	C2 (Parador)	C3 (Parador)
Climate change (including biogenic carbon)	kg CO2-eq	-10,4	0,3	0,3	0,05	11,7
Renewable primary energy resources (PERT)	MJ	241	0,2	2,2	0,03	113
Non-renewable primary energy resources (PENRT)	MJ	70	4,6	1,3	0,7	4,6

Table 13: Climate change impact and resource use for the floor from Verband der Deuchen Parkett Industrie e.V per m² of flooring. The data for A4 and A5 are retrieved from the EPD by Parador GmbH.

Impact	Unit	A1-A3 (Parquet Industry)	A4 (Parador)	A5 (Parador)	C2 (Parquet Industry)	C3 (Parquet Industry)
Climate change (including biogenic carbon)	kg CO_2-eq	-5,3	0,3	0,3	0,008	14,6
Renewable primary energy resources (PERT)	MJ	484	0,2	2,2	0,0002	-154
Non-renewable primary energy resources (PENRT)	MJ	170	4,6	1,3	0,1	-2,4

Table 14: Climate change impact and resource use for an average multilayer parquet per m² of flooring. The data for A4 and A5 are retrieved from the EPD by Parador GmbH.

Impact	Unit	A1-A3 (average)	A4 (Parador)	A5 (Parador)	C2 (average)	C3 (average)
Climate change	kg CO_2-eq	-5,6	0,3	0,3	0,03	12,5
Renewable primary energy resources (PERT)	MJ	198	0,2	2,2	0,02	-13,7
Non-renewable primary energy resources (PENRT)	MJ	88	4,6	1,3	0,4	0,7

Resilient homogenous PVC floor

The EPDs for PVC flooring collected through the EPD search are presented in Table 15. Two EPDs were found in the search and these reflect typical floorings installed in commercial properties.

Table 15: Environmental product declarations considered for a PVC floor.

Declaration holder	Programme operator	EPD nr	Weight [kg/m²]	Thickness [mm]
Forbo Flooring B.V.	UL Environment	4788294459.103.1	2,9	2
Tarkett France	EPD International AB	00000886	2,75	2

The life-cycle environmental impact and resource use for the two floorings are presented in Table 16 and Table 17 and have been used as a reference for the comparison.

Table 16: Climate change impact and resource use for the PVC floor from Forbo Flooring B.V. per functional unit.

Impact	Unit	A1-A3	A4	A5	C1	C2	C3
Climate change	kg CO_2-eq	5,9	0,5	0,7	0,007	0,02	7,7
Renewable primary energy resources (PERT)	MJ	19	0,2	0,5	0,04	0,01	2
Non-renewable primary energy resources (PENRT)	MJ	148	4	12	0,1	0,3	15

Table 17: Climate change impact and resource use for the PVC floor from Tarkett France per functional unit.

Impact	Unit	A1-A3	A4	A5	C1	C2	C3
Climate change	kg CO2-eq	6	0,6	1,4	0	0,01	0
Renewable primary energy resources (PERT)	MJ	27	0,1	4	0	0	0
Non-renewable primary energy resources (PENRT)	MJ	138	10	26	0	0,2	0

The EPD published by Tarkett France does not report any climate change impact and use of energy resources in category C3 (end of life). This since their flooring is assumed to be landfilled after use. Landfilling of plastics results in that the flooring material becomes a carbon sink and a limited amount of carbon dioxide emissions are emitted.

In the EPD published by Forbo Flooring B.V. the impact from C3 is reported being the most dominant source for climate impact along the product life cycle. Instead of applying a landfill scenario, turning the flooring material to a carbon sink, Forbo Flooring B.V. assumes that the used product is incinerated in a waste incineration plant. Incineration of plastics generates carbon dioxide which is reported under category C3.

The environmental performance reported in the studied EPDs, both for parquet and PVC flooring and for all environmental impact considered in this study, are presented in Appendix B.

4 Results

4.1 Life cycle impact assessment (LCIA)

In this chapter, the result of the study is presented. It is divided into two parts, Part one –Floor refinishing and Part two – Impact comparison of floor refinishing and new flooring. The main focus for Part one is climate change, although other impact categories are also considered and presented in Table 18 and Table 19. In Part two, the impact on climate change and the use of renewable and non-renewable primary energy resources are presented.

4.1.1 Part one – Floor refinishing

Refinish of parquet

The environmental impact as a result of refinishing 1 m^2 of multilayer parquet using Bona system is shown in Table 18. The results presented represent the impact from a cradle to grave perspective and cover activities as specified in the chapters above.

Table 18: Environmental impact (cradle to grave) as a result of refinishing 1m² of multilayer parquet.

Parameter	Unit	Parquet refinishing
Climate change (excluding biogenic carbon)	kg CO2-eq	1,42
Eutrophication potential (EP)	kg PO4-eq	0,0006
Acidification potential (AP)	kg SO2-eq	0,002
Photochemical Ozone Creation Potential (POCP)	kg Ethene-eq	0,004
Total use of renewable primary energy resources (PERT)	MJ	2,0
Total use of non-renewable primary energy resources (PENRT)	MJ	17,3

Figure 8 shows the climate change impact per functional unit. The global warming potential includes the impact from non-biogenic carbon and consequently does not include the impact from uptake and emissions of biogenic carbon dioxide.

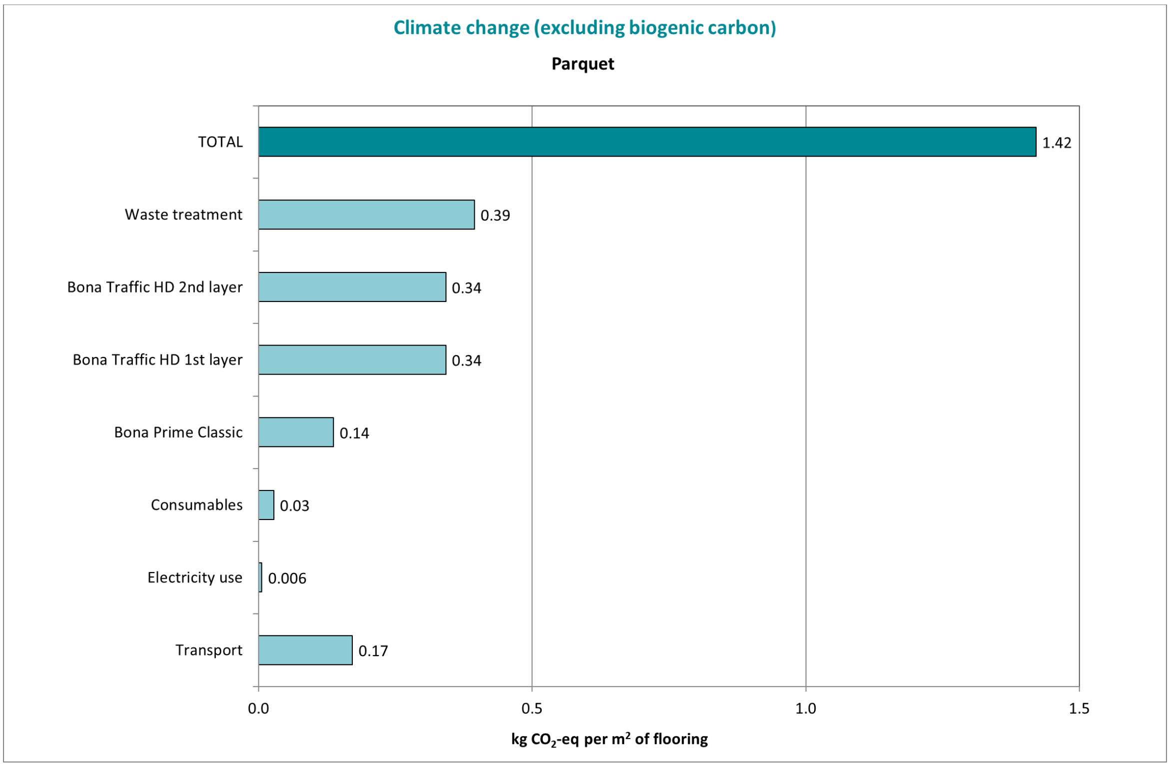

Figure 8: Climate change impact (kg CO_2-eq per functional unit) for the parquet refinishing process. Consumables are mainly sanding discs and rollers. Waste treatment refers to EoL treatment of consumables, packaging, sanding dust and wastewater. The evaporation of solvent during application is included in the product categories.

Refinish 1 m^2 of flooring results in a potential impact on climate change of 1,4 kg carbon dioxide equivalents. The main impact is caused by the products used (58%), specifically from the extraction and production of raw materials. The impact from Bona's production has minor influence on the total global warming potential which is shown in Appendix C. Greenhouse gas emissions from the use of the varnish is greater than the impact from the primer mainly due to that more varnish is used per m^2 flooring.

The impact from waste management has the second largest impact (28%) on climate change, next to the products used. This is predominantly caused by end of life treatment (incineration) of sanding dust (varnish) and product packaging. End of life treatment of wood (part of sanding dust) is not included in Figure 8 since the impact from biogenic carbon dioxide is out of the scope of this study – the uptake of emissions from biobased materials is assumed to be net zero and does not influence the result.

The impact from return trips to the premises of the craftsman (Transport in Figure 8) has a significant impact on the climate change impact (12%). The assumption is that the craftsman needs to travel 20 km to get back and forth to the premises where 100 m^2 of flooring is refinished.

