The impact of shared facilities on the environmental performance and construction costs of apartment buildings for first-time buyers in the Dutch housing market

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Summary

To address the housing shortage in the Netherlands, which makes it difficult for first-time buyers to find affordable housing, new dwellings must be constructed. However, to mitigate the environmental impact of these constructions, the Dutch government intends to tighten the environmental performance standards. Meeting these enhanced standards is expected to increase the construction costs for the construction of small dwellings and apartments, negatively influencing the affordability of newly constructed affordable housing for first-time buyers.

Sharing facilities in apartment buildings for first-time buyers is viewed as a possible solution to ensure the construction of affordable housing that adheres to environmental performance standards. This approach is associated with sustainable, economic, and social benefits. Although the advantages of sharing facilities are well-documented, less is known about their impact on the sustainability and affordability of housing. To assess this impact and explore the potential for contributing to affordable housing construction, the main research question is formulated as follows:

What is the impact of shared facilities in apartment buildings on environmental performance and construction costs, and to what extent can this approach contribute to the development of affordable dwellings for first-time buyers in the Netherlands?

To answer this research question, a literature & statistical data review will be conducted in combination with developing a tool to assess the impact of shared facilities on the construction costs and MileuPrestatie Gebouwen (MPG) of a residential building. The tool will be validated using expert interviews, technical and functional validation methods, and a case study.

In the literature and statistical data review, six shared facilities are identified that can be shared by first-time buyers to potentially reduce construction costs and environmental impact in line with the Dutch building code. These facilities include a shared garden or terrace, kitchen, bike parking space, laundry room, living room, and workspace. Additionally, the literature and statistical data review indicated a lack of methods for testing multiple design variants and their effects on construction costs and environmental performance without the need for individual modeling of each variant.

To address this gap, the design cycle has been employed to develop a decision support tool in Excel. This tool is organized according to the MPG calculation method, incorporating the construction cost calculation method before implementing the framework into Excel through a combination of Excel features and VBA. This tool incorporates the six shared facilities and enables users to assess the impact of a specific shared facility or a combination of them on the MPG and construction costs of the building by comparing these to the base design in the basic design stage.

Three professionals involved in the construction of affordable housing participated in expert interviews to gather qualitative data on the tool's usability and the intended users' willingness to adopt it. The results were analyzed using a semantic approach and indicated that the

participants are willing to utilize the tool in their projects, as it offers the information to support informed design decisions regarding the application of shared facilities.

A case study has been applied to determine the impact of the six shared facilities and various combinations of these facilities on environmental performance and construction costs. Opus | de Tuin van Elden, an apartment building established in 2021 in Arnhem and considered affordable, served as the reference project for this case study. The initial step involved preparing the data to ensure its relevance to current market conditions. Following this, six shared facilities were designed based on the project's characteristics. Subsequently, the impact on environmental performance and construction costs was assessed for each shared facility and various combinations of these facilities, utilizing the developed decision support tool.

It can be concluded that based on the outcomes of the case study, most of the shared facilities considered, or combinations thereof, have a positive effect on lowering the construction costs of buildings. It is found that a combination of a shared garden/terrace, bike parking, laundry room, and workspace has the biggest positive impact on lowering the construction costs. By reducing the construction costs, the transaction prices of dwellings can be decreased, thereby enhancing housing affordability. However, the extent to which shared facilities improve affordability is influenced by the initial transaction value of the dwelling. Furthermore, it can be concluded that shared facilities negatively impact the MPG of apartments and that a combination of a shared kitchen, living room, bike parking, and laundry room has the most negative impact on the MPG.

Consequently, shared facilities can have a positive impact on construction costs but negatively impact the MPG. Therefore, the extent to which shared facilities can contribute to improving the affordability of dwellings for first-time buyers in the Netherlands depends on the financial implications associated with the supplementary measures necessary to meet the MPG standards.

To effectively evaluate the impact of shared facilities on the affordability for first-time buyers, it is essential to conduct more comprehensive research into the facilities that first-time buyers are willing to share. Additionally, addressing the existing knowledge gap about the quantification of the effects of shared facilities would be beneficial. Thus, it is recommended that further case studies be undertaken aimed at assessing how shared facilities influence construction costs and overall environmental performance. Future studies should also examine the impact of shared facilities on products that need to be determined by energy performance calculations and consider more recent reference projects to yield more realistic results. This approach aims to enhance the generalizability and address the limitations of the findings from this research.

Samenvatting

Om het woningtekort in Nederland, dat het voor starters lastig maakt om betaalbare woningen te vinden, aan te pakken, moeten nieuwe woningen worden gebouwd. Aan de andere kant moet de impact van de nieuwe woningen op het milieu beperkt worden, waardoor de Nederlandse overheid van plan is om de eisen omtrent milieuprestaties aan te scherpen. Echter is de verwachting dat de aangescherpte norm extra kosten meebrengt bij de bouw van kleine woningen en appartementen om te kunnen voldoen aan de aangescherpte eisen, waardoor de betaalbaarheid van betaalbare woningen nog verder onder druk komt te staan.

Het delen van faciliteiten in appartementen voor starters wordt gezien als een mogelijke oplossing om ervoor te zorgen dat betaalbare woningen worden gebouwd die voldoen aan de milieuprestatie-eisen. Het delen van faciliteiten wordt geassocieerd met voordelen op het gebied van duurzaamheid, betaalbaarheid en op sociaal vlak. Hoewel de voordelen van het delen van faciliteiten uitgebreid zijn beschreven in de wetenschappelijke literatuur, is er minder bekend over de daadwerkelijke impact van gedeelde faciliteiten op de duurzaamheid en betaalbaarheid van woningen. Om de impact te beoordelen en de mogelijke bijdrage van gedeelde faciliteiten aan de bouw van betaalbare woningen te onderzoeken is de onderstaande onderzoeksvraag geformuleerd:

Wat is de impact van gedeelde faciliteiten in appartementen op de milieuprestaties en bouwkosten, en in hoeverre kan deze aanpak bijdragen aan de ontwikkeling van betaalbare woningen voor starters in Nederland?

Om de onderzoeksvraag te beantwoorden, wordt een literatuur studie aangevuld met statistische data uitgevoerd in combinatie met het ontwikkelen van een tool om de impact van gedeelde faciliteiten op de constructie kosten en MileuPrestatie Gebouwen (MPG) van een woongebouw te bepalen. Na afloop zal de tool gevalideerd worden doormiddel van expert interviews, technische en functionele validatie methodes en een case studie.

In de literatuur en statistische data studie zijn zes faciliteiten geïdentificeerd die in overeenstemming zijn met het bouwbesluit, mogelijk een positieve impact hebben op het reduceren van de bouwkosten en milieu-impact en welke kunnen worden gedeeld door starters. Dit betreft de volgende faciliteiten: een gedeelde tuin/terras, keuken, fietsenstalling, wasruimte, woonkamer en werkruimte. Daarnaast werd duidelijk uit de literatuur en statistische data dat er een methode ontbreekt die gebruikt kan worden om meerdere ontwerp varianten te beoordelen op bouwkosten en milieu-impact zonder daarvoor alle varianten apart te hoeven modelleren.

De design cycle is gebruikt om een beslissingsondersteunende tool te ontwikkelen in Excel. De structuur van de tool is georganiseerd in overeenstemming met de MPG-berekeningsmethode, waarin de berekening van bouwkosten is geïntegreerd voordat het geheel middels een combinatie van Excel-functies en Excel VBA is geïmplementeerd in Excel. De tool bevat de zes geselecteerde gedeelde faciliteiten en stelt gebruikers in staat om de impact op de MPG en bouwkosten van een gedeelde faciliteit of een combinatie van gedeelde faciliteiten te beoordelen door deze te vergelijken met het originele ontwerp.

Drie professionals die betrokken zijn bij de bouw van betaalbare woningen hebben deelgenomen aan de expert interviews die gericht waren op het verzamelen van kwalitatieve gegevens over de bruikbaarheid van de tool en de bereidheid van potentiële gebruikers om de tool toe te passen. De resultaten zijn geanalyseerd met behulp van een semantische benadering methode en gaven aan dat de deelnemers welwillend zijn om de tool in hun eigen projecten te gebruiken, aangezien de tool de benodigde informatie verstrekt voor het maken van weloverwogen ontwerpbeslissingen met betrekking tot het toepassen van gedeelde faciliteiten.

Middels een case studie is de impact op de milieuprestaties en bouwkosten van de zes faciliteiten en combinaties van gedeelde faciliteiten bepaald. Opus | de Tuin van Elden, een appartementencomplex dat in 2021 in Arnhem is opgeleverd en geclassificeerd is als betaalbaar, diende als referentieproject voor deze case studie. De eerste stap bestond uit het voorbereiden van de gegevens om deze representatief te maken voor de huidige marktomstandigheden. Vervolgens zijn de zes gedeelde faciliteiten ontworpen op basis van de project eigenschappen. Waarna met behulp van de ontwikkelde beslissingsondersteunende tool de impact op de milieuprestaties en bouwkosten van alle gedeelde faciliteiten en combinaties van gedeelde faciliteiten is bepaald.

Het kan worden geconcludeerd dat op basis van de uitkomsten van de case studie, de meeste gedeelde faciliteiten, of combinaties van gedeelde faciliteiten, een positief effect hebben op het verlagen van de bouwkosten van gebouwen. Daarnaast kan geconcludeerd worden dat een combinatie van een gedeelde tuin/terras, fietsenstalling, wasruimte en werkplek de meest positieve invloed heeft op het verlagen van de bouwkosten. Door de bouwkosten verlagen, kunnen de verwachte verkoopprijzen verlaagd worden, wat resulteert in een betere betaalbaarheid. De mate waarin de betaalbaarheid verbeterd is echter afhankelijk van de origineel berekende verkoopprijs van een woning. Bovendien kan het worden geconcludeerd dat gedeelde faciliteiten een negatieve invloed hebben op de MPG en dat een combinatie van een gedeelde keuken, woonkamer, fietsenberging en wasruimte de meest negatieve impact heeft op het verlagen van de MPG.

Het kan worden geconcludeerd dat gedeelde faciliteiten kunnen een positieve invloed kunnen hebben op de bouwkosten, maar een negatieve op de MPG. Daardoor is de mate waarin gedeelde faciliteiten kunnen bijdragen aan het verbeteren van de betaalbaarheid van woningen voor starters in Nederland afhankelijk van de kosten die gemaakt moeten worden om aan de MPG eisen te voldoen.

Om de impact van gedeelde faciliteiten op de betaalbaarheid van woningen voor starters met meer zekerheid te kunnen bepalen dient uitgebreider onderzoek gedaan te worden naar de faciliteiten die starters bereid zijn om te delen. Daarnaast zou het waardevol zijn om de kennis omtrent de impact van gedeelde faciliteiten te vergoten. Het wordt daarom geadviseerd om meer case studies uit te voeren die gericht zijn op het bepalen van de impact van gedeelde faciliteiten op de bouwkosten en milieuprestatie van gebouwen. Waarbij de impact van producten die moeten worden bepaald met een energieprestatieberekening worden meegenomen en waarbij gebruik wordt gemaakt van recentere referentieprojecten. Met als doel de generaliseerbaarheid van de uitkomsten te vergroten en de tekortkomingen van dit onderzoek op te lossen.

Abstract

Housing shortages present challenges for first-time buyers seeking affordable homes, and the construction of such housing is increasingly complex. This underscores the necessity for innovative solutions to enhance the availability of affordable housing options. This master's thesis explores the implementation of shared facilities within apartment buildings for first-time buyers in the Netherlands as a potential strategy to improve both affordability and environmental sustainability. To this end, a decision support tool has been developed, which evaluates six shared facilities through a case study approach. This tool offers users valuable insights into how shared facilities can affect both the environmental performance and construction costs of a building compared to the base design, empowering them to make informed design decisions. The findings from the case study will help assess the potential of shared facilities to aid in the development of affordable housing that meets environmental performance standards for first-time buyers.

Keywords: Shared facilities, Affordable Housing, First-time buyers, Environmental performance standards

List of abbreviations

GFA = Gross floor area
UFA = Usable floor area
MPG = MilieuPrestatie Gebouwen
MKI = MilieuKostenIndicator
NMD = National Environmental Database
EPD = Environmental Product Declaration
EDN = Environmental Declaration Number
ITO = Information Takeoff

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1 Introduction

The Netherlands is facing a housing shortage, making it difficult for first-time buyers to find affordable housing (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2022c). Therefore the Dutch Government aims to construct 981,000 by 2030 (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2022a). It has been stated that two-thirds of these new dwellings must be affordable (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2022b). Additionally, the Dutch government aims to tighten the environmental performance requirements for newly constructed residential buildings in line with the goals of the Paris Agreement. However, meeting these requirements for small dwellings and apartments is expected to pose challenges, which could further complicate the construction of affordable housing for first-time buyers (Economisch Instituut voor de Bouw et al., 2023). To address this, the consideration of shared facilities in apartment buildings is being proposed as a potential solution to ensure the construction of housing that is affordable for first-time buyers and meets environmental performance standards.

1.1 Problem definition

To accommodate the projected increase in household numbers and alleviate the housing shortage, the Dutch government has set a goal to build 100,000 new dwellings annually to reach a total of 981,000 new dwellings by 2030, from which two-thirds need to be affordable (Gopal et al., 2023; De Jonge, 2023; Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2022b; Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2022c). However, The number of constructed dwellings in both 2022 and 2023 fell short of the annual target, with only 178,253 dwellings completed instead of the anticipated 200,000 (Ministerie van Volkshuisvesting en Ruimtelijke Ordening, 2024). This trend of constructing fewer dwellings than the annual goal is expected to persist in 2024 and 2025 (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2024a; Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2024b). Data from January to September 2024 indicate that only 58,850 houses have been built, compared to 64,350 during the same period in 2023, further confirming this trend (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2024a). Moreover, the percentage of newly constructed dwellings classified as affordable was below the intended target of 66.66%, as reported by the Ministerie van Binnenlandse Zaken en Koninkrijksrelaties (2022a, pp. 7–9). This results in a lag in the construction of affordable dwellings in the Netherlands. Furthermore, Vereniging Eigen Huis (2023b) noted that newly constructed dwellings that are defined affordable by the Dutch Government, are not considered affordable for first-time buyers in the Netherlands. This raises questions about the affordability of dwellings defined as affordable by the Dutch government for first-time buyers in the Dutch housing market.

In addition to the existing shortage and the lack in the construction of affordable housing, outgoing minister De Jonge mentioned in a letter to the House of Representatives that the standard for the environmental performance of new residential buildings needs to be sharpened from 0.8 to 0.5 starting January 1, 2025 (Economisch Instituut voor de Bouw et al., 2023). A study on the impacts of this measure revealed that sharpening the environmental performance will pose challenges for 8 to 19% of the newly constructed dwellings, especially for small houses and large apartment buildings with small apartments (Economisch Instituut voor de Bouw et al., 2023). Meeting these enhanced standards is expected to increase the

construction costs for the construction of small dwellings and apartments, negatively influencing the affordability of newly constructed affordable housing for first-time buyers.

It is found that the popularity of shared housing among young adults in the Western World is growing (McNamara & Connell, 2007; Clark et al., 2018). Cho et al. (2019) point out that modern shared housing differs from traditional home sharing, as it is offered as individual housing units that share common facilities. This implies that shared facilities are communal domestic areas located outside of privately owned spaces shared by a limited number of neighbors (Hasu et al., 2017, p. 37). This contributes to the fact that shared housing is no longer seen solely as a temporary measure for individuals with financial constraints, such as students, but has evolved into a structural solution offering economic, sustainability, and social advantages (Kenyon & Heath, 2001; J. Kim et al., 2020; Oh & Kim, 2021). This is underlined by Pirinen & Tervo (2020) who state that the rise of the sharing economy, increasing focus on sustainability, lack of affordable housing, and limited urban construction land availability offer opportunities to integrate shared spaces and amenities into urban housing projects. This indicates that shared facilities can be considered a potential solution to ensure the development and construction of affordable houses for first-time buyers in the Netherlands and that they meet environmental performance standards.

To maximize the impact of the application of shared facilities, these need to be considered early in the design stage since the MacLeamy Curve indicates that the biggest impact on a project's costs and capabilities occurs during the design phase, as visible in Figure 1.

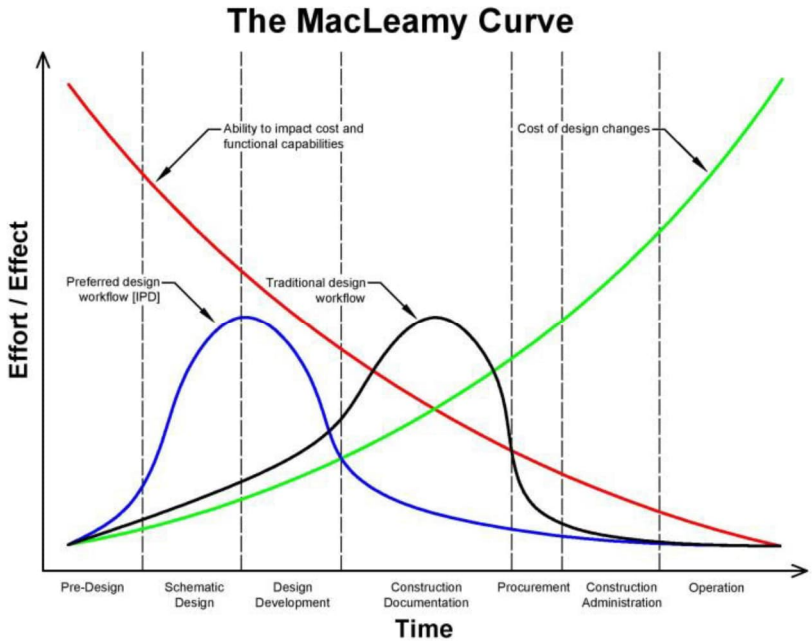


Figure 1: The MacLeamy Curve (Walasek, D., & Barszcz, A., 2017, p. 1233)

Since the existing literature focuses on defining the benefits of sharing facilities and the reasoning behind people opting for sharing facilities and not on testing and quantifying these benefits, knowledge regarding the impact of shared facilities in buildings on the environmental performance and construction costs of buildings can enhance the existing literature. Furthermore, this knowledge can be used to determine if shared facilities can be considered a solution to ensure the development and construction of affordable houses for first-time buyers in the Netherlands.

1.2 Research objective and questions

The goal of this master's thesis is to contribute to the knowledge regarding the application of shared facilities in residential buildings by determining the impact of shared facilities on the environmental performance and construction costs of a building in order to consider if the application of shared facilities in an apartment building for first-time buyers in the Netherlands can positively contribute to the development and construction of affordable dwellings for first-time buyers in the Netherlands that meet environmental performance standards.

Therefore, the following research question has been formulated:

What is the impact of shared facilities in apartment buildings on environmental performance and construction costs, and to what extent can this approach contribute to the development of affordable dwellings for first-time buyers in the Netherlands?

The following sub-questions are defined to answer the research question, and achieve the objective of this master thesis:

1. What is the definition of an affordable and suitable dwelling for first-time buyers in the Dutch housing market?
2. What facilities can be shared in apartment buildings for first-time buyers?
3. How is the environmental performance of dwellings in the Netherlands assessed?
4. How can the impact of shared facilities on the environmental performance and construction costs of a building be determined?
5. How can the determined impact of shared facilities on the environmental performance and construction costs of a building be modeled to create a decision support tool?

1.3 Research design

The following steps will be performed to realize the objective of this research, as shown in Figure 2 below.

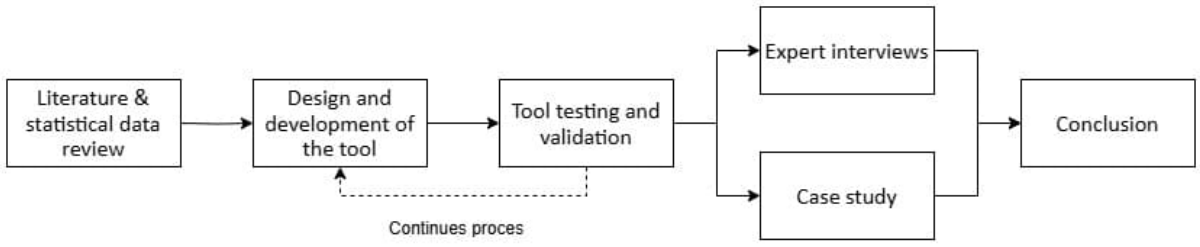


Figure 2: Research design

Literature & statistical data review

A literature & statistical data review will be conducted to create a definition of a first-time buyer and to define a suitable dwelling for first-time buyers in the Dutch housing market. Furthermore, existing literature about incorporating shared facilities in residential buildings will be considered to determine the facilities that can be shared in an apartment building for first-time buyers. In order to evaluate the influence of shared facilities on the environmental performance and construction costs of buildings, a review of the literature pertaining to the

assessment of environmental performance in construction and methodologies for estimating construction costs will be conducted.

Design and development of the tool
The information collected from the literature & statistical data review will inform the definition of the design objectives and highlight the tool's contributions in relation to existing solutions. Based on these objectives, design requirements will be established, and a framework for the development of the decision-support tool will be outlined. To evaluate the impact of shared facilities on both the environmental performance and construction costs of a building, several software systems will be examined, ultimately leading to the selection of one system for the development of the decision support tool.

Tool testing and validation
Throughout the entire design process of the tool, summative and artificial evaluations will be conducted to ensure the accuracy and correctness of the tool and its outcomes. Therefore, the outcomes will be compared with anticipated results to check if the calculation is performed correctly. The process is finalized by conducting a final summative artificial evaluation to ensure the accuracy and correctness of the finalized tool and its outcomes. In addition, the finalized decision support tool will undergo evaluation through an ex-post analysis. This process serves as a completeness assessment, wherein the developed decision support tool will be checked on the established design requirements.

Expert interviews
After conducting the final evaluation of the decision support tool, the developed tool will be presented to the tool's intended users. A small introduction to the tool's usage will be given to these, after which they should do a minor assignment using the tool. After this assignment, these experts will be asked several questions to validate the functionality and usability of the tool.

Case study
Data from a reference project will be used to conduct a case study to determine the impact of shared facilities on the environmental performance and construction costs of an apartment building for first-time buyers in the Netherlands. During the case study, the developed tool will be used to determine the impact of the selected shared facilities and combinations of shared facilities compared to the base design of the reference project. By using the tool, it is also tested which makes the case study an integral part of the tool's validation process.

Conclusion
The research is finalized with conclusions and recommendations.

1.4 Scientific and practical relevance

As defined in the problem definition, there is a housing shortage in the Netherlands, which makes it difficult for first-time buyers to find affordable housing. To improve the position of first-time buyers, affordable dwellings need to be constructed. However, the construction of affordable dwellings is lagging. Even though sharpening the standard for environmental performance for newly constructed dwellings will further complicate the development and construction of affordable dwellings, the Dutch government intends to do this. Therefore,

solutions need to be found to ensure the construction of affordable dwellings that meet environmental performance standards.

By considering the application of shared facilities in apartment buildings for first-time buyers, a solution is considered that potentially has a positive influence on the environmental performance and construction costs of the building. To test this solution, the impact of shared facilities on environmental performance and construction costs needs to be determined.

However, data regarding the impact of shared facilities on environmental performance and construction costs is lacking. There are tools available that assess the construction costs of a building or the environmental performance of a building but neither of these considers the impact of shared facilities on these aspects. Generating insight into the impact of shared facilities on environmental performance and construction costs is therefore necessary in the search for solutions to ensure the construction of affordable dwellings for first-time buyers that meet the environmental performance standards to improve the position of first-time buyers in the Netherlands.

Existing literature on the application of shared facilities focuses on defining the benefits of sharing facilities and the reasoning behind people opting for sharing facilities. However, it does not focus on quantifying these benefits. Indicating that the scientific contribution of this master's thesis lies in quantifying the the impact of shared facilities on environmental performance and construction costs of an apartment building.

1.5 Reading guide

The second chapter contains a literature & statistical data review in which a first-time buyer, a suitable and affordable dwelling for first-time buyers, and shared facilities that can be shared among first-time buyers are defined. Furthermore, the assessment method to assess the environmental performance of residential buildings and the method to calculate the estimated construction cost are considered. The methodology of the tool development process is provided in the third chapter, just as the selected validation methods to validate the tool. The fourth chapter describes the creation of the decision support tool. In the fifth chapter, the data preparation for the case study is described, the selected shared facilities are defined, and the case study results are presented. In chapter six, the outcomes of the selected validation methods are described, just as the outcomes of the expert interviews. Chapter seven, the final chapter, contains the conclusion of the research and recommendations to improve the research further.

2 Literature & statistical data review

This section will explore first-time buyers and their relation to the housing market. A housing market encompasses both sellers and buyers of residential real estate. While numerous factors influence this market, the dynamics of supply and demand are particularly crucial (Torab, 2018; Kholodilin, 2022; The Investopedia Team, 2023). This highlights the fundamental role of the law of supply and demand within the housing market, as originally articulated by Adam Smith in 1776 (Torab, 2018). Furthermore, the assessment methods for environmental performance will be examined, and insights into the housing development and construction process will be gathered. Relevant literature on cost estimation methods will be referenced to illustrate how the construction costs of a building can be determined.

As previously noted, the circumstances facing first-time buyers in the Dutch housing market are concerning. This demographic faces challenges when it comes to purchasing affordable homes. To improve the situation for first-time buyers, the factors influencing supply and demand within the housing market for this group need to be identified. Therefore, scientific literature will be used to provide a foundation for understanding the issue's global context and highlight the field's current state. The scientific literature is expanded with statistical data to address the local conditions.

2.1 First-time buyers

This subchapter examines various definitions of first-time buyers, focusing on the definition used in this research. Additionally, an analysis of this group's characteristics will provide insights into first-time buyers' behavior, needs, and wishes in the Netherlands.

2.1.1 Definition

In the Netherlands, various definitions are used to define first-time buyers. These definitions include different variables and are therefore presented in a comparison table, as visible in Table 1. All the definitions agree upon the fact that a first-time buyer in the Netherlands is a household that is looking to purchase or has purchased their first owner-occupied dwelling (Stuart-Fox et al., 2022; Plegt & Het Kadaster, 2021; Belastingdienst, 2023; NVM, 2023; De Vries et al., 2020). Stuart-Fox et al. (2022) extend this definition by categorizing first-time buyers based on their previous housing situation. They define starters as households that currently do not reside in an independent dwelling and intend to become the primary residents of an owner-occupied independent dwelling (Stuart-Fox et al., 2022). As shown in Table 1, the Belastingdienst (2023) adds an age restriction to the definition of a first-time buyer by stating that first-time buyers must be of legal age but younger than 35 years old. The definition of a starter, as defined by the Belastingdienst (2023), is used to determine eligibility for the starter exemption of the transfer tax. However, the starter exemption of the transfer tax applies only to dwellings in the existing housing stock, while in this master's thesis, newly-constructed dwellings will be considered (ABN AMRO, n.d.). Based on the definitions of a first-time buyer in the Netherlands, a first-time buyer in this master is defined as a household seeking or buying their first owner-occupied dwelling.

Table 1: *Comparison table of the variables that are used in the different definitions of a first-time dwelling buyer in the Netherlands*

First-time dwelling buyer	First-time buying an owner-occupied dwelling	Division in types based on the previous housing situation	Age restrictions
Stuart-Fox et al. (2022)	X	X	
Plegt & Het Kadaster (2021)	X		
Belastingdienst (2023)	X		X
NVM (2023)	X		
De Vries et al. (2020)	X		

2.1.2 Characteristics

In 2021, 1.024 million first-time buyers were actively searching for a dwelling in the Netherlands, and the majority of these first-time buyers were single- or two-person households, as indicated in Table 2 (Stuart-Fox et al., 2022). It cannot be determined whether the percentage of single- or two-person first-time buyers has increased between 2021 and 2023 since the data from Vereniging Eigen Huis (2023) is based on quantitative research among individuals who signed the starter petition of Vereniging Eigen Huis and may therefore be biased. However, based on the data provided by NVM (2023), it can be concluded that between 2021 and 2022, the percentage of single-person households increased. While both the data from Stuart-Fox et al. (2022) and Vereniging Eigen Huis (2023) indicate that most first-time buyers are single- or two-person households.

Table 2: Percentage of first-time dwelling buyers based on household type

	Single-person household	Two-person household	Other household types	Year
Stuart-Fox et al. (2022)	29,6%	43,3%	27,1%	2021
NVM (2023)	35,0%		65,0%	2022
Vereniging Eigen Huis (2023)	58,0%	31,0%	11,0%	2023

Figure 3 indicates that the average age of single- and two-person first-time buyers in the Netherlands has decreased. For single-person first-time buyers, the average age has dropped from 36 to 34 years (blue line), and for two-person first-time buyers, the average age has decreased from 34 to 31 years between 2019 and 2023 (pink line). The decline in the average age of first-time buyers can be attributed to a decrease in the number of first-time buyers older than 35 (NVM, 2023, p.23). This is supported by the fact that the average age of first-time buyers younger than 35 years old remained stable between 2019 and 2023, as depicted by the dashed blue and pink lines in Figure 3.

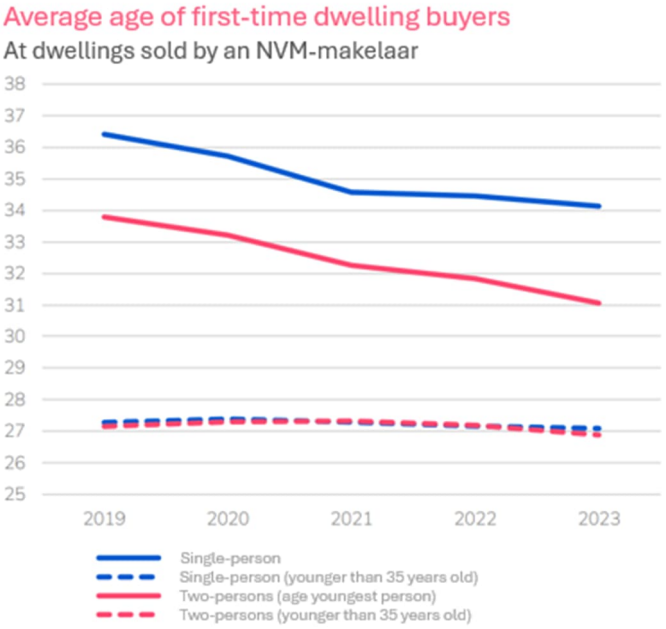


Figure 3: average age of first-time dwelling buyers in the Netherlands (NVM 2023, p.23)

An analysis of the age demographics of first-time buyers in the Netherlands reveals that the majority of the single- and two-person first-time buyers are under 35 years of age (NVM, 2023, p. 24; Plegt & Het Kadaster, 2021, p. 6; Stuart-Fox et al., 2022, p. 111). As illustrated in Figure 4, the proportion of single-person first-time buyers under 35 has risen from 2019 to 2023, reaching 67% in 2023. Also, the

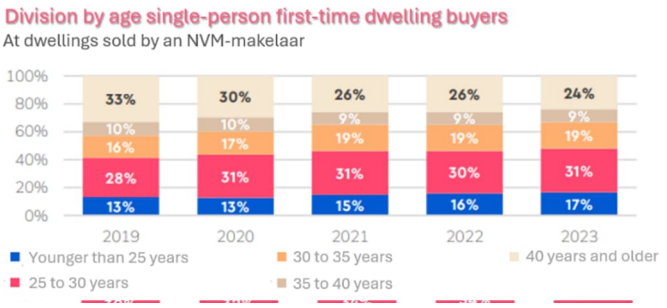


Figure 4: The percentage of single-person first-time buyers categorized on their age (NVM, 2023, p. 24)

Figure 5: The percentage of two-person first-time buyers categorized on their age (NVM, 2023, p. 24)

percentage of two-person first-time buyers under 35 increased between 2019 and 2023, reaching 78% in 2023, as shown in Figure 5. This indicates that the majority of the single- and two-person first-time buyers in the Netherlands are younger than 35 years old.

According to the WoON 2021 data, 37% of first-time buyers transitioned from a non-independent living space, while 63% moved from a rental dwelling in 2021 (Stuart-Fox et al., 2022, p. 43). More, recent findings from Vereniging Eigen Huis (2023) indicate that in 2023, 56% of first-time buyers reside in non-independent living spaces, as illustrated in Figure 6. Gielen (2022) noted that the increased percentage of first-time buyers who lived with their parents while they were searching for or purchased a dwelling in 2023 may be attributed to the prolonged period that young individuals in the Netherlands spend living with their parents.

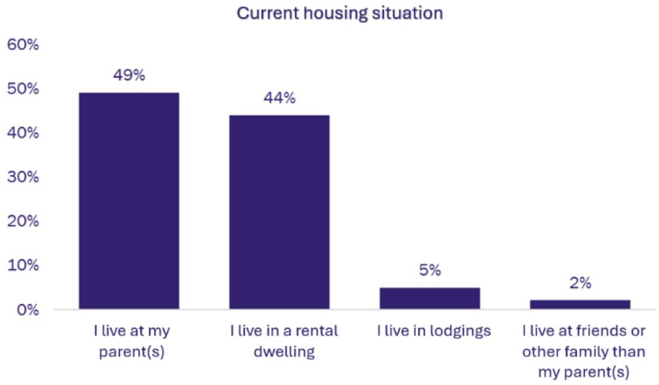


Figure 6: *Current housing situation of first-time buyers who participated in the research by Vereniging Eigen Huis*

The net household income quantiles of 2021, as indicated in Table 3, are used to categorize the incomes of first-time buyers in the Netherlands in 2021. The average yearly net household income of first-time buyers in 2021 was equal to €51,579 and Table 4 indicates that in 2021, the largest proportion of first-time buyers (starters + rental) had a net household income ranging from €42,550 to €61,750 (Stuart-Fox et al., 2022, p. 39). Table 4 also indicates that in 2021, 40% of first-time dwelling buyers (starters + rental) had a net household income lower than €42,550 and that 25% had an income higher than €61,750. A taxable income higher than €39,055 was considered middle or high in 2021 (Stuart-Fox et al., 2022, p. 96; CBS, 2023). This indicates that most first-time buyers had a middle or high income.