The use of consumables (roller, sanding discs, etc) during refinishing has a limited impact on the overall global warming potential. Also, the impact from sanding (Electricity use in Figure 8) has a small impact, partly since a Swedish grid mix is used but also due to that the power use is limited relative to the total energy use.

Furthermore, the use of renewable and non-renewable primary energy resources used by the system studied is presented in Table 18. It shows that mostly non-renewable energy resources are used (90%). About three-quarters relate to the products (production of raw materials and resources) whereas 14% is caused by trips by the craftsman. Manufacturing of products and the processes related to refinishing have no significant effect on the results.

The cradle to grave results of the other impact categories studied show a similar trend as for climate change impact and energy use. The impact on eutrophication, acidification and photochemical ozone creation is predominantly caused by using products and specifically correlates to the raw materials used in product formulations, see tables in Appendix C. The varnish is contributing the most due to that more product is applied compared to the primer – the varnish, which is applied two times whereas the primer is applied once.

Sensitivity analysis – refinish of parquet

As part of the sensitivity analysis, the impact from the craftsman's trips on climate change is further evaluated. The scenarios applied is explained in section 2.2.5 above. The result is presented in the figure below (Figure 9).

The sensitivity analysis shows that the impact from the craftsman's trip has a significant impact on climate change and that the impact from refinishing 1 m² of floor increases by 36% if the craftsman needs to travel 80 km each day instead of 20 km for refinishing 100m² flooring.

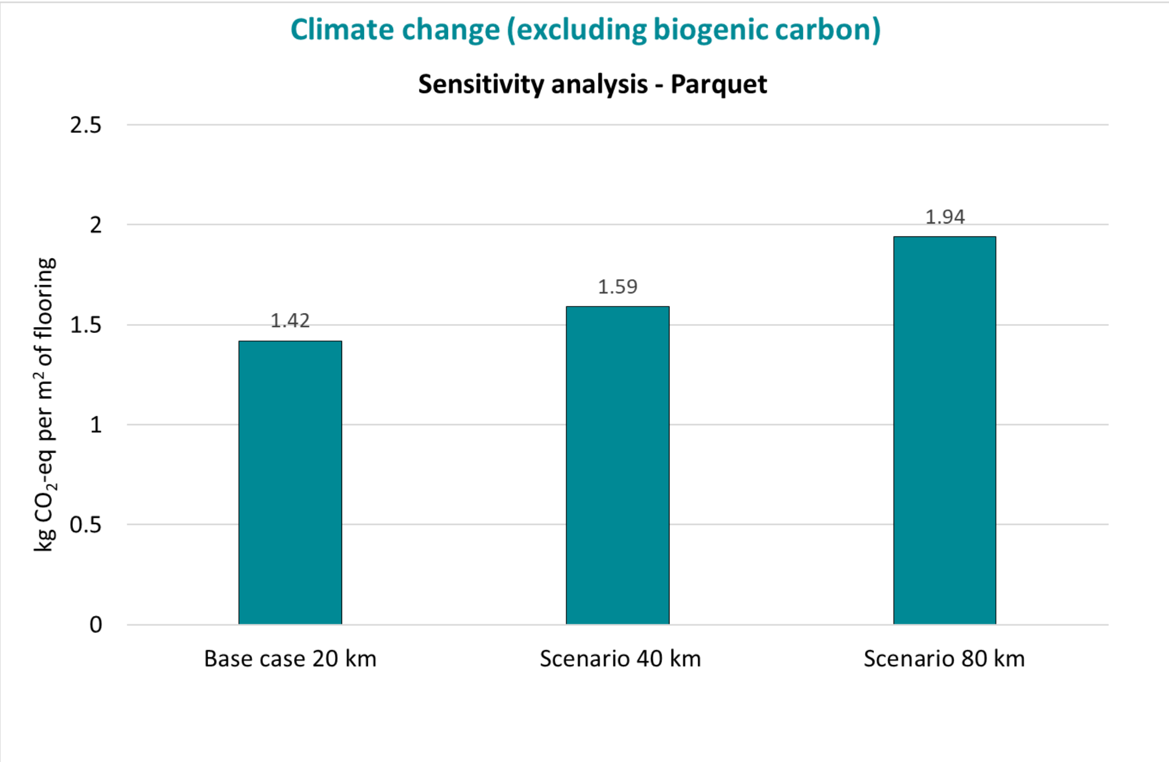

Figure 9: Climate change impact (kg CO_2-eq per functional unit) for parquet refinish in three different transportation scenarios.

The impact from using alternative electricity-mix for sanding has been evaluated in an additional sensitivity analysis which is explained in section 2.2.5. The result is presented in Figure 10 and it shows that the climate change impact increases by approximately 7% when a fossil-based grid mix is applied for the sanding process (instead of a Swedish grid mix).

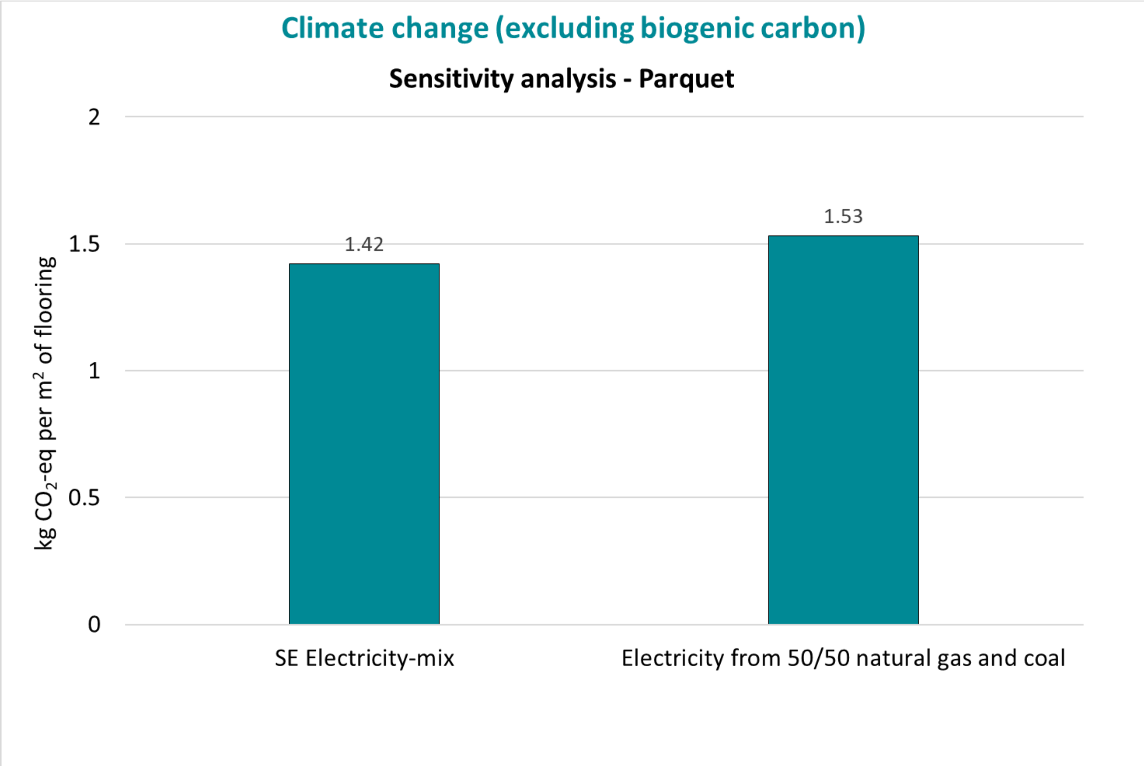

Figure 10: Climate change impact (kg CO_2-eq per functional unit) for parquet refinish in two different electricity scenarios.

Refinish of PVC flooring

The environmental impact as a result of refinishing using Bona system for PVC flooring is shown in Table 19. The results presented represent the impact from a cradle to grave perspective and includes all the activities as specified above.

Table 19: Environmental impact (cradle to grave) as a result of refinishing 1 m² of homogenous PVC flooring.

Parameter	Unit	PVC floor refinishing
Climate change (excluding biogenic carbon)	kg CO2-eq	1,14
Eutrophication potential (EP)	kg PO4-eq	0,0009
Acidification potential (AP)	kg SO2-eq	0,003
Photochemical Ozone Creation Potential (POCP)	kg Ethene-eq	0,002
Total use of renewable primary energy resources (PERT)	MJ	1,25
Total use of non-renewable primary energy resources (PENRT)	MJ	19,5

Figure 11 shows the total impact on climate change per functional unit.

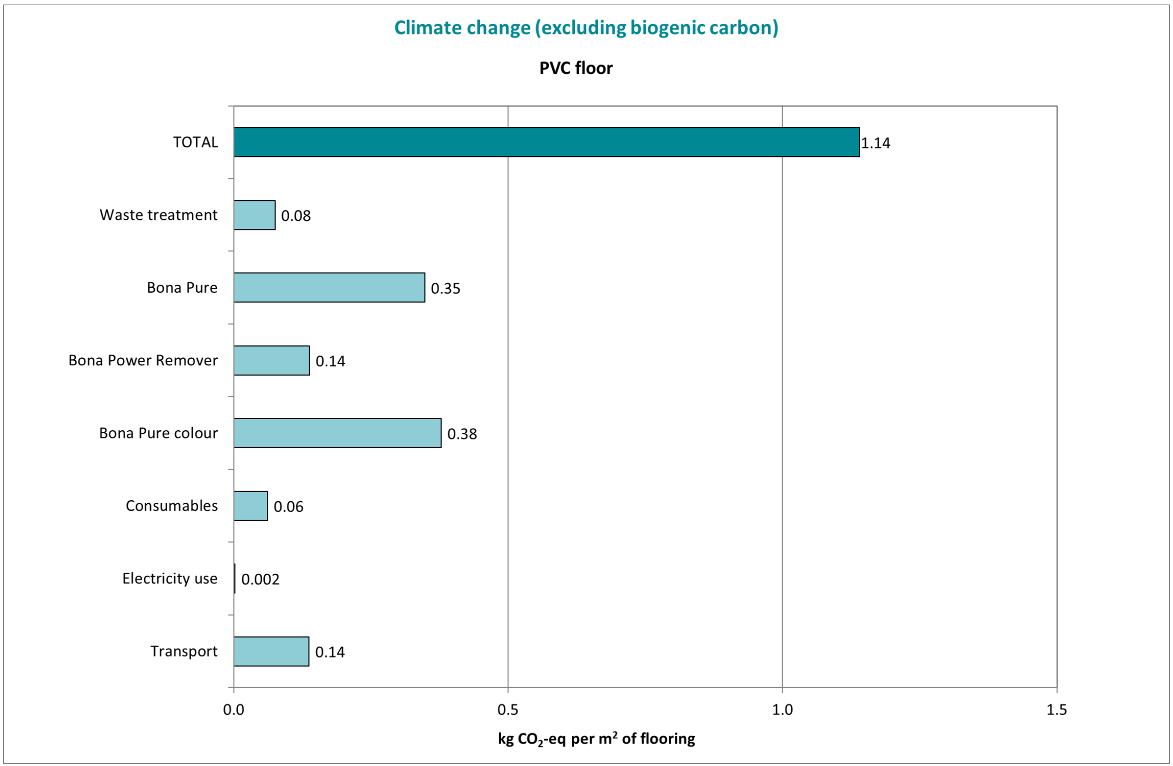

Figure 11: Climate change impact (kg CO_2-eq per functional unit) for the PVC floor refinishing process. Consumables are sanding discs, cotton cloths, mixing buckets and rollers. Waste treatment refers to the EoL treatment of consumables, packaging and sludge.

Refinishing 1 m^2 of flooring result in an impact on climate change equal to 1,14 kg carbon dioxide equivalents. As for refinish of parquet, most of the impact is caused by the products used (76%). Production of raw materials to produce and formulate the products used is the predominant source. The primer and the varnish contribute the most, 33% and 31% respectively. But also, the cleaner used to dissolve worn out varnish and dirt before sanding contributes to the result (12%). Further on, the impact on climate change from trips of the craftsman (Transport in Figure 11) is the second most contributing aspect next to the products (12%).

Waste management has a relatively low impact on the overall result (7%). The impact is mostly caused by end of life treatment of packaging and consumables (incineration), while sludge generated during wet sanding is treated in a wastewater treatment plant with low impact.

For renewable and non-renewable primary energy resources some 95% originates from non-renewable sources. The main part (90%) is associated with the production of the products used for refinishing (raw materials and resources). Consumables and the craftsman's trips contribute also to depletion of fossil energy resources, 7% and 10% respectively.

Similarly, to refinishing of parquet flooring, the other impact categories studied show a comparable impact trend as for global warming potential and primary energy use, see tables in Appendix B. The impact on eutrophication, acidification and photochemical ozone creation is predominantly caused by the products used. The primer is contributing the most followed by the varnish and the cleaner.

Scenario analysis – Refinish of PVC flooring

The impact of switching from wet sanding to dry sanding is analysed in a scenario analysis. The key difference in this scenario is that no sludge containing flooring residue is created. Instead, dry sanding dust (polish and plastic particles) is generated, collected and sent to waste incineration.

The result from the scenario analysis is presented in Figure 12. It shows that the global warming potential increases by 8% in cases where dry sanding is replacing wet sanding. This increase is because sanding dust is collected and sent to waste incineration, with carbon dioxide emissions as a consequence.

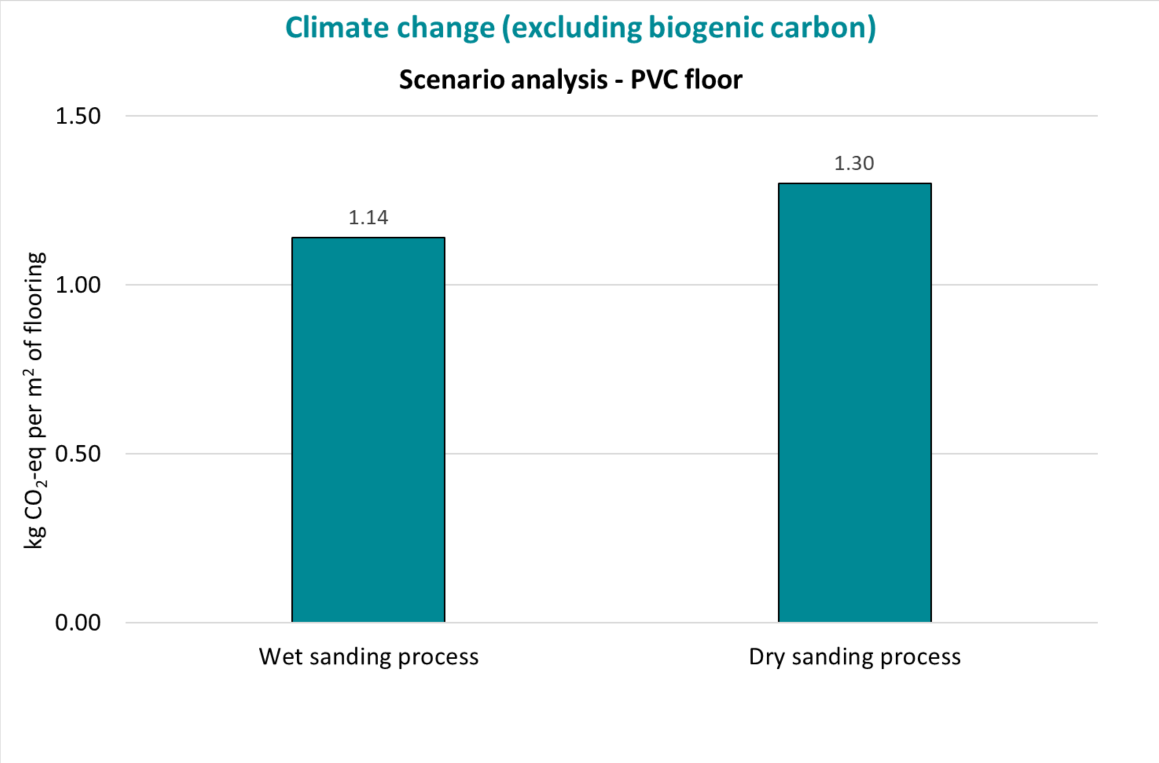

Figure 12: Climate change impact (kg CO_2-eq per functional unit) for PVC floor refinishing including two scenarios for the waste management; sanding sludge from the wet process to waste water treatment and dust from the dry process to waste incineration.

Sensitivity analysis – Refinish of PVC flooring

Similarly, to refinishing of parquet two aspects are further evaluated for refinishing of PVC flooring as part of the sensitivity analysis. In the first analysis, the impact from increased distances the craftsman is assumed to travel are assessed. In the second the impact from substituting the electricity-mix used for sanding is evaluated. Both scenarios are explained in section 2.2.5.

The result from the first sensitivity analysis is presented in Figure 13. It shows that the distance the craftsman must travel to get to the premises has a significant impact on climate change. In fact, the impact increases by 36% if the craftsman daily needs to travel 80 km instead of 20 km to refinish 100 m^2 of PVC flooring.