Table 3: The net household incomes based on the five quantiles for the years 2015, 2018, and 2021 (Stuart-Fox et al., 2022, p.96)

	2015	**2018**	**2021**
First quantile	€ 16.880	€ 17.810	€ 19.840
Second quantile	€ 25.010	€ 26.270	€ 29.360
Third quantile	€ 35.780	€ 37.590	€ 42.550
Fourth quantile	€ 50.780	€ 53.900	€ 61.750
Fifth quantile	From €50.780	From €53.900	From €61.750

Table 4: *Categorization of the first time buyers in the Netherlands in 2021, based on their income 2021 (Stuart-Fox et al., 2022, p.96)*

	Starters			First-time dwelling buyers who move out of a rental dwelling			First time dwelling buyers (starters + rental)		
	2015	**2018**	**2021**	**2015**	**2018**	**2021**	**2015**	**2018**	**2021**
First quantile	5%	8%	7%	4%	3%	3%	4%	5%	4%
Second quantile	29%	20%	24%	15%	12%	8%	20%	15%	14%
Third quantile	29%	27%	26%	26%	23%	20%	27%	24%	22%
Fourth quantile	27%	31%	28%	30%	30%	38%	29%	30%	34%
Fifth quantile	10%	14%	16%	26%	31%	31%	20%	25%	25%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

When the net housing costs burden is considered, it is found that this was the highest among first-time buyers who transitioned from rental dwellings to an owner-occupied dwelling. The average net housing cost burden in 2021 for first-time buyers was 26.4% (Stuart-Fox et al., 2022, p. 39).

2.1.3 Conclusion

Based on the reviewed literature and statistical data, the characteristics of first-time buyers in the Dutch housing market are illustrated in Figure 7. It can be concluded that the majority of first-time buyers in the Netherlands consist of one- or two-person households under the age of 35. Notably, single-person first-time buyers are older on average than their two-person counterparts. Additionally, both groups reside in non-independent or rental accommodations, with an average net housing cost burden of 26.4% and an average annual household income of €51,579 in 2021.

Figure 7: Characteristics of first-time buyers in the Netherlands

2.2 Demand

This section of the literature & statistical data review delves into the demand side of the housing market, examining the general concept of affordable housing and the definition of an affordable dwelling for first-time buyers in the Netherlands. Furthermore, the housing needs and preferences of first-time buyers in the Netherlands and their willingness to share facilities will be explored.

2.2.1 Affordability

Affordable housing is deemed a fundamental necessity by the Organisation for Economic Co-operation and Development [OECD] and has been recognized as a fundamental human right by the United Nations Universal Declaration of Human Rights (Woetzel et al., 2014). The demand for affordable housing is substantial worldwide, particularly in urban areas (Reichle et al., 2023; Alshubiri & Ani, 2024). However, the provision of affordable housing is a challenge in housing markets globally (Cai & Lu, 2015; Alshubiri & Ani, 2024; Kim & Kang, 2024; Reichle et al., 2023; Poon & Garret, 2012; Ezennia & Hoşkara, 2021). Woetzel et al. (2014, p. 2) projected that in 2014, 330 million urban households worldwide faced financial strain due to housing costs or resided in inadequate housing, with the number expected to rise to 440 million households by 2025. Coupé (2020, p. 432) found that, on average, around 27% of people across all countries lack the financial means to secure suitable housing, and approximately 47% express dissatisfaction with the availability of affordable housing options.

In the Netherlands, 5.8% of the population had a housing cost overburden rate in 2020. When considering low-income owners and tenants, the housing cost overburden rate was higher and equal to 21.8% (Organisation for Economic Co-operation and Development [OECD], 2020). The OECD (2020) defines households with housing costs overburden rates as those spending more than 40% of their disposable income on mortgage and rent. According to the Dutch Government, two-thirds of newly constructed dwellings need to be affordable to accommodate the housing needs and financial capabilities of households in the Netherlands (Ministerie van Algemene Zaken, 2023a).

Deepak et al. (2023) and Perera & Lee (2021) emphasize that housing affordability is determined by a household's capacity to afford housing based on their income. Ezennia & Hoşkara (2021) and Stone et al. (2011) expand this definition by including a maintainability component, which considers the duration the housing needs to remain affordable. Stone et al. (2011) propose that the concept of affordability should address three key questions:

1. For whom is it affordable?
2. What is the standard for affordability?
3. How long does it need to remain affordable?

These questions will be addressed to establish the affordability of dwellings for first-time buyers in the Netherlands. Additionally, the actions that municipalities, first-time buyers, and developers can take to enhance the affordability of dwellings will be outlined.

To address the question for whom dwellings need to be affordable, it can be stated that the dwellings need to be affordable for first-time buyers in the Dutch housing market.

To determine the standard for affordability, affordability needs to be assessed. Two prominent approaches for assessing affordability are found, which are the ratio approach and the residual income approach (Wang & Li, 2022; Stone et al., 2011). The internationally recognized ratio approach originates from the principle that one week's income should cover the monthly housing expenses and involves dividing housing costs by housing income to determine the ratio of income spent on housing expenses (Cai & Lu, 2015). On the other hand, the residual income approach considers variations in non-housing costs and is based on the concept that a household needs sufficient income to cover basic non-housing costs after

paying for housing (Herbert et al., 2018). This approach involves calculating the residual income by establishing the minimum level of non-housing costs based on household size and composition and then deducting these non-housing from the household's income.

The ratio approach has been criticized by Wang & Li (2021) and Herbert et al. (2018) for not adequately incorporating non-housing costs. Addressing this limitation, the residual income approach, as suggested by Perera & Lee (2021), allocates a suitable percentage of income based on household size and composition to non-housing costs. However, the residual income approach's complexity stems from the need for specific and detailed household data and the necessity to make assumptions about the minimum non-housing costs (Stone et al., 2011; Herbert et al., 2018). Consequently, the ratio approach remains the most widely used method for assessing housing affordability (Perera & Lee, 2021; Stone et al., 2011, p.43).

In the Netherlands, Nibud utilizes the ratio approach to determine the maximum acceptable percentage of income a household can allocate to housing expenses, known as the net woonquote, which is set at 30% (Nibud, 2022). Housing expenses encompass not only rent or mortgage payments but also include costs such as property taxes, waste taxes, sewerage taxes, water authority levies, and home and building insurance (Nibud, 2023).

The Dutch government sets annual financing burden percentages to ensure homeowners' housing expenses align with their income and other financial obligations. The financing burden percentage represents the maximum portion of a household's income that can be allocated to mortgage costs (Nibud, 2024). These percentages are determined using a calculation method that is based on the residual income approach. Therefore, Nibud calculates a household's maximum acceptable housing expenses by deducting taxes, premiums, and projected living costs from the gross income, resulting in the household's acceptable net housing expenses. Subsequently, the acceptable net mortgage expenses are calculated by subtracting the additional housing costs, such as maintenance, property tax, home insurance premiums, and water authority levies, which depend on the property value (Warnaar et al., 2023).

The maximum mortgage value is determined using annuity factors and considers the acceptable net mortgage expenses. The mortgage's interest rate depends on the financing burden percentage and the required annuity factors for a household. Additionally, the maximum mortgage amount for a household is influenced by factors such as the building's energy label, the age of the individuals in the household, unavoidable personal expenses, and potential investments to improve the building's energy label.

The Dutch government plays a crucial role in defining an affordable dwelling. It has set a general standard, stating that an affordable owner-occupied dwelling in the Netherlands should be within reach for a household of two people with an income around two times the modal, which is equal to an annual income of approximately €88,000 in 2024 (Randstad, 2024). This standard is not static, as it is set to change in 2024 when the maximum value of an owner-occupied dwelling in the Netherlands to be classified as affordable will be €390,000.

Despite the Dutch government's affordability standard, there is a significant gap between this standard and the actual affordability for first-time buyers in the Netherlands. A study

conducted by Vereniging Eigen Huis (2023) among individuals in the Netherlands who supported Vereniging Eigen Huis's initiative for first-time buyers revealed that, on average, first-time buyers indicated a willingness to pay a maximum of €269,607 for a dwelling. For two-person first-time buyers, the average indicated maximum price for an owner-occupied dwelling was equal to €323,241, which is almost 9 percent lower than the maximum value of an affordable dwelling in 2023, which was equal to €355,000 (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2023). The gap between the willingness to pay and the definition of an affordable dwelling is even bigger when the average maximum price single-person first-time buyers are willing to pay for an owner-occupied dwelling is considered, which equals €240,294 (Vereniging Eigen Huis, 2023).

The findings from the WoON 2021 underline the significant demand for affordable dwellings among first-time buyers since it was found that 768,000 of the 1,024,000 first-time buyers were searching for a dwelling with a maximum value of €325,000, as indicated in Table 5 (Stuart-Fox et al., 2022). Additionally, Table 5 demonstrates that 71% of the first-time buyers who purchased a dwelling in the previous two years bought a dwelling with a WOZ value of up to €325,000. Even though the fact that the WOZ value is not directly comparable to the price of a dwelling, this underlines that the dwellings that were bought by first-time buyers are in the same price category as the dwellings that were searched by first-time buyers (Van Bruggen Adviesgroep, n.d.).

Table 5: The demanded dwelling price and WOZ-value of dwellings bought by first-time dwelling buyers, based on data from (Stuart-Fox et al., 2022, p. 113, 115)

<table>
<tr><th></th><th colspan="2">The demanded dwelling price of actively seeking first-time dwelling buyers (pricelevel 2021)</th><th colspan="2">The WOZ-value of dwellings that were bought by first-time dwelling buyers in the previous 2 years (pricelevel 2021)</th></tr>
<tr><td>≤ € 180,000</td><td>16%</td><td rowspan="3">75%</td><td>15%</td><td rowspan="3">71%</td></tr>
<tr><td>€ 180,000 - € 250,000</td><td rowspan="2">59%</td><td>29%</td></tr>
<tr><td>€ 250,000 - € 325,000</td><td>27%</td></tr>
<tr><td>> € 325,000</td><td>25%</td><td>25%</td><td>29%</td><td>29%</td></tr>
<tr><td>Total</td><td colspan="2">100%</td><td colspan="2">100%</td></tr>
</table>

In certain Dutch municipalities, first-time buyers have the opportunity to secure an additional loan alongside their mortgage, known as a starterslening, in order to enhance their borrowing capacity (SVn, n.d.). However, the availability of the starterslening is not universal across all municipalities in the Netherlands, and the funding amount is also limited. Therefore, it is not included in the determination of affordability for first-time buyers in the Netherlands.

In addition to increasing the financial burden, reducing this burden is another option to enhance the affordability of dwellings for first-time buyers in the Netherlands. Several options exist in the Netherlands to decrease the required mortgage for first-time buyers. Programs such as Koopgarant and Koopstart alleviate the financial burden by offering a discount on the home's market value. This discount is incorporated into the increase in market value and settled when the buyer decides to sell the property (Stichting OpMaat, 2023; Stichting OpMaat, 2024). With Koopgarant, the buyer has the assurance that the housing corporation or developer will repurchase the property within three months after the buyer decides to sell (Stichting OpMaat, 2023). Another option is Duokoop, whereby DNGB purchases a portion of the property, and monthly compensation is paid to DNGB for using this share. When the buyer

decides to sell the property, the share owned by DNGB will be settled (DNGB, n.d.). Furthermore, buyers have the option with Koopstart and Duokoop to settle the discount or share if they choose not to move. Under all these different options, any potential market value development of the property will be shared between the first-time buyer(s) and the other party. However, since these products are not available for all first-time buyers, these products will also not be considered in defining the affordability

As noted by Stone et al. (2011), it is essential to consider the duration for which a dwelling needs to remain affordable. In the Netherlands, there is no nationwide regulation regarding the duration for which dwellings must remain affordable for the target group. However, municipalities have the authority to implement measures to maintain the affordability of dwellings (Beuzenberg et al., 2020). Platform31 et al. (2020) have outlined 34 measures municipalities can adopt to support first-time buyers in the Dutch housing market. Among these measures, the self-occupancy requirement and anti-speculation clause are designed to ensure that dwellings remain affordable for first-time buyers (Platform31 et al., 2020, p. 29 & 31). The self-occupancy requirement legally obligates the intended target group to become the owner of the dwelling through an agreement with dwelling owners, a prior agreement with developers, or in the housing permit (Platform31 et al., 2020, p. 31). The anti-speculation clause enables municipalities to prohibit the sale of the dwelling within a specified period by imposing a (decreasing) fee (Platform31 et al., 2020, p. 29). Both measures can be applied for varying durations to manage the length of time that a dwelling remains affordable.

Furthermore, municipalities can ensure a stable supply of affordable dwellings by mandating a percentage of affordable housing in new developments (Platform31 et al., 2020, p. 15). Constructing smaller, market-competitive homes should result in affordable options for the target demographic. These requirements can be detailed in the Program of Requirements (Platform31, 2020, p. 18).

While affordability for first-time buyers who have already purchased a home may not be a concern, ensuring affordability for future first-time buyers is crucial. This can be accomplished through municipal regulations and by constructing the correct type of dwellings (Beuzenberg et al., 2020).

2.2.2 Housing needs and preferences

Affordable housing for first-time buyers must meet their financial constraints and address their housing needs and preferences (Beamish et al., 2001). In addition to financial constraints, housing choices are influenced by factors such as available housing stock, housing preferences, and various constraints (Beamish et al., 2001). Housing preferences play a significant role in housing choice decisions, but Kam et al. (2018) noted that locational, dwelling, and neighborhood attributes, known as housing characteristics, also impact these decisions. Overall, individuals strive to align their housing preferences with their housing choice decisions (Beamish et al., 2001).

King (1998) made a distinction between housing needs and preferences, emphasizing that while housing needs are essential and time-specific, housing preferences represent individual household desires. Applying this perspective to the Netherlands indicates that the basic requirements are outlined in the Dutch building code. Therefore, a thorough analysis of the

housing preferences of first-time buyers is necessary to understand their housing choice decisions in the Netherlands.

The housing preferences of first-time buyers in the Netherlands will be analyzed using the framework developed by Beamish et al. (2001). This framework visualizes the relationships between different criteria and how they influence housing preferences. As depicted in Figure 8, the framework illustrates that the various criteria are interrelated, emphasizing the importance of considering the definitions and characteristics of first-time buyers when determining their housing preferences. Additionally, the framework highlights the importance of considering the housing norms of first-time buyers in understanding their housing preferences.

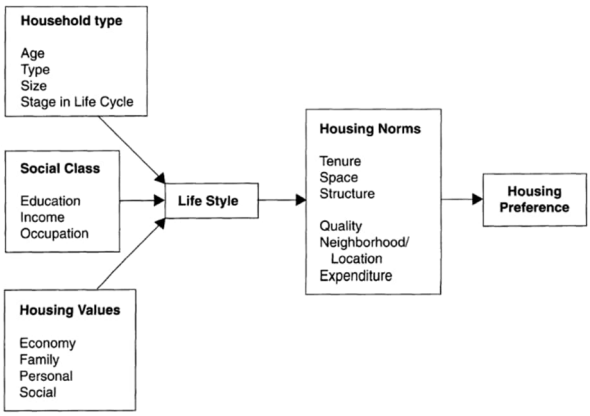


Figure 8: Framework of the different criteria that influence housing preference (Beamish et al. 2001, p. 4)

Table 6 indicates that the most significant percentage of first-time buyers indicate that the location of the dwelling in the country is the most crucial aspect (Funda, 2024b). However, it is also found that in general, 33% of first-time dwelling buyers search for an owner-occupied dwelling in a larger area than they would prefer, and 49% of the first-time buyers who prefer to buy a dwelling in one specific village or city search for an owner-occupied dwelling in a larger area than they would prefer (Vereniging Eigen Huis, 2023, p.23).

Table 6: The aspects of a dwelling that are considered most important by first-time dwelling buyers in the Netherlands, based on data from (Funda, 2024b)

Position	Aspect	Percentage of first-time dwelling buyers that indicated it most important
1	Location of the dwelling in the country	29%
2	Indoor space	28%
3	Outdoor space	18%
4	Attitude	15%
5	Direct living environment	11%
		100%

Considerations for first-time buyers regarding the location of their prospective dwellings often revolve around factors such as proximity to work and the availability of public transportation options. According to Tan (2012), Kam et al. (2018), and Opit et al. (2019, p. 137), these factors play a crucial role in shaping the preferences of first-time buyers. In the Netherlands, for instance, nearly 50% of first-time buyers express a preference for living close to their workplace (Funda, 2024b). Notably, while these buyers often opt for proximity to work, they tend to rely on bicycles or cars rather than public transportation for their daily commute.

A study by Funda (2024b) discovered that 58% of first-time buyers strongly prefer buying a home in the province where they currently reside. According to the

Table 7: The different aspects that are considered when choosing a province to buy a dwelling and the percentage of first-time dwelling buyers in the Netherlands that considered these aspects, based on data from Funda (2024b)

		certain province
1	Proximity of friends and family	50%
2	Affordability of the housing stock	35%
3	Job opportunities	31%
4	Proximity of big cities	22%
5	Proximity of nature/green	22%
6	Availability of dwellings	19%

data in Table 7, most first-time buyers in the Netherlands prioritize proximity to friends and family when selecting a province to purchase a home. This aligns with findings from Hurtubia et al. (2010) and McCrindle (2003), who also acknowledge the importance of living close to friends and family. Research by Hans en Plegt (2022) highlights regional variations in the ability of first-time buyers in the Dutch housing market to make a purchase. Table 7 reveals that 35% of first-time buyers take into account the affordability of housing in a particular region, while 22% consider the availability of housing when choosing a province to purchase their first home.

Analyzing the location preferences of first-time buyers in the Netherlands indicates that in 2023, 57% of first-time buyers purchased their first home in a strongly or extremely urbanized area (NVM, 2023, p. 19; Statistics Netherlands, n.d.). The inclination of first-time buyers towards urban living is evident from the decrease in the percentage of first-time buyers as a municipality's population decreases, as depicted in Figure 9.

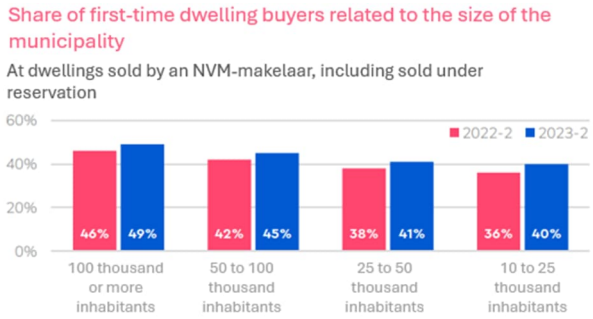


Figure 9: Percentage of first-time dwelling buyers based on the number of inhabitants of the municipality (NVM, 2023, p. 19)

In addition to the location of the residence, Figure 8 also illustrates that tenure, space, and structure are integral components of housing norms. These variables are best understood by examining the preferred housing type and characteristics of first-time buyers in the Netherlands. In 2021, 46% of the actively seeking first-time buyers in the Netherlands were searching for an owner-occupied residence (Stuart-Fox et al., 2022, p. 115). Homeownership provides shelter and meets the fundamental human need for accommodation but is also considered advantageous for maintaining relationships with friends and family and as a means of saving money and accumulating capital (Kam et al., 2018; Opit et al., 2019).

In 2023, 71% of first-time buyers in the Netherlands purchased single-family dwellings, while 29% opted for apartments (NVM, 2023). Analysis shows that two-person first-time buyers tended to choose single-family dwellings, whereas one-person first-time buyers favored apartments (NVM, 2023, p. 21). The demand for apartments among single-person first-time buyers has also been acknowledged by Plegt & Het Kadaster (2021, p9), and Stuart-Fox et al. (2022). Stuart-Fox et al. (2022) discovered that in 2021, 56% of single-person first-time buyers under the age of 35 actively seeking a dwelling were looking for an apartment. Additionally, NVM (2023, p. 21) observed that in 2023, two out of three apartments purchased by first-time buyers were acquired by single-person households. Furthermore, it was noted that a higher number of apartments were sold in larger municipalities as opposed to smaller municipalities (NVM, 2023, p. 17).

Significant regional differences are found when the size of dwellings bought by first-time buyers is considered. These differences can be explained by the significant differences in available dwelling types per region and the prices of dwellings. Generally, the average size of a dwelling bought by first-time buyers has decreased from 104 m^2 in 2021 to 102 m^2 in 2023 (NVM, 2023, p.18). The demand for smaller dwellings is also recognized by Funda (2024a), who analyzed the search and click behavior on Funda and conducted a housing preference study. When the division is made between apartments and single-family dwellings, it is found that in 2023, the average size of an apartment bought by first-time dwelling buyers in the Netherlands was equal to 73 m^2 and that the average size of a single-family dwelling bought by first-time dwelling buyers was equal to 114 m^2 (NVM, 2023, p.18). More specific data about the size of the dwellings bought in 2023 by first-time dwelling buyers in the Netherlands shows that 58% of the first-time dwelling buyers bought a dwelling with a size of 75 to 125 m^2, as visible in Figure 10.

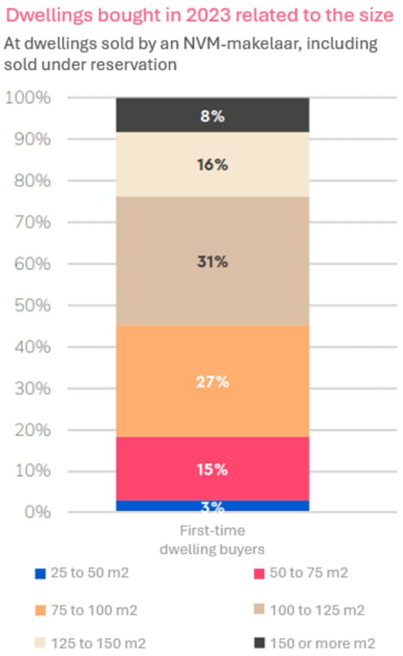


Figure 10: Dwelling size of dwellings bought by first-time dwelling buyers in 2023 (NVM, 2023, p.18)

Data on preferred dwelling characteristics indicates that, in general, prospective residents are most interested in two-room apartments that are bright, sustainable, spacious, and functional. The primary living spaces of interest are the living room and kitchen (Funda, 2024a). When focusing on first-time buyers, it is evident that they prefer modern dwellings that are bright, pleasant, spacious, and functional. Most first-time buyers do not strongly prefer new construction over existing homes. Additionally, the sustainability of a dwelling ranks lower in importance for first-time buyers, with outdoor space for relaxation and entertaining ranking higher in priority (Funda, 2024a).

In general, first-time buyers in the Netherlands gravitate towards urbanized areas close to their family and friends. Single-person first-time buyers tend to favor apartments, whereas two-person first-time buyers prefer single-family dwellings. Additionally, single-person first-time buyers generally have a lower maximum mortgage than their two-person counterparts, making affordability even more important in their search for a dwelling.

2.2.3 Shared facilities

Maalsen (2018) highlights that to address the housing affordability issue, there is a need to re-evaluate the traditional housing career paths when considering shared housing as a potential solution. Shared housing involves residents sharing facilities within a household. It is being increasingly recognized as a housing option for young adults, with potential benefits for affordability and sustainability, as noted by J. Kim et al. (2020). The growing interest in shared housing is attributed to demographic shifts and the rise of the sharing economy (Cho et al., 2019; J. Kim et al., 2020; Woo et al., 2019). Furthermore, shared housing is no longer seen solely as a temporary measure for individuals with financial constraints, such as students, but has evolved into a structural solution offering economic and social advantages (Kenyon & Heath, 2001; Oh & Kim, 2021). Cho et al. (2019) also point out that modern shared

housing differs from traditional home sharing, as it is offered as individual units and managed by private rental housing companies as comprehensive service offerings.

Bricocoli and Sabatinelli's (2016) study revealed that young people often face financial constraints due to their lengthy education, lower incomes, unstable job prospects, and limited money-saving opportunities. Consequently, economic constraints significantly influence young people's housing choices, leading many to opt for shared housing, as noted in literature by Clark et al. (2017), Bricocoli and Sabatinelli (2016), Mause (2008), Woo et al. (2019), and Cho et al. (2019). This indicates that young people are willing to compromise on their housing preferences and share facilities to cope with financial limitations. When considering first-time buyers in the Netherlands, it becomes evident that most of them are single or two-person households under 35 years old with moderate incomes. However, due to challenging market conditions, most first-time buyers in the Netherlands face obstacles in securing an affordable mortgage. Therefore, they align with the profile of young individuals with financial constraints.

The prevalence of economic challenges among first-time buyers in the Netherlands indicates a willingness to embrace shared housing arrangements to attain affordability. This is reinforced by Woo et al. (2019), who reported an 89.7% increase in the likelihood of young single-person households choosing shared housing due to economic considerations.

The economic advantages of sharing facilities are often highlighted in discussions about shared housing, but the social benefits are equally significant. According to Cho et al. (2019, p.36), individuals living in shared housing report higher satisfaction with social aspects, and Oh & Choi (2014) suggest that shared housing enhances resident interactions. Additionally, Cho et al. (2019, p.36) found that increased social interaction among residents can alleviate feelings of loneliness. Bricocoli and Sabatinelli (2016) further elaborate on the distinction between "cold" and "warm" forms of house sharing, emphasizing that warm arrangements foster social interaction, while cold arrangements entail cohabitation and shared space. The positive social outcomes observed in some shared housing situations may be attributed to the changing nature of relationships among young people, as noted by Clark et al. (2017). Which has led to a growing interest in forming non-kin relationships.

Moreover, in 2022, a study by GGD GHOR Nederland found that 63% of young adults in the Netherlands experienced some level of loneliness. Considering the positive impact of shared housing on social well-being, it appears that promoting shared facilities among young first-time buyers could help alleviate loneliness among young adults in the Netherlands since most first-time buyers in the Netherlands are individuals under the age of 35.

Despite the positive aspects of shared housing, the literature also acknowledges some negative aspects. According to Wilkinson and Ortega-Alcázar (2019), Green and Mccarthy (2015), and Mause (2008), sharing a dwelling or facility can lead to nuisance and on-site management difficulties. Moreover, the loss of privacy is highlighted as a significant drawback by Wilkinson and Ortega-Alcázar (2019) and Green and McCarthy (2015).

Furthermore, it found that the desirability of housing solutions is influenced by the existing housing stock (Clapham, 2005). This indicates that the willingness to share facilities is location-dependent.

However, despite these drawbacks, a study by Cho et al. (2019, p.36) found that tenants in shared housing reported higher residential satisfaction than residents in studios or detached houses. They also expressed higher satisfaction with economic factors, dwelling facilities, and locational characteristics. This indicates that despite the challenges associated with shared housing, it is still considered preferable.

Two other noteworthy findings are that young single individuals who have previously lived independently are less likely to opt for shared housing and that the willingness to share facilities is location-dependent (Clapham, 2020; Woo et al., 2019, p.17). This indicates that first-time buyers in the Netherlands who are transitioning from rental properties may be less inclined to share facilities and that the willingness to share facilities is dependent on the location in the Netherlands.

2.2.4 Conclusion

It can be concluded that while affordable housing is recognized as a fundamental human right, access to such housing remains elusive for individuals globally and within the Netherlands. In evaluating affordability, three critical aspects must be considered: the intended demographic for whom housing should be affordable, the criteria defining affordability, and the duration for which the housing must remain affordable. Analyzing the situation of first-time buyers in the Netherlands, this implies that housing should be affordable for this demographic and that the standard for affordability ought to be determined by the maximum mortgage amount that first-time buyers could feasibly secure.

The impact of household composition is highlighted by the finding that single-person first-time buyers exhibit a lower willingness to pay compared to their two-person counterparts. Concurrently, the criterion concerning the duration of affordability is less pertinent, as it is found that first-time buyers who have successfully acquired properties typically encounter no ongoing affordability issues, mainly attributable to subsequent increases in their income levels.

Regarding the housing needs and preferences of first-time buyers, it can be ascertained that the determinants influencing these preferences are interrelated. This interconnection underscores the necessity of considering the distinct characteristics of first-time buyers when assessing their housing needs and preferences. Statistical data reveals that first-time buyers predominantly favor urbanized areas; furthermore, single-person first-time buyers are inclined to purchase apartments, while two-person first-time buyers more frequently opt for single-family dwellings. It is also evident that nearly all first-time buyers acquire properties exceeding 50 square meters of usable floor area.

Moreover, first-time buyers demonstrate a willingness to share facilities as a strategy to mitigate financial constraints, and this sharing of resources is associated with favorable outcomes relating to mental health.

Consequently, it becomes apparent that defining the housing needs and preferences of first-time buyers in a generalized manner is insufficient, given the diverse array of variables influencing these factors. Nevertheless, the insights provided can serve to inform a more nuanced understanding of the housing needs and preferences of first-time buyers within a specific contextual framework.

2.3 Supply

The housing market is composed of a demand and supply side. The demand side of the Dutch housing market is discussed in the previous section, and in this section, the focus is on the supply side. This literature study aims to provide insight into the affordability and characteristics of the supply in the Dutch housing market. Additionally, projects with shared facilities will be analyzed to determine which facilities can be shared among first-time buyers in the Dutch housing market.

2.3.1 Affordability

It is found that the affordability of newly constructed apartments and single-family dwellings is decreased when the relation between the average selling prices and the maximum mortgage when earning 1 or 1.75 times the modal income is considered, as indicated in Figure 11. It indicates that between 2000 and 2024, the average selling prices of newly constructed apartments (orange line) and single-family dwellings (blue line) has increased more rapidly than the maximum mortgage for a person earning the modal income (light orange line) or a person earning 1.75 times the modal income (light blue line).

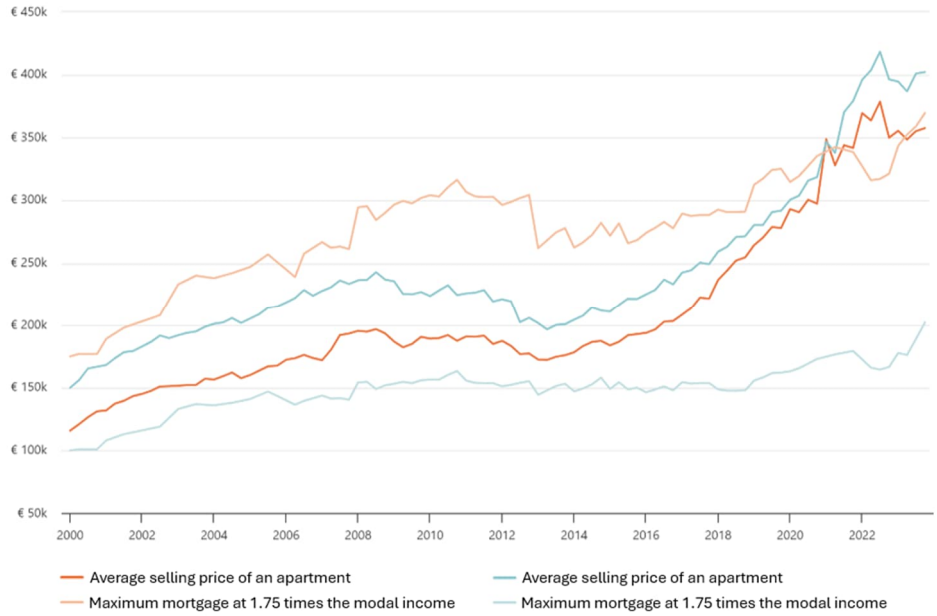
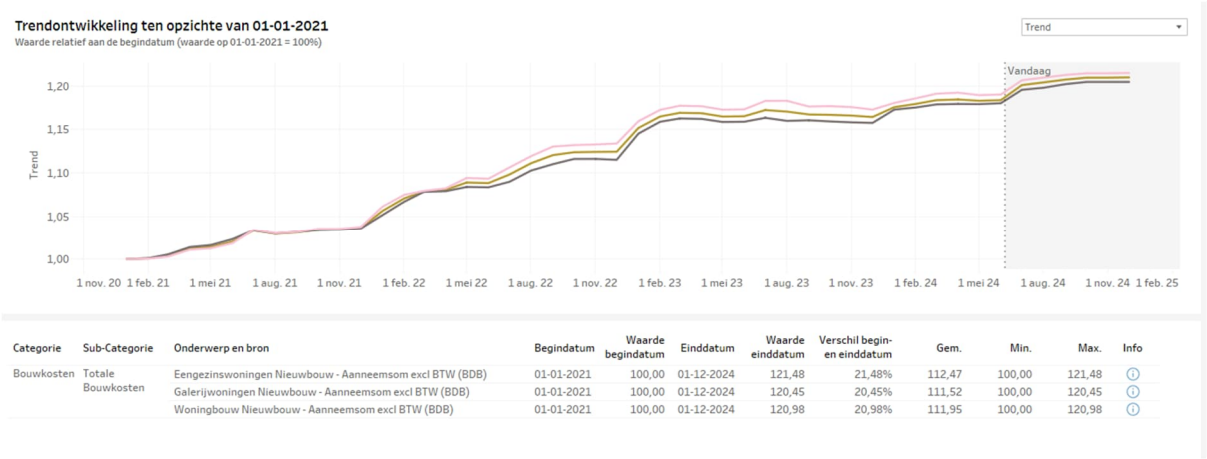


Figure 11: The borrowing capacity of a person earning 1 or 1.75 times the modal income in relation to the average selling price of newly constructed apartments and single-family dwellings (WoningbouwersNL & Xitres Data, 2024d)

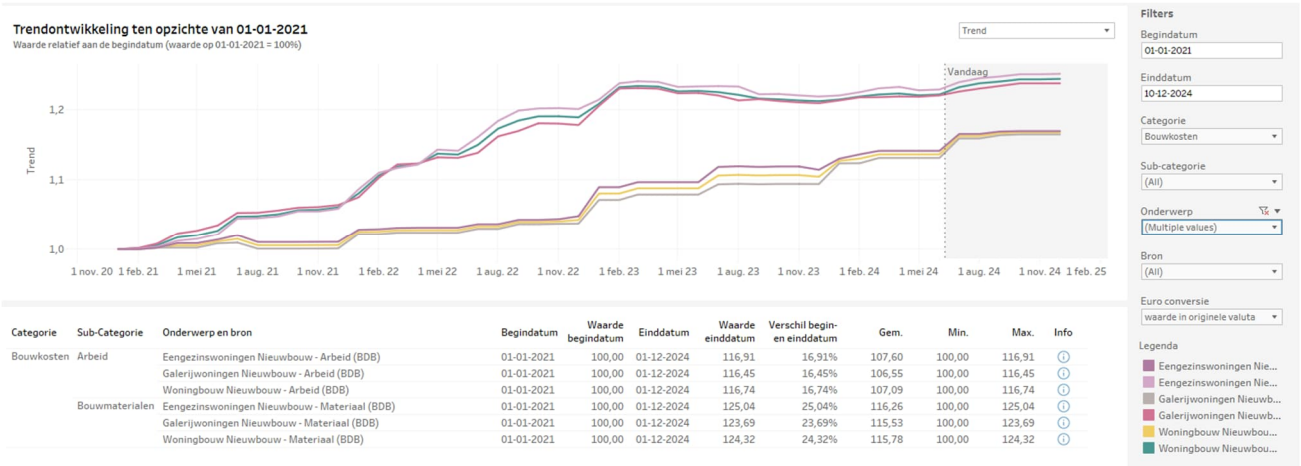
The construction costs significantly impact the average selling price of newly constructed houses. As indicated in Figure 12, there has been a noticeable upward trend in the total construction costs for newly constructed gallery apartments, single-family dwellings, and overall residential properties in the Netherlands. It indicates that, between 01-01-2021 and 01-12-2024, the total construction costs generally increased by 20.98%, excluding taxes. Furthermore, figure 12 shows that the increase has been more pronounced for single-family dwellings than gallery apartments.