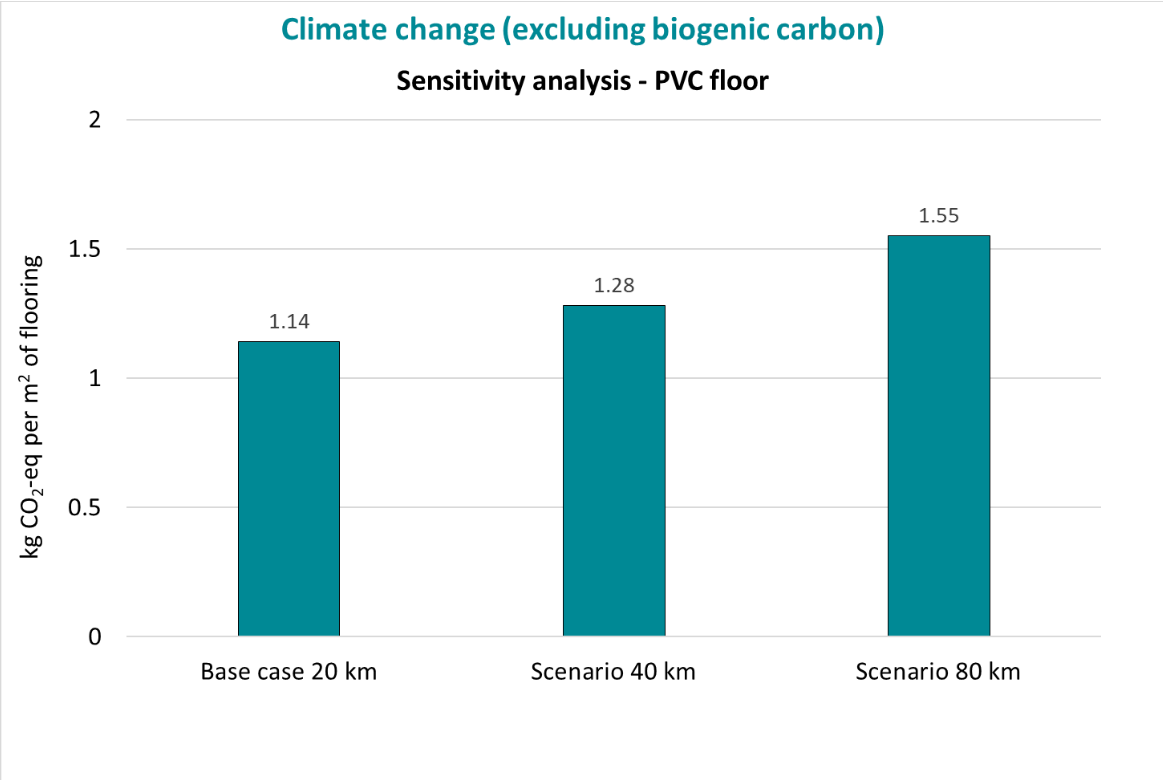

Figure 13: Climate change impact (kg CO_2-eq per functional unit) for refinish of PVC flooring in three different transportation scenarios.

The second sensitivity analysis (Figure 14) shows that the choice of electricity-mix used for the sanding process has a limited impact on the overall climate change results. The cradle to grave impact increases by 4 %.

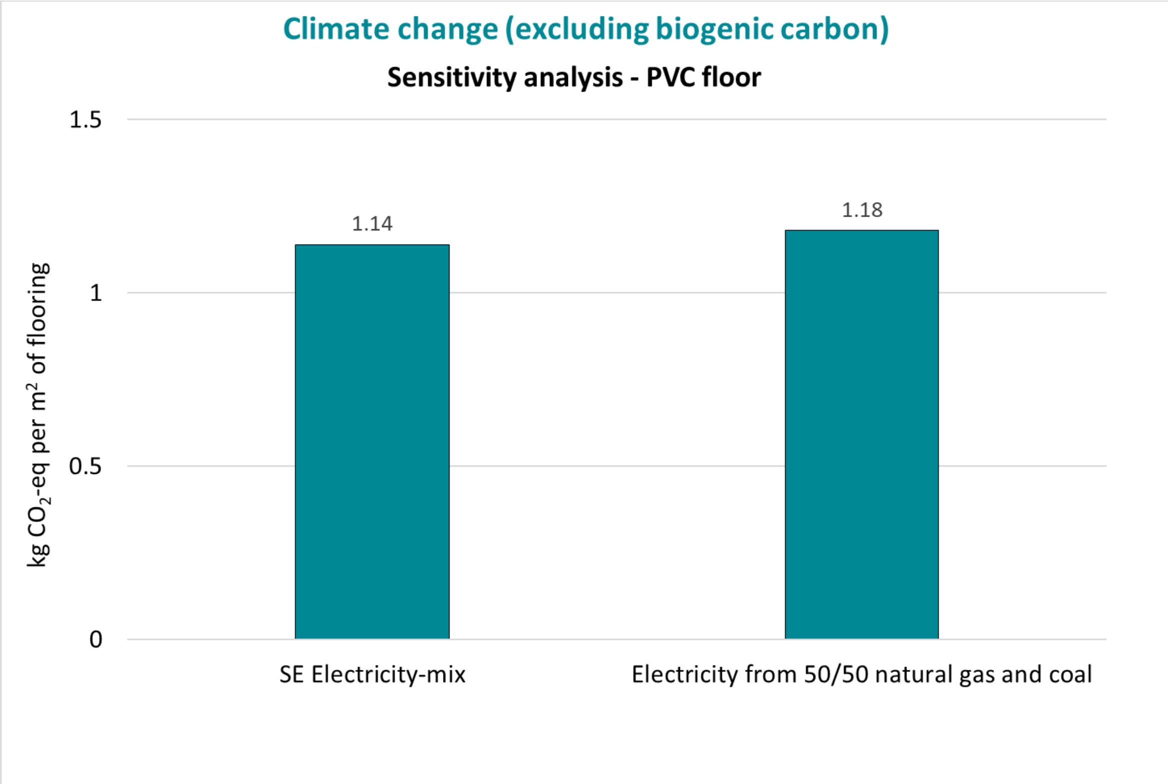

Figure 14: Climate change impact (kg CO_2-eq per functional unit) for refinishing of PVC flooring in two different electricity-mix scenarios.

4.1.2 Part two – Impact comparison of floor refinishing and new flooring

Parquet flooring

The result of the comparison between refinishing of multilayer parquet and installing new flooring is presented in Figure 15.

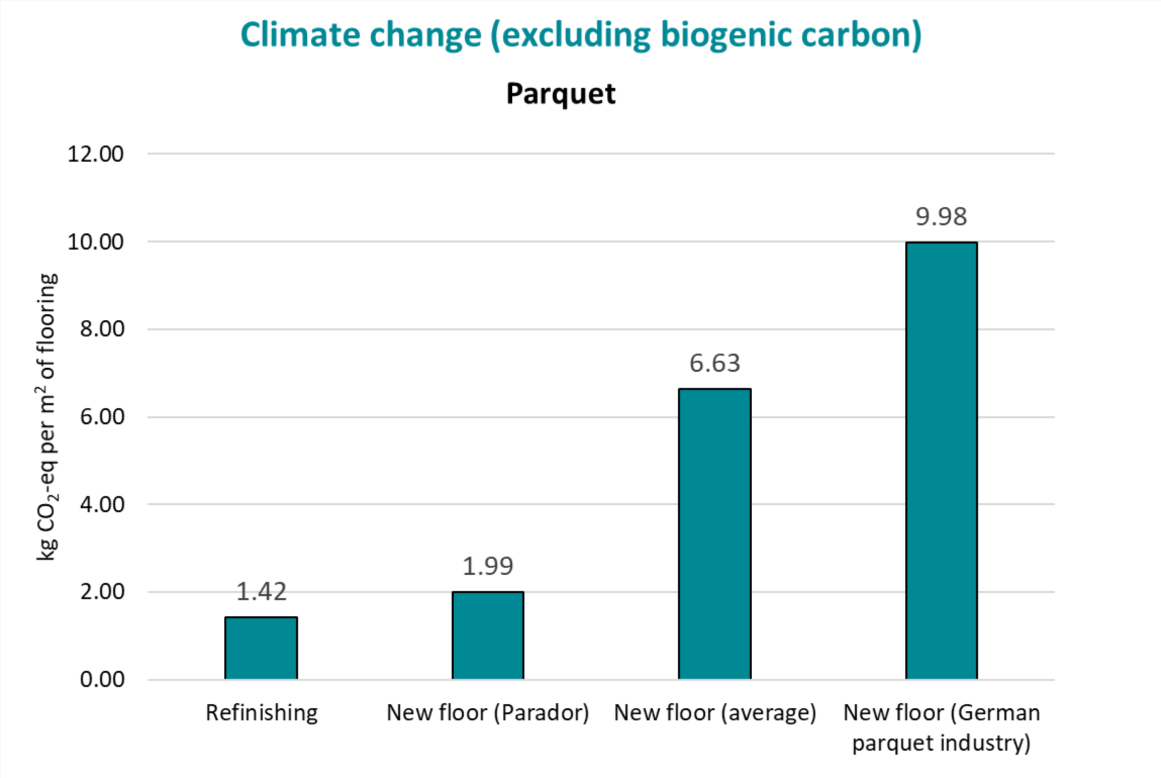

Figure 15: Comparison of climate change impact (kg CO_2-eq per functional unit) between floor refinishing and new parquet floor.

The results show that refinishing has a significantly lower impact on climate change (more than four times) than the average for new flooring. The comparison also shows that the impact from new flooring varies vastly and compared to the new flooring from Parador refinishing stills scores better, but the benefits are less clear.

The results for the use of renewable and non-renewable primary energy resources are presented in Figure 16.