Categorie	Sub-Categorie	Onderwerp en bron	Begindatum	Waarde begindatum	Einddatum	Waarde einddatum	Verschil begin- en einddatum	Gem.	Min.	Max.	Info
Bouwkosten	Totale Bouwkosten	Eengezinswoningen Nieuwbouw - Aanneemsom excl BTW (BDB)	01-01-2021	100,00	01-12-2024	121,48	21,48%	112,47	100,00	121,48	
		Galerijwoningen Nieuwbouw - Aanneemsom excl BTW (BDB)	01-01-2021	100,00	01-12-2024	120,45	20,45%	111,52	100,00	120,45	
		Woningbouw Nieuwbouw - Aanneemsom excl BTW (BDB)	01-01-2021	100,00	01-12-2024	120,98	20,98%	111,95	100,00	120,98	

Figure 12: Trend developments of the contract sum for newly constructed gallery apartments, single-family dwellings, and overall residential properties (VolkerWessels, 2024).

Comparing the increase in material costs, as depicted by the green, pink, and light pink lines in Figure 13, with the increase in labor costs, as depicted by the purple, yellow, and grey lines in Figure 13, of newly constructed dwellings in the Netherlands reveals that material costs have experienced a more pronounced increase than labor costs. Starting from March 2021, the purple line in Figure 14 indicates a significant upsurge in material costs, and since August 2021, material costs have surpassed the labor component. De Jong (2024) attributed this increase to international market turmoil. Additionally, the increase in material costs has been further heightened from February 2022 due to the conflict between Ukraine and Russia. However, as of May 2023, material costs have stabilized and even decreased, which is beneficial for the construction costs of houses. On the other hand, the labor costs have markedly increased as of January 2024, as a result of the new collective labor agreement compensating for the high inflation (Bouwend Nederland, n.d.; Centraal Bureau voor de Statistiek, 2023).



Categorie	Sub-Categorie	Onderwerp en bron	Begindatum	Waarde begindatum	Einddatum	Waarde einddatum	Verschil begin- en einddatum	Gem.	Min.	Max.	Info
Bouwkosten	Arbeid	Eengezinswoningen Nieuwbouw - Arbeid (BDB)	01-01-2021	100,00	01-12-2024	116,91	16,91%	107,60	100,00	116,91	
		Galerijwoningen Nieuwbouw - Arbeid (BDB)	01-01-2021	100,00	01-12-2024	116,45	16,45%	106,55	100,00	116,45	
		Woningbouw Nieuwbouw - Arbeid (BDB)	01-01-2021	100,00	01-12-2024	116,74	16,74%	107,09	100,00	116,74	
	Bouwmaterialen	Eengezinswoningen Nieuwbouw - Materiaal (BDB)	01-01-2021	100,00	01-12-2024	125,04	25,04%	116,26	100,00	125,04	
		Galerijwoningen Nieuwbouw - Materiaal (BDB)	01-01-2021	100,00	01-12-2024	123,69	23,69%	115,53	100,00	123,69	
		Woningbouw Nieuwbouw - Materiaal (BDB)	01-01-2021	100,00	01-12-2024	124,32	24,32%	115,78	100,00	124,32	

Figure 13: Trend developments of the labor and material components of the construction costs for newly constructed gallery apartments, single-family dwellings, and overall residential properties in the Netherlands (VolkerWessels, 2024).

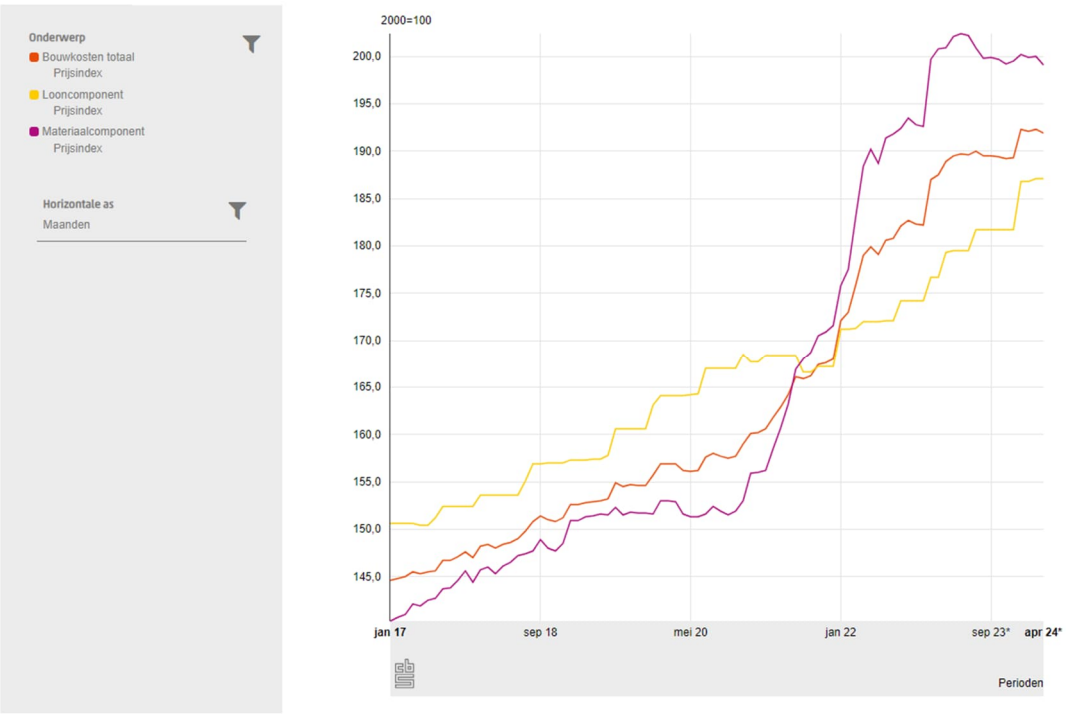


Figure 14: Trend developments of the labor and material components just as the total construction costs for newly constructed residential properties in the Netherlands (CBS, 2024d).

As a result of the rising construction costs, an increase in the average selling price of newly constructed houses in the Netherlands is noted in 2021, as visible in Figure 11. It is evident from the light blue line in Figure 11 that neither newly constructed apartments (orange line) nor single-family dwellings (blue line) were affordable for first-time buyers earning the modal income until the fourth quarter of 2023. Conversely, the light orange line indicates that newly constructed apartments were affordable before 2021 and after the second quarter of 2023 for households earning 1.75 times the modal income. This illustrates that the average selling price of newly constructed houses is not affordable for most first-time buyers in the Netherlands when considering the maximum mortgage.

To enhance the borrowing capacity of homebuyers, Nibud recommended that the Dutch government boost the borrowing capacity for non-vulnerable households, such as single-person households, by raising their borrowing capacity by €16,000. Additionally, they suggested modifying the method for incorporating student loans in determining the maximum mortgage and increasing the borrowing capacity for households purchasing energy-efficient homes or planning to make investments to improve the energy efficiency of their homes (Warnaar et al., 2023). As a result of the decrease in interest rates, substantial wage increases, and changes to the method used to determine the maximum mortgage, first-time buyers' borrowing capacity has risen (NVM, 2024a). However, this increase in borrowing capacity has not been reflected in Figure 11. It is impossible to establish a universal figure by which the borrowing capacity has increased, as the maximum borrowing capacity varies depending on individual circumstances and the characteristics of the home, but in average the borrowing capacity has increased. As a result of this increased borrowing capacity, more people can afford to buy a house, leading to increased demand and, subsequently, higher prices.

In addition to the maximum mortgage, it is essential to consider the affordability of homes in the housing market by determining their prices. According to Table 8, the average median transaction prices of newly constructed dwellings and existing housing stock have increased between the first quarter of 2023 and the first quarter of 2024. Using median transaction prices has the advantage of filtering out extreme values. Additionally, the data in Table 8 indicates that, based on the average median transaction price, dwellings in the existing housing stock are more affordable than newly constructed dwellings. The table also reveals that apartments in the existing housing stock can be considered affordable, especially considering their lowest median transaction prices.

Figure 16 illustrates the average selling prices of apartments and single-family dwellings in the existing housing stock. It shows that in 2023, the average selling price of apartments was at least €80,955 lower than that of single-family dwellings. However, this discrepancy is not visible in Figure 15, which shows the average selling price of newly constructed apartments and single-family dwellings.

In conclusion, apartments seem to be a logical choice for providing affordable dwellings for first-time buyers, as they have the lowest average selling prices. Therefore, the likelihood of first-time buyers purchasing apartments is higher. Eventually, even less affordable newly constructed apartments will become more affordable.

		Existing housing stock						Newly constrcuted dwellings					
		Median asking price			**Median transaction price**			**Median asking price**			**Median transaction price**		
		Q1 2023	Q1 2024	%-year	Q1 2023	Q1 2024	%-year	Q1 2023	Q1 2024	%-year	Q1 2023	Q1 2024	%-year
Single-family Dwellings	Terraced house	€ 407.000	€ 433.000	6,3%	€ 361.000	€ 399.000	10,7%	€ 493.000	€ 440.000	-10,6%	€ 428.000	€ 434.000	1,2%
	Corner house	€ 439.000	€ 457.000	4,0%	€ 383.000	€ 423.000	10,2%	€ 525.000	€ 494.000	-6,0%	€ 470.000	€ 482.000	2,6%
	Semidetached house	€ 494.000	€ 521.000	5,5%	€ 425.000	€ 467.000	9,9%	€ 595.000	€ 571.000	-4,0%	€ 571.000	€ 566.000	-0,9%
	Detached house	€ 719.000	€ 809.000	12,5%	€ 581.000	€ 628.000	8,0%	€ 804.000	€ 779.000	-3,2%	€ 786.000	€ 774.000	-1,5%
Apartments	Apartment	€ 384.000	€ 416.000	7,3%	€ 332.000	€ 357.000	7,4%	€ 490.000	€ 468.000	-4,4%	€ 426.000	€ 431.000	1,7%
Average		**€ 502.000**	**€ 553.000**	**7,9%**	**€ 395.000**	**€ 432.000**	**9,1%**	**€ 534.000**	**€ 508.000**	**-5,6%**	**€ 473.000**	**€ 479.000**	**1,2%**

Table 8: Median asking and transaction prices of newly constructed dwellings and dwellings in the existing housing stock in the first quartile of 2024 (NVM, 2024b; NVM, 2024b)

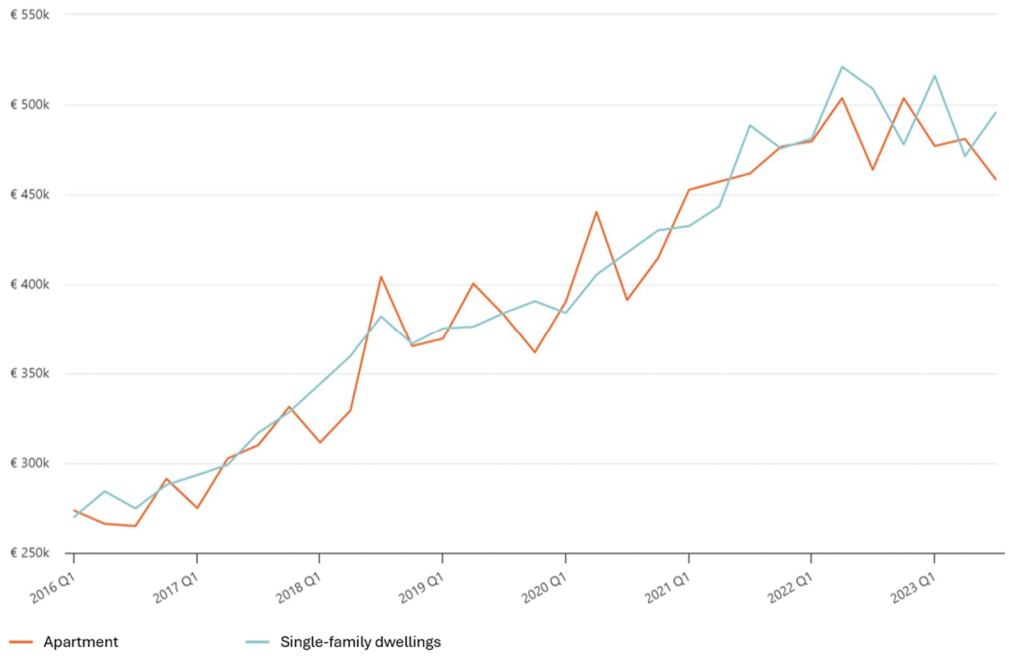


Figure 15: Average selling price of newly constructed dwellings in the Netherlands (WoningbouwersNL & Xitres Data, 2024b)

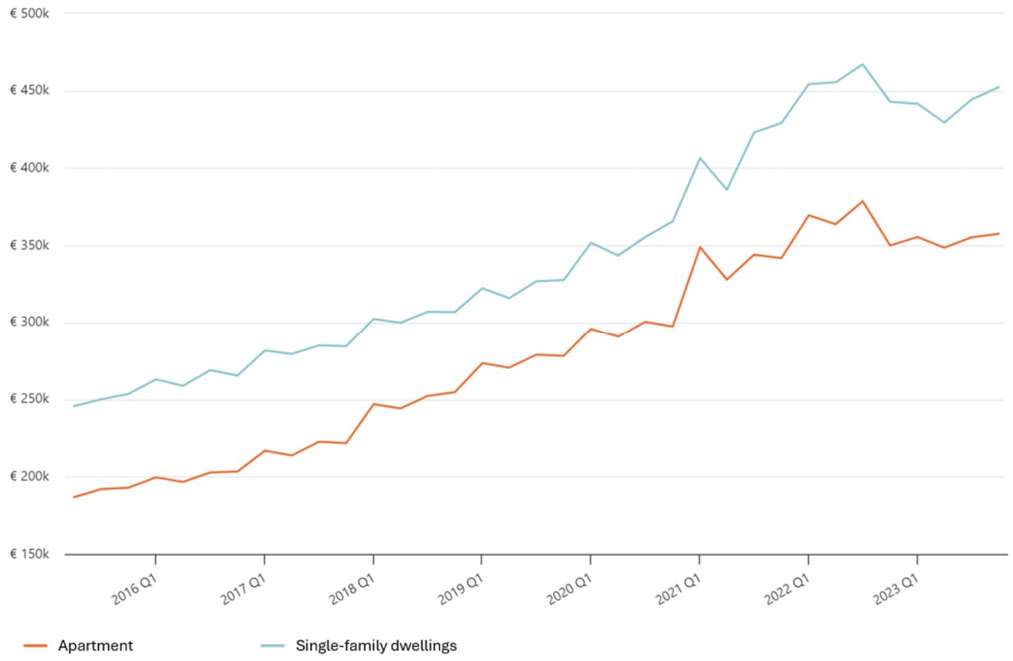


Figure 16: Average selling price of dwelling in the existing housing stock in the Netherlands (WoningbouwersNL & Xitres Data, 2024a)

In Table 8, alongside the median transaction price, the average median asking price of houses in the Netherlands is detailed. This data reveals that newly constructed houses are more affordable, as indicated by their lower median asking prices in the first quartile of 2024. The decrease in the median asking price of newly constructed houses might be attributed to regulations governing the housing program and maximum selling prices. Nevertheless, when considering the average median transaction and asking prices, as shown in Table 8, it can be concluded that, on average, neither newly constructed houses nor houses in the existing housing stock can be deemed affordable.

In the first quartile of 2024, the number of newly constructed dwellings sold below the Dutch government's affordability border of €390,000 has increased to 2000 (NVM, 2024a; Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2023). However, as depicted in Figure 17, most dwellings are still sold above this affordability border. Table 9 indicates that the average median transaction price per square meter of gross floor area (GFA) has risen more than the average median transaction price, suggesting a decrease in the average dwelling size. Between 2020 and 2024, the average size of apartments has decreased from 75 m2 to 65 m2, and the average size of single-family dwellings has decreased from 115 m2 to 105 m2 (NVM, 2024a). It is also worth noting that the average transaction price per square meter of GFA for apartments was €5348, the highest among all dwelling types.

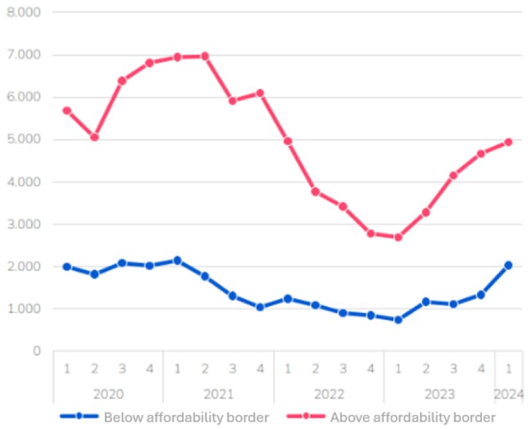


Figure 17: Number of newly constructed dwellings sold above/under the affordability limit of the Dutch Government (NVM, 2024a)

		Newly constrcuted dwellings					
		Median transaction price			Median transaction price per m2 GFA		
		Q1 2023	Q1 2024	%-year	Q1 2023	Q1 2024	%-year
Single-family Dwellings	Terraced house	€ 428.000	€ 434.000	1,2%	€ 3.495	€ 3.696	5,7%
	Corner house	€ 470.000	€ 482.000	2,6%	€ 3.718	€ 3.863	3,9%
	Semidetached house	€ 571.000	€ 566.000	-0,9%	€ 3.801	€ 3.872	1,9%
	Detached house	€ 786.000	€ 774.000	-1,5%	€ 4.617	€ 4.585	-0,7%
Apartments	Apartment	€ 426.000	€ 431.000	1,7%	€ 5.016	€ 5.348	6,8%
Average		**€ 473.000**	**€ 479.000**	**1,2%**	**€ 4.149**	**€ 4.344**	**4,9%**

Table 9: Median transaction prices and median transaction prices per m2 UFA for newly constructed dwellings in the first quartile of 2024 (NVM, 2024d)

In Table 10, the willingness to pay of first-time buyers and the definition of an affordable dwelling by the Dutch Government, as outlined in Chapter 2.2.1, are divided by the median transaction price per square meter of newly constructed apartments in the Netherlands in the first quartile of 2024. The outcomes indicate the maximum UFA of a newly constructed apartment to be considered affordable in line with the used willingness to pay or definition. These calculated dwelling sizes provide an indication of the maximum size of a newly constructed affordable apartment for first-time buyers in the Netherlands and can be used to evaluate the availability of affordable apartments in the Dutch housing market. Furthermore, Table 10 shows the estimated transaction price for an average apartment in the Netherlands. This value is calculated by multiplying the average size of an apartment in the Dutch housing stock, which is 75m2, by the median transaction price of newly constructed apartments in the first quartile of 2024. It can be concluded that the estimated transaction price of a dwelling cannot be considered affordable.

	Boundary value of affordability	Dwelling size of an affordable apartment(m2)
Dutch Government		
General	€ 390.000	73
Vereniging Eigen Huis		
Average	€ 269.607	50
Single-person first-time dwelling buyer	€ 240.294	45
Two-person first-time dwelling buyers	€ 323.241	60

	Price	Dwelling size (m2)
Price of an average size apartment	€ 401.100	75

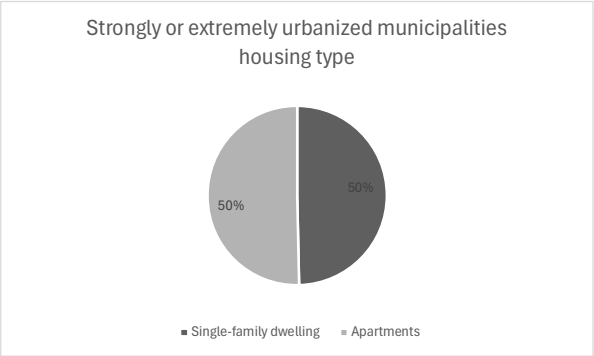
Assumptions	
Median transaction price (Q1 2024)	€ 5.348

Table 10: Dwelling sizes of affordable newly constructed apartments and the price of an average size apartment based on the median transaction price of newly constructed apartments (NVM, 2024d)

2.3.2 Characteristics of the housing supply

In 2023, the Netherlands had a total housing stock of 8,125,229 houses, with 4,634,411 being owner-occupied and 3,479,588 designated rental properties. According to CBS (2024a), 64% of the housing stock comprises single-family dwellings, while 36% are apartments. When considering the location of the housing stock, 57% is situated in strongly or extremely urbanized municipalities, with the remaining 43% located in moderately, fewly, or not urbanized municipalities (CBS, 2024a; CBS, 2024b). Notably, significant disparities exist between strongly or extremely urbanized areas and moderately, fewly, or not urbanized areas regarding housing type and ownership. Figures 18 and 19 indicate that the percentage of apartments in strongly or extremely urbanized municipalities is notably higher than in their less urbanized counterparts. This distinction can be attributed to the scarcity and relatively higher cost of construction land in urban areas compared to rural areas. Additionally, figures

20 and 21 illustrate that the percentage of rental dwellings in more urbanized municipalities surpasses that in more rural areas.



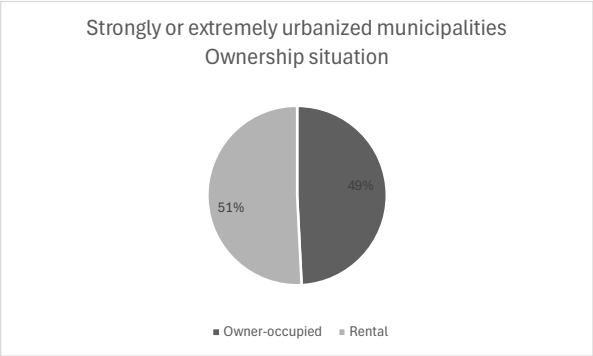
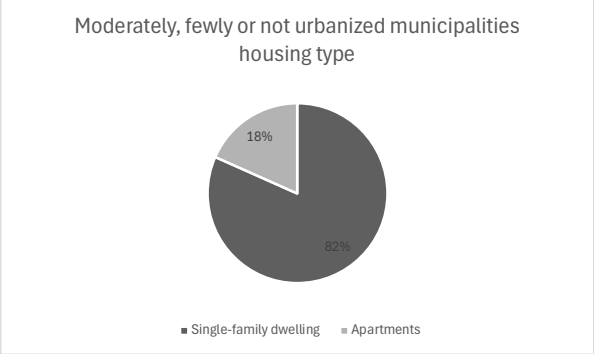


Figure 18: The different housing types in strongly or extremely urbanized municipalities in the Netherlands (CBS, 2024b)
Figure 19: The ownership situation of dwellings in strongly or extremely urbanized municipalities in the Netherlands (CBS, 2024a)



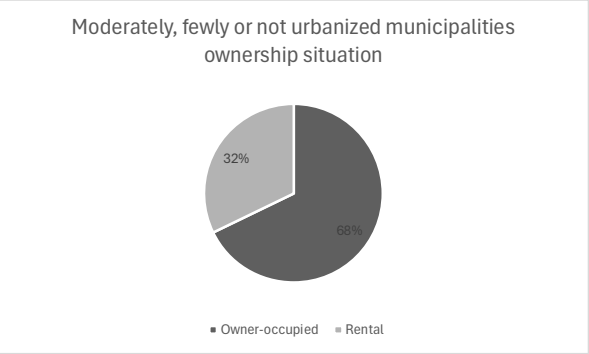
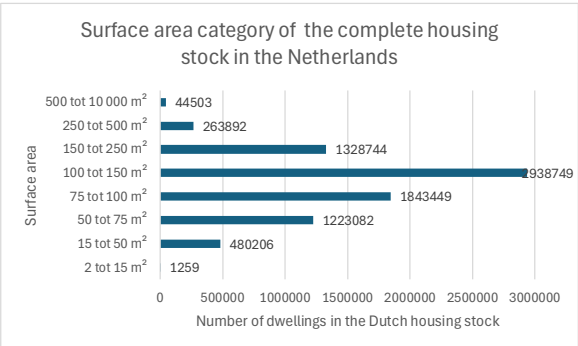


Figure 20: The different housing types in moderately, fewly, or not urbanized municipalities in the Netherlands (CBS, 2024b)
Figure 21: The ownership situation of dwellings in moderately, fewly, or not urbanized municipalities in the Netherlands (CBS, 2024a)

In the data presented in Figure 22, it is clear that most dwellings in the Dutch housing stock range in size from 100 to 150 m2. Additionally, when the differentiation is made between single-family dwellings and apartments, it becomes evident in Figure 23 that most single-family dwellings have a surface area of 100 to 150 m2. In contrast, most apartments have a smaller surface area, ranging from 50 to 75 m2, as visible in Figure 24. This indicates that apartments generally have a smaller UFA compared to single-family dwellings



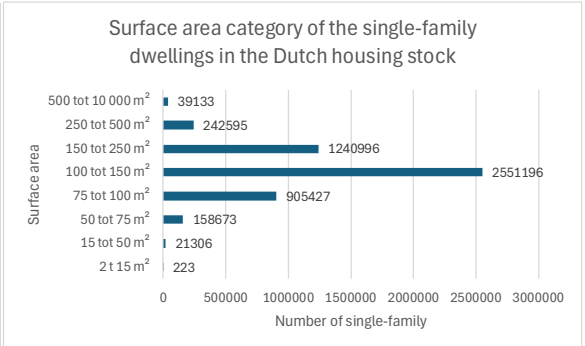


Figure 22: Surface area category of the complete housing stock in the Netherlands based on data from CBS (2024c)
Figure 23: Surface area category of the single-family dwellings in the Netherlands based on data from CBS (2024c)

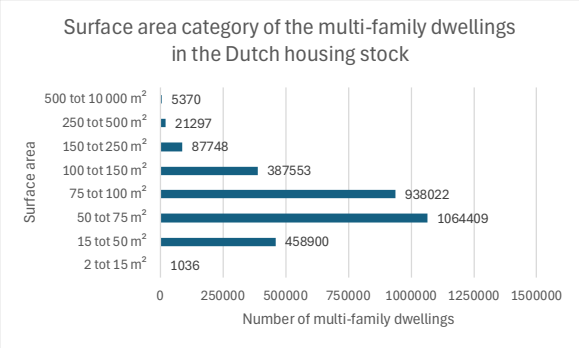


Figure 24: Surface area category of the multi-family dwellings in the Netherlands based on data from CBS (2024c)

Additionally, Table 11 shows that the average size of dwellings built after 2015 is smaller than those constructed between 1995-2005 and 2005-2015. This suggests a reduction in the average surface area of the housing stock. The decrease in dwelling size is also acknowledged by NVM (2024a), who reported that the average surface area of newly built apartments priced below €390,000 decreased from 75 m2 to 65 m2 between 2020 and 2024, and for single-family dwellings from 115 m2 to 105 m2. One reason for this decrease in average dwelling size is the Dutch government's focus on constructing affordable housing (NVM, 2024a).

	Total housing stock	1000 to 1850	1945 to 1955	1985 to 1995	1995 to 2005	2005 to 2015	From 2015
Total housing stock	120 m2	166 m2	110 m2	115 m2	132 m2	126 m2	118 m2
Single-family dwelling	143 m2	245 m2	127 m2	134 m2	156 m2	164 m2	152 m2
Multi-family dwelling	80 m2	98 m2	73 m2	74 m2	89 m2	90 m2	71 m2

Table 11: Average surface area of the Dutch housing stock per construction period based on data from CBS (2024c)

	Total average usable floor area	Average usable floor area per person
Single-person households younger than 35 years old	73 m2	73 m2
Two-person households younger than 35 years old	100 m2	49m2

Table 12: Average usable floor area of household types in the Netherlands (Stuart-Fox et al., 2022, p. 111)

The data presented in Chapter 2.2.2 indicates that most first-time buyers in the Netherlands belong to single-person and two-person households under 35. According to Table 12, single-person households under 35 have a usable floor area that is nearly 1.5 times larger than the usable floor area per person for two-person households in the same age group. Additionally, single-person first-time buyers typically have a lower income than their two-person counterparts, resulting in a lower housing budget, as discussed in Chapter 2.2.2. Moreover, the total number of single-person households is projected to increase from 3.1 million in early 2021 to 3.8 million in 2045 (Centraal Bureau voor de Statistiek, 2021).

Given the projected increase in single-person households and the comparatively generous amount of livable floor space per household, the current housing supply consists of too large and, therefore, less economical residences. Due to the size of the dwellings in the housing stock, these can be considered majorly unaffordable for single-person households.

2.3.3 Shared facilities in the housing supply

Numerous examples in the literature demonstrate the sharing of facilities among residential building residents. These examples can be categorized based on how facilities are shared and the purpose behind the sharing. This master's thesis aims to analyze the potential positive impact of specific shared facilities, such as communal kitchens, shared laundry rooms, and shared living spaces, on the construction costs and environmental performance of individual apartments within a multi-apartment building. Hence, identifying potential shared facilities

for apartment residents is essential. By referring to the existing literature on projects with shared facilities and by considering the regulations, potential shared facilities for first-time buyers in the Netherlands are determined.

In the Netherlands, the regulations for new constructions are outlined in the Besluit bouwwerken leefomgeving, which differentiates between common and collective facilities (IPLO, n.d.). Common facilities are those that are shared among the residents of different housing units, such as a shared gym in an apartment building. Collective facilities are shared by the residents of the same housing unit, so for example students sharing a kitchen in a student house. This master thesis focuses on sharing facilities among different apartments and, therefore, the concept of sharing common facilities. Additionally, the Besluit bouwwerken leefomgeving stipulates that all facilities can be shared unless explicitly prohibited by the regulations (IPLO, n.d.).

Table 13: Shared facilities within co-housing projects focused on improving affordability and the number of times they were mentioned in the literature (Cho et al., 2018; Hagbert et al., 2019; Pirinen & Tervo, 2020)

Shared facility	Number of sources and/or projects
Kitchen	6
Laundry room	4
Dining room	4
Living room	4
Bathroom	3
Shared sauna	2
Hobby rooms	2
Garden	2
Toilet	2
Meeting room	1
Guest room	1
Workshop	1
Library	1
Sport rooms	1
Restaurant	1
Rooftop	1

Table 13 provides an overview of the various shared facilities within co-housing projects focused on improving affordability, as noted in the literature. A communal kitchen is the most commonly mentioned shared facility, followed by shared laundry, dining, and living areas.

Mans (2024) analyzed 32 co-housing projects in Denmark, the Netherlands, Belgium, and Germany, targeting elderly or exclusively for elderly residents. Figure 25 illustrates the shared facilities identified in Mans' research and the frequency of their presence in co-housing projects. A shared terrace/garden was present in all projects examined. Additionally, a shared living room, kitchen/dining room, and shared bike parking were prevalent in most projects. While the primary focus of sharing facilities among the elderly is social, this master's thesis concentrates on affordability and sustainability. Nonetheless, the analysis by Mans (2024) offers valuable insights into the potential facilities that could be shared among apartment building residents. It is important to note that implementing shared facilities may pose challenges, such as increased maintenance costs or potential conflicts among residents.

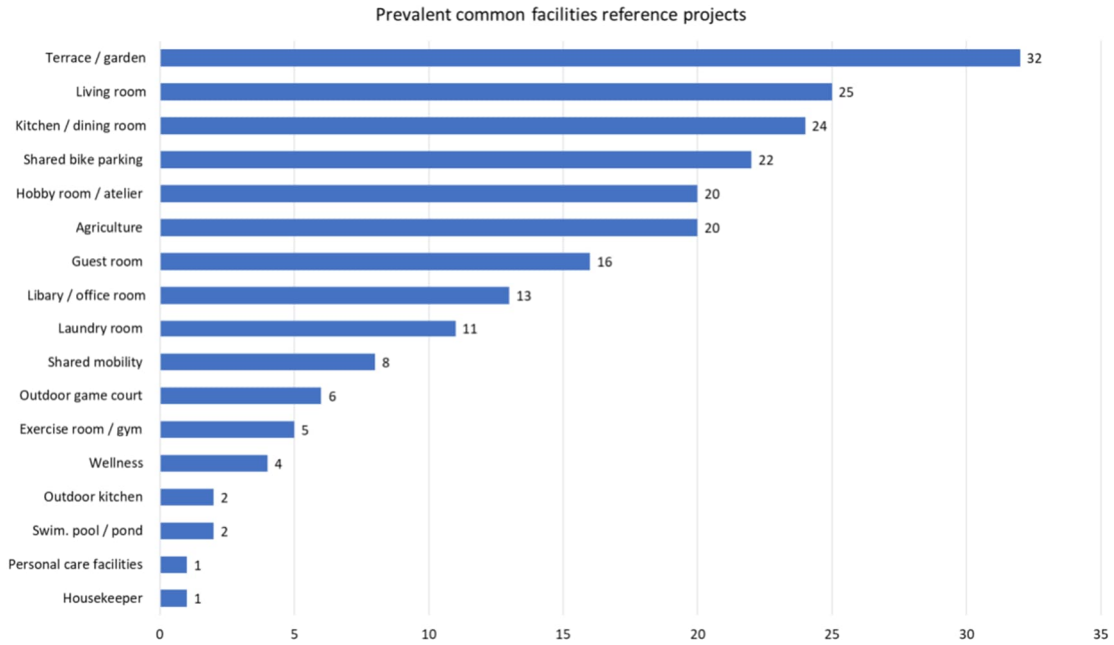


Figure 25: The prevalent common facilities found in reference projects by Mans (2024)

Combining the findings from Figure 25 and Table 13 yields Table 14. The selected shared facilities should focus on reducing the costs and applied materials of the building and should be in line with the Dutch building code. In the Netherlands, an apartment is classified as an independent dwelling. Therefore, it must adhere to the Dutch government's standards for independent living spaces and the requirements stated in the Besluit bouwwerken leefomgeving. These standards encompass having a private entrance, kitchen, toilet, and shower or bath (bathroom) (Ministerie van Algemene Zaken, 2023b). Therefore, including a shared kitchen, toilet, shower, or bath (bathroom) may be deemed irrelevant since these need to be present in each apartment. However, a shared kitchen presents a different scenario, as incorporating a shared kitchen might allow for a minimization of the kitchens within the apartments. Implementing kitchens that meet the minimum standards as described in articles 4.177 and 4.178 of the Besluit bouwwerken leefomgeving in individual apartments while considering a larger communal kitchen can be an effective strategy for reducing costs and enhancing sustainability and will therefore be considered in this master thesis.

Table 14: The combined findings from Table 13 and Figure 25 in which the applicable shared facilities for first-time buyers are indicated.

Shared facility	Number of sources and/or projects	Applicable sharing among first-time buyers	Type
Terrace/garden	2 + 32=34	Yes	Common
Kitchen	6 + 24 = 32	Yes	Common
Living room	4 + 25 = 29	Yes	Common
Hobby room / atelier	2 + 20 = 22	No	Common
Shared bike parking	0 + 22 = 22	Yes	Common
Agriculture	0 + 20 = 20	No	Common

Guest room	1 + 16 =17	No	Common
Laundry Room	4 + 11 = 15	Yes	Common
Library / office room	1 + 13 = 14	Yes	Common
Shared mobility	0 + 8 = 8	No	Common
Exercise room / gym / sport room	1 + 5 = 6	No	Common
Wellness / Sauna	2 + 4 = 6	No	Common
Bathroom	3 + 0 = 3	No	Collective
Outdoor kitchen	0 + 2 = 2	No	Common
Swim. Pool / pond	0 + 2 = 2	No	Common
Toilet	2 + 0 = 2	No	Collective
Personal care facilities	0 + 1 = 1	No	Common
Housekeeper	1 + 0 = 1	No	Common
Meeting room	1 + 0 = 1	No	Common
Workshop	1 + 0 = 1	No	Common
Restaurant	1 + 0 = 1	No	Common
Rooftop	1 + 0 = 1	No	Common

Articles 4.30.1 and 4.31.1 of the Besluit bouwwerken leefomgeving state that houses must include a lockable storage space for bicycles and mobility scooters, which should be shielded from weather and wind. Furthermore, Article 4.34.1 of the Besluit bouwwerken leefomgeving stipulates that each house must have a directly accessible outdoor space. However, Articles 4.31.2 and 4.35.2 of the Besluit bouwwerken leefomgeving specify that these spaces can be shared in cases where the usable floor area of the dwellings is less than 50 m2. In such instances, there must be a minimum of 1 m2 of shared outdoor space per dwelling with a minimum of 4 m2, and each dwelling must have a floor area of at least 1.5 m2 in the shared storage space. Sharing the outdoor space and storage space can offer significant cost savings and enhance sustainability, and therefore, will be considered in this master thesis.

According to Table 14, a shared living room is referenced in 29 sources and projects. Introducing a shared living room could help alleviate feelings of loneliness among the residents of the apartment building, fostering a sense of community. This could be particularly beneficial considering the outcomes of the study by GGD GHOR Nederland (2022), which revealed that 63% of young adults in the Netherlands experience some level of loneliness. Additionally, a shared living room could create the opportunity to decrease the size of individual living rooms in the apartments, leading to positive impacts on affordability and sustainability.

In 2023, 52% of the working population in the Netherlands embraced occasional remote work. Most of these individuals worked from home for less than half their hours (Centraal Bureau voor de Statistiek, 2024). Having a dedicated workspace at home is crucial for remote work. However, the workspace will remain unused for most of the time. Providing shared library/office rooms can be a practical and efficient solution and could allow for a reduction in apartment size since the need for individual workspaces within each apartment is eliminated.

This master's thesis will also explore the inclusion of a shared laundry room. Having a shared laundry room presents the opportunity to decrease the size of the apartment since there is

no need for space to accommodate a washing machine and dryer. Additionally, residents will not need to purchase a washing machine and dryer individually, and there will be no need for piping in each apartment for the connections. The anticipated positive impact on affordability and sustainability makes incorporating a shared laundry room worth considering.

This master's thesis focuses only on essential shared facilities. Although a bathroom and toilet are essential, they are excluded from consideration due to regulations for independent dwellings in the Netherlands, which require each dwelling to have its own private bathroom and toilet. Other shared facilities mentioned in the literature and Table 14 will not be part of this research, as they are deemed unnecessary or may not comply with these regulations.

The analysis indicates that several facilities could be shared among first-time buyers in a Dutch apartment building. Sharing these facilities primarily aims to enhance apartment affordability and sustainability. Upon consideration of the essential nature of these potentially shareable facilities and their compatibility with regulations, it is evident that only a shared terrace/garden, kitchen, living room, bike parking, laundry room, and library/office room could potentially contribute to the goal of enhancing affordability and sustainability. Therefore, these six facilities will be the focus of this master's thesis.

2.3.4 Conclusion

It can be concluded that the majority of the existing housing supply is not affordable for first-time buyers, indicating that the housing demand does not match the housing supply. This issue is largely attributed to the relatively large surface area of housing, particularly when considering single-person households. Additionally, while various shared facilities could be explored, most tend to emphasize providing additional luxurious amenities. Consequently, only six common shared facilities appear to be relevant for first-time buyers in terms of potentially enhancing affordability, which are a shared garden/terrace, kitchen, bike parking, living room, laundry room, and workspace.

2.4 Environmental Performance

Buildings worldwide account for 39% of global energy-related carbon emissions (World Green Building Council, 2023). Efforts to mitigate the environmental impact of the building sector have predominantly concentrated on the operational phase, which is responsible for 28% of these emissions (Le et al., 2023; Le et al., 2024; World Green Building Council, 2023). However, the greenhouse gas emissions associated with materials used during construction contribute to the other 11% of buildings' total energy-related carbon emissions (World Green Building Council, 2023). The demand for materials strains global resources, a situation expected to worsen due to the increased need for housing and infrastructure (Le et al., 2023). In Europe, the construction sector accounts for approximately 50% of the consumption of natural resources (Trigaux et al., 2020). Moreover, research indicates that efforts to reduce carbon emissions during the operational stage of buildings may inadvertently lead to an increase in material-related carbon emissions during their construction (Röck et al., 2019).

Sustainability rating systems and assessment methods have been created to evaluate and improve the sustainability of developments. According to Awadh (2017), most of these systems are founded on the three pillars of sustainability: environment, society, and economy. Additionally, Awadh (2017) notes that these systems prioritize enhancing a

building's performance by minimizing its environmental impact, allowing for measuring its environmental effects to compare and assess its construction objectively.

2.4.1 International Environmental Performance Assessment

Building Research Establishment Environmental Assessment Method (BREEAM), Leadership in Energy and Environmental Design (LEED), and German Sustainable Building Council (DGNB) are internationally recognized sustainability rating and certification systems used to evaluate the environmental performance of buildings (Awadh, 2017; Ganassali et al., 2016; Trigaux et al., 2019; Trigaux et al., 2020; Turk et al., 2018). All these systems aim to evaluate the sustainability of a design using benchmarks to make it possible to objectively compare and asses its sustainability. Even though these systems have the same goal, their benchmarks are different and determined in different ways. These systems can be classified into internal and external categories based on their comparative benchmarks. As shown in Table 15, BREEAM and DGNB fall under the external category, meaning they assess buildings against a benchmark that represents the environmental impact of a particular category of buildings. In contrast, LEED is considered an internal system, as it evaluates a building against a base-design structure that possesses similar geometric and contextual characteristics. External systems provide the advantage of comparing a building's performance with the broader building stock, enabling stakeholders to gauge its standing in the market based on environmental impact. Additionally, external systems evaluate the comprehensive effects of the entire design, whereas internal systems only focus on the impacts stemming from material choices alone (Trigaux et al., 2019).

BREEAM and DGNB employ a bottom-up approach for their assessments, meaning that benchmark values are established through statistical analysis of the existing building stock. This method offers the advantage of deriving realistic benchmark values based on current construction methods and technologies. In contrast, LEED does not utilize a standardized approach for defining benchmarks, as its values are determined by the specific design characteristics of each building (Trigaux et al., 2019).

BREEAM employs a benchmark scale to assign scores to buildings, whereas DNGB utilizes a system of limit values, reference values, and two target values. The limit value establishes the minimum required performance, while the reference value reflects the state of the art, based on average or median values. Although both limit and reference values are useful in the short term, they must be regularly updated to ensure they progress towards more ambitious standards. The target values serve to define the intended goals to aspire toward; however, they may not always be attainable due to limitations in knowledge or technology. None of these typologies to define sustainability is used by LEED since they compare the design to a design based on the specific design characteristics (Spirinckx et al., 2018; Trigaux et al., 2019).

Table 15: Characteristics of the three internationally recognized sustainability rating and certification systems (Trigaux et al., 2019).

Sustainability rating and certification systems	Comparative base	Life cycle stages	Building types
BREEAM	External	Embodied impacts	Residential
LEED	Internal	Whole life cycle	Utility + high-rise residential

DNGB	External	-Whole life cycle -Indicative values for embodied impacts and energy use	Residential + Utility

The analysis of the life cycle stages depicted in Figure 26 reveals that the environmental impact of a building can be classified into six distinct stages. Additionally, it identifies two types of systems for assessing this environmental impact: Type 1 and Type 2. Type 2 systems evaluate the total environmental impact throughout the entire life cycle of the building, whereas Type 1 systems differentiate between embodied and operational impacts. As shown in Table 15, BREEAM focuses solely on the embodied impact of a building, while LEED and DNGB take into account the building's entire life cycle.

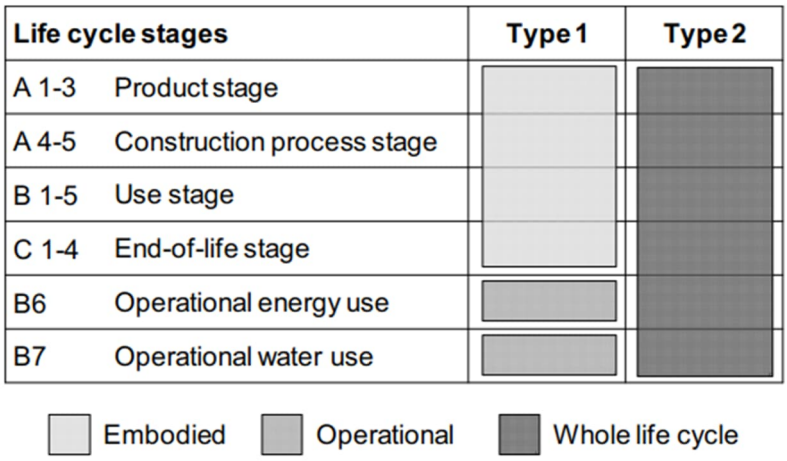


Figure 26: The scope of the benchmarks to assess environmental performance based on the life cycle stages (Trigaux et al., 2019).

When examining the building types that can be evaluated using the various assessment methods presented in Table 15, it becomes evident that DNGB is the most versatile and applicable to both residential and utility functions. In contrast, BREEAM is restricted to residential buildings, while LEED primarily targets utility functions and high-rise residential structures.

In addition to the internationally recognized sustainability rating and certification systems that assess the environmental performance of buildings in accordance with international or European Life Cycle Assessment (LCA) standards, there also exist sustainability rating and certification systems grounded in national LCA methods and guidelines. The implementation of these national methods and guidelines enhances the reproducibility and comparability of benchmarks, which is particularly essential when the benchmarks are included as part of national requirements (Trigaux et al., 2020).

2.4.2 Environmental Performance Assessment in the Netherlands

The material-related environmental performance of residential buildings in the Netherlands is measured by the Milieuprestatie Gebouwen (MPG). As illustrated in Table 16, the MPG benchmark is defined externally, meaning it assesses buildings against a standard that reflects the environmental impact typical of specific categories of buildings (Trigaux et al., 2019). This benchmark is established through a bottom-up approach and is defined as a limit value

(Trigaux et al., 2019). Currently, the limit value for residential buildings is set at 0.8; however, the Dutch government plans to tighten this requirement to 0.5, effective January 1, 2025, to encourage the construction of more sustainable buildings (Economisch Instituut voor de Bouw et al., 2023). Additionally, Table 16 shows that the MPG focuses on the embodied environmental impact of the building, excluding the operational impact from its considerations, and that both residential and utility buildings are assessed by the MPG.

Table 16: The characteristics of the MPG (Trigaux et al., 2019)

Sustainability rating and certification system	Comparative base	Life cycle stages	Building types
MPG	External	Embodied impacts	Residential + Utility

The Environmental Performance Assessment Method for Construction Works (Assessment Method) examines the MPG. The Assessment Method is unambiguous and verifiable and is based on the European standard EN 15804:2012+A1:2019 (EN 15804). It contains general agreements for construction works and building or civil engineering-specific agreements. The assessment method forms a cohesive package with the National Environmental Database (NMD) and the calculation rules, which are administered by Stichting National Environmental Database (Stichting NMD) (Stichting National Environmental Database, 2022, pp. 4–5).

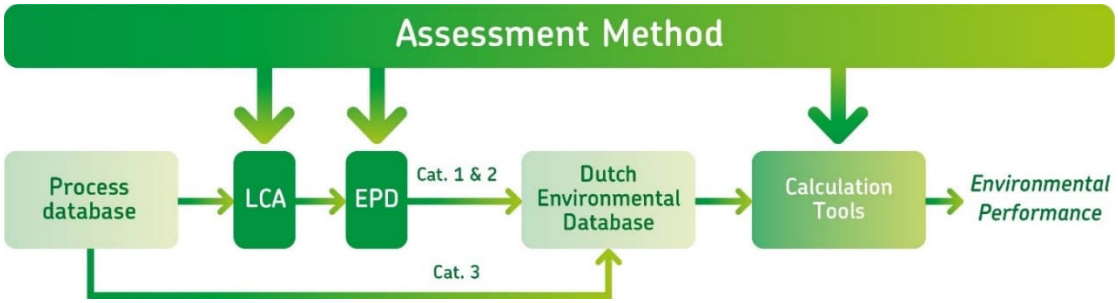


Figure 27 Visualization of the structure to determine the environmental performance of a building (Stichting Nationale Milieudatabase, 2023)

The diagram in Figure 27 illustrates the relationship between the various elements involved in calculating the MPG. It demonstrates that the calculation tools utilize data from the NMD to assess the environmental performance of a building's materials. The NMD comprises three types of product information categories. Figure 27 depicts that the data related to product information categories is sourced from the Process database. The Process database, which is based on the Ecoinvent 3.6 database and overseen by Stichting NMD (Stichting National Environmental Database, 2022, p. 6), contains Life Cycle Assessment (LCA) data regarding raw materials and background processes. The data obtained from the process database is utilized to model category 3 data of the NMD and for category 1 and 2 data of the NMD in cases where specific data is unavailable. Figure 28 indicates the three different types of data stored in the NMD.

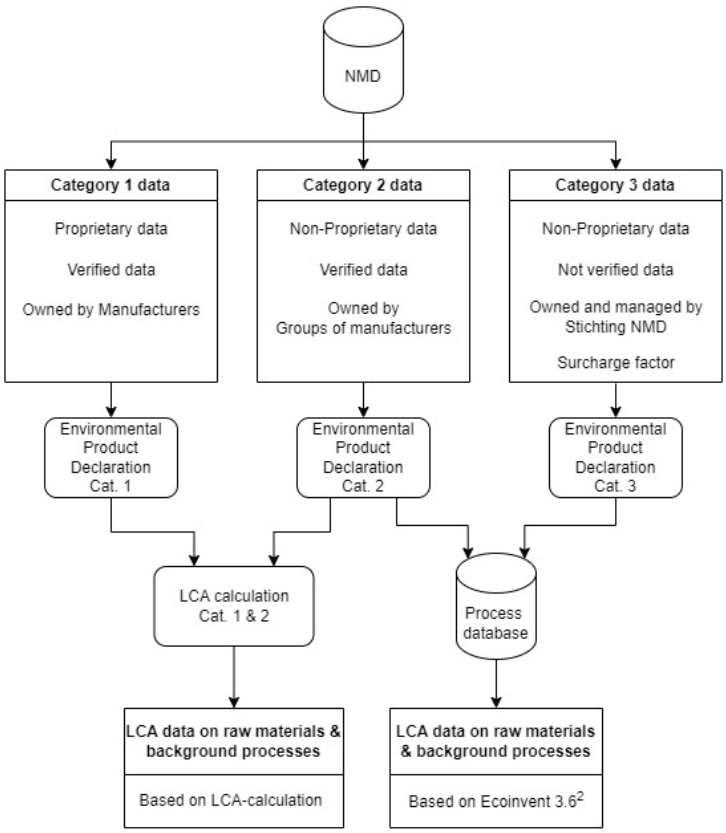


Figure 28: Types of EPD data stored in the NMD

Category 1 data, which is proprietary and verified, is typically owned by manufacturers and/or suppliers of a product and requires a product-specific lifecycle analysis. This analysis is conducted using the assessment method known as a Product Category Rule (PCR) to assess the product's life cycle and guide the formulation of the Environmental Product Declaration (EPD). Category 2 data, on the other hand, is non-proprietary and generally owned by a group of manufacturers and/or suppliers. This data is derived from LCA calculations and the process database. However, both Category 1 and 2 data are verified and compliant with the latest NMD Verification protocol (Stichting National Environmental Database, 2022).

The process database, managed by Stichting NMD, contains LCA data for various basic raw materials and processes. Category 3 EPDs are generated solely using data from the process database. However, as the environmental impact indicated by unverified category 3 data is often found to be too low, a surcharge factor is applied to correct this. Therefore, verified category 1 and 2 data consistently demonstrate better environmental performance than category 3 data.

Producers and sectors in the construction industry must generate an Environmental Product Declaration (EPD) for their products to be included in the NMD under product information category 1 or 2, as visible in Figure 27. The production of EPDs requires conducting an LCA whereby the Assessment Method functions as a Product Category Rule (PCR). The LCA yields 11 indicators for the environmental impact, which will increase to 19 indicators by January 1, 2025, and considers the environmental impact during the lifecycle of the material. Besides functioning as a PCR the Assessment Method is utilized to specify the formulation of EPDs. This ensures that the EPDs are in line with the EN 15804 and that they are transparent and

comparable (Quist, 2024). Additionally, the EPD and the project documentation must be verified by an independent, qualified third party using the NMD Verification protocol to be classified as Category 1 or 2.

Figure 27 shows that calculation tools that have been pre-validated by the National Environment Database Foundation can be utilized to calculate the MPG of a building (Stichting National Environmental Database, 2021c). This calculation is carried out in accordance with the Determination Method Environmental Performance Construction Works, which is founded on a Life Cycle Assessment (LCA) of the entire building. As the method centers on the environmental performance of a complete building, the functional equivalent is the building level. Thus, the design and planned service life dictate the selected products and the number of replacements (National Environmental Database Foundation, 2020). As depicted in Figure 27, the product data in the NMD is utilized by the calculation tools to measure the environmental performance of a building, ensuring that the environmental performance of buildings is comparable, as they are grounded in the same type of data.

Table 17 presents the certified calculation tools available for determining a building's MPG and indicates if they are freely available. Notably, only the MRPI-FREEtool is offered free of charge. This tool is developed by Stichting MRPI and can calculate the MPG of a building (Stichting MRPI, n.d.-b). However, it does not allow users to directly assess shared facilities' impact on environmental performance. While testing this influence is feasible, it requires the creation of a new calculation for each shared facility or any combination of shared facilities.

Table 17: certified calculation tools available for determining a building's MPG (Stichting National Environmental Database, 2021c).

Calculation tool	Owner	Freely available
GPR Materiaal	W/E adviseurs	No
MPG Toetshulp	Bimpact B.V	No
Dubocalc	Netcompany / Witteveen+Bos	No
MRPI-MPG Tool	Stichting MRPI	No
MRPI-FREEtool	Stichting MRPI	Yes
BCI Gebouw	Alba Concepts	No
Madaster MPG Tool	Madaster	No
MPGcalc	DGMR	No

2.4.3 Conclusion

It can be concluded that there are three internationally recognized sustainability rating and certification systems used to assess the environmental performance of buildings. While these systems all evaluate the environmental impact of a building, they exhibit differences in approach and methodology. In addition to these internationally recognized systems, there are also localized assessments grounded in national or regional LCA data, which are more representable in these local contexts. In the Netherlands the MPG is utilized. However only one of the systems to assess the MPG is freely accessible, and it lacks the capability to create and compare designs that incorporate shared facilities. Given the objective of sustainability rating and certification systems to evaluate the sustainability of designs through benchmarks

for objective comparison and assessment, a tool that offers insights into the impact of shared facilities on environmental performance would be beneficial.

2.5 Housing development and construction

A specific party initiates a housing development project; in the Netherlands, these are often municipalities and project developers (Groot et al., 2019). The process begins with conducting feasibility studies to assess the initiative's viability. Subsequently, the design phase begins, as illustrated in Figure 29. The design phase typically encompasses four stages: conceptual design, basic design, Front-End Engineering Design (FEED), and detailed design (Faraji et al., 2022). Early intervention in the design process can significantly impact a project, as indicated by the MacLeamy curve. Therefore, it is crucial to consider the quantity and quality of available data at different stages in the design phase. The Level of Development (LOD) defines the development phases in a Building Information Modeling (BIM) project, offering insights into the data and information accessible at each design stage (Catenda, 2023).

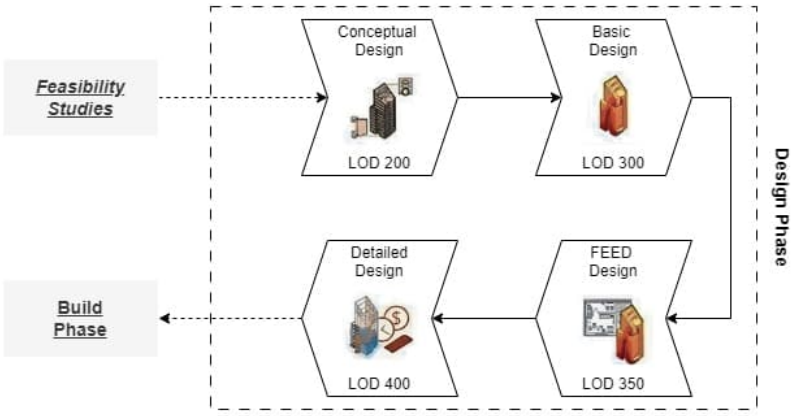


Figure 29: The design phase of housing development and construction projects in the Netherlands (Catenda, 2023; Faraji et al., 2022)

In the conceptual design stage, the project's overall appearance is determined based on defined requirements, input from project stakeholders, and technical knowledge. This phase involves evaluating different design options that align with the project goals. After comparing the various design options and their alignment with the project's objectives, one design option is selected as the starting point for the basic design phase. The LOD at this stage is 200, indicating that the model is graphically projected and that estimated data about orientation, quantities, area, shape, and positioning will be available (Catenda, 2023). Although data and information are limited in the design phase, having comprehensive data and information is valuable for effectively comparing the options.

During the basic design phase, the conceptual design is refined using a combination of field studies and engineering calculations to determine the key components. This detailed analysis leads to the development of the basic design stage, where the model achieves an LOD of 300, indicating the availability of information about materials and systems (Catenda, 2023). As the design progresses through the FEED stage, more detailed information becomes available, allowing for more informed design decisions.

In the FEED stage, the outcomes of the basic design phase are integrated into a comprehensive design that meets technical and economic requirements, with the LOD

reaching 350, signifying the integration of elements. This stage allows for more specific decisions related to the product, as well as more precise estimations and comparisons.
The final phase of the design process is the detailed design stage, during which final calculations are performed, technical specifications and engineering documents are created, and executive and construction plans are prepared. The LOD at this stage is 400, providing specific information about the entire model and allowing for precise comparisons and calculations with minimal design changes (Catenda, 2023).

2.5.1 Tools and methods

The development and design of a building is a very complex process that is influenced by a large variety of variables. In the traditional design process, design decisions were made based on the personal experience of the designers. As a result, designers were often not capable of fully exploring all the design solutions. Nowadays there are several tools that can be used to provide designers with the required data to make informed design decisions.

Revit and SketchUp are two of the most widely used software applications for 3D modeling in the architecture, engineering, and construction (AEC) industry (Hnin, 2024; Jiang, 2011). Another commonly utilized tool by architects during the design phase is ArchiCAD (Archicad, n.d.; KUBUS BV, 2024). SketchUp is often regarded as the easiest tool to use, while Revit is noted for having the steepest learning curve, with ArchiCAD positioned somewhere in between these two (Archisoup, 2024; Hnin, 2024; Robert Mann Architecture and Design Pty Ltd, 2020). Both ArchiCAD and Revit are BIM software tools, enabling users to create and manage all data related to a building within a single model, making them valuable for professionals such as architects, project managers, and developers (Archisoup, 2024; Christo, 2024; Hnin, 2024). In contrast, SketchUp is not categorized as BIM software, as it does not allow for the creation and storage of additional building-related data within the model. However, its straightforward nature makes it less time-consuming and more accessible, thereby appealing to users of all skill levels (Archisoup, 2024; Hnin, 2024).

Both ArchiCAD and Revit are BIM software systems that facilitate the creation and storage of model data, enabling users to analyze and utilize this information effectively (Archisoup, 2024; Christo, 2024; Hnin, 2024). This functionality allows for the extraction of data from the model for further analysis or calculations. In contrast, SketchUp lacks this capability, as it does not support data assignment to the model and is primarily a design software (Trimble Inc., n.d.). A common feature among these three tools is that they all require manual modeling of a design. This means that to create and compare different designs, each one must be modeled manually before any comparisons can be made.

Generative design (GD) is a methodology that utilizes Artificial Intelligence (AI) to create and evaluate design alternatives based on user input. This approach considers various factors, such as performance requirements and material properties, to produce optimized designs (PTC, 2023). As a result, generative design enables the automation of the design creation process. All three tools mentioned are capable of parametric modeling using platforms like Grasshopper or Dynamo. These visual programming tools allow users to develop algorithms that generate designs by modifying various design parameters (Graham, 2023). While both Revit and ArchiCAD can optimize models using their data, optimizing in SketchUp is more limited due to a lack of model data.

In addition to generative design capabilities found in ArchiCAD, SketchUp, or Revit, there are other tools available that complement these software options. Testfit and Archistar are generative design tools that can be utilized during the pre-design and conceptual design stages to create and evaluate designs based on specific criteria (aec+tech, n.d.-a; aec+tech, n.d.-b; Archistar, 2024). Planalogic is a Dutch company that employs generative design to create and assess designs based on defined parameters (Planologic, n.d.). These software tools have the potential to enhance building efficiency by optimizing design. However, none of these tools currently account for the possibility of defining a shared facility or a combination of shared facilities as a design parameter.

2.5.2 Conclusion

The design process for housing development can be characterized as complex yet well-structured. It begins with feasibility studies and culminates in a detailed design. The design phase, situated between these two stages, features an increasing level of detail and a growing amount of data, as indicated by the Level of Development (LOD). Various tools are available to assist designers during this phase in generating and evaluating design solutions. While Revit, SketchUp, and AutoCAD are widely recognized, these design tools require manual creation or adjustment to develop different alternatives for comparison. Generative design presents a solution by automating the creation of design alternatives. By utilizing adjustable design parameters, it is possible to manually or automatically produce diverse design solutions. When combined with the data embedded in the model, this approach allows for further design optimization. Nevertheless, it appears that none of these tools currently incorporate shared facilities as a design parameter.

2.6 Cost estimation

The overall aim is to have highly predictable, cost-effective construction projects. However, construction projects are carried out over a long period of time and are complex. As a result, they face high levels of uncertainty and several risks that can affect the project outcomes (Biolek & Hanák, 2019). Therefore, cost estimation is a crucial iterative process used to produce accurate cost estimates, which in turn are used to determine the financial feasibility of a project and consider alternative solutions. Cost estimation involves quantifying and valuing project resources and continuously updating the estimates as new information becomes available during the design phase. Different cost estimation methods are utilized, and the choice of technique depends on the available information, the project design phase's specific objectives, the required accuracy level, and the effort to create the cost estimation (Miranda et al., 2022; Ramos, 2020).

The American Society of Professional Estimators (ASPE) uses a five-level system to categorize the accuracy of cost estimations in construction (Ramos, 2020). This system demonstrates that the precision of cost-estimating methods varies based on the intended use of the cost estimation. When considering the different phases, particularly during the design of a construction project and the LOD at these stages, it becomes evident that accuracy improves as the design becomes more refined, as depicted in Table 18.

Table 18: The five level system of cost estimations methods and their LOD based on Ramos (2020)

Level	Name	Accuracy	Purpose/Use	Common method	(Design) Phase	LOD
Level 1	Order of magnitude	Very low	Screening decision	Analogous, parametric, expert judgement	Feasibility studies	
Level 2	Feasability	Low	Go/No-go decision	Parametric	Conceptual design	200
Level 3	Preliminary	Moderate	Budget authorization, design decision	Bottom up - unit cost assembly level	Basic design	300
Level 4	Substantive	High	Bid/tender control	Bottom up - unit cost detailed	FEED design	350
Level 5	Definitive	Very high	Bid/tender, check estimate, control, performance evaluation	Bottom up - unit cost detailed	Detailed design	400

Cost estimation methods can be classified into qualitative and quantitative methods. Qualitative methods rely on the estimator's knowledge about the project, factors that influence the project, and project scope. They are based on the result of past estimations of the professional based on judgments (Hashemi et al., 2020). On the other hand, quantitative estimation methods rely on the analysis and application of historical data to estimate the costs (Hashemi et al., 2020).

One commonly used estimation method is the analogous estimation method, which falls under quantitative estimation methods (Ashburn & Goff, 2024; Hashemi et al., 2020). According to Rad (2002), this method is the easiest to apply. However, Ramos (2020), Ashburn & Goff (2024), and Hashemi et al. (2020) note that it has low accuracy because it relies on comparing the project costs of previous similar projects to estimate the specific project costs. Expert judgment, a qualitative method often used in conjunction with the analogous estimation method, involves estimations made by experts drawing on their knowledge and previous experience (Hashemi et al., 2020). As this method is largely intuition-based, it also has low accuracy. Nonetheless, expert judgment and analogous methods are applicable with minimal project information, within a short timeframe, and at low cost (Ashburn & Goff, 2024; Hashemi et al., 2020; Ramos, 2020). Therefore, these methods are primarily employed during feasibility studies.

Parametric construction cost estimating is considered to be more precise than analogous estimating methods. However, it requires more time and data since it relies on project parameters (Ramos, 2020). As a result of the increased accuracy, it is commonly used for level 2 cost estimations. In cases where more accurate cost estimations are needed, this method is also applied during level 1 estimations (Ramos, 2020). In this method, project parameters are multiplied by the construction costs of specific parameters based on previous projects (Ashburn & Goff, 2024). For example, if an apartment building has a gross floor area (GFA) of 100 m2, and the average construction cost per GFA based on previous projects is €200, the estimated construction costs would be €200,000. In the Netherlands, parametric estimation methods are often applied based on key figures and the GFA or volume of the designed building following level 1 of the NEN 2699 (Interplan bouwsupport, n.d.)

The cost estimations for construction at levels 3, 4, and 5 are derived using the bottom-up approach, albeit at varying levels of detail. This method involves calculating the total estimated costs by aggregating the estimated costs of a project's necessary components (Ashburn & Goff, 2024; Ramos, 2020). Detailed consideration of the project and material takeoffs are combined with information about product and labor costs to make these estimations (Ashburn & Goff, 2024). While this approach offers a high level of accuracy, it

necessitates a substantial amount of data and is time-consuming and, therefore, costly (Ashburn & Goff, 2024; Hashemi et al., 2020).

In the basic design phase, a bottom-up approach is employed at the unit cost assembly level. Here, project elements are organized into unit groups, and cost estimates are developed for each group (Ramos, 2020). This method is referred to as component estimation in the Netherlands, adhering to the NL-SfB coding structure and corresponding to level 2 of the NEN 2699 (Interplan bouwsupport, n.d.). The data regarding the utilized components and quantities must be extracted from the architectural models or calculated based on the architectural designs, contingent upon the software system employed for the design. The costs associated with the various components are determined based on previous projects and company-specific pricing agreements with subcontractors. While this construction cost data is moderately accurate, it serves as a useful tool for making informed design decisions and obtaining budget approval during the basic design phase.

As the project progresses to the FEED and detailed design phase, the level of detail increases to the unit level. Each element or group of elements is individually analyzed for cost estimations. Both level 4 and 5 cost estimations are highly accurate, with level 5 estimations surpassing the accuracy of level 4 since level 5 estimations are predominantly based on quotations and agreements (Ramos, 2020). In the Netherlands, level 4 estimations are called element estimations and align with the NL-SfB coding structure. These calculations correspond to level 3 of the NEN 2699 and provide insight into the estimated costs at the element level (Interplan bouwsupport, n.d.). Level 5 estimations are often referred to as element budgets in the Netherlands and consist of detailed substantiations of the cost estimations in line with the NL-SfB coding structure (Interplan bouwsupport, n.d.).

2.6.1 Tools

Two types of cost estimation methods can be considered: manual and BIM methods. Manual methods rely on drawings of the building, which a quantity surveyor uses to measure and calculate the quantities manually. The BIM method utilizes the BIM model of the building to assess product and quantity data (Haider et al., 2020).

A more detailed examination of the BIM method for cost estimation reveals two distinct approaches for utilizing product and quantity data from the model in cost assessments (Jiang, 2011). The first approach entails extracting product and quantity data through data take-offs. To conduct the data take-off, data take-off functions within tools like Revit and Archicad can be used, or plugins or external software can be used. This information can then be exported to a spreadsheet or an external database, enabling the integration of construction cost data. It was found that Excel is the most commonly used tool for estimating construction costs (Jiang, 2011). Such integration may be accomplished by connecting the spreadsheet or database to a cost database or, alternatively, by having a quantity surveyor process the data and assign estimated construction costs. The second approach involves directly linking the cost database to the data within the BIM model. For instance, plugins can be employed in programs like ArchiCAD, facilitating direct cost estimations of the design without relying on data take-offs (Jiang, 2011).