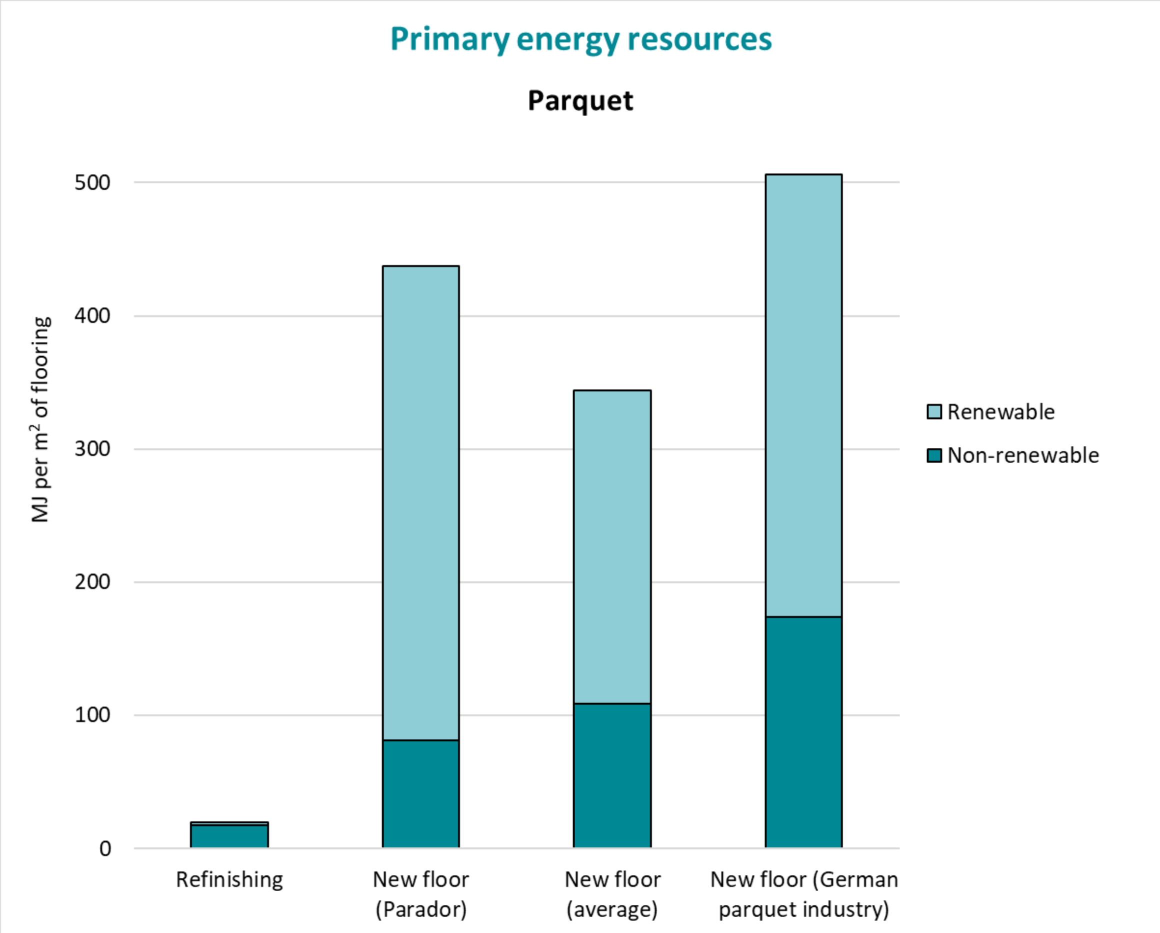

Figure 16: Comparison of primary energy resources, both renewable and non-renewable, between refinishing of parquet and new flooring.

The results show that regardless of manufacturer, the use of primary energy resources can significantly be reduced if existing floors are refinished instead of being replaced by new ones.

When analysing results for other impacts than climate change, refinish of parquet scores better (shows a lower impact) also for eutrophication, acidification and photochemical ozone creation potential. This is obvious when comparing the impact results presented in Table 18 with those presented in Appendix B (Table 20,
Table 21 and Table 22).

PVC flooring

The impact on climate change for refinishing of PVC flooring compared to a new floor can be seen in Figure 17. Unlike parquet flooring, the result for floor refinishing shows a significantly lower impact compared to either of the floorings studied. Refinish would reduce the impact on climate change by 85% compared to a new floor from Tarkett France and 92% compared to a new floor from Forbo Flooring B.V., the analysis shows.

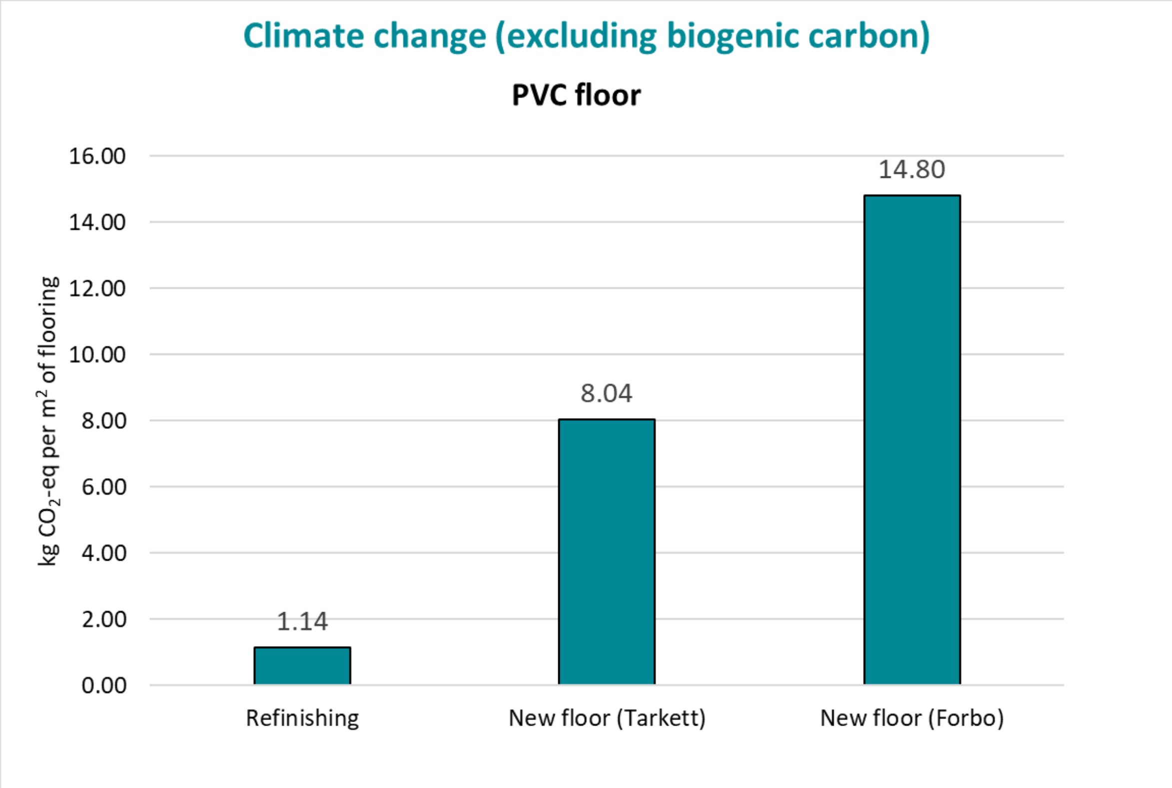

Figure 17: Comparison of climate change impact (kg CO_2-eq per functional unit) between floor refinishing and a new PVC floor.

The use of primary energy resources for refinishing of PVC flooring compared to new floors can be seen in Figure 18. It shows that energy use can be significantly decreased through floor refinishing.

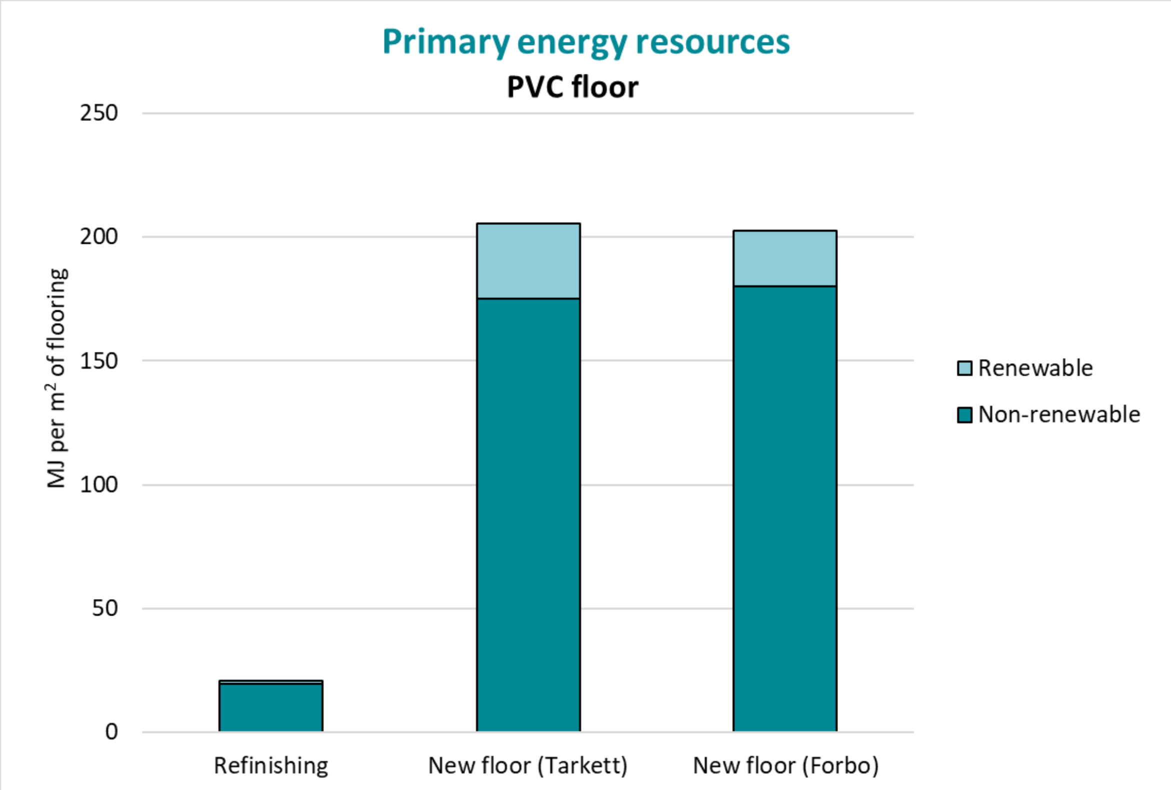

Figure 18: Comparison of primary energy resources, both renewable and non-renewable, between refinishing of PVC flooring and new flooring.