In the manual method, product and quantity data are typically recorded in spreadsheets or databases, allowing for the assignment of construction costs (Haider et al., 2020). However,

because this data is entered manually, it can lead to human errors, resulting in less accurate and reliable cost estimations compared to BIM estimation methods. However, to ensure the correctness and accuracy of the estimations, it is required that the BIM model is accurately constructed and that data is correctly assigned to the objects. Aligning the data is especially important when a direct connection between the model and the cost database is made to ensure that the costs are assigned correctly to the associated products. Achieving accurate modeling and data alignment is time-intensive and, consequently, costly (Jiang, 2011).

Accessing a cost database is essential for obtaining accurate and up-to-date construction cost data (Ellis, 2024). Numerous construction cost databases exist at various levels of detail. Some are designed to provide data for rough cost estimations based on project parameters such as building type, location, and GFA; examples include Bouwkostenkompas (Calcsoft bv, n.d.). In contrast, other estimation software systems, like ProEst and Sage, utilize databases that track construction costs at the element level (Sage Group plc, n.d.; ProEst, n.d.). However, relying on a general cost database may overlook project-specific factors, such as the construction process and company-specific considerations (Jadhav, 2024).

2.6.2 Conclusion

It can be concluded that cost estimation is a critical process in the design and development of housing, as it ensures the project's feasibility. The method chosen to assess construction costs depends on the project's design stage, with accuracy increasing as the design process progresses. Furthermore, there are two primary approaches to estimating construction costs: manual methods and BIM-based methods. While BIM-based methods require a well-modeled design, they offer greater accuracy and reliability, making them preferable to manual techniques. Although construction cost data is available in numerous databases, such data often lacks company- and project-specific information. Consequently, it is still common to utilize the BIM model for quantity take-offs while employing Excel to assign construction costs.

2.7 Conclusion

It can be concluded that various factors influence the Dutch housing market, with the interplay of supply and demand being the most significant. Currently, demand exceeds supply, creating challenges for first-time buyers in their search for affordable housing. Most first-time buyers are single or two-person households whose financial capabilities are limited by the maximum mortgage they can obtain, which is determined by both the characteristics of the household and the dwelling itself. This highlights that affordability is the key criterion when evaluating suitable housing options for first-time buyers.

Moreover, there are differences in the types of housing sought by first-time buyers. As a result, a generalized approach to defining the housing needs and preferences of first-time buyers is insufficient, given the variety of factors influencing these aspects.

While affordable housing is recognized as a fundamental human right, it is found that most dwellings in the Dutch housing market are not affordable for first-time buyers. Furthermore, a disparity exists in housing affordability between single-person and two-person households, with dwellings generally being less affordable for single-person buyers. This can be attributed to the larger usable floor area (UFA) of most dwellings, a situation that is particularly pronounced when comparing the UFA per person between single-person and two-person

households. Therefore, reducing the UFA of dwellings should be considered a solution to enhance housing affordability, especially for single-person first-time buyers.

Shared facilities in residential buildings are often adapted to address financial constraints. Given the current circumstances, shared facilities offer a solution for enhancing housing affordability. Additionally, research and existing projects indicate that shared spaces such as gardens or terraces, kitchens, bike parking areas, living rooms, laundry rooms, and workspaces contribute to reducing construction costs and have a positive impact on environmental performance.

To assess the impact of shared facilities on environmental performance, various internationally recognized sustainability rating and certification systems can be employed. Localized assessment methods, utilizing national or regional life cycle assessment (LCA) data, tend to provide more comprehensive insights within the local context. Consequently, the MPG, which serves as the assessment method for environmental performance in the Netherlands, should be considered for evaluating the environmental impact of residential buildings in the Netherlands. This is particularly significant, given that regulations also rely on this method. Nonetheless, it is important to highlight that there is only one freely available tool for assessing this method, and it currently lacks the functionality to create and compare designs that incorporate shared facilities.

Moreover, it can be concluded that there are numerous tools available for use throughout the design process to create and assess various designs. However, all these tools necessitate manual creation or adjustment to generate different alternatives for comparison. This issue is effectively addressed by generative design tools, which utilize design parameters to automatically produce design alternatives. Nonetheless, it seems that none of these tools currently incorporate shared facilities as a design parameter.

The tools used for creating and evaluating designs can also be adapted for estimating construction costs, much like generative design tools. Therefore, it is essential to integrate these tools with a database to facilitate direct cost estimations. However, it has been noted that when connecting to general data within a database, the specific impacts of a project or company on construction costs can be overlooked. As a result, many companies extract quantities and products using these models but ultimately rely on Excel as their calculation tool. Furthermore, while cost estimation can be based directly on a model, it still requires the manual creation of the design for which the construction costs are being determined.

Therefore, it can be concluded that a method that can be used to test multiple design variants and the impact of these on the construction costs and environmental performance of a building without the need to model them individually is missing.

3 Methodology

This chapter describes the methodology that is used to execute the research. To address the research questions and structure of this master's thesis, the design science research methodology will be employed. According to Hevner (2007), design science research aims to enhance the environment by introducing and constructing new artifacts. Wieringa (2014, p. 10) further explains that, in addition to creating new artifacts, design science research involves examining artifacts within their context. The design artifact for this thesis is to provide insight into the impact of shared facilities on the environmental performance and affordability of an apartment building for first-time buyers in the Netherlands. Designing and investigating artifacts in design science research involves iterative problem-solving and addressing knowledge questions (Wieringa, 2014, p. 10). Wieringa's (2014) framework for design science illustrates how design science interacts with the knowledge and social contexts of the artifact.

Figure 34 visualizes the framework for design science for this master's thesis. It indicates that the social context encompasses the stakeholders and their objectives and that in this thesis, the stakeholders are the intended users of the tool, which are professionals involved in the design process of affordable dwellings for first-time buyers in the Netherlands, seeking to gain insight into the impact of implementing one or multiple shared facilities in an apartment building on the construction costs and environmental performance early in the design process. The knowledge context involves literature about design science and specifications, which will be utilized to structure and evaluate the design process. The available literature about the different aspects of the artifact will be used to create a research framework. The requirements that must be fulfilled are defined by considering the regulations and calculation methods described in the "Besluit bouwwerken leefomgeving" and the data from Stichting NMD. Practical knowledge and common sense will also be applied throughout the entire process.

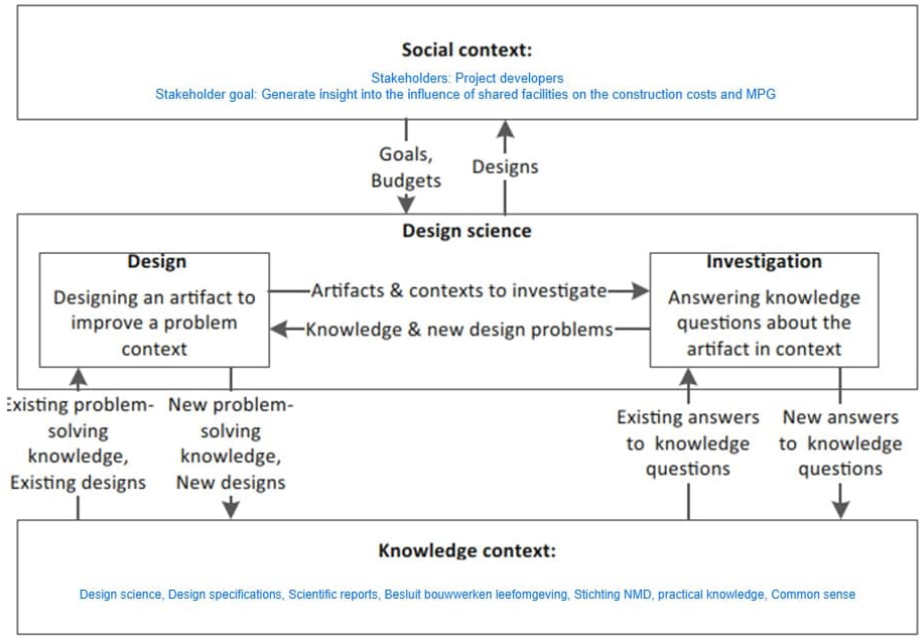


Figure 30: The Framework for design science as proposed By Wieringa (2014, p. 7) and adjusted to represent this master thesis

3.1 Design Cycle

The design cycle is used to structure design science and interactions with the social and knowledge context. The design cycle is part of the engineering cycle and consists of three phases: the implementation evaluation/problem investigation phase, the treatment design phase, and the treatment validation phase (Wieringa, 2014, p. 28). Throughout this master's thesis, the design cycle approach proposed by Wieringa (2014), as depicted in Figure 35, will serve as the guiding structure.

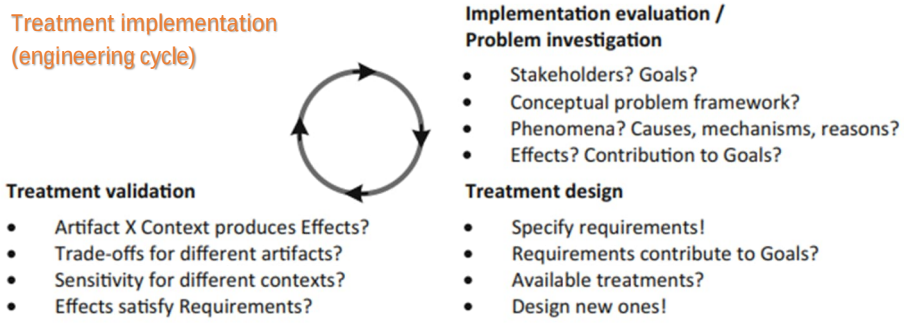


Figure 31: The design cycle (Wieringa, 2014, p. 28)

To investigate the design artifact and address the design problem, a decision support tool has been developed to offer project developers insights into the impact of shared facilities on the construction costs and environmental performance of apartment buildings for first-time buyers in the Netherlands. The development process of this tool follows the design cycle, starting with identifying the stakeholders involved in the decision support tool, which includes professionals engaged in the design of affordable housing. Based on the literature & statistical data review, a conceptual problem framework is established. This framework and the knowledge obtained from the literature will be utilized to further explore the causes, mechanisms, and factors associated with the artifact. The final step of this initial stage involves considering how the decision support tool can provide early insights into the effects of shared facilities on the affordability and environmental performance of buildings and how these insights can be used to improve the affordability and environmental performance of apartment buildings for first time buyers in the Netherlands.

The next step in the decision support tool involves outlining the requirements for the functionality and output of the decision support tool. After establishing the tool's requirements and their contribution to the overarching goal of enhancing the affordability of homes for first-time buyers, as well as ensuring these homes comply with environmental performance standards, a decision support tool will be designed in which these specified requirements are integrated.

In the third and final stage of the design cycle, the effects of shared facilities on the MPG and construction costs of an apartment building intended for first-time buyers in the Netherlands will be evaluated through a case study. Drawing upon the findings from the literature & statistical data review and the opportunities identified within the reference project's design, six shared facilities are defined to assess their impact on both the MPG and construction costs of the reference building. Various configurations of the shared facilities will be tested, and the results will be presented in a summary table.

Throughout the entire design process of the decision support tool, a summative evaluation method, known for its more artificial approach, is utilized to validate its accuracy and outcomes. In the third stage of the design cycle, a thorough technical validation of the complete tool is performed to conclude the design process. Functional validation is conducted through an ex-post analysis based on ten Boolean design requirements. Additionally, expert interviews are carried out, employing both summative and naturalistic evaluation methods to collect qualitative data regarding the tool's usability and potential improvements from the intended users of the tool's perspective. Furthermore, the case study is utilized to validate the design process.

Upon finalizing the design cycle, the case study outcomes are utilized to answer the research question. Additionally, the insights gained from the case study, along with findings from the literature & statistical data review concerning the affordability and environmental performance of homes for first-time buyers, as well as the willingness to share facilities among first-time buyers in the Netherlands, are considered to conclude the extent to which shared facilities can increase the affordability and/or environmental performance of apartment buildings for first-time buyers in the Netherlands. Ultimately, the quantitative data collected from expert interviews will be used to conclude the potential implementation of this tool in the design process of apartment buildings aimed at first-time dwelling buyers in the Netherlands.

3.2 Tool development

The initiation of the problem evaluation phase within the design cycle employs the CAMO logic framework, as articulated by Denyer et al. (2008), to define the design principle, which can be defined in the following manner: In order to overcome the existing and expected problems with the development and construction of affordable dwellings for first-time buyers in the Netherlands (C), a decision support tool needs to be developed (A), to determine the impact of shared facilities on the environmental performance and construction costs of a building (M) in order to consider if the application of shared facilities in an apartment building for first-time buyers in the Netherlands can positively contribute to the development and construction of affordable dwellings for first-time buyers in the Netherlands that meet environmental performance standards (O).

From the design principle, it can be concluded that the stakeholders are intended users of the tool, which are professionals engaged in the design, development, and construction stages of affordable housing for first-time buyers, where design decisions regarding the application of shared facilities are made. These are project developers, architects, and consultants. The goal of these stakeholders is to utilize the decision-support tool to determine the impact of shared facilities on the environmental performance and construction costs of the building, such that they can consider if the application of shared facilities positively contributes to the development and construction of affordable dwellings for first-time buyers in the Netherlands that meet environmental performance standards.

During the basic design stage, the conceptual design is refined using a combination of field studies and engineering calculations to determine the key components. This implies that during the basic design stage, design decisions regarding the application of shared facilities are made. To consider if the application of shared facilities in an apartment building for first-

time buyers in the Netherlands can positively contribute to the development and construction of affordable dwellings for first-time buyers in the Netherlands that meet environmental performance standards, the impact of shared facilities on the environmental performance and construction costs of a building needs to be determined during the Basic design stage. Therefore, the scope of the decision support tool that needs to be developed is the basic design stage, as visible in Figure 36.

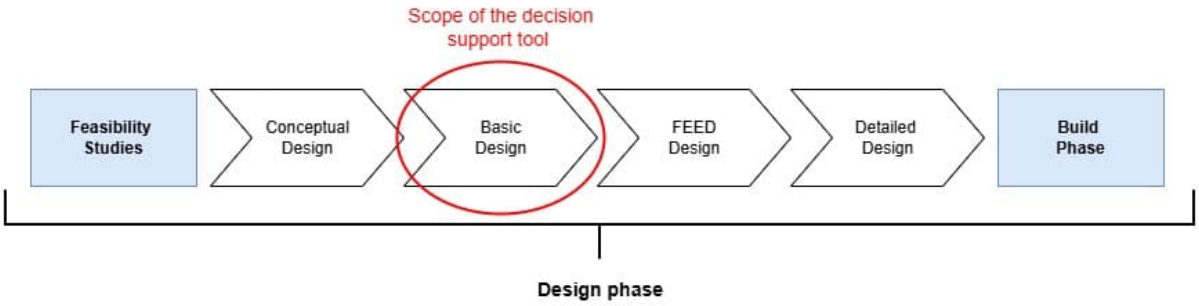


Figure 32: Scope of the decision support tool

3.2.1 Design requirements

The next step is the definition of the design requirements, which aligns with the treatment design step of the decision support tool. The design requirements are categorized into functional requirements, user requirements, boundary conditions, and design restrictions (Van Aken et al., 2007).

Ten functional requirements are defined and must be implemented in the decision support tool to ensure that the impact of shared facilities on the environmental performance and construction costs of a building can be determined during the basic design stage.

1. The construction costs and environmental performance must be indicated per building element, and for the complete building, they must align with the NL-SfB coding structure.
2. Costs associated with the development and construction of housing, other than construction costs, must be incorporated into the decision support tool.
3. It must be possible to add NMD data and construction costs data to the database of the decisions support tool, and it needs to be possible to edit or delete the data stored in the database of the decision support tool.
4. The decision support tool needs to provide an overview of the data stored in the tool's database.
5. Product data stored in the tool's database can be accessed and used for calculations and analyses.
6. It must be possible to store product-specific environmental performance and construction cost data in the decision support tool
7. To assess the impact of shared facilities on the construction costs and environmental performance of a building, several predefined shared facilities need to be selectable in the decision support tool
8. It must be possible to create different design variants in the decision support tool to test different combinations of shared facilities.
9. The influence of a shared facility or combination of shared facilities on the construction costs of the original design needs to be indicated for the entire building.

10. The influence of a shared facility or combination of shared facilities on the environmental performance of the original design needs to be indicated for the entire building.

Functional requirement 1 ensures that the data entered and stored aligns with the coding structure utilized in both MPG and construction cost estimations. Functional requirement 2 acknowledges that the transaction price of housing is not determined solely by construction costs. As a direct connection to the NMD database is not feasible, it is imperative that NMD data can be stored, updated, or removed from the tool's database. To accurately calculate the construction costs and MPG of a project, the system must allow for the creation and storage of project-specific data, leveraging the NMD data stored in the local database. This functionality is supported by functional requirements 3, 4, 5, and 6. Furthermore, to address the limitations of existing tools, which lack the capability to select and compare various shared facilities, functional requirements 7 and 8 have been established. Functional requirements 9 and 10 are designed to ensure that users can directly consider impacts, thereby reducing the potential for human interpretation errors.

Functional requirements 1, 4, 7, 9, and 10 are also considered user requirements. User requirements are requirements defined based on the user's viewpoint (Van Aken et al., 2007). Besides these five functional user requirements, two non-functional user requirements are defined. These two non-functional requirements describe how the decision support tool needs to perform to ensure the usability and intuitiveness of the tool and are described below (AltexSoft, 2023):

1. The tool's usability needs to be considered sufficient according to the intended users of the decision support tool.
2. The tool needs to feel intuitive for the intended users of the decision support tool.

The following boundary condition must be met unconditionally to secure the correctness and accuracy of the tool and its outcomes:

1. The calculation method that is applied in the decision support tool to determine the environmental performance of a building should be in line with the calculation rules for environmental performance calculations in the Netherlands, which Stichting NMD defines (Stichting Nationale Milieudatabase, 2021a)

Finally, one design restriction is defined. It states that the decision support tool is preferably created in an open-source software system.

3.2.2 Software system

A software system needs to be selected to build the decision support tool. The software system to build the decision support tool is considered a design parameter. To determine the parameter value, the parameter range, consisting of the available software systems, needs to be considered, and eventually, a design decision needs to be made by selecting one software system to build the decision support tool. A set of requirements and preferences has been defined to facilitate the assessment of various software systems, as indicated in Table 19. These criteria will help evaluate the different software options and are based on the previously defined functional and user requirements and the design restriction.

Table 19: The defined requirements and preferences that are used to evaluate the different software systems

Requirements
It must be possible to store data in the tool or in a database connected to the tool.
It must be possible to add data to the database and to edit or delete data stored in the database.
It must be possible to provide an overview of the data that is stored in the database.
It must be possible to create and compare different variants.
It must be possible to create and compare different variants.
It must be possible to create an intuitive user interface.
Preferences
An open-source software system is selected to allow easy modification of the decision support tool by its users.
The selected software system is familiar to the intended users of the tool.

After conducting an initial search for software development systems, it was found that the market offers a wide range of software systems for building decision support tools. Furthermore, it was found that software systems can be divided into three categories: data analysis and visualization software, programming languages, and spreadsheet-based solutions. Therefore, a selection of software systems is made consisting of two data analysis and visualization software systems, two programming language-based software systems, and two spreadsheet-based software systems. The selected software systems are Microsoft Power BI, Python with Pandas and Tkinter, Excel VBA, R with Shiny, Tableau, and Google Sheets with Apps Script.

The first selection is made by comparing the user-friendliness of similar types of software systems, after which the software system which the highest considered user friendliness will be further evaluated. Python is considered more intuitive and easier to use than R and will, therefore, be further evaluated. (Luna, 2022; Coursera Staff, 2024). Microsoft Excel is widely used and familiar to many individuals and organizations, making it the preferred choice over Google Sheets (Mangindin, 2022; Mitchell, 2023). Both Tableau and Microsoft Power BI are widely used analytics and business intelligence platforms. Power BI boasts the largest market share and has a user-friendly interface which is comparable to Microsoft Excel. On the other hand, Tableau provides more advanced functionalities and flexibility (Manis, 2024; Gartner Inc., n.d.). Since the user-friendliness of both software systems is considered equal, both options will be further evaluated.

Python with Pandas and Tkinter

Python is a user-friendly programming language suitable for application development (Python, n.d.). Pandas, a powerful data analysis and manipulation tool built on top of Python, stores data in various databases or files. Additionally, Pandas is proficient in data manipulation and variation comparison (Pandas, n.d.). The standard Python library Tkinter facilitates stakeholder interaction with the tool and creates intuitive user interfaces (Python Software Foundation, n.d.). Using Python with Pandas and Tkinter does not require a license, as Python is open-source and freely available.

Excel VBA

Microsoft Excel is a versatile spreadsheet program for organizing, analyzing, and visualizing data (Microsoft, n.d.-a). Data can be stored in Excel sheets or linked databases and then

visualized in tables and graphs. Different scenarios can be created by utilizing multiple sheets or scenarios. Excel Visual Basic for Applications (VBA) is a powerful programming language that extends the functionalities of Excel. With VBA, users can create forms and macros to add, update, or remove data, enabling seamless user interaction and intuitive user interfaces (Microsoft, 2022). Excel is widely used across various industries, including the built environment, where it is relied upon for cost estimations by many companies and professionals (Mitchell, 2023; Rodriguez, 2024). While a Microsoft license is required to use Excel VBA, the widespread availability of Microsoft Office means that obtaining a license is typically straightforward for most users.

Tableau
Tableau is a user-friendly software that was developed to analyze and visualize data. Tableau can connect to different databases to retrieve and store data and has extensive capabilities for data visualization. Scenario comparison can be done by creating interactive dashboards, while the many options to visualize the data ensure the creation of an intuitive dashboard (Tableau, n.d.). Tableau Prep can be used to manipulate the data (Tableau Prep Builder, n.d.). A license is required to use Tableau, but students can obtain a free student license for one year (Tableau Voor Studenten, n.d.).

Microsoft PowerBI
Microsoft PowerBI can connect to various databases for storing and extracting data and offers extensive features for data visualization. It allows the creation of interactive dashboards for scenario comparison. While numerous options exist for creating an intuitive dashboard, mastering more advanced tasks in Microsoft PowerBI may have a steep learning curve (Agnese, 2024; Chernik, 2024; Patnaik, 2024). Data manipulation can be performed using Power Query (Microsoft, 2024). A license is necessary to use Microsoft PowerBI (Microsoft, n.d.-b).

The analysis indicates that all the software systems meet the tool requirements, each with its advantages and disadvantages. As emphasized by Stoltz et al. (2023, p. 14), it is essential to prioritize the needs of stakeholders and users during the tool's development to ensure its success. The stakeholders are, the intended users of the tool, which are professionals engaged in the development and construction stages of affordable housing for first-time buyers, where design decisions regarding the application of shared facilities are made, and the decision support tool should determine the impact of shared facilities on the environmental performance and construction costs of a building in order to consider if the application of shared facilities in an apartment building for first-time buyers in the Netherlands can positively contribute to the development and construction of affordable dwellings for first-time buyers in the Netherlands that meet environmental performance standards. Since Excel VBA is widely used, it is considered the most familiar tool for the intended users of the tool. Furthermore, given the popularity of Excel, it can be assumed that the intended users of the tool already have a license for it. Therefore, Excel VBA was selected as the software system to build the decision support tool.

3.3 Tool testing and validation

Several steps must be undertaken to achieve the objectives and create a decision-support tool. The development of this tool will, therefore, be segmented into distinct phases. The first

phase involves defining a framework for assessing environmental performance, followed by integrating construction costs into this framework. Upon completion of the design process, which entails the implementation of the framework within Excel and the generation of several design alternatives, it is imperative to validate and test the developed tool. This validation process ensures the tool's functionality, reliability, and effectiveness in meeting the intended design objectives.

To test and evaluate the developed decision support tool, the Quick and Simple evaluation strategy, as defined by Venable et al. (2014), will be implemented. This strategy will include one summative and more naturalistic evaluation following the completion of the design process, along with a continuous series of summative and more artificial evaluations throughout the entire design process. This approach was chosen due to the limited timeframe and minimal risk involved in developing the decision support tool. Additionally, the developed tool is relatively small and straightforward, as its development is not the primary focus of the master's thesis.

3.3.1 Expert interviews

Qualitative data regarding the tool's usability and willingness to adopt the tool will be collected by conducting a summative and naturalistic evaluation through expert interviews following the completion of the tool's development (Venable et al., 2014). The tool will undergo testing and evaluation by three prospective users. This expert group comprises three project developers from different housing construction companies in the Netherlands. The participants include individuals in management, mid-level, and junior roles, offering a diverse range of professional experience.

Each participant will receive a concise introduction to the features of the decision support tool to ensure they can effectively utilize it. During this session, the following topics will be addressed and demonstrated:

- How to input project data, which includes:
    - Project information
    - Building characteristics
    - Financial principles
- Locating NMD product data and how to store this information in the tool's NMD_DATABASE using the “Launch NMD database form.”
- Accessing NMD data stored in the NMD_DATABASE and assigning project-specific quantities and construction costs to this data through the “Launch project data form.”
- Assigning relevant NMD data and construction costs to the corresponding shared facility using the “Launch shared facilities form.”
- Defining construction costs for shared facilities that cannot be linked to an NMD product applied within the shared facility.
- Setting the GFA/UFA and specifying any changes in UFA due to the shared facilities.
- Editing or deleting data from a specific database.
- Utilizing the “Variant comparison” feature to visualize the impact of various (combinations of) shared facilities on MPG and construction costs, and comparing these with the base design.

After a brief introduction to the decision support tool, participants will be assigned a task. This assignment involves evaluating the influence of various designated shared facilities on the base design, saving a product from the NMD database in the NMD_DATABASE of the tool, assigning the EPD of a kitchen to the shared facility “Kitchen” and removing a duplicate product from the base design. Upon completion of the assignment, the results will be discussed with the participants. Subsequently, questions will be posed to facilitate a deeper understanding of the participants' perspectives and experiences. The questions include:

1. Do you think that you are capable of using the decision support tool on your own project(s) with only the knowledge you have right now?
    a. If the answer is no: What do you need to make you capable of using the decision support tool on your own project(s)?
2. Does the tool provide you with sufficient information concerning the impact of the six considered shared facilities on the MPG and construction costs to make informed design decisions regarding the application of shared facilities?
    a. Do you have any suggestions on which data should be added to make informed design decisions regarding the application of shared facilities?
3. Does the tool feel intuitive to use and can you explain why?
    a. Do you have any suggestions to improve the intuitiveness of the tool?
4. What do you think about the user-friendliness of the tool?
    a. Do you have any suggestions to improve the user-friendliness of the tool?
5. Would you use this tool during the initial design phases of an apartment building for first-time buyers in the Dutch housing market to consider the application of shared facilities?
    a. If answered No: What prevents you from using the decision support tool during the initial design phases of an apartment building for first-time buyers in the Dutch housing market?
6. Do you have any other recommendations or points of improvement regarding the decision support tool and/or the way it is intended to be used?

3.3.2 Technical validation

Besides expert interviews to collect qualitative data regarding the tool's usability and willingness to adopt the tool, a summative evaluation method, characterized by a more artificial approach, will be employed throughout the entire design process and upon its finalization to validate the accuracy of the tool and its outcomes, as illustrated in Figure 37 (Venable et al., 2014). After introducing new functionalities and components to the decision support tool during the design phase, input data will be processed, and the resulting outcomes will be compared with anticipated results. These anticipated results related to environmental performance are determined using the MRPI-FREEtool developed by Stichting MRPI (n.d.-a). This tool is a validated calculation resource, making it suitable for assessing the expected environmental performance outcomes (Stichting Nationale Milieudatabase, 2021c). Meanwhile, anticipated results concerning construction costs are calculated in a standalone Excel document, where the costs for each material used are multiplied by the quantity required.

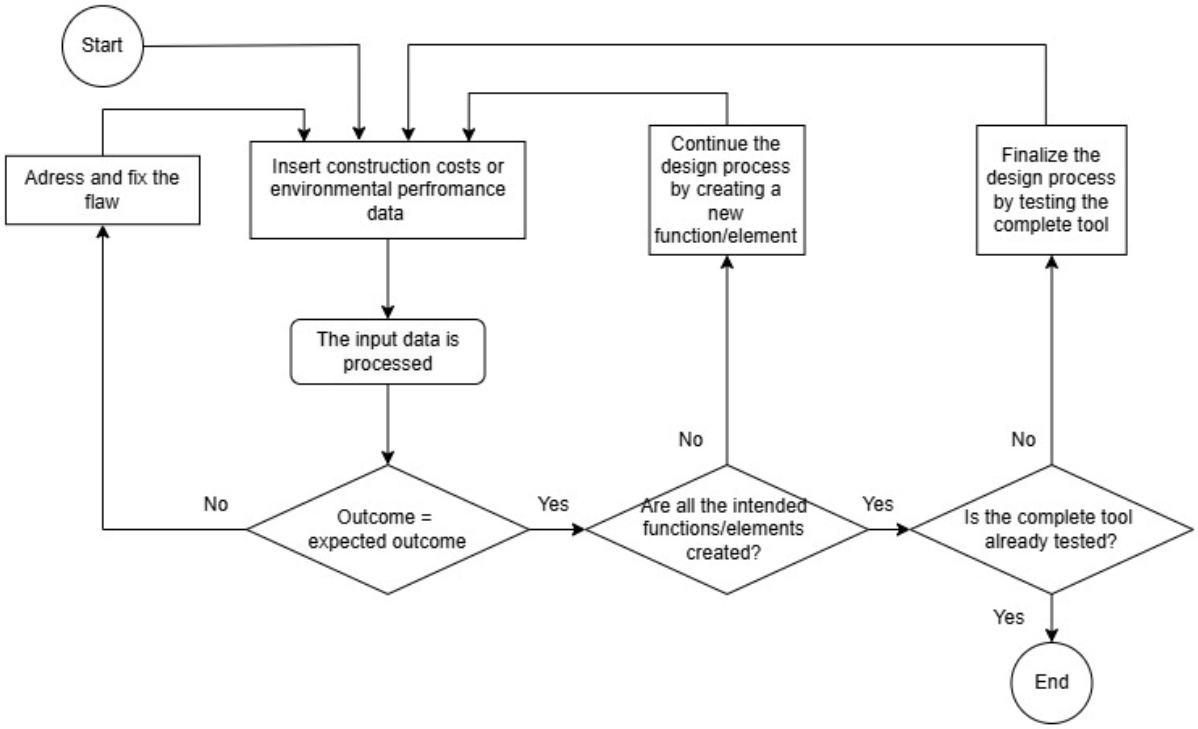


Figure 33: Technical validation process of the decision support tool during the design process

By comparing the outcomes derived from input data to the expected results, any potential flaws in the tool's performance or outcomes can be identified and addressed prior to implementing additional functions or elements into the decision support tool (MID-Software Partners & SP Swedish National Testing and Research Institute, 2004, p. 21). This iterative process will commence after the first function or element is added, continue throughout the entire design process, and conclude once the complete decision support tool has undergone thorough testing.

3.3.3 Functional validation

After conducting expert interviews and validating the correctness of the outcomes of the decision support tool, the tool will be evaluated through an ex-post analysis based on ten specified design requirements. These requirements are regarded as Boolean in nature, prompting their reformulation as Boolean conditions, as illustrated in Table 20.

Table 20: Ten design requirements reformulated as Boolean conditions

1	The construction costs and environmental performance are indicated per building element and for the complete building.
2	Costs associated with the development and construction of housing, other than construction costs, are incorporated in the decision support tool.
3	Environmental declaration and construction costs data can be added to the database, and stored data can be edited or removed.
4	An overview of the stored data is provided.
5	Product data stored in the NMD database of the tool can be used to perform calculations and analyses.
6	The decision support tool can store environmental performance data and construction cost data on product level.
7	A number of predefined shared facilities can be selected.
8	Different variants can be created and can be compared directly.
9	The influence of shared facilities on the construction costs is indicated for the complete building.
10	The influence of shared facilities on the environmental performance is indicated for the complete building.

These ten Boolean requirements will be used to conduct a completeness assessment of the tool.

3.3.4 Case study

The case study that will be undertaken is an integral component of the validation process. Through the utilization of the tool, its functionalities will be systematically examined. Consequently, this assessment aims to identify potential errors and areas for enhancement, which can then be addressed.

3.4 Conclusion

It can be concluded that the design cycle will serve as the framework for structuring the tool's development process. Consequently, design requirements have been established based on the design objectives. Additionally, Excel has been chosen as the software platform for tool development, given the intended users' familiarity with it. After the tool has been developed, it will be validated to assess its functionality, reliability, and effectiveness in achieving the intended design goals.

4 Development of the tool

The core structure of the decision support tool will be grounded in the environmental performance calculation method. Consequently, the initial phase of developing the decision support tool involves defining this calculation method for assessing environmental performance in the Netherlands. This includes understanding and implementing the specifications for the environmental performance assessment of buildings within the Netherlands.

The subsequent step will be to incorporate construction costs into this framework. This requires consideration of the methods for determining construction costs and the input data. The development of the tool will be completed with the implementation of the framework in Excel and the design of the user interface. Additionally, the input data for the decision support tool in Excel must be identified.

4.1 Environmental Performance Framework

The environmental performance of buildings in the Netherlands is assessed using the Milieuprestatie Gebouwen (MPG), which is the indicator of the environmental impact of a building's materials and plays a role in evaluating sustainability (Stichting Nationale Milieudatabase, 2022). The goal of the decision support tool is to develop an open-source MPG calculation mechanism that not only calculates the MPG but also the estimated construction costs of a project. Therefore, this tool can be classified as a calculation tool.

Figure 27 illustrates how calculation tools leverage the Dutch Environmental Database (NMD) alongside the Assessment Method to evaluate environmental performance. The NMD serves as a product database that contains Environmental product data for conducting MPG calculations. The Assessment Method offers a structured framework for these calculations, detailing general and construction-specific agreements and referencing the calculation rules. These guidelines are managed by the Stichting National Environmental Database (Stichting NMD) and are based on the European standard EN 15804:2012+A1:2019 (EN 15804) (Stichting National Environmental Database, 2022). This framework ensures clarity, verifiability, and adherence to established environmental standards. Consequently, it is imperative that the decision support tool is aligned with the assessment method and utilizes the data contained in the NMD as input.