When analysing results for other impacts than climate change, refinish of parquet scores better (shows a lower impact) also for eutrophication, acidification and photochemical ozone creation potential. This is obvious when comparing the impact results presented in Table 19 with those presented in Appendix B (Table 23 and Table 24).

5 Conclusions

In this chapter the main conclusions of this study are presented. Initially, the key findings from the LCA (Part one) of the two Bona systems used for refinishing of multilayer parquet and homogenous PVC flooring are shown. Secondly, the main result from Part two is presented i.e. the comparison of the environmental impact between floor refinishing and installation of new flooring systems. The focus of the result analysis, for both parts of the report, is climate change impact and resource use. For the refinishing systems also eutrophication, acidification and photochemical ozone creation have been considered. The assumptions in this study are adapted to Swedish conditions and applicable for flooring used in commercial properties.

5.1 Part one – Floor refinishing

Impact on climate change

This LCA shows that using Bona's refinishing systems on a multilayer parquet generates a climate change impact equal to 1,4 CO_2 equivalents per m^2 of flooring refinished. For homogenous PVC this value is instead 1,1 kg CO_2 equivalents per m^2. For both types of flooring, it is the use of products during refinishing (primer and varnish) that influences the outcome significantly, particularly the extraction and production of raw materials used to formulate and produce the products.

The result further shows that processes related to the production of varnishes (pre-blending, mixing, filling and labelling at Bona) have limited impact on total climate change impact.

Another aspect identified as important in the LCA and which contributes significantly to the climate change impact is the car trips the craftsman must do to perform the refinishing. The sensitivity analysis shows that longer distances travelled by the craftsman could increase the impact on climate change significantly.

The outcome of the LCA also shows that the sanding process and consumables used during refinishing have relatively low impact on climate change. This is true for both parquet and PVC flooring. It is also validated that the impact is not likely to increase even though the sanding process is performed by using a fossil-based electricity mix. This is shown in the sensitivity analysis.

For parquet flooring, waste generation during refinish contributes significantly to the systems overall impact on climate change (28% of total impact). The impact is primarily connected to that sanding dust containing worn out varnish is collected and incinerated at its end of life.

The outcome of the study further indicates that applying dry sanding instead of wet sanding for PVC flooring is likely to increase the systems overall impact on climate change. Dry sanding eliminates the generation of sludge (water and micro plastic particles) which has the benefit of that a reduced quantity of particles is sent to municipal wastewater treatment. But the generated sanding dust is of fossil origin and destructed through waste incineration generating fossil carbon dioxide emissions as a consequence.

Impact on resource use and other impact categories studied

The outcome of the LCA further shows that predominantly primary energy from non-renewable resources is consumed by the two product systems studied. Less than 10% of the primary energy is of renewable origin. The main part of the non-renewable resources is used in the extraction and production of the raw materials used in the varnishes. Less than 10% of the primary energy is consumed by activities related to refinishing, such as sanding, use of consumables and trips made by the craftsman.

Similarly, to the conclusions for the climate change impact and resource use, the impacts on eutrophication, acidification and creation of photochemical ozone are predominantly caused by the activities related to extraction and production of raw materials used in Bona's products. One exception is found for refinish of parquet where the end of life treatment of wood dust generated by sanding activities contributes to 10% of the system's eutrophication and acidification potential.

5.2 Part two – Impact comparison of floor refinishing and new flooring

The overall result in the comparative assessment of this study indicates that significant environmental impact benefits are likely obtained if existing flooring is refinished instead of being replaced by new flooring systems. Refinishing enables the possibility of utilizing already available flooring material (resources) and consequently reduces the need for resources and emissions associated to the production of new flooring material.

The study shows that for multilayer parquet, the impact on climate change is equal or significantly reduced by selecting floor refinishing instead of installation of new flooring. The use of primary energy resources, especially renewable energy resources, can be significantly decreased since refinishing allows continued use by already available flooring material. The outcome of the report further demonstrates that the impacts on eutrophication, acidification and the creation of photochemical ozone are reduced by refinishing of parquet flooring.

The conclusions drawn from this study for PVC flooring are that refinishing is clearly the preferred alternative considering the impact on climate change. This can be explained by the fact that the amount of product required to refinish flooring is considerably less than the material needed to produce a new flooring system. The result further shows that a large amount of non-renewable primary energy resources can be saved in cases where refinishing is selected. This is the case since PVC is made by fossil resources. Furthermore, the impact on eutrophication and acidification is likely to be reduced as a consequence of refinishing.

One aspect that has been shown to have a significant effect on the impact on climate change is the trips the craftsman makes during refinishing. The sensitivity analysis shows that long trips could lead to that the clear benefits of refinishing are cut compared to installing new flooring materials.

6 References

[Gabi LCA software]
The Gabi LCA software and corresponding database are provided by thinkstep in Leinfelden-Echterdingen, Germany. Gabi version 7 was used.

[Gabi database]
The Gabi database 2019 (SP39) was used. SP39 relates to the ServicePak level of the Gabi 2019 database.

7 Appendix

Appendix A: Impact categories

Climate change

Global warming is caused by increases in the atmospheric concentration of chemical substances that absorb infrared radiation. These substances reduce the energy flow from Earth in a way that is similar to the radiative functions of a glass greenhouse. The category indicator is the degree to which the substances emitted from the system investigated contribute to the increased radiative forcing. The characterisation factor stands for the extent to which an emitted mass unit of a given substance can absorb infrared radiation compared to a mass unit of CO2. As the degree of persistence of these substances is different, their global warming potential (GWP) will depend on the time horizon considered, such as 20, 100 and 500 years. In this study, a time horizon of 100 years has been applied.

Eutrophication

When the nutritional balance in the soil and waters is disturbed, it is called eutrophication (when the amount of nutrition is increased). In aquatic systems, this leads to increased production of biomass, which may lead to oxygen deficiency when it is subsequently decomposed. The oxygen deficiency, in turn, kills organisms that live in or near the bottom of the lakes or coastal waters. It also makes the reproduction of fish more difficult. The category indicator is the potential of the emissions from the system investigated to deplete oxygen in aquatic systems, e.g. through increased biomass production. The potential contribution to eutrophication is in this study expressed as phosphate-equivalents, i.e., the capacity of 1 mg of a substance to favour biomass formation compared to that of 1 mg of phosphate (PO_4^{3-}).

Acidification

Acidification stands for the decrease of the pH value in terrestrial and water systems. This is a problem, because it causes substances in the soil to dissolve and leak into the water systems. These substances include nutrients, which are needed by plants, as well as metals such as aluminium and mercury, which can have toxic effects in the aquatic ecosystems. Reduced pH in the water system also has direct, ecotoxic effects, reducing the number of species that can live in lakes, etc. Emission of acidifying substances also causes damage on human health, and on buildings, statues and other constructions. The characterisation considers the substances that contribute to the acidification of the soil and of lakes. The category indicator is the ability of the emissions from the system investigated to release H^+ ions. The acidification potential is the ability of 1 mg of a substance to release H^+ ions compared to that of 1 mg of SO_2.

Photochemical ozone creation

This impact category reflects the problem of creation of oxidising compounds (oxidants) through photochemical reactions in the air (close to the ground). The most important oxidant in this context is ozone. Surface ozone has toxic effects on humans and vegetation. Smog in large cities is an effect of these kinds of reactions. The ozone is formed by volatile organic compounds (VOC) and radiation from the sun, under the presence of NO_X. Peroxy radicals mainly from decomposed VOCs act as oxidising agents. The most efficient ozone producers are propene and ethene, but also higher alkenes, aromatics, alkanes and ethers produce ozone. The impact indicator for photochemical oxidant formation (POCP) is the potential of the emissions from the system investigated to contribute to the creation of oxidising compounds. The equivalent used for this impact category is mg ethene (C_2H_4); the photochemical oxidant creation potential of a substance is a measure of the extent to which a mass unit of the substance forms oxidants compared to the oxidant formation from a mass unit of ethene.

Total use of primary energy resources

The category reflects the use of renewable and non-renewable primary energy resources. Renewable primary energy resources are, for example, biomass, wind power and hydropower. Non-renewable primary energy resources are, for example, crude oil, coal and natural gas.

Appendix B: EPD data

Parquet flooring

The environmental impact and resource use for the three parquet flooring systems are presented in Table 20,**Error! Reference source not found.** Table 21 and Table 22.

Table 20: Environmental impact and resource use for the floor from Parador per functional unit.

Impact	Unit	A1-A3 (Parador)	A4 (Parador)	A5 (Parador)	C2 (Parador)	C3 (Parador)
Climate change	kg CO_2-eq	-10,4	0,3	0,3	0,05	11,7
Renewable primary energy resources (PERT)	MJ	241	0,2	2,2	0,03	113
Non-renewable primary energy resources (PENRT)	MJ	70	4,6	1,3	0,7	4,6
Eutrophication potential (EP)	kg PO4-eq	0,004	0,0005	0,00001	0,0001	0,001
Acidification potential (AP)	kg SO2-eq	0,02	0,004	0,0001	0,0003	0,004
Photochemical Ozone Creation Potential (POCP)	kg Ethene-eq	0,006	-0,0003	0,0000001	-0,0001	0,0003

Table 21: Environmental impact and resource use for the floor from the German parquet industry per functional unit. The data for A4 and A5 are retrieved from the EPD by Parador.