4.1.1 MPG calculation

The environmental performance of buildings is assessed using the MPG and should be presented per m^2 GFA per year (Stichting Nationale Milieudatabase, 2021a). The initial step in evaluating the MPG of a building involves calculating the MKI per unit of a product, which reflects the product's environmental impact throughout the product's life cycle. The MKI per unit of a product for more than 4000 products has been established through life cycle analysis and is stored in the NMD using Environmental Product Declarations (EPDs) (Stichting Nationale Milieudatabase, 2021a).

To assess the MKI of a product within the context of the construction work, the MKI per unit of the product is utilized. The MKI for a given product is calculated by multiplying the MKI per unit by one plus the number of replacements anticipated over the lifespan of the building, as illustrated in Equation 1 (Stichting Nationale Milieudatabase, 2021b).

Equation 1: MKI of a product within the context of the construction work

$$MKI_{p,icw} = MKI_{p,l} * (1 + V_p)$$

$MKI_{p,icw} = MKI\ of\ product\ p\ as\ calculated\ in\ the\ context\ of\ the\ construction\ work$
$MKI_{p,l} = MKI\ per\ unit\ of\ a\ product\ of\ product\ p$
$V_p = number\ of\ replacements\ of\ the\ product\ during\ the\ lifespan\ of\ the\ construction\ work$

The number of product replacements throughout the lifespan of a construction project must always be positive, as any material is applied at least once during the lifetime of a building. This means that the number of replacements of the product during the lifespan of the construction work can be determined by dividing the lifespan of the construction work by the lifespan of the product, then subtracting 1, as illustrated in Equation 2 (Stichting Nationale Milieudatabase, 2021b).

Equation 2: Number of product replacements throughout the lifespan of a construction project

$$V_p = \frac{L_{cw}}{L_p} - 1$$

$V_p \geq 0, else\ V_p = 0$
$L_{cw} = lifespan\ of\ the\ construction\ work$
$L_p = lifespan\ of\ the\ product\ p$

Additionally, some of these MKI per unit of product values are scalable, meaning that a scaling factor can be applied to adjust the default value of the product. The scaled MKI of product p as calculated in the context of the construction work can be calculated by multiplying the MKI of product p as calculated in the context of the construction work by the scaling factor of p, as shown in Equation 3 (Stichting Nationale Milieudatabase, 2021a).

Equation 3: Scaled MKI of product p as calculated in the context of the construction work

$$MKI_{p,icw,scaled} = MKI_{p,icw} * SF_p$$

$MKI_{p,icw,scaled} = Scaled\ MKI\ of\ product\ p\ as\ calculated\ in\ the\ context\ of\ the\ construction\ work$
$SF_p = Scaling\ factor\ of\ product\ p$

After determining the MKI of product p as calculated in the context of the construction work or the scaled MKI of product p as calculated in the context of the construction work, the MKI of the construction work during the entire lifespan can be calculated. Therefore, the (scaled) MKIs of the products p as calculated in the context of the construction work need to be multiplied by their respective quantities utilized. Subsequently, these products must be aggregated, as illustrated in Equation 4 (Stichting Nationale Milieudatabase, 2021b).

Equation 4: MKI of the construction work during the entire lifespan

$$MKI_{cw,lifespan} = q_p \sum_{p=1}^{y} MKI_{p,icw} \text{ or } MKI_{cw,lifespan} = q_p \sum_{p=1}^{y} MKI_{p,icw,scaled}$$

$MKI_{cw,lifespan} = MKI\ of\ the\ construction\ work\ during\ the\ entire\ lifespan$
$q_p = Applied\ quantity\ of\ product\ p\ in\ the\ construction\ work$

After establishing the MKI of the construction work, the MPG of the construction work can be calculated by dividing the MKI of the construction work during the entire lifespan by the lifespan and GFA of the construction work, as illustrated in Equation 5 (Stichting Nationale Milieudatabase, 2021b).

Equation 5: The MPG of the building measured per m2 GFA per year

$$MPG_y = \frac{MKI_{cw,lifespan}}{L_{cw} * GFA_{cw}}$$

$MPG_y = The\ MPG\ of\ the\ building\ measured\ per\ m^2\ GFA\ per\ year$
$GFA_{cw} = The\ Gross\ Floor\ Area\ (GFA)\ of\ the\ construction\ work$

4.1.2 Input data

Six types of input data are required to determine the MPG of a building, as indicated in Table 21.

Table 21: Required input data to determine the MPG of a building

1	$MKI_{p,l}$; $MKI\ per\ unit\ of\ a\ product\ of\ product\ p$
2	L_{cw}; $lifespan\ of\ the\ construction\ work$
3	L_p; $lifespan\ of\ the\ product\ p$
4	SF_p; $Scaling\ factor\ of\ product\ p$
5	q_p; $Applied\ quantity\ of\ product\ p\ in\ the\ construction\ work$
6	GFA_{cw}; $The\ Gross\ Floor\ Area\ (GFA)\ of\ the\ construction\ work$

4.1.2.1 NMD

The MPG calculation tools, as illustrated in Figure 27, utilize data from the NMD to assess a building's environmental performance. Direct access to this database is exclusively granted to seven calculation tools validated and licensed by Stichting NMD (Stichting Nationale Milieudatabase, 2021c). Additionally, the information within the NMD can be accessed indirectly through the “Viewer” available on the Stichting NMD website, as shown in Figure 38 (Stichting Nationale Milieudatabase, n.d.-a).

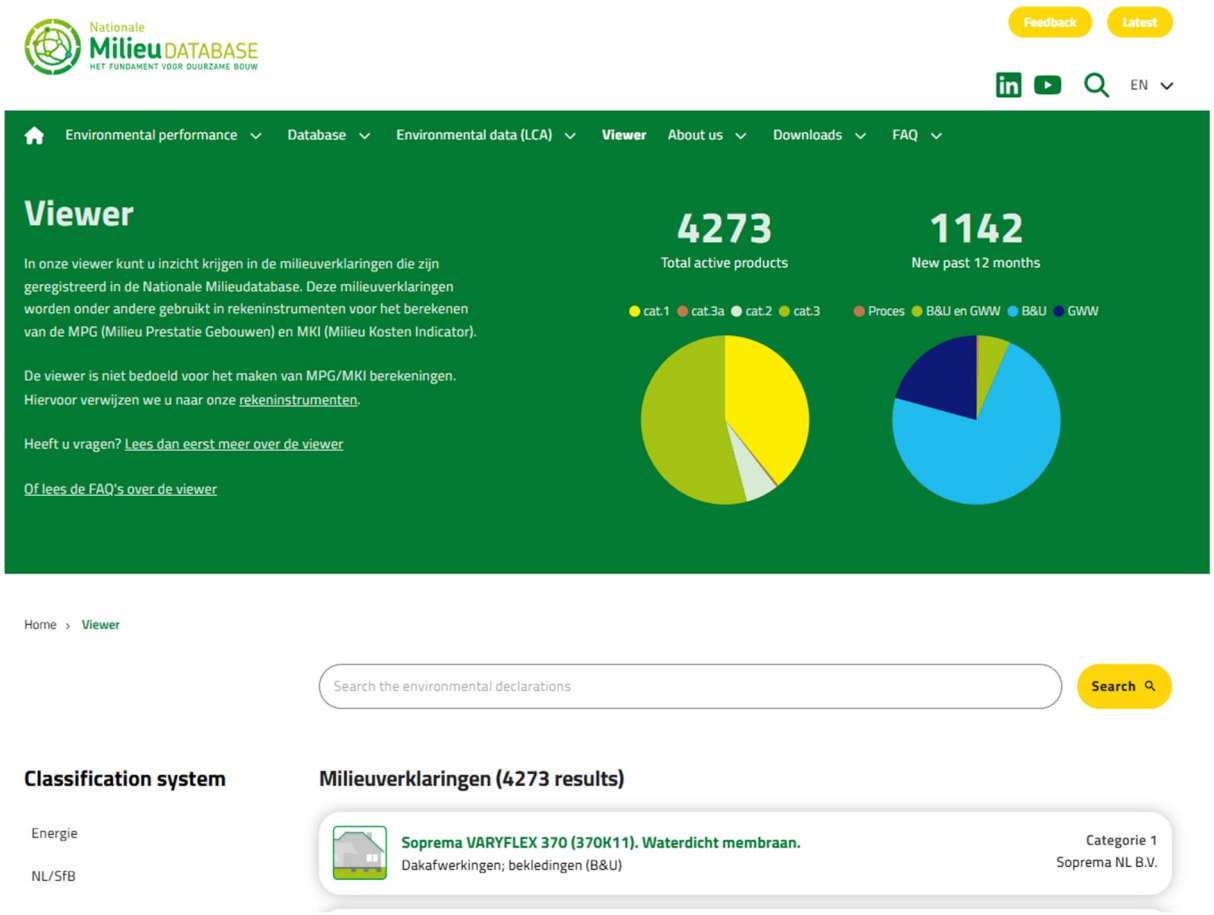


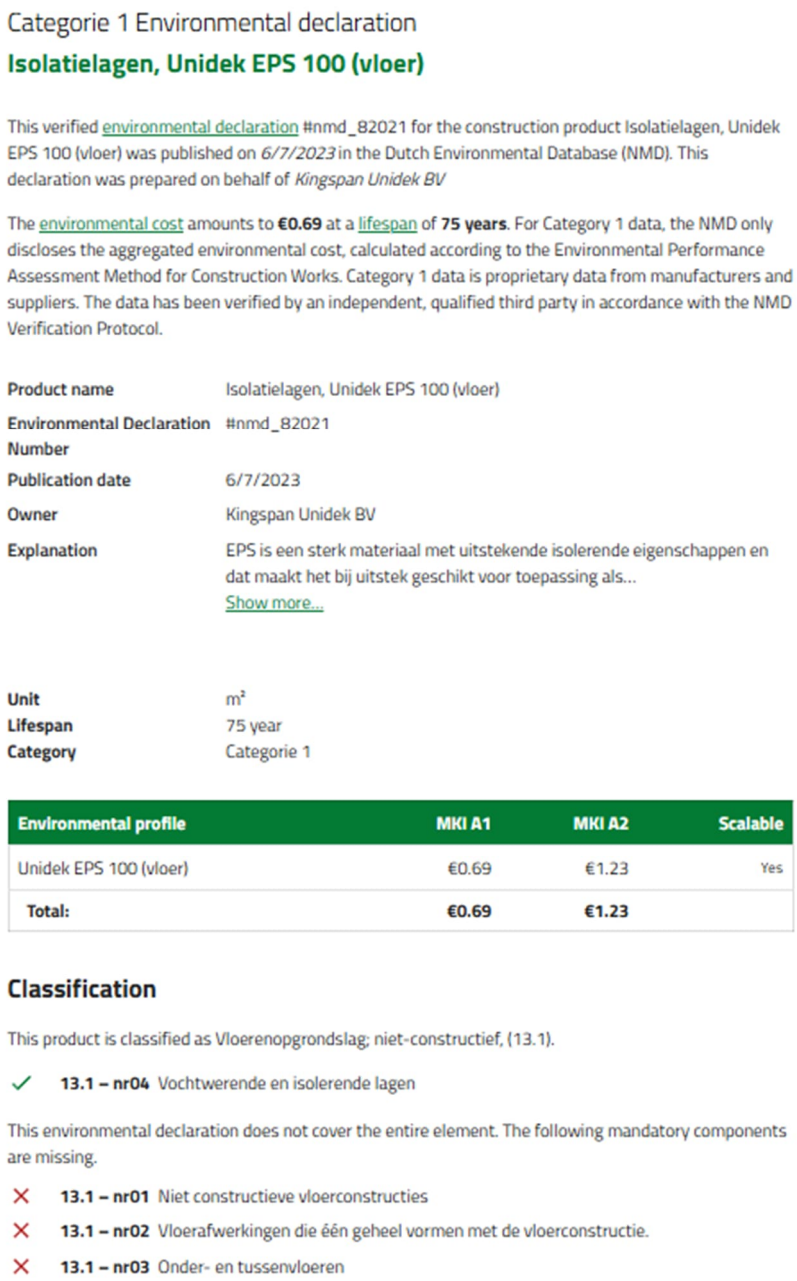
Figure 34: Screenshot of the NMD Viewer on the website of Stichting NMD (Stichting Nationale Milieudatabase, n.d.-a).

Table 22 displays the open-source data stored in an EPD, accessible via the NMD viewer. An example of an EPD can be found in Figure 39. Each environmental declaration is associated with a unique product name and environmental declaration number, along with publication and update dates. The owner of the environmental declaration is the individual or organization for which it was prepared, and the explanation provides details about the product.

Table 22: Data that is stored in an EPD which is accessible via the NMD Viewer

Product name
Environmental Declaration Number
Publication date
Updated at
Owner
Explanation
Unit
Lifespan
Category
MKI A1
MKI A2
Scalable
Classification

Additionally, specific product information is included, such as the unit for data input and the product's lifespan for calculating replacements over the building's lifespan. The category indicates the category of the EPD. The MKI generally consolidates a product's environmental impacts into a score in euros per unit. The MKI A1 is based on the current determination method, which includes 11 environmental impact categories, and MKI A2 is based on the new determination method, which includes 19 environmental impact categories. MKI A1 will be applicable until July 2025 (Stichting Nationale Milieudatabase, 2024). The classification of the EPD adheres to the NL-SfB coding structure and indicates which mandatory components are covered and which are not covered by the EPD (Hillege, 2024).



Categorie 1 Environmental declaration

Isolatielagen, Unidek EPS 100 (vloer)

This verified environmental declaration #nmd_82021 for the construction product Isolatielagen, Unidek EPS 100 (vloer) was published on *6/7/2023* in the Dutch Environmental Database (NMD). This declaration was prepared on behalf of *Kingspan Unidek BV*

The environmental cost amounts to **€0.69** at a lifespan of **75 years**. For Category 1 data, the NMD only discloses the aggregated environmental cost, calculated according to the Environmental Performance Assessment Method for Construction Works. Category 1 data is proprietary data from manufacturers and suppliers. The data has been verified by an independent, qualified third party in accordance with the NMD Verification Protocol.

Product name	Isolatielagen, Unidek EPS 100 (vloer)
Environmental Declaration Number	#nmd_82021
Publication date	6/7/2023
Owner	Kingspan Unidek BV
Explanation	EPS is een sterk materiaal met uitstekende isolerende eigenschappen en dat maakt het bij uitstek geschikt voor toepassing als... Show more...
Unit	m²
Lifespan	75 year
Category	Categorie 1

Environmental profile	MKI A1	MKI A2	Scalable
Unidek EPS 100 (vloer)	€0.69	€1.23	Yes
Total:	**€0.69**	**€1.23**	

Classification

This product is classified as Vloerenopgrondslag; niet-constructief, (13.1).

✓ **13.1 – nr04** Vochtwerende en isolerende lagen

This environmental declaration does not cover the entire element. The following mandatory components are missing.

✗ **13.1 – nr01** Niet constructieve vloerconstructies

✗ **13.1 – nr02** Vloerafwerkingen die één geheel vormen met de vloerconstructie.

✗ **13.1 – nr03** Onder- en tussenvloeren

Figure 35: Example of an EPD, accessed via the NMD Viewer (Stichting Nationale Milieudatabase, n.d.-a).

According to the explanation provided by Stichting NMD, the data available in the viewer is not intended for conducting MPG calculations (Stichting Nationale Milieudatabase, n.d.-a). This distinction is made because certain information is not included in the EPDs accessible through the NMD viewer. However, it has been observed that both the MKI per unit of product p and the lifespan of product p—essential input data for MPG calculations—are available in the EPDs accessed by the NMD viewer.

4.1.2.2 Scaling factor

Table 22 shows that the EPD indicates whether a product is scalable, although it does not detail its specific scaling factor. The scaling factor can be calculated by dividing the scaled product's scaling value by the original product's scaling value, as illustrated in Equation 6 (Stichting Nationale Milieudatabase, 2021a).

Equation 6: Scaling factor of a product

$$SF_p = \frac{SV_{p,s}}{SV_{p,o}}$$

$SV_{p,s} = Scaling\ value\ of\ the\ scaled\ product$
$SV_{p,o} = Scaling\ value\ of\ the\ original\ product$

In the assessment method, three different scaling methods are described. Linear scaling can apply to the MKI per unit of a product, implying that Equation 7 needs to be applied to determine the scaling value of the scaled product (Stichting Nationale Milieudatabase, 2021a).

Equation 7: Scaling value of the scaled product using linear scaling

$$SV_{p,s} = c1 * Dim + c2$$

$C1 = Constant\ value\ 1$
$C2 = Constant\ value\ 2$
$Dim = Scalable\ dimension\ of\ the\ product$

Furthermore, exponential scaling can apply to the MKI per unit of a product, implying that Equation 8 needs to be applied to determine the scaling value of the scaled product (Stichting Nationale Milieudatabase, 2021a).

Equation 8: Scaling value of the scaled product using exponential scaling

$$SV_{p,s} = c1 * e^{(c3*Dim)} + c2$$

$C3 = Constant\ value\ 3$

Finally, logarithmic scaling can be applied to the MKI per unit of a product, implying that Equation 9 needs to be applied to determine the scaling value of the scaled product (Stichting Nationale Milieudatabase, 2021a).

Equation 9: Scaling value of the scaled product using logarithmic scaling

$$SV_{p,s} = c1 * Ln(Dim) + c2$$

The scaling method applicable to a product and the necessary input data are not provided in the EDPs accessible by the NMD viewer (Stichting Nationale Milieudatabase, n.d.-a). Consequently, the relevant scaling factor can be determined using the MRPI-FREEtool, as illustrated in Figure 40 (Stichting MRPI, n.d.-b). The MRPI-FREEtool is a free, licensed, and validated web-based calculation tool granting direct NMD access. By utilizing this tool, the scaling factor for a product can be identified. This ensures that the required input data for MPG calculations is provided.

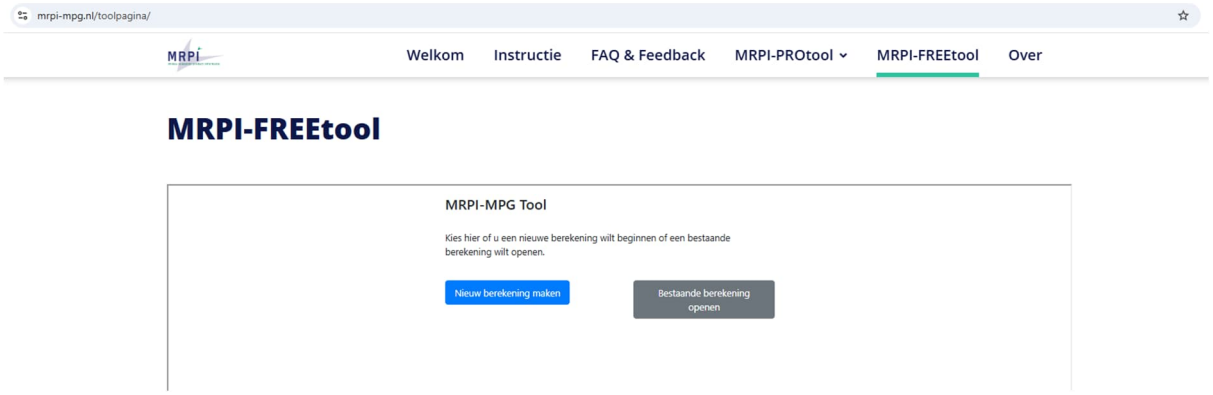


Figure 36: Snapshot of the free-to-use MRPI-FREEtool, which is a validated and licensed MPG calculation tool

4.1.2.3 Construction work data

The lifespan of the construction work, applied quantity of product p in the construction work, and the Gross Floor Area (GFA) of the construction work are required input data to determine the MPG of a building, as indicated in Table 21.

In the assessment method, it is defined that buildings with a residential function have a lifespan of 75 years and that buildings with a utility function have a lifespan of 50 years (Stichting Nationale Milieudatabase, 2022). This indicates that the lifespan of a construction work depends on its function and should be determined based on the function of the building. The applied quantity of a product in the construction work and the GFA of the construction work need to be determined based on the design of the building. This indicates that this input data needs to be provided based on the function and design of the construction work.

4.2 Incorporation of the construction costs

The bottom-up approach is employed for cost estimations during the basic design phase of a construction project. This method consists of aggregating the estimated costs of all necessary components, as illustrated in Equation 10, to determine the estimated construction costs (Ashburn & Goff, 2024; Ramos, 2020).

Equation 10: Estimated construction costs of the construction work based on construction costs per unit of product p

$$CC_{cw} = q_p \sum_{p=1}^{y} CC_p$$

$CC_{cw} = Estimated\ construction\ costs\ of\ the\ construction\ work$
$CC_p = Estimated\ construction\ costs\ of\ the\ product\ p$
$q_p = Applied\ quantity\ of\ product\ p\ in\ the\ construction\ work$

The formula used to estimate the construction costs of a project demonstrates that similar to the formula for determining the MKI of the construction work throughout its lifespan, the applied quantity of product p in the construction work is considered. Additionally, the estimated costs of all necessary components should be aggregated in the same manner as the (scaled) MKIs of the products p calculated in the context of the construction work. Furthermore, both the estimated costs of these components and the (scaled) MKIs of the products p adhere to the NL-SfB coding structure.

This underscores that the same calculation method is employed for determining the MKI of the construction work throughout its lifespan and estimating the construction costs and that the input data is structured following the same coding structure. To determine the construction costs per unit of a product recorded as an Environmental Product Declaration (EPD), it is essential to aggregate the construction costs of all components associated with that product. For example, the expenses for bricks, mortar, and labor must be allocated to the product classified as brick masonry. Since both the estimated costs of these components and the (scaled) MKIs of the products adhere to the NL-SfB coding structure, this coding system can be utilized to accurately assign the construction costs of products to their respective EPDs.

Consequently, the formula for determining the estimated construction costs of the project must be adjusted, such that the construction costs per EPD are considered, as indicated in Equation 11.

Equation 11: Estimated construction costs of the construction work calculated based on the construction costs per EPD

$$CC_{cw} = q_p \sum_{p=1}^{y} CC_{p,assigned}$$

$CC_{cw} = Estimated\ construction\ costs\ of\ the\ construction\ work$
$CC_p = Estimated\ construction\ costs\ of\ the\ product\ p\ assigned\ to\ the\ EPDs$
$q_p = Applied\ quantity\ of\ product\ p\ in\ the\ construction\ work$

4.3 Implementation of the Framework in Excel

Excel has been selected as the software platform for developing the decision support tool due to its widespread familiarity among the intended users of the tool. The implementation of the environmental performance framework employs a combination of Microsoft Excel VBA scripting and various Excel formulas. This chapter outlines the primary scripts and formulas utilized. The complete Excel VBA script can be accessed and modified through the Excel Developer tab. To enable the Developer tab in Excel, follow these steps (Microsoft, n.d.-f):

1. Open the Excel file containing the decision support tool.
2. Navigate to the File tab.
3. Select Options.
4. Click on Customize Ribbon.
5. Check the Developer box under Customize the Ribbon; Main Tabs.

To open the VBA editor, where all coding is stored, press “Alt + F11” or visit the Developer tab and select “Visual Basic.”

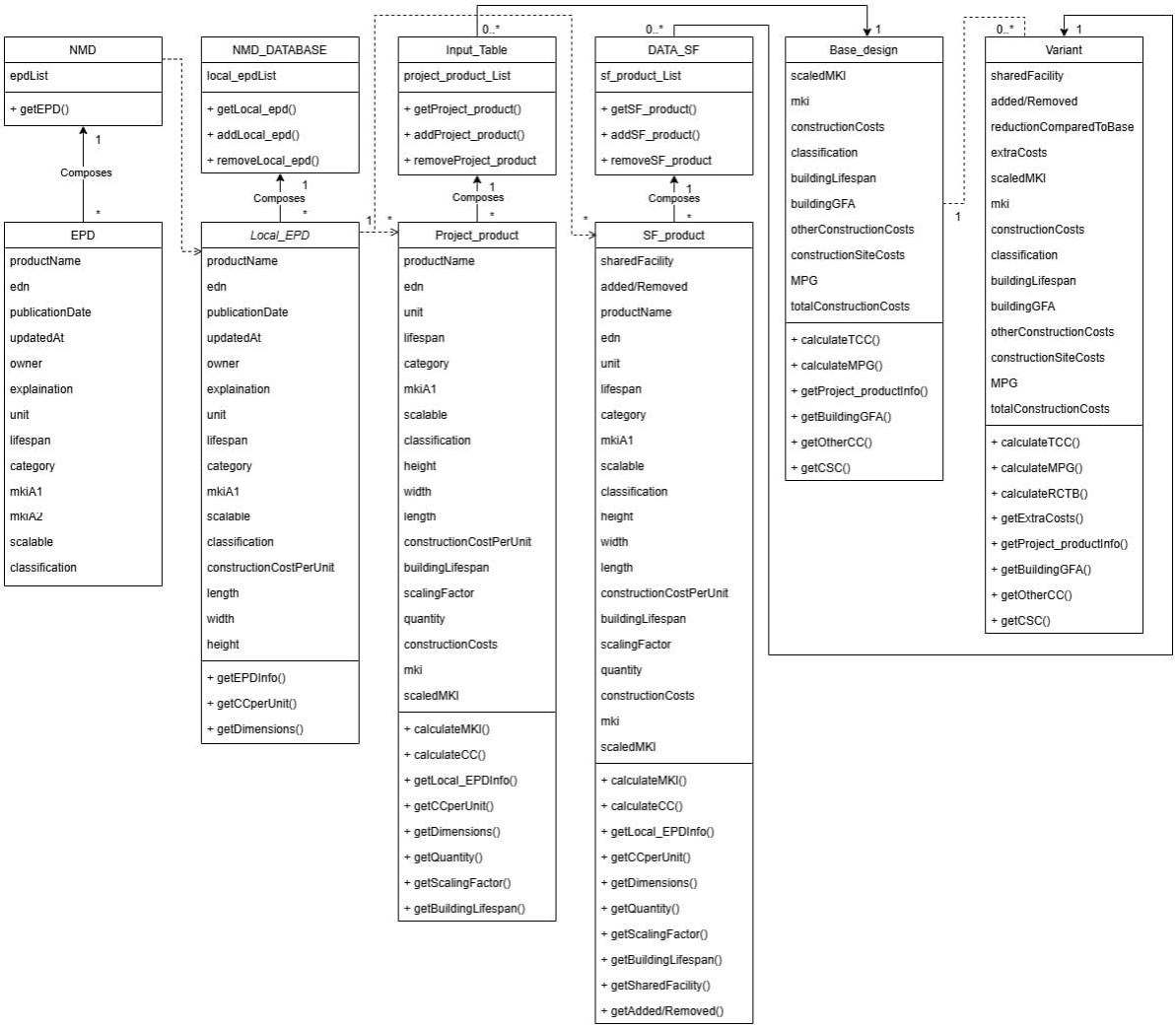


Figure 37: UML diagram of the system architecture of the decision support tool developed in excel

The UML diagram presented in Figure 41 illustrates the system architecture of the decision support tool that will be implemented in Excel.

4.3.1 NMD data

Given the inability to connect directly to the NMD for data access, the initial step involves creating a database within the Excel document to store the relevant NMD data. A table titled "NMD_DATABASE" has been established on the worksheet, designed to accommodate all data available in the EPDs accessed through the NMD viewer. Additionally, the construction costs per unit of the EPD can also be recorded in this table.

A data entry form is designed using VBA UserForms to facilitate the structured input of EPD and construction cost data per unit, as illustrated in Figure 42 (Microsoft, n.d.-d). The layout of the data entry form employs ActiveX controls and is aligned with the organization of data on EPDs, as shown in Figure 39. Combo boxes enable users to either type an entry or select an option from a predefined list (Microsoft, n.d.-d). Thus, combo boxes are utilized for data input that has a limited set of options, such as the product unit. Option buttons, which allow for a single choice, are employed for data entries requiring a binary decision, for instance, whether or not the product is scalable (Microsoft, n.d.-d). For entries that do not have a fixed

number of options, text boxes are used, permitting users to input any data (Microsoft, n.d.-d).

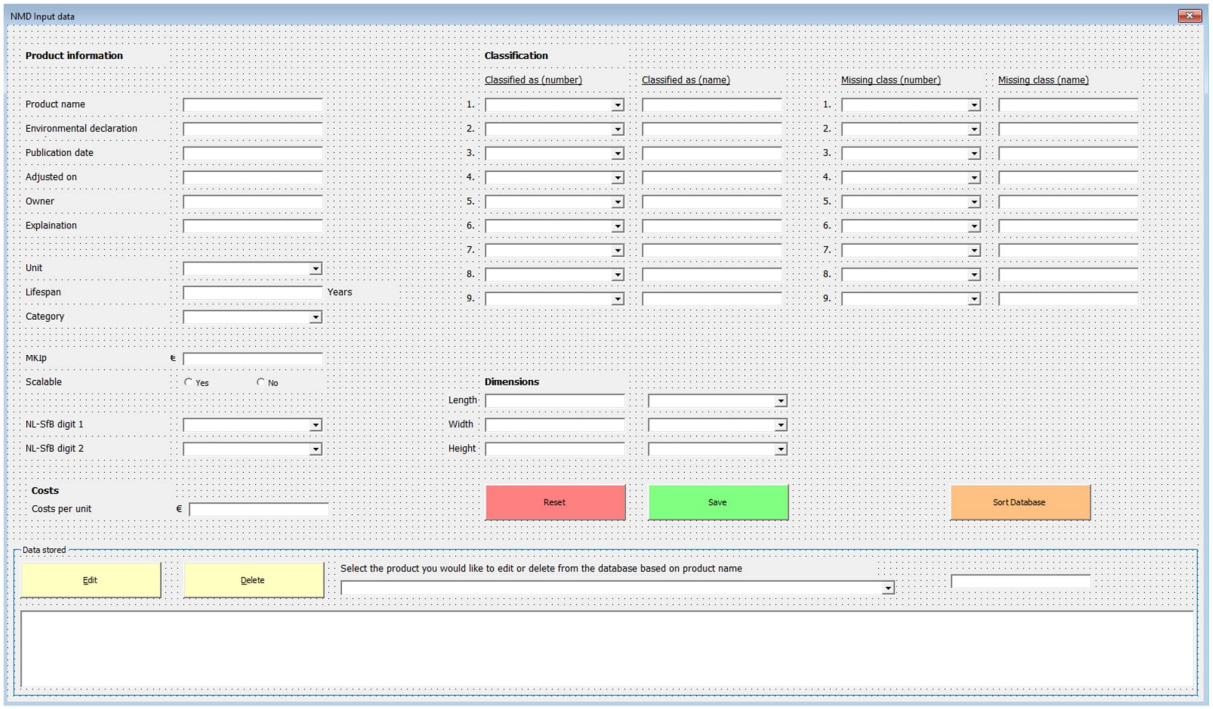


Figure 38: Design of the VBA UserForm to structure the data entry of EPD and construction costs per unit data

Private Subs are utilized to initialize the data in the combo boxes and ensure that only the appropriate data type can be entered in the text boxes. An example can be found in line 721 of Appendix 10. Private Subs are segments of code in Microsoft Excel VBA that execute specific tasks (CFI Team, 2024). Events, such as the "BeforeUpdate" event, are employed to automatically trigger the execution of the defined code (O365devx et al., 2022).

Command buttons are designed and applied to trigger macros that execute upon user interaction (Microsoft, n.d.-d; Microsoft, n.d.-e). The actions associated with the macro are defined in VBA code using Private Subs. The Sub corresponding to the “Save” command button can be found in line 159 of Appendix 9. This code, called the “Submit_NMDform” sub which outlines in which column and row in the “NMD_DATABASE” the data entered in the UserForm should be stored. Additionally, it specifies that along with the entered EPD and construction costs per unit data, a row indicator is stored in column 1, the username of the tool user is recorded in column 58, and the date and time of data saving are retained in column 59, as visible in row 961 of Appendix 9.

As demonstrated in Figure 42, the UserForm for inputting NMD data includes a section labeled "Data Stored." The names of all the stored EPDs are populated into the combo box, allowing users to make selections. The list box at the bottom of the UserForm continuously displays the data stored in the NMD_DATABASE. When a product is selected from the combo box, it is prominently displayed and highlighted in the list box. This selected product can subsequently be deleted from the database using the delete button. Additionally, a selected product can be edited, implying that the stored product data is loaded into the UserForm, enabling the user to adjust and save the data.

Developing a database within the Excel file enables the storage of EPD and construction cost per unit data, thereby providing access to the essential input data required for conducting MPG calculations. The needed EPD data can be located using the NMD viewer and stored in the database using the NMD database form. Furthermore, integrating features to edit or delete stored data allows users to update the database.

4.3.2 Project data

To perform MPG and construction cost calculations, defining the project-specific EPD and construction cost data is essential. Consequently, a database is established to store this information, located on the "Input_Table" sheet. A UserForm, organized in six sections, will facilitate the structured entry of project-specific EPD and construction cost data, as illustrated in Figure 43.