Impact	Unit	A1-A3 (Parquet Industry)	A4 (Parador)	A5 (Parador)	C2 (Parquet Industry)	C3 (Parquet Industry)
Climate change	kg CO_2-eq	-5,3	0,3	0,3	0,008	14,6
Renewable primary energy resources (PERT)	MJ	484	0,2	2,2	0,0002	-154
Non-renewable primary energy resources (PENRT)	MJ	170	4,6	1,3	0,1	-2,4
Eutrophication potential (EP)	kg PO4-eq	0,01	0,0005	0,00001	0,00001	0,00001
Acidification potential (AP)	kg SO2-eq	0,04	0,004	0,0001	0,00003	0,0001
Photochemical Ozone Creation Potential (POCP)	kg Ethene-eq	0,007	-0,0003	0,0000001	0,000004	0,00001

Table 22: Environmental impact and resource use for an average multilayer parquet per functional unit. The data for A4 and A5 are retrieved from the EPD by Parador.

Impact	Unit	A1-A3 (average)	A4 (Parador)	A5 (Parador)	C2 (average)	C3 (average)
Climate change	kg CO_2-eq	-5,6	0,3	0,3	0,03	12,5
Renewable primary energy resources (PERT)	MJ	198	0,2	2,2	0,02	-13,7
Non-renewable primary energy resources (PENRT)	MJ	88	4,6	1,3	0,4	0,7
Eutrophication potential (EP)	kg PO4-eq	0,006	0,001	0,00001	0,00004	0,0003
Acidification potential (AP)	kg SO2-eq	0,03	0,004	0,0001	0,0002	0,001
Photochemical Ozone Creation Potential (POCP)	kg Ethene-eq	0,005	-0,0003	0,0000001	-0,0001	0,0001

PVC floor

The environmental impact and resource use for the two PVC flooring systems are presented in Table 23 and Table 24.

Table 23: Environmental impact and resource use for the floor from Forbo Flooring B.V. per functional unit.

Impact	Unit	A1-A3	A4	A5	C1	C2	C3
Climate change	kg CO_2-eq	5,9	0,5	0,7	0,007	0,02	7,7
Renewable primary energy resources (PERT)	MJ	19	0,2	0,5	0,04	0,01	2
Non-renewable primary energy resources (PENRT)	MJ	148	4	12	0,1	0,3	15
Eutrophication potential (EP)	kg PO4-eq	0,001	0,0005	0,0002	0,000002	0,00001	0,0004
Acidification potential (AP)	kg SO2-eq	0,01	0,004	0,001	0,00002	0,0001	0,01
Photochemical Ozone Creation Potential (POCP)	kg Ethene-eq	0,002	-0,0002	0,0001	0,000001	-0,00002	0,0002

Table 24: Environmental impact and resource use for the floor from Tarkett France per functional unit.

Impact	Unit	A1-A3	A4	A5	C1	C2	C3
Climate change	kg CO2-eq	6	0,6	1,4	0	0,01	0
Renewable primary energy resources (PERT)	MJ	27	0,1	4	0	0	0
Non-renewable primary energy resources (PENRT)	MJ	138	10	26	0	0,2	0
Eutrophication potential (EP)	kg PO4-eq	0,006	0,0003	0,001	0	0,000008	0
Acidification potential (AP)	kg SO2-eq	0,02	0,002	0,01	0	0,00005	0
Photochemical Ozone Creation Potential (POCP)	kg Ethene-eq	0,006	0,0003	0,001	0	0,000008	0

Appendix C: Refinishing products

The climate change impact result for the production of Bona Prime Classic are presented in Figure 19. The two activities that contribute mostly to the climate change impact are the raw material production and the end-of-life (EoL) treatment of refinishing products. The impact related to BONA's operations hardly impacts the result (Site emissions, Nitrogen use and Energy use). Also the impact from packaging has a limited impact on the total greenhouse gas emissions.

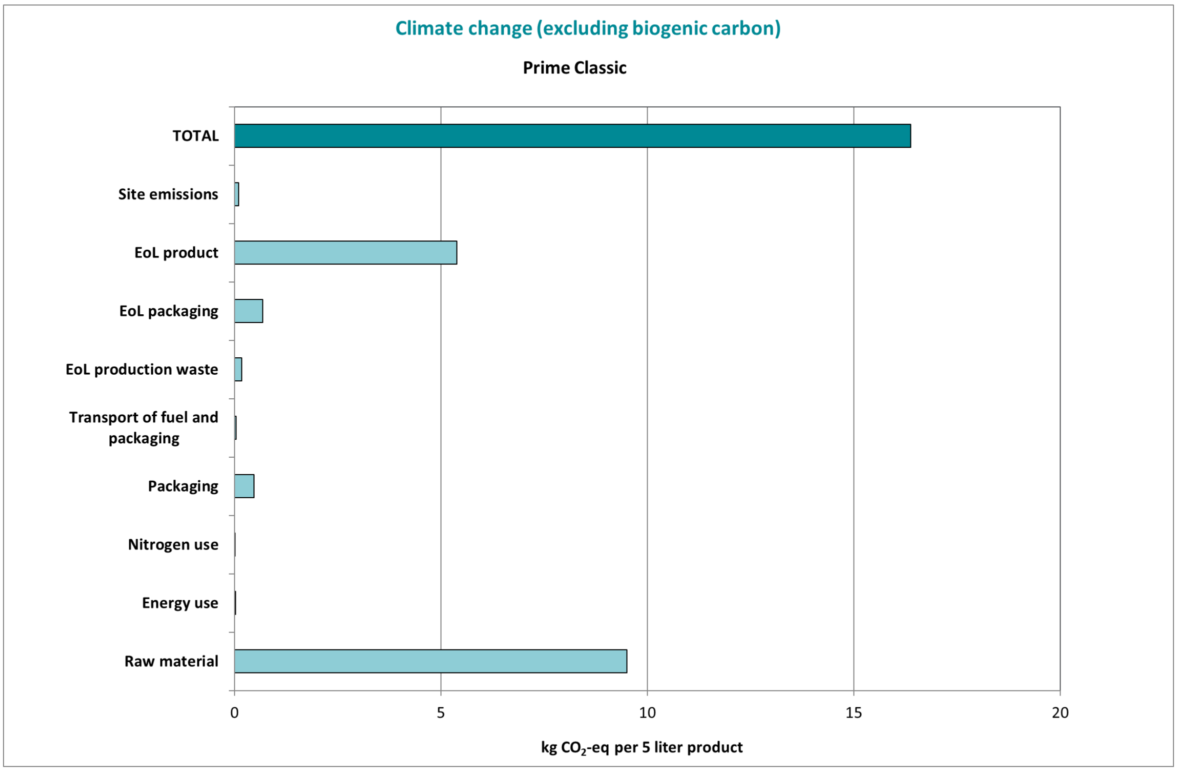

Figure 19: Climate change impact cradle-to-gate including end of life (kg CO_2-eq per functional unit) for primer Prime Classic.

The climate change impact results for the remaining Bona products are found below. The same trends as for Bona Prime Classic applies to all products considered.

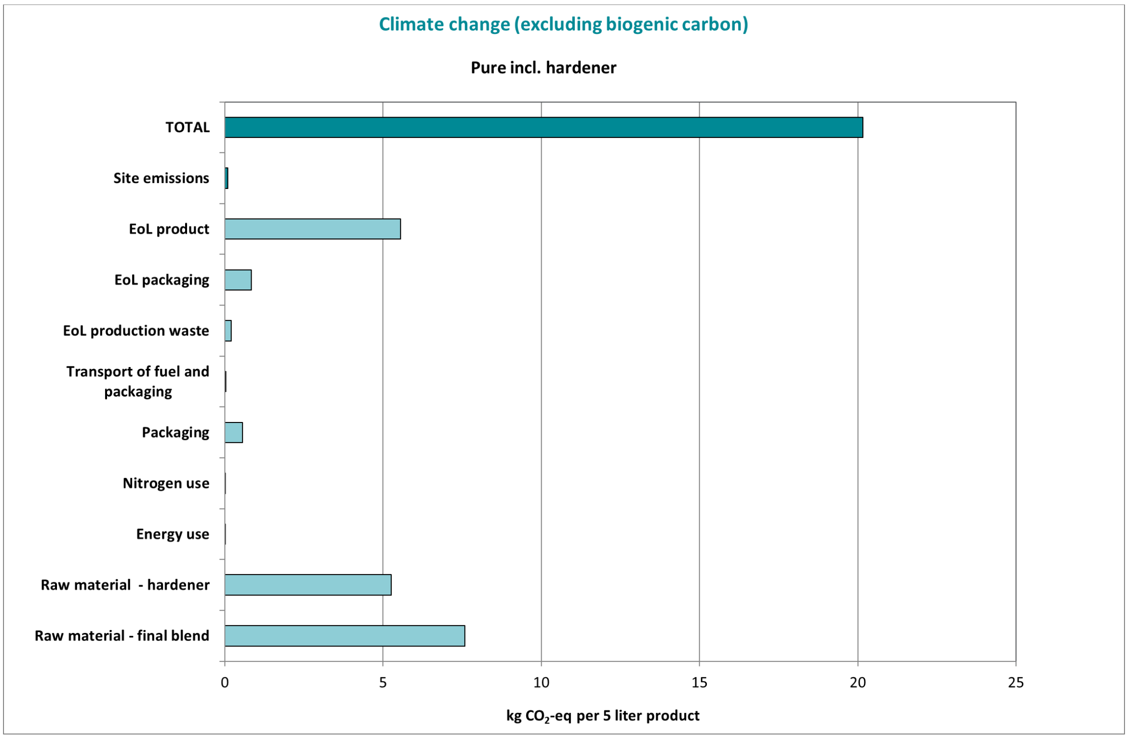

Figure 20: Climate change impact cradle-to-gate including end of life (kg CO_2-eq per functional unit) for Bona Pure.