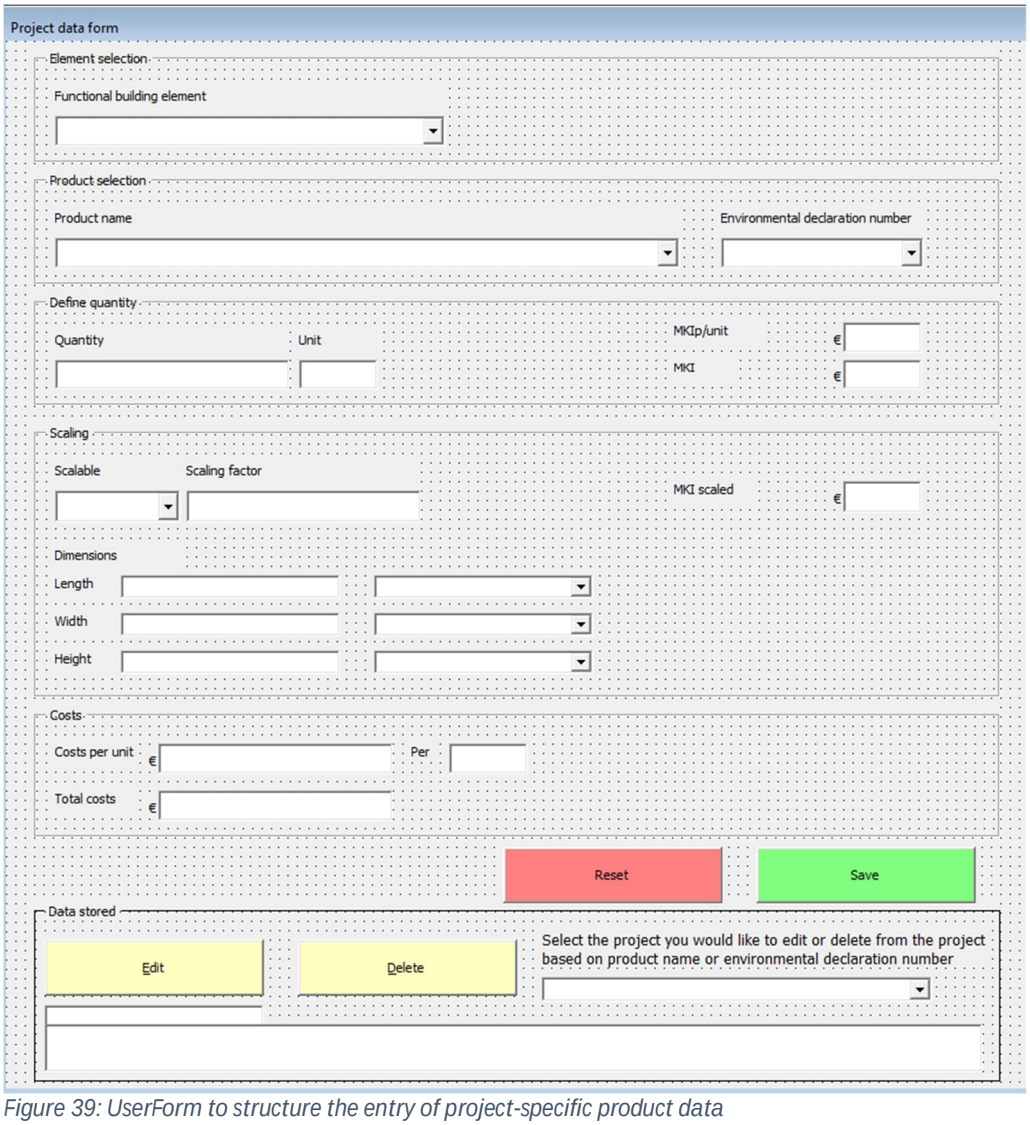


Figure 39: UserForm to structure the entry of project-specific product data

EPD data is organized within the NMD_DATABASE of the tool according to the NL-SfB classification system. This system enables buildings to be categorized into eight Functional Building Elements, as outlined in Table 23. Consequently, the first step in defining project-specific data involves selecting the appropriate Functional Building Element for the product. This selection is made in the element selection section, which features a combo box displaying the eight classifications of Functional Building Elements. To ensure all options are accurately

represented, the options in the element selection combo box are initialized, as can be seen in line 193 of Appendix 10

Table 23: The eight functional building elements in which a building can be divided in lin with the NL-SfB coding structure (NL-SfB 4 Cijfers, n.d.)

1	Ground, Substructure
2	Primary elements, Carcass
3	Secondary elements
4	Finishes
5	Services mainly piped and ducted
6	Services mainly electrical
8	Fittings
9	Terrain

As depicted line 290 of Appendix 10, a change event is implemented to determine the product names and Environmental Declaration Numbers (EDNs) that should be presented as options in the combo boxes within the element selection section. In this Private Sub, the initial value of the NL-SfB coding structure acts as the selection criterion, and the change event guarantees that when the value in cmbElementSelection is modified, the procedure will be executed accordingly.

Another change event is utilized to load the corresponding data stored in the NMD_DATABASE into the UserForm when a product name is selected in cmbProductName, as visible in line 333 of Appendix 10. The same type of coding structure utilizing a change event is utilized when the EDN is selected.

Figure 44 illustrates that for the selected product, the quantity unit, the associated cost unit, and the MKI per unit are sourced from the NMD_DATABASE. Specifying the product quantity in the designated section using the Quantity textbox is essential. Figure 44 illustrates that the construction costs per unit are also retrieved from the NMD_DATABASE. The cost per unit textbox allows for adjustments to the pre-loaded construction cost per unit, facilitating project-specific modifications or defining construction costs per unit when they are not saved in the NMD_DATABASE for the selected product. Furthermore, hidden textboxes within the UserForm contain data not meant for display but crucial for inclusion in the Input_Table or for calculating the MKI of the product related to the construction work, as depicted in Figure 45.

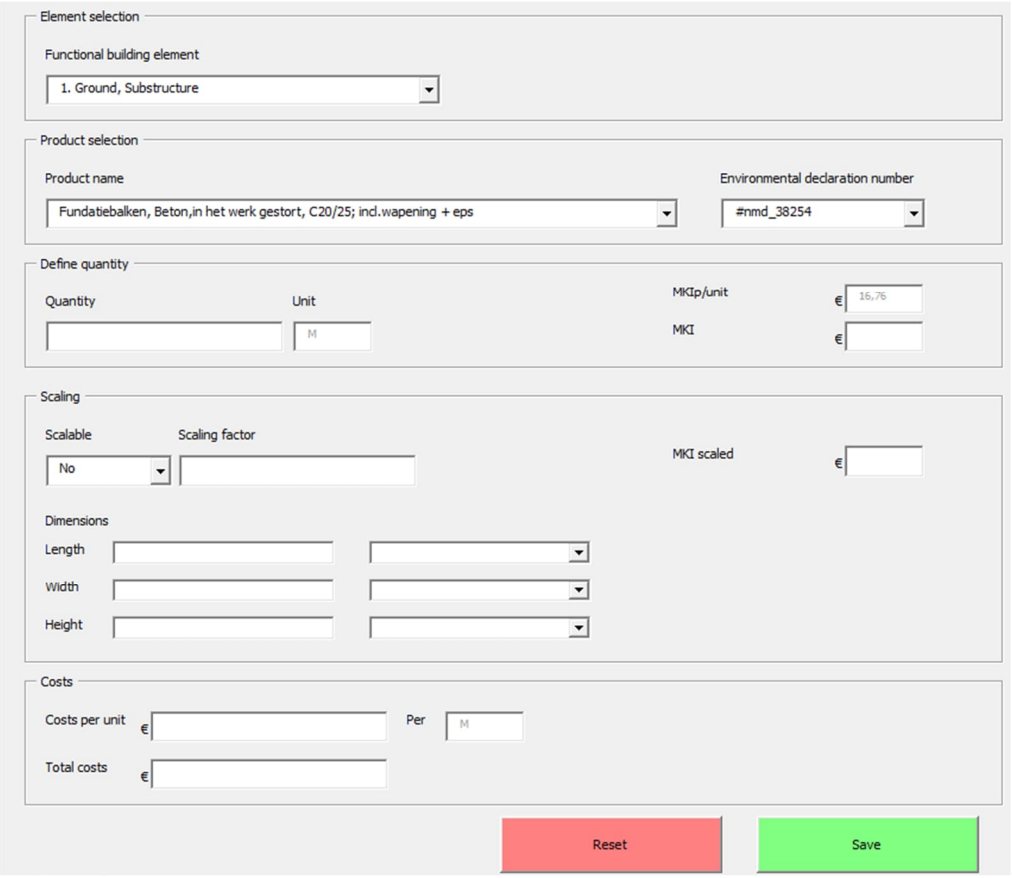


Figure 40: Screenshot of the UserForm in which the EDN and construction costs stored in the NMD_DATABASE are loaded

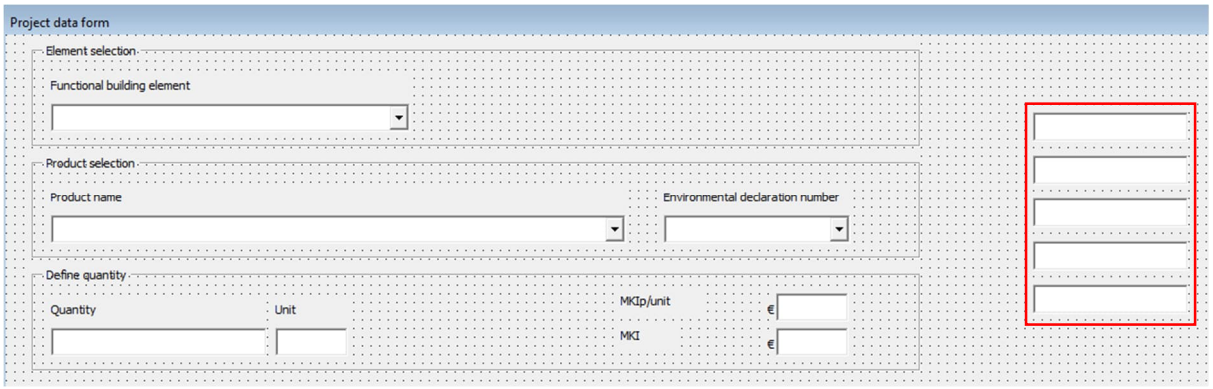


Figure 41: The textboxes (in red) that are used to store data but which are hidden in the UserForm

The NMD_DATABASE also specifies whether a product is scalable. When a selected product is determined to be scalable, the combo box in the scaling section becomes unlocked and enabled, as shown in Figure 44. If the combo box value is set to "Yes," the textbox for defining the scaling factor will also be unlocked and enabled, utilizing the change function as shown in line 455 of Appendix 10.

The MKI of a product in relation to the construction work is calculated based on the loaded MKI per unit of the product, the lifespan of the building, the lifespan of the product, and the applied quantity. This calculation is performed in the Private Sub, as illustrated in line 621 of Appendix 10. Additionally, the method for calculating the scaled MKI of the product in relation to the construction work is defined within the same Private Sub. After calculating these values, the values are indicated in the textboxes “MKI” and “MKI scaled” so that these can be

saved into the Input_Table. A Private Sub is also used to define the calculation method for the construction costs, as shown in line 645 of Appendix 10.

Similar to the UserForm used for structuring NMD data entry, the UserForm designed for defining project-specific data includes a section that displays the data stored in the Input_Table database. Users can select this data and, if necessary, edit or delete it. As a result, the same coding structure is employed, with modifications made to ensure it accurately reflects the data from the Input_Table database.

By creating the Input_Table datasheet project-specific construction costs and MKI data can be stored.

4.3.3 Shared Facility Data

To determine the impact of shared facilities compared to the base design, MPG and construction cost calculations need to be performed. Therefore it is essential to define the shared facility-specific EPD and construction cost data. Consequently, a database is established to store this data, located on the "DATA_SF" sheet. A UserForm based on the UserForm designed for defining project-specific data to structure the entry of shared facility specific EPD and construction cost data, as illustrated in Figure 46.

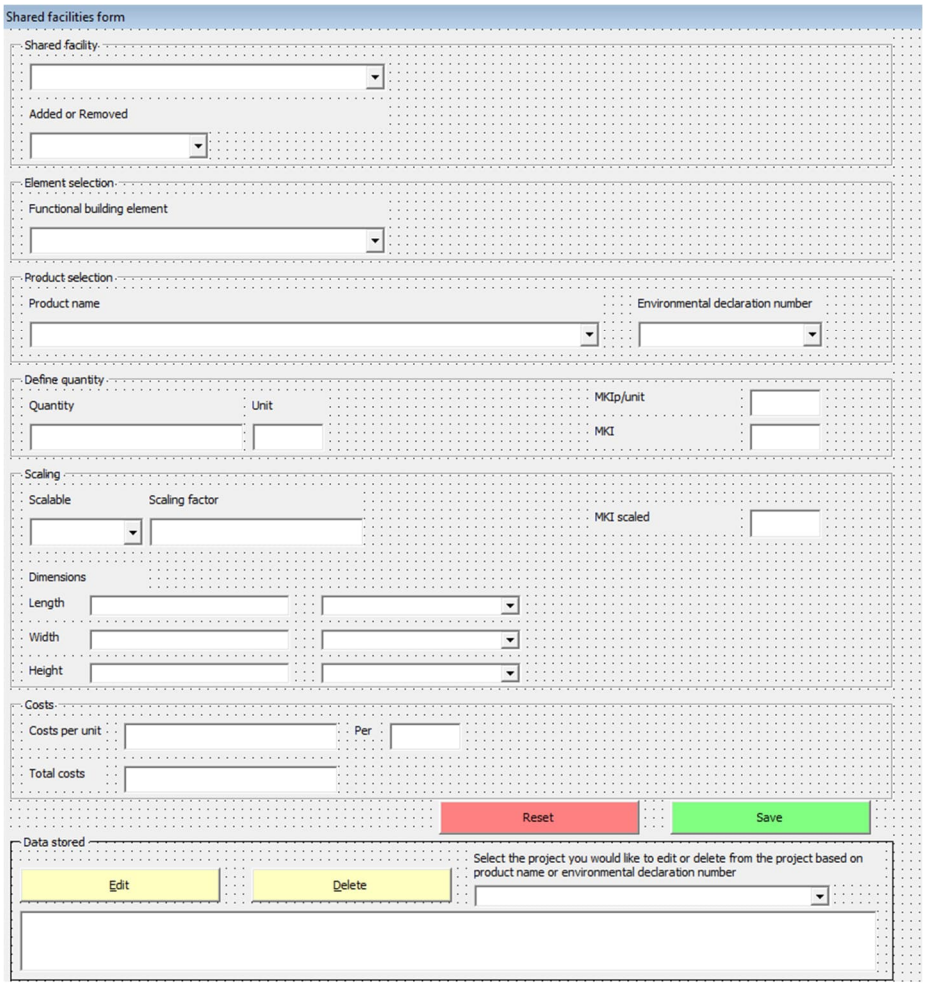


Figure 42: UserForm to structure the entry of shared facility specific product data

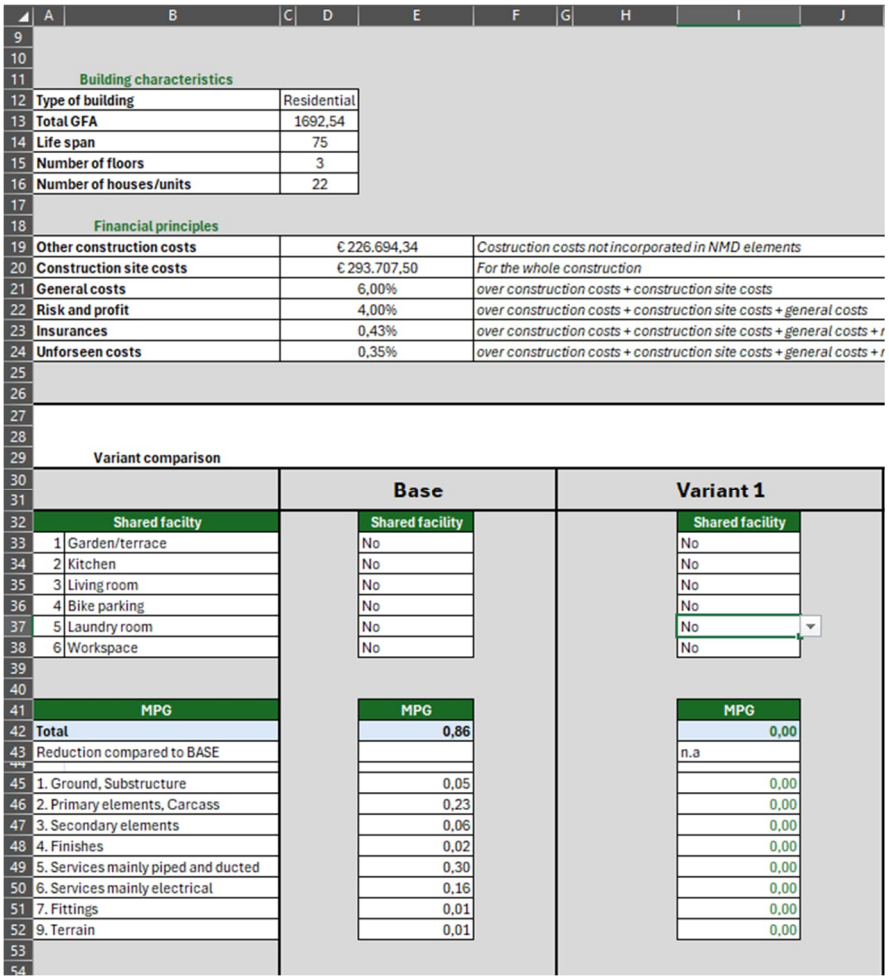
Figure 46 illustrates the addition of a seventh section to the UserForm, which aligns with the UserForm used for defining project-specific data. Consequently, the same coding structure is employed, albeit with modifications, to ensure that data is stored in the SF_DATA datasheet.

In this seventh section, users must specify information about the shared facility. At the top, a combo box presents six predefined shared facilities as options. Users should select the appropriate shared facility to which they wish to assign the product. Additionally, the Added or Removed combo box determines whether the product data will be added to or removed from the base design, a crucial step for calculating the MPG and associated costs of the shared facility. The VBA coding of this can be found in Appendix 11

By creating the DATA_SF datasheet, shared facility-specific construction costs and MKI data can be stored.

4.3.4 MPG and construction cost calculations

To determine the MPG of the products applied in the base design, it is necessary to aggregate the MKIs or scaled MKIs of these products, as calculated in the context of the construction work, and divide the outcome by the GFA of the building and the lifespan of the building. The products listed in the Input_Table are classified according to the NL-SfB coding structure, which allows for the calculation of MPG of the base design per Functional Building Element, as shown in Figure 47.



Building characteristics

Type of building	Residential
Total GFA	1692,54
Life span	75
Number of floors	3
Number of houses/units	22

Financial principles

Other construction costs	€ 226.694,34	*Costruction costs not incorporated in NMD elements*
Construction site costs	€ 293.707,50	*For the whole construction*
General costs	6,00%	*over construction costs + construction site costs*
Risk and profit	4,00%	*over construction costs + construction site costs + general costs*
Insurances	0,43%	*over construction costs + construction site costs + general costs +*
Unforseen costs	0,35%	*over construction costs + construction site costs + general costs +*

Variant comparison

		Base	Variant 1
	Shared facilty	Shared facility	Shared facility
1	Garden/terrace	No	No
2	Kitchen	No	No
3	Living room	No	No
4	Bike parking	No	No
5	Laundry room	No	No
6	Workspace	No	No
	MPG	MPG	MPG
	Total	0,86	0,00
	Reduction compared to BASE		n.a
	1. Ground, Substructure	0,05	0,00
	2. Primary elements, Carcass	0,23	0,00
	3. Secondary elements	0,06	0,00
	4. Finishes	0,02	0,00
	5. Services mainly piped and ducted	0,30	0,00
	6. Services mainly electrical	0,16	0,00
	7. Fittings	0,01	0,00
	9. Terrain	0,01	0,00

Figure 43: Screenshot of the overview page of the decision support tool in which the MPG is calculated per functional building element

The formula illustrated in Figure 48 is utilized to compute the MPG for the Functional Building Element "1. Ground, Substructure," as shown in cell E45 of the overview sheet.

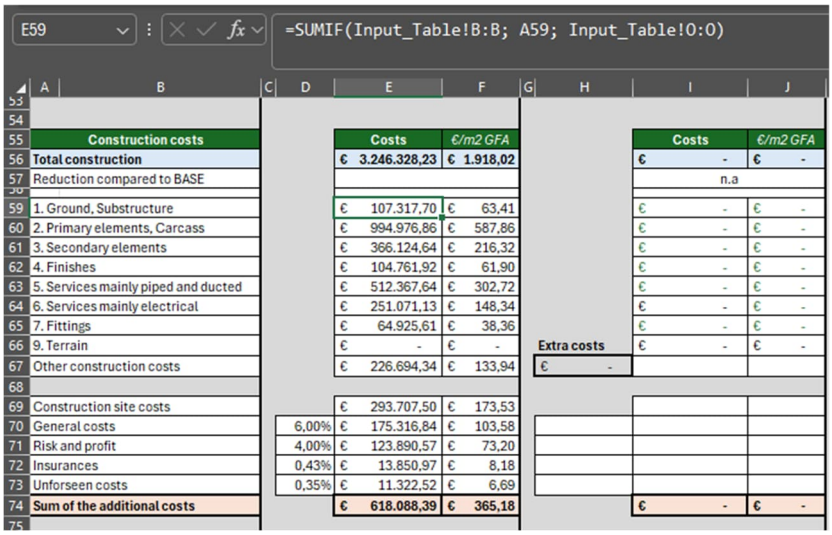
```
=(SUMIFS(Input_Table!$L:$L; Input_Table!$B:$B;$A45; Input_Table!$L:$L; "<>0")
+ SUMIFS(Input_Table!$K:$K; Input_Table!$B:$B; $A45; Input_Table!$L:$L; 0))/$C$13/$C$14
```

Figure 44: Excel Formula used to calculate the MPG of the base design for the Functional Building Element "1. Ground, Substructure"

In column L of the Input_Table, the scaled MKI values are recorded, while column K contains the original MKI values. Additionally, column B defines the NL-SfB classification of the product. Cell $A45 specifies the Functional Building Element for which the MPG is being calculated, cell $C$13 represents the GFA of the base design, and cell $C$14 indicates the building's life span, as shown in Figure 47.

The SUMIFS function is utilized to calculate the total Scaled MKI of the scaled products associated with the Functional Building Element for which the MPG is being assessed, as outlined by the NL-SfB classification of the product, provided that the Scaled MKI value is not equal to zero. Additionally, another SUMIFS function calculates the total MKI of the products that are not scaled, again pertaining to the same Functional Building Element according to their NL-SfB classification and whose MKI value is not equal to zero. The results of these two SUMIFS functions are then added together and subsequently divided by the GFA and the lifespan of the building. This yields the MPG of the base design for the specified Functional Building Element. After entering this formula in cell E45, it is copied to cells E46 to E52. The total MPG, displayed in cell E42, is computed using a SUM function to aggregate the MPG values from cells E45 to E52.

The construction costs of the base design are detailed by Functional Building Element on the Overview sheet of the tool, as illustrated in Figure 49. A SUMIF expression is utilized to calculate the construction costs for each functional building element. This expression sums the construction costs of the products stored in column O of the Input_Table when the NL-SfB classification of the product, as specified in column B of the Input_Table, matches the functional building element for which the costs are calculated.



	Construction costs		Costs	€/m2 GFA		Costs	€/m2 GFA
56	**Total construction**		**€ 3.246.328,23**	**€ 1.918,02**		**€ -**	**€ -**
57	Reduction compared to BASE					n.a	
59	1. Ground, Substructure		€ 107.317,70	€ 63,41		€ -	€ -
60	2. Primary elements, Carcass		€ 994.976,86	€ 587,86		€ -	€ -
61	3. Secondary elements		€ 366.124,64	€ 216,32		€ -	€ -
62	4. Finishes		€ 104.761,92	€ 61,90		€ -	€ -
63	5. Services mainly piped and ducted		€ 512.367,64	€ 302,72		€ -	€ -
64	6. Services mainly electrical		€ 251.071,13	€ 148,34		€ -	€ -
65	7. Fittings		€ 64.925,61	€ 38,36		€ -	€ -
66	9. Terrain		€ -	€ -	Extra costs	€ -	€ -
67	Other construction costs		€ 226.694,34	€ 133,94	€ -		
69	Construction site costs		€ 293.707,50	€ 173,53			
70	General costs	6,00%	€ 175.316,84	€ 103,58			
71	Risk and profit	4,00%	€ 123.890,57	€ 73,20			
72	Insurances	0,43%	€ 13.850,97	€ 8,18			
73	Unforseen costs	0,35%	€ 11.322,52	€ 6,69			
74	**Sum of the additional costs**		**€ 618.088,39**	**€ 365,18**		**€ -**	**€ -**

Figure 45: Screenshot of the overview page of the decision support tool in which the construction costs are calculated per functional building element

As shown in Figure 47, six shared facilities can be selected using the combo box of the selected shared facility to state if the shared facility needs to be applied “Yes” or “No”.

The MPG of the shared facilities is calculated based on the MPG of the base design since changes in the applied quantities of materials as a result of a shared facility are stored in the DATA_SF sheet compared to the number of applied materials in the base design, as defined in the Input_Table sheet. Figure 50 shows a screenshot of the first part of the formula that is used in cell I45 to calculate the MPG of the selected shared facilities for the Functional Building Element known as “1. Ground, Substructure”.

```
=IF(OR(I$33="Yes"; I$34="Yes"; I$35="Yes"; I$36="Yes"; I$37="Yes"; I$38="Yes");
    (
        IF(I$33="Yes";
            SUMPRODUCT((DATA_SF!$B$2:$B$934=Overview!$B$33)*(DATA_SF!$D$2:$D$934=Overview!$A45)*
                       ((DATA_SF!$N$2:$N$934="Yes")*DATA_SF!$M$2:$M$934 +
                        (DATA_SF!$N$2:$N$934<>"Yes")*DATA_SF!$L$2:$L$934)*
                       (DATA_SF!$C$2:$C$934="Added")) -
            SUMPRODUCT((DATA_SF!$B$2:$B$934=Overview!$B$33)*(DATA_SF!$D$2:$D$934=Overview!$A45)*
                       ((DATA_SF!$N$2:$N$934="Yes")*DATA_SF!$M$2:$M$934 +
                        (DATA_SF!$N$2:$N$934<>"Yes")*DATA_SF!$L$2:$L$934)*
                       (DATA_SF!$C$2:$C$934="Removed"));
            0) +
        IF(I$34="Yes";
            SUMPRODUCT((DATA_SF!$B$2:$B$934=Overview!$B$34)*(DATA_SF!$D$2:$D$934=Overview!$A45)*
                       ((DATA_SF!$N$2:$N$934="Yes")*DATA_SF!$M$2:$M$934 +
                        (DATA_SF!$N$2:$N$934<>"Yes")*DATA_SF!$L$2:$L$934)*
                       (DATA_SF!$C$2:$C$934="Added")) -
            SUMPRODUCT((DATA_SF!$B$2:$B$934=Overview!$B$34)*(DATA_SF!$D$2:$D$934=Overview!$A45)*
                       ((DATA_SF!$N$2:$N$934="Yes")*DATA_SF!$M$2:$M$934 +
                        (DATA_SF!$N$2:$N$934<>"Yes")*DATA_SF!$L$2:$L$934)*
                       (DATA_SF!$C$2:$C$934="Removed"));
            0) +
```

Figure 46: Screenshot of the first part of the formula that is used in cell I45 to calculate the MPG of the selected shared facilities

Cells I33 through I38 on the Overview sheet contain the outcomes of the combo boxes used to determine whether a shared facility is applicable, and cell A45 is used to identify the Functional Building Element for which the MPG calculation is being conducted. In the DATA_SF sheet, column B records the shared facility associated with the product, column M holds the scaled MKI values, and column L presents the original MKI values. Furthermore, column D specifies the NL-SfB classification of the product; column N specifies if the product is scalable, and column C indicates whether the product has been added or removed in relation to the base design.

An IF statement determines whether a shared facility has been selected. If no shared facility is chosen, the formula returns False, halting the calculation. Conversely, when a shared facility is selected, the formula continues its execution. Additional IF statements are then used to identify which specific shared facilities have been chosen. When a shared facility is identified, the formula advances to calculate a number of SUMPRODUCT expressions (Microsoft, n.d.-f).

The first SUMPRODUCT expression verifies three conditions:

1. If the shared facility associated with the product matches the selected shared facility,
2. If the NL-SfB classification of the product corresponds to the Functional Building Element for which the MPG is being calculated, and
3. If the product is marked as “Added.”

When all three conditions are satisfied, the formula sums the scaled MKI of the products that are scaled along with the original MKI of products that have not been scaled.

The second SUMPRODUCT expression operates similarly to the first; however, it focuses explicitly on summing the MKI and scaled MKI of products marked as “Removed.” Finally, the result of the SUMPRODUCT expression for the removed products is subtracted from the result of the SUMPRODUCT expression for the added products.

Figure 51 presents a screenshot of the final part of the formula utilized in cell I45 to calculate the MPG of the selected shared facilities for the Functional Building Element referred to as “1. Ground, Substructure.” It illustrates that to determine the MKI of the selected shared facilities, the MPG value of the base design, as indicated in cell E45, is multiplied by the GFA and lifespan of the building found in cells C13 and C14. This product is then added to the total sum of the MKIs for the selected shared facilities. Subsequently, the MKI of the selected shared facilities is divided by the GFA and lifespan of the building, which includes these shared facilities. To ascertain the GFA of the building encompassing the selected shared facilities, the impact of each selected shared facility on the GFA is added to the base design's GFA.

The impact of each shared facility on the GFA of the base design needs to be defined by the user of the tool in the Extra_data_SF sheet.

```
...
        IF(I$38="Yes";
            SUMPRODUCT((DATA_SF!$B$2:$B$934=Overview!$B$38)*(DATA_SF!$D$2:$D$934=Overview!$A45)*
                       ((DATA_SF!$N$2:$N$934="Yes")*DATA_SF!$M$2:$M$934 +
                        (DATA_SF!$N$2:$N$934<>"Yes")*DATA_SF!$L$2:$L$934)*
                       (DATA_SF!$C$2:$C$934="Added")) -
            SUMPRODUCT((DATA_SF!$B$2:$B$934=Overview!$B$38)*(DATA_SF!$D$2:$D$934=Overview!$A45)*
                       ((DATA_SF!$N$2:$N$934="Yes")*DATA_SF!$M$2:$M$934 +
                        (DATA_SF!$N$2:$N$934<>"Yes")*DATA_SF!$L$2:$L$934)*
                       (DATA_SF!$C$2:$C$934="Removed"));
            0)
    ) + ($E45 * $C$13 * $C$14)) /
    (
        $C$13 +
        IF(I$33="Yes"; Extra_data_SF!$B$7; 0) +
        IF(I$34="Yes"; Extra_data_SF!$B$8; 0) +
        IF(I$35="Yes"; Extra_data_SF!$B$9; 0) +
        IF(I$36="Yes"; Extra_data_SF!$B$10; 0) +
        IF(I$37="Yes"; Extra_data_SF!$B$11; 0) +
        IF(I$38="Yes"; Extra_data_SF!$B$12; 0)
    )/$C$14
```

Figure 47: Screenshot of the last part of the formula that is used in cell I45 to calculate the MPG of the selected shared facilities

The construction costs of the shared facilities are outlined by the functional building element on the Overview sheet of the tool, as depicted in Figure 49. To determine the construction costs for each functional building element, a formula comparable to that used for calculating the MPG of the shared facilities is employed, as illustrated in Figure 52. This process entails assessing whether each shared facility is selected. When a shared facility is chosen, its impact on the construction costs of the base design is calculated. Subsequently, the impacts of all selected shared facilities are summed and added to the construction costs of the base design, resulting in the total construction costs for the design that includes the selected shared facilities.

```
=IF(OR(I$33="Yes"; I$34="Yes"; I$35="Yes"; I$36="Yes"; I$37="Yes"; I$38="Yes");
    IF(I$33="Yes";
        SUMPRODUCT((DATA_SF!$B$2:$B$934=Overview!$B$33)*(DATA_SF!$D$2:$D$934=Overview!$A59)*
                   (DATA_SF!$P$2:$P$934)*(DATA_SF!$C$2:$C$934="Added")) -
        SUMPRODUCT((DATA_SF!$B$2:$B$934=Overview!$B$33)*(DATA_SF!$D$2:$D$934=Overview!$A59)*
                   (DATA_SF!$P$2:$P$934)*(DATA_SF!$C$2:$C$934="Removed"));
        0) +
...
    IF(I$38="Yes";
        SUMPRODUCT((DATA_SF!$B$2:$B$934=Overview!$B$38)*(DATA_SF!$D$2:$D$934=Overview!$A59)*
                   (DATA_SF!$P$2:$P$934)*(DATA_SF!$C$2:$C$934="Added")) -
        SUMPRODUCT((DATA_SF!$B$2:$B$934=Overview!$B$38)*(DATA_SF!$D$2:$D$934=Overview!$A59)*
                   (DATA_SF!$P$2:$P$934)*(DATA_SF!$C$2:$C$934="Removed"));
        0) + $E59;
    0)
```

Figure 48: Screenshot of the initial and final part of the formula that is used to calculate the construction costs of the shared facilities for the depicted functional building element

Figure 53 illustrates the financial principles that must be established for the base design, enabling the calculation of total construction costs. It indicates that other construction costs can be specified in cell C19 of the overview sheet within the decision support tool. Moreover, construction site expenses can be documented in cell C20, and cells C20 to C24 are allocated to detail the project's overhead costs. An explanation of the required costs and the methodology for their assessment is provided in cells F19 to F24.

Financial principles			
Other construction costs	€ 226.694,34	*Costruction costs not incorporated in NMD elements*	
Construction site costs	€ 293.707,50	*For the whole construction*	
General costs	6,00%	*over construction costs + construction site costs*	
Risk and profit	4,00%	*over construction costs + construction site costs + general costs*	
Insurances	0,43%	*over construction costs + construction site costs + general costs + risk and profit*	
Unforseen costs	0,35%	*over construction costs + construction site costs + general costs + risk and profit + insurances*	

Figure 49: Screenshot of the overview page of the decision support tool in which the financial principles of the base design must be stored

4.4 Conclusion

It can be concluded that a framework has been established, structured in accordance with the MPG-calculation method, to which the calculation method for construction costs is linked, as both rely on the same input values. The necessary input data should be provided by the user and can partly be found on the NMD-viewer website, with some information being specific to the project. Manual input of data is essential, as a direct connection to the data stored in the NMD is not possible. The developed user interface presents the user with the MPG and construction costs of the base design at the building and building element level, thereby offering them information for comparison. Additionally, the user can define various shared facilities using five different variants to calculate the MPG and construction costs for these options and assess the reductions compared to the base design. This enables informed design decisions regarding the implementation of shared facilities.

5 Case study

The impact on the environmental performance and affordability of the six different shared facilities will be assessed through a case study. The selected reference project for this analysis is Opus | De Tuin van Elden, a construction project featuring an apartment building with 22 rental units spread across three floors, completed in 2021 and located at the Opusstraat in Arnhem. Affordability was a key consideration for this project, as the apartments are classified within the mid-rental sector. The development was undertaken by Kondor Wessels Projecten, with construction carried out by Veluwezoom Verkerk (Veluwezoom Verkerk, n.d.).