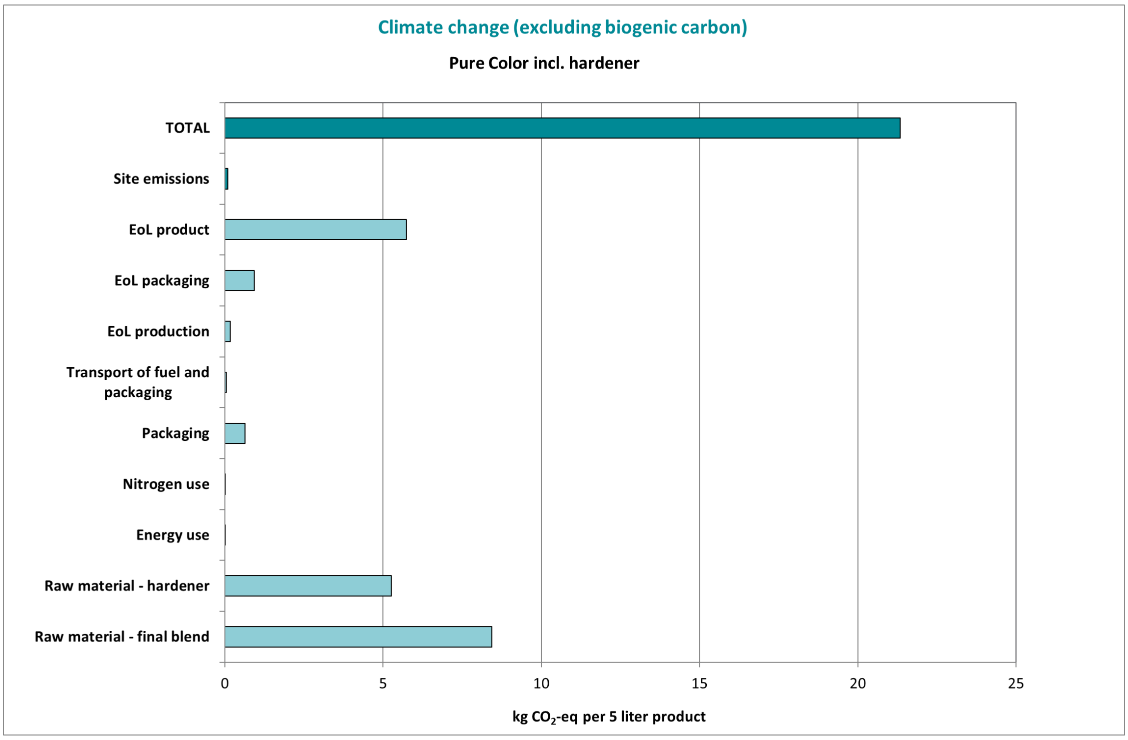

Figure 21: Climate change impact cradle-to-gate including end of life (kg CO_2-eq per functional unit) for Bona Pure Colour.

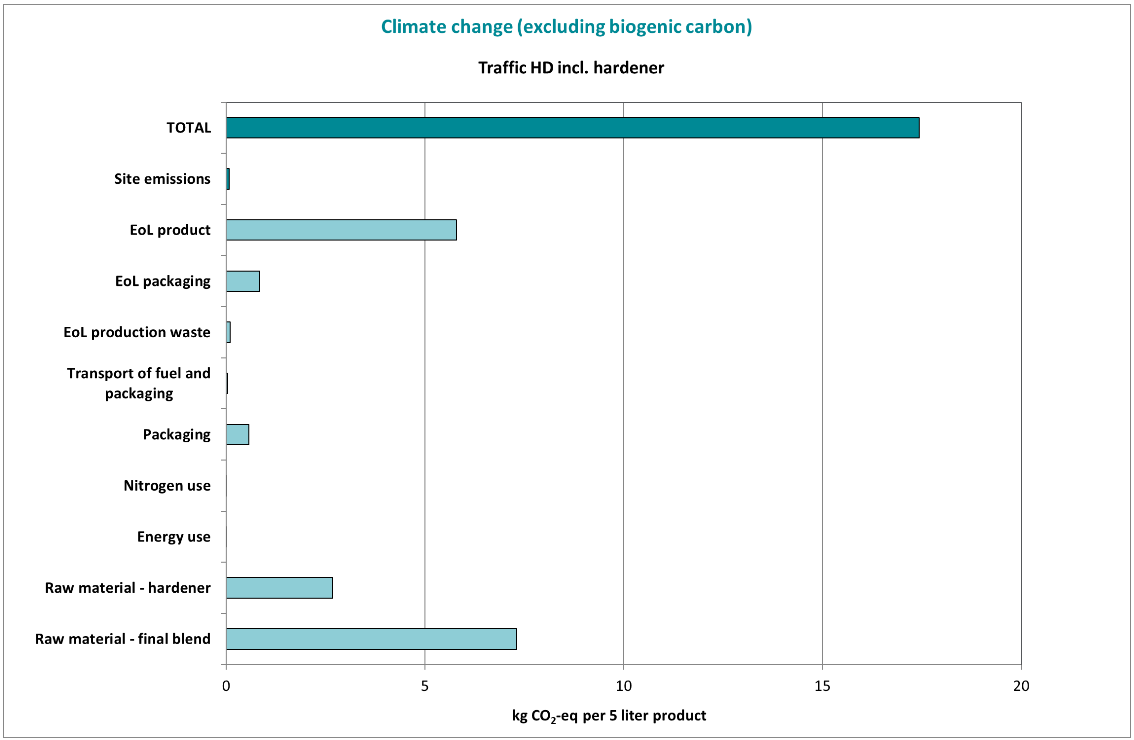

Figure 22: Climate change impact cradle-to-gate including end of life (kg CO_2-eq per functional unit) for Bona Traffic HD

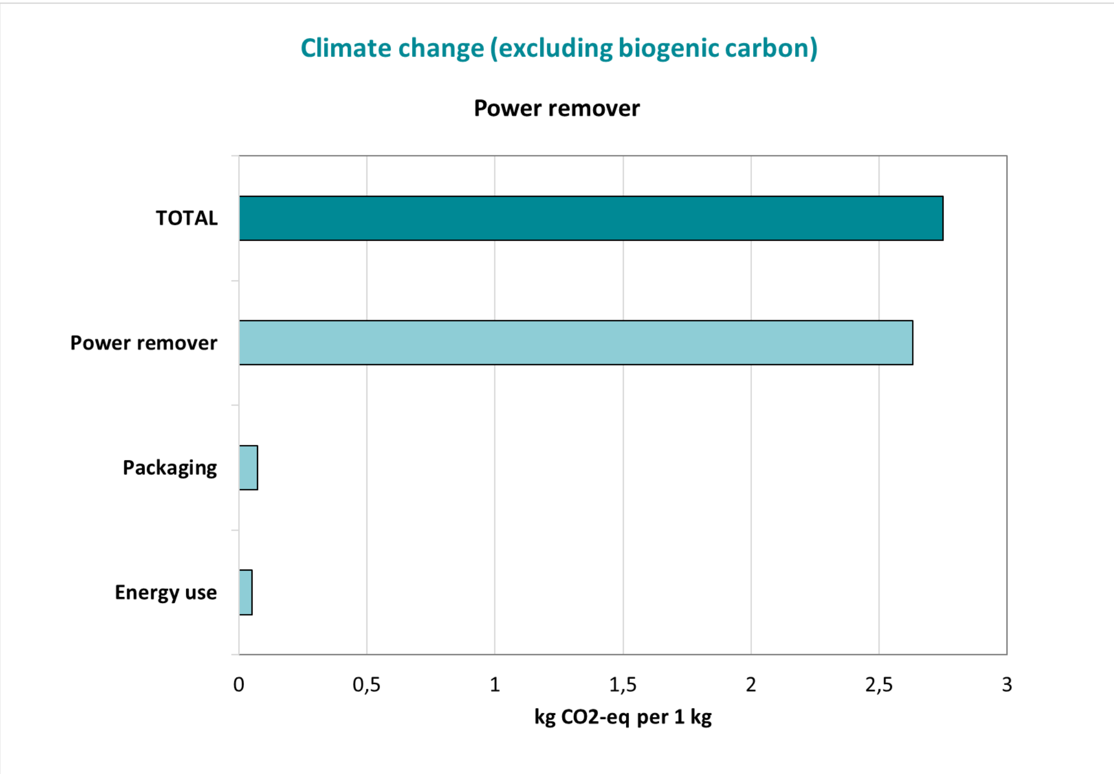

Figure 23: Climate change impact cradle-to-gate including end of life (kg CO_2-eq per functional unit) for Bona PowerRemover R.

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