Figure 50: Picture of the front of the apartment building Opus | de Tuin van Elden (Veluwezoom Verkerk, n.d.-a)
Figure 51: Picture of the back of the apartment building Opus | de Tuin van Elden and the storage spaces (Veluwezoom Verkerk, n.d.-a)

Table 24 illustrates that the building has a UFA of 1214.94 m², while the entire structure, including the detached storage spaces, comprises a total GFA of 1692.54 m². The apartments, each with a UFA of 55.22 m², are accessible via the gallery at the back of the building and feature two bedrooms and a balcony. The apartment building includes a communal entrance area equipped with both a staircase and an elevator and is situated on a plot measuring 2390 m², as shown in Figure 56 (KadastraleKaart.com, 2024). According to the zoning plan displayed in Figure 57, the area is designated for mixed-use purposes, with the plot allocated for traffic and garden functions (KadastraleKaart.com, 2024). A complete set of architectural drawings for the building is available in Appendix 1.

Table 24: Characteristics of the project Opus | De Tuin van Elden

Opus | De Tuin van Elden	
Adress	Opusstraat 31-71, 6842 DR Arnhem
Developer	Kondor Wessels Projecten
Contractor	Veluwezoom Verkerk Bouw
Construction year	2021
Number of apartments	22
Usable floor area	1214.94 m2
Gross floor area	1692.54 m2
Usable floor area per apartment	55.22 m2
Construction costs	€2,600,000.18
Original MPG	€0.41 per m2 GFA per year

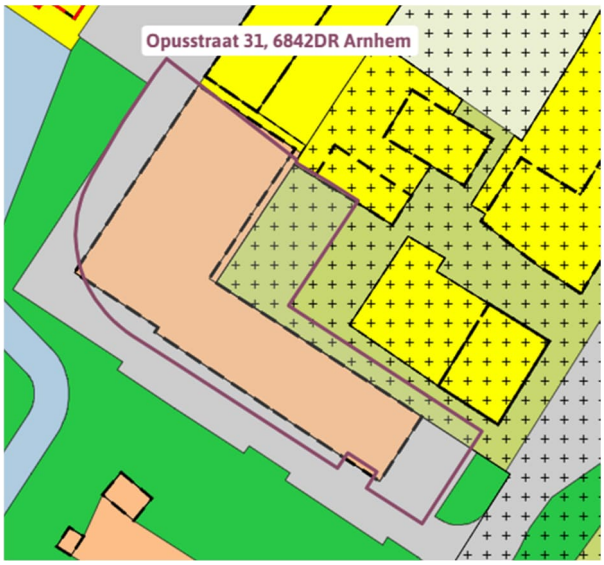


Figure 52: Cadastral map of the location of the project Opus| de Tuin van Elden (KadastraleKaart.com, 2024)
Figure 53: Zoning plan of the location of the project Opus | de Tuin van Elden (Omgevingsloket, n.d.)

Furthermore, as indicated in Table 24, the construction costs of the building amounted to €2.6 million. The construction costs are outdated since they originated in September 2020 and do not include the costs related to the apartment kitchens. Therefore, the construction costs must be recalculated to represent current market conditions. The MPG equals 0.41 and should also be recalculated to align with the latest determination methods and to incorporate the most recent product data since the MPG is currently based on the outdated version 1.0 of the Bepalingsmethode 'Milieuprestatie Bouwwerken' while also outdated product data is used.

5.1 Data preparation

To ensure the representativeness and accuracy of the case study data, the IFC model of OPUS | de Tuin van Elden will be used to extract both product and quantity data. This will facilitate the assignment of materials and their quantities to the corresponding EPD products. Additionally, the construction costs will be adjusted to account for price increases, and the 22 individual kitchens, which were excluded from the original construction costs, will be included. Subsequently, the construction costs will be allocated to the EPD products and divided by the quantities of the selected EPD products to determine the costs per unit.

The building's IFC model was utilized to extract the necessary products and quantities involved in its construction, allowing for an updated input for the MPG calculation. This extraction process employed Information Takeoff (ITO) in Solibri (Solibri Inc, 2024). ITO definitions were established to determine the data that needed to be extracted from the model. This encompassed the use of existing ITO definitions, as well as modified or newly created definitions. An example of an ITO definition is illustrated in Figure 58.

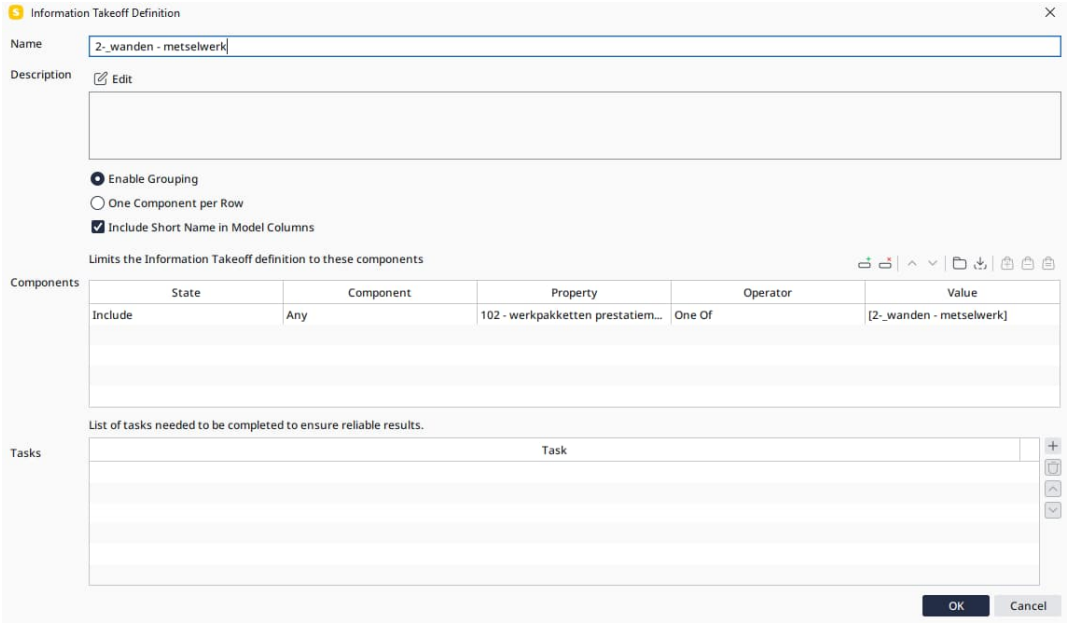


Figure 54: Example of an ITO definition

After the ITO definitions were established, the ITO view was employed to organize the requested output data by appropriately adjusting the columns. This facilitated a clear visualization of the product data and quantities, as depicted in Figure 59. Following this, spreadsheet reports of the ITO view data were generated in the Excel document titled "22_app_TuinvanElden_base_V3."

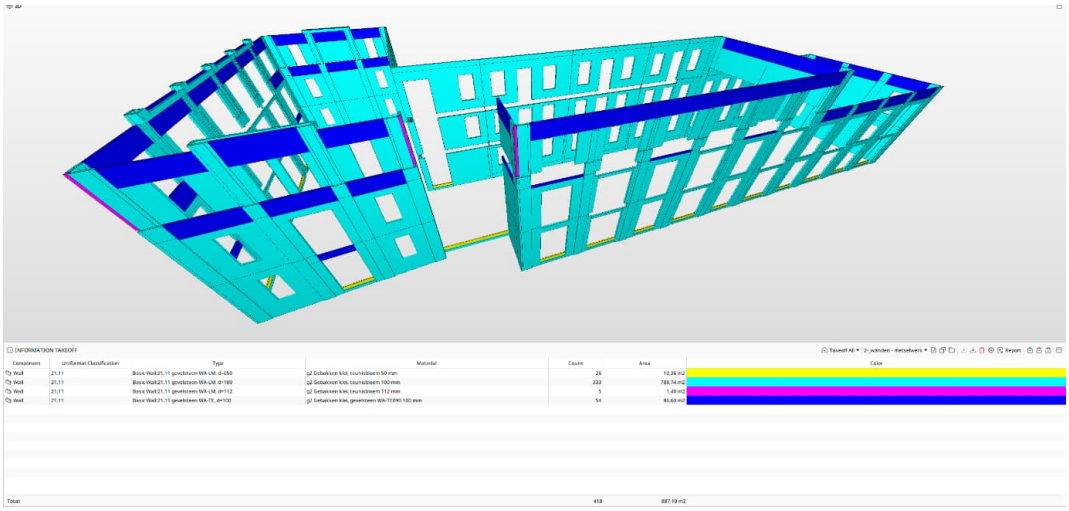


Figure 55: Example of an ITO view in Solibri

However, since the IFC model was created in 2020, some product data within it was not correctly modeled. Consequently, the product data and quantities that could not be extracted from the building's IFC model were obtained from construction-related documents. Using the information gathered from the ITOs and these documents, the quantity and product details for the building were revised and recorded in Appendix 2. Further enhancements were made to this data by including the Environmental Product Name, Environmental Declaration Number, and scaling factor for the corresponding EPD product, as sourced from the NMD viewer (n.d.-a).

The next step involved manually allocating the construction costs from the working budget to the corresponding EPD products in the tool's project database. Figure 60 provides a snapshot from the "Werkbegroting,". It highlights (in red text) that the associated costs for the specified product "Lijmelementen dik 300 mm" will be assigned to the product categorized as "Draagconstructie; hoofddraagconstructie; Dragende wanden, massief; Calduran d=300." Additionally, Figure 61 presents a part of the product data for this item, as outlined in Appendix 3, demonstrating that construction costs amounting to €26393.95 are allocated to the specified product. For all costs included in the "Werkbegroting," it is clearly defined which product or cost classification they are assigned to.

2242.5	**Lijmelementen dik 300 mm**	**392,00**	**m2**									
2242.5	lijmelementen E300	392,00	m2			32,98	12.928,09					12.928,09
2242.5	zaagwerk lijmelement E300	44	m1			10,59	465,96					465,96
2242.5	stelspecie tbv kimmen	143	m1			0,25	35,75					35,75
2242.5	calsifix elementenlijm mat.	1.725	kg			0,55	948,75					948,75
2242.5	centreerdoken	392	m2			0,45	176,40					176,40
2242.5	kim stellen incl											
2242.5	lijmelementen verwerk. d=300mm	392	m2	Draagconstructie; hoofddraagconstructie;						22,00	8.624,00	8.624,00
2242.5	stelvoetjes	32	st	dragende wanden, massief; Calduran d=300						5,00	160,00	160,00
2242.5	opperen blokken incl											
2242.5	kraankosten opperen	24,2	uur					125,00	3.025,00			3.025,00
	Lijmelementen dik 300 mm	**392,00**	**m2**			**37,13**	**14.554,95**	**7,72**	**3.025,00**	**22,41**	**8.784,00**	**26.363,95**
	Eenheidsprijs: 67,26/m2											

Figure 56: Snapshot from the "Werkbegroting", indicating to which product the associated construction costs need to be assigned in the project database

Materialisering		Quantity	Unit	Construction costs	Construction costs corrected for inflation	Construction costs/unit	Comment costs
Draagconstructie							
Hoofddraagconstructie							
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=300	392,99	m2	€ 26.363,95	€ 32.478,18	€ 82,64	

Figure 57: A part of the table in which the product characteristics, quantities, and associated construction costs are defined

As shown in Figure 61, the construction costs are corrected for inflation. Equation 12 shows the indexation applied to account for price increases to ensure that the construction costs accurately reflect current market conditions.

Equation 12: Calculation of the construction costs corrected for price increases

$$C_{P,updated} = F_{BDB} * C_{P,Original}$$

$C_{P,updated} = Updated\ construction\ costs\ of\ product\ P$
$F_{BDB} = Indexation\ to\ account\ for\ price\ increases$
$C_{P,Original} = Original\ construction\ costs\ of\ product\ P$

This indexation to account for price increases is calculated by dividing the total BDB index value for newly constructed residential buildings in September 2024, equal to 121.43, by the total BDB index value for the same in September 2020, equal to 98.57, resulting in a price increase of 23.19%, as shown in Equation 13 (VolkerWessels, 2024).

Equation 13: Indexation to account for price increases in the construction costs

$$F_{BDB} = \frac{121.43}{98.57} * 100\% = 123.19\%$$

The expenses for the individual kitchens in the apartments are set to €1,773.12 per kitchen and determined based on the construction costs of a comparable kitchen applied in the project Park Julianaweide Heteren (Veluwezoom Verkerk, n.d.-b). This kitchen does not need

to be indexed since it is a recent project. This indicates that the total construction costs for the 22 kitchens in the apartments are €39,008.64, as calculated in Equation 14.

Equation 14: Total construction costs of the 22 kitchens in the apartment

$$C_{kitchen} = €1773.12 * 22 = €39{,}008.64$$

$C_{kitchen} = Total\ construction\ costs\ of\ the\ 22\ kitchens$

To determine the construction costs per unit, as visible in Figure 61. The updated construction costs assigned to the corresponding products are divided by the quantity of the assigned product, as shown in Equation 15.

Equation 15: Calculation to calculate the construction costs per unit

$$C_{p/unit} = \frac{C_{P,updated}}{Q_p}$$

$C_{p/unit} = Construciton\ costs\ per\ unit$
$Q_p = Quantity\ of\ the\ assigned\ product$

Utilizing equations 12 through 15 facilitates the preparation of data from the reference project OPUS | de Tuin van Elden for integration into the decision support tool. This methodological approach ensures that the data is appropriately structured and ready for subsequent analysis and application within the tool.

5.2 Shared facilities

To enable testing of the six different shared facilities, these need to be designed and design modifications made from the original design need to be outlined. Consequently, the following subchapters establish the shared facilities' requirements and principles. Using these requirements and principles, the impact of each shared facility on the original design will be assessed, as outlined in Appendix 4. Additionally, the cost and environmental performance data for the products needed to construct the shared facilities will be included in the definition sheets for these facilities, also found in Appendix 4. For products required for the shared facilities that are ineligible for MPG calculation and, therefore, cannot be linked to a product in the NMD database, the costs will be categorized as other construction costs to ensure correct integration into the tool.

Each change to the original design is explained in the definition sheets of the shared facilities, as can be found in Appendix 4. The influence of the shared facility on most of the products of the original design is determined based on equation 16 and indicated in the explanation as “UFA increase -UFA decrease”:

Equation 16: Corrected quantity of the product based on the UFA

$$Q_{ufa,corrected} = (Q_{op} * P_{i,ufa}) - (Q_{op} * P_{d,ufa})$$

$Q_{ufa,corrected} = corrected\ quantity\ of\ the\ product\ based\ on\ the\ UFA$

$Q_{op} = original\ quantity\ of\ the\ product$
$P_{i,ufa} = Percentual\ increase\ in\ UFA\ of\ the\ building$
$P_{d,ufa} = Percentual\ decrease\ in\ UFA\ of\ the\ building$

The percentual increase and decrease in UFA of the building are determined using the formula in equation 17:

Equation 17: Calculation methods to determine the increase and decrease in UFA of the building as a result of the shared facility

$$P_{i,ufa} = \frac{UFA_{i,sf,x}}{UFA,b} \qquad P_{d,ufa} = \frac{UFA_{d,sf,x}}{UFA,b}$$

$UFA_b = Usable\ floor\ area\ of\ the\ base\ design$
$UFA_{i,sf,x} = Increase\ in\ UFA\ due\ to\ shared\ facility\ x$
$UFA_{i,sf,x} = Decrease\ in\ UFA\ due\ to\ shared\ facility\ x$

Except for the shared bike parking, the UFA is used to specify the impact of a shared facility on the original building. However, to determine the MPG, the impact of the shared facility on the total GFA of the building needs to be determined. Therefore, the change in the UFA of the building is multiplied by the GFA-UFA ratio of the base design and added to the original GFA of the building, as can be found in equation 18.

Equation 18: Formula to calculate the GFA of the design with the shared facility

$$GFA_{sf,x} = GFA_b + (A_{ufa} * \frac{GFA_b}{UFA_b})$$

$GFA_{sf,x} = Gross\ floor\ area\ of\ the\ design\ with\ shared\ facility\ x$
$GFA_b = Gross\ floor\ area\ of\ the\ base\ design$
$A_{ufa} = change\ in\ the\ UFA\ of\ the\ building\ due\ to\ shared\ facility\ x$

As previously mentioned, the impact of the shared bike parking on the original building is measured in GFA. This was done since sufficient information was available regarding the impact of the application of shared bike parking on the building's GFA. The influence of the shared bike parking on the majority of the products of the original design is determined based on equation 19 and indicated in the explanation as “GFA increase -GFA decrease”:

Equation 19: Formula to calculate the corrected quantity of the product based on the GFA

$$Q_{gfa,corrected} = (Q_{op} * I_{gfa}) - (Q_{op} * D_{gfa})$$

$Q_{gfa,corrected} = corrected\ quantity\ of\ the\ product\ based\ on\ the\ GFA$
$I_{gfa} = Percentual\ increase\ in\ GFA\ of\ the\ building$
$D_{gfa} = Percentual\ decrease\ in\ GFA\ of\ the\ building$

The percentual increase and decrease in GFA of the building as a result of the applied shared facility are determined using equation 20.

Equation 20: Formulas to calculate the percentual increase and decrease in GFA of the building

$$P_{i,gfa} = \frac{GFA_{i,sf,x}}{GFA, b} \qquad P_{d,ufa} = \frac{GFA_{d,sf,x}}{GFA, b}$$

$GFA_{i,sf,x} = Increase\ in\ GFA\ due\ to\ shared\ facility\ x$
$GFA_{i,sf,x} = Decrease\ in\ GFA\ due\ to\ shared\ facility\ x$

In addition to the modifications to the applied materials resulting from the shared facility, which are identified through the "UFA increase - UFA decrease" and "GFA increase - GFA decrease" methods, other determination techniques are also employed. For instance, a direct reduction in applied windows will occur when a bedroom is removed. These alterations concerning the basic design are detailed in the "Explanation" column of the shared facility.

Generally, it is assumed that the introduction of shared facilities within the apartment building—excluding shared gardens/terraces and bike parking—the created spaces should include at least the following elements:

- One external entrance door
- One external doorframe for the entrance door
- A window with a minimum surface area of 1.6 m²
- A PVC floor
- Finished white walls

If deemed applicable, the quantity of these elements may be increased based on the shared facility chosen. The provision of shared furnishings, such as dining tables, sofas, and chairs, along with their associated costs, will not be covered in this case study. This furniture category is excluded from the MPG calculations, and the selection of preferred furnishings largely relies on the personal tastes of the future residents. One potential approach for financing furniture costs is incorporating it into the monthly service fee for the apartments, implying that the furniture would be leased. For some shared facilities, monthly fees have been established to offer perspective on the available options, but these are not incorporated into the results.

Additionally, it should be noted that no energy performance calculations are conducted as part of this master's thesis. Therefore, the impacts of the six shared facilities on the construction costs and MPG of the following components will not be considered:

- The number and capacity of heat pumps (both indoor and outdoor units)
- The number and capacity of ventilation and heat recovery systems
- The number and capacity of solar panels and inverters

5.2.1 Shared garden/terrace

Figure 58: Area of green space located at the back of the building Omgevingsloket (n.d.)

Articles 4.34.1 and 4.35.1 of the Besluit bouwwerken leefomgeving specify that each apartment must include a directly accessible outdoor space with a minimum surface area of 4m² and a minimum width of 1.5 meters. Article 4.35.2 states that as an exception to articles 4.34.1 and 4.35.1, a shared outdoor space may be permitted, provided it offers a minimum of 1m² per apartment, a minimum width of 1.3 meters, and a total minimum of 4m², applicable only when the usable floor area of the apartments is less than 50m². Since the usable floor area of the apartments in De Tuin van Elden is 55.65m², they do not meet these requirements. Consequently, a shared garden or terrace cannot be pursued independently. However, given that other shared facilities are being considered, which would reduce the usable floor area of the apartments, the application of a shared garden or terrace remains under consideration.

The cadastral map (KadastraleKaart.com, 2024) indicates that the apartment building occupies a plot of 2390 m² and according to the Omgevingsloket (n.d.), the zoning plan for the area behind the apartment building is designated as garden space, as illustrated in figures 56 and 57. Additionally, Figure 62 shows approximately 115 m² of green space between the apartment building, the external storage areas, and the parking lot.

Following the Dutch building code requirements, the shared garden must have a minimum area of 22 m² (calculated as 22 x 1 m²). This indicates that such a garden can be established in the indicated green space. To facilitate the creation of the shared garden, 22 m² of pavement will need to be installed; consequently, this would allow for the removal of the balconies and balustrades. Further details concerning the impact of these proposed shared facilities on the materials used are outlined in Appendix 4.

5.2.2 Shared kitchen

Article 4.38.1 of the Dutch building code stipulates that buildings designated for residential use must include at least one residential area suitable for installing a counter and a stove. Articles 4.39.1 and 4.39.2 specify that the area designated for the counter should measure at least 1.5m x 0.6m, while the area for the stove should be a minimum of 0.6m x 0.6m. To qualify as an independent apartment, the unit must feature a kitchen equipped with a counter, supply, and disposal of water and a connection point for a stove.

These regulations allow for a minimized kitchen configuration, with a depth of 0.6 meters and a counter length of 1.5 meters, including a sink, a water tap, and a connection point for a stove. As shown in Figure 63, the existing kitchens have a counter measuring 1.65 meters, supplemented by an additional 0.6-meter cabinet that houses a refrigerator and microwave. Furthermore, these kitchens are equipped with a dishwasher and an induction stove. Since the client ordered the kitchen, specific cost information is unavailable. Thus, the basic design

reflects the costs of a kitchen without equipment but maintains the same counter length and number of cabinets. To attain the minimum kitchen size, the extra cabinet measuring 0.6 meters can be eliminated, as can the additional 0.15 meters of counter length.

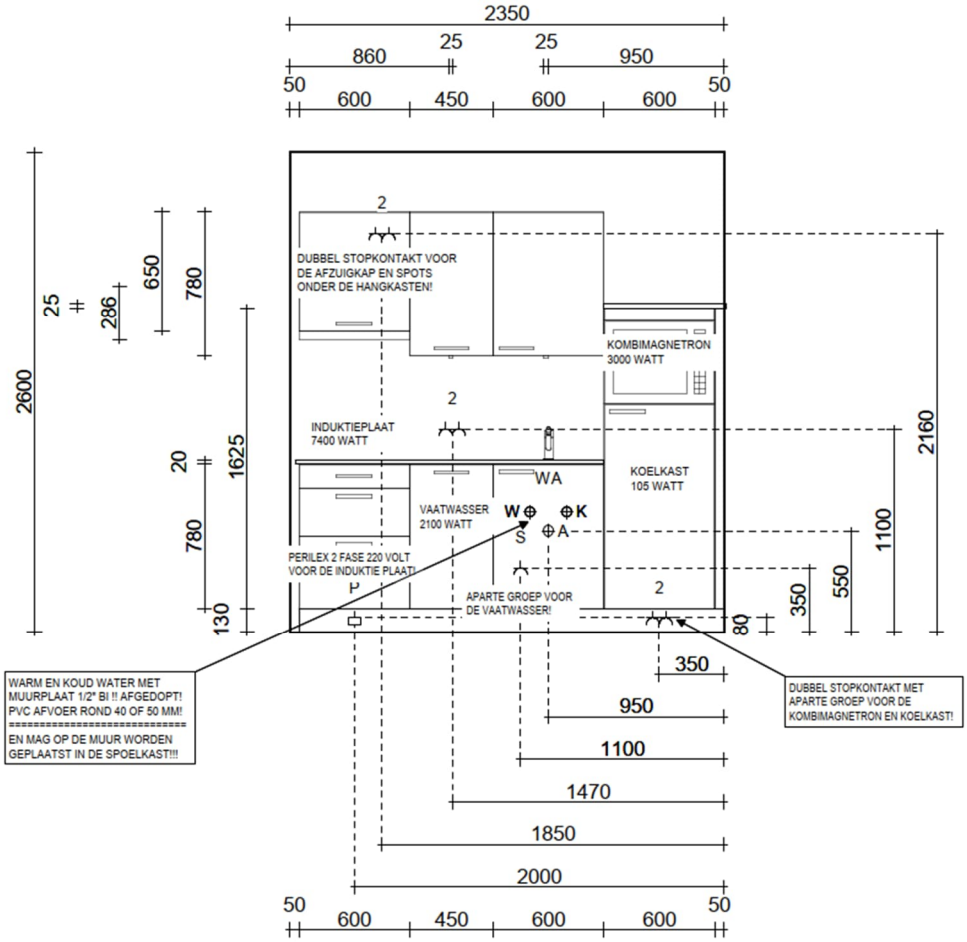


Figure 59: The kitchen that is applied in the apartments, in the basic design it, is applied without an induction stove, dishwasher, microwave, and fridge.

According to Kitchen4All (n.d.), a kitchen longer than 4 meters is classified as large; therefore, the kitchen in the shared area is designed to be 4 meters long. The budget planner tool from Keukenconcurrent (n.d.) is utilized to design the basic kitchen that will fit into the shared kitchen space of the apartment building. This kitchen has appliances such as a dishwasher, oven, induction stove, fridge, and extractor hood. Additionally, the Vtwonen redactie (2023) suggests that a minimum free space of 1 meter should be maintained in front of the kitchen, indicating that the total area required for the kitchen equals 6.4m^2, as shown in Equation 21.

Equation 21: Total UFA required for the kitchen in the shared kitchen facility

$$Kitchen\ area = \ 1.6m * 4m = 6.4m^2$$

A dining table allows residents to host friends for dinner and encourages social interaction by serving as a communal gathering spot. Therefore, it must be possible to place a dining table measuring 280 cm in length and 90 cm in width, which accommodates eight people, in the shared kitchen area (Happy@Home, 2021). To ensure ample space for movement around the table and to accommodate chairs, a clearance of 0.9 meters should be maintained on both long sides, while one short side can be positioned against a wall. The opposite short side

should have a clearance of 1.0 meters. Consequently, the total surface area required for the dining table equals 10.26 m², as shown in Equation 22.

Equation 22: Total UFA required for the dining table in the shared kitchen facility

$$Dining\ table\ area = (2.8m + 1.0m) * (0.9m * 3) = 10.26m^2$$

To determine the surface area of the shared kitchen, the dining table area and kitchen area are summarized. Applying a 20% multiplier—acknowledging that a room is seldom perfectly designed—yields a required surface area of 20 m², as shown in Equation 23.

Equation 23: Total UFA required for the shared kitchen facility

$$Shared\ kitchen\ area = (10.26m^2 + 6.4m^2) * 120\% = 20.0m^2$$

The shared kitchen will also feature two windows with a total surface area of 3.2 m² to ensure adequate natural light, one external entrance door, a PVC floor, and finished white walls.

5.2.3 Shared living room

The living room area in the apartments is measured at 18.57 m². According to Article 4.3.4 of the Dutch building code, each residential unit must include at least one living space with a minimum surface area of 11 m² and a minimum width of 3 meters. To ensure the dining and sitting areas remain functional, the design requirements established by Netwerk Conceptueel Bouwen (NCB) and Aedes (2023) for one or two persons are utilized since the apartments are designed for single and two-person first-time buyers. As outlined in Figures 64 and 65, the sitting area should have a minimum dimension of 3.4 m x 3.6 m, while the dining area should be at least 2.55 m x 2.05 m. Therefore, the living room's total UFA should equal 17.47 m², as shown in Equation 24.

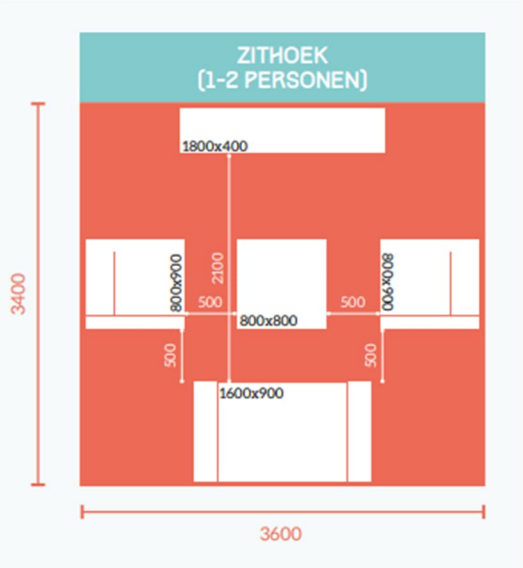
Equation 24: Total UFA of the shared living room facility

$$Total\ UFA\ of\ the\ living\ room = (3.4m * 3.6m) + (2.55m * 2.05m) = 17.47m^2$$

This implies that the total UFA of each apartment can be reduced by 1.1 m², as shown in Equation 25.

Equation 25: Reduction of the UFA of the living room in the apartments

$$Recuction\ UFA\ living\ room = 18.57m^2 - 17.47m^2 = 1.1m^2$$



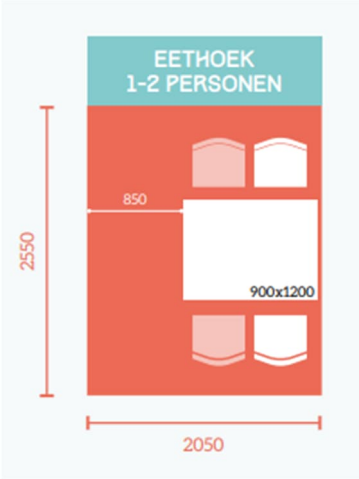


Figure 60: Design requirements for a sitting area for one or two persons (Netwerk Conceptueel Bouwen [NCB] & Aedes, 2023)
Figure 61 Design requirements for a dining area for one or two persons (Netwerk Conceptueel Bouwen [NCB] & Aedes, 2023)

The shared living room should be spacious enough to accommodate at least eight people and primarily consist of a sitting area, as the dining space falls under the shared kitchen. According to Netwerk Conceptueel Bouwen (NCB) and Aedes (2023), the dimensions for a sitting area suitable for families of more than two individuals should be 3.4 meters by 4.0 meters, as illustrated in Figure 66.

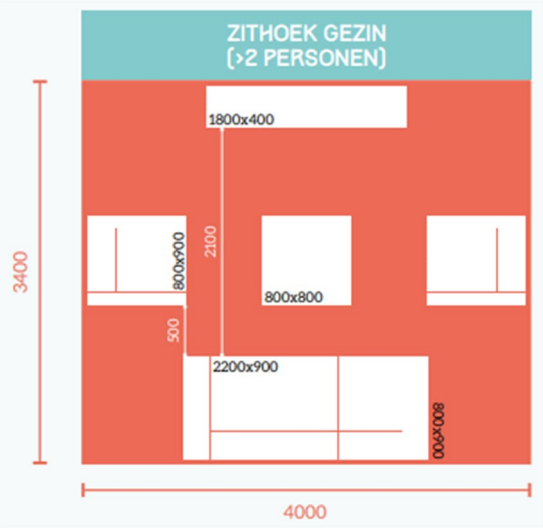


Figure 62: Design requirements for a sitting area for two or more persons (Netwerk Conceptueel Bouwen [NCB] & Aedes, 2023)

To ensure the shared living room has adequate space for eight people, the recommended surface area is multiplied by 1.5, assuming five individuals can comfortably sit in the designated area. This indicates that the shared living room should have a total surface area of 20.4 m², as shown in Equation 26.

Equation 26: Required UFA of the shared living room facility

$$Required\ UFA\ shared\ living\ room = (3.6m * 4.0m) * 1.5 = 20.4m^2$$

Furthermore, the room will be enhanced by two windows, each with a surface area of 1.6 m², to provide ample natural light, along with an entrance door. The floor will be finished with a PVC floor, and the walls will be white.

5.2.4 Shared bike parking

According to Article 4.31.2 of the Dutch building code, a residential unit may have shared storage space instead of private storage when the UFA of the apartment is less than 50 m². Each apartment is allocated 1.5 m² in the shared storage space designated for bike and scooter parking. However, since the UFA of the apartments in De Tuin van Elden is 55.65 m², they do not comply with these requirements. Therefore, pursuing a shared storage space independently is not an option. Nevertheless, as other shared facilities that could reduce the apartments' usable floor area are being considered, the possibility of incorporating a shared storage space remains under review.

The shared storage space necessitates a minimum UFA of 33 m², as shown in Equation 27.

Equation 27: Required UFA of the shared storage spaces

$$Required\ UFA\ shared\ storage\ spaces = 1.5m^2 * 22 = 33.0m^2$$

To ensure accessibility, a pathway between the storage areas is incorporated, as visible in Figure 67. This pathway covers an additional 13.2 m², as shown in Equation 28.

Equation 28: UFA of the pathway to assess the shared storage facilities

$$UFA\ pathway = 1.2m * 11m = 13.2m^2$$

The walls enclosing the shared storage area have a thickness of 10.8 cm. Thus, the extra area needed to convert from UFA to GFA equals 3.33 m², as shown in Equation 29.

Equation 29: Difference between the UFA and GFA of the shared storage space

$$Diff.UFA\ and\ GFA = (2 * 11m * 0.108m) + \big(2 * (4.2m + 0.108m * 2)\big) * 0.108m = 3.33m^2$$

By adding the required UFA of the shared storage spaces, pathway, and the difference between the UFA and GFA, the total GFA of the shared storage space is calculated and equal to 49.51 m². as shown in Equation 30.

Equation 30: Total GFA of the shared storage space

$$GFA\ shared\ storage\ space = 33.0m^2 + 13.2m^2 + 3.33m^2 = 49.51m^2$$

In comparison to the existing storage space, as illustrated in Figure 68, the required GFA can be reduced by 79.14 m², as shown in Equation 31.

Equation 31: Decrease in GFA of the storage space

$$Decrease\ GFA = 128.65m^2 - 49.51m^2 = 79.14m^2$$

Additionally, the number of entrance doors can be minimized from 22 to just two, as shown in Figure 67.

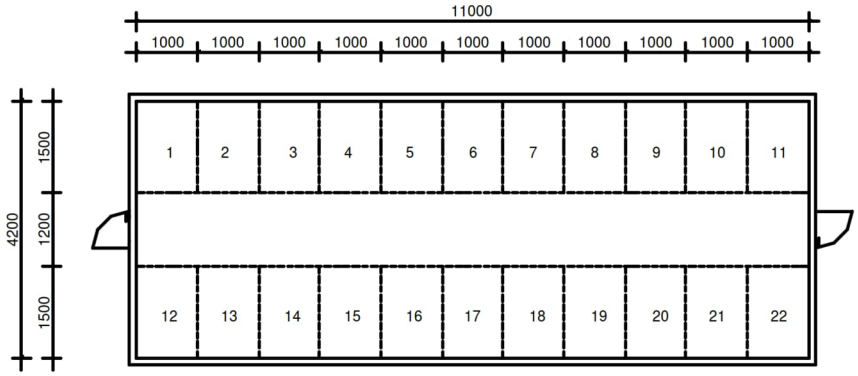


Figure 63: Design of the shared storage space/shared bike parking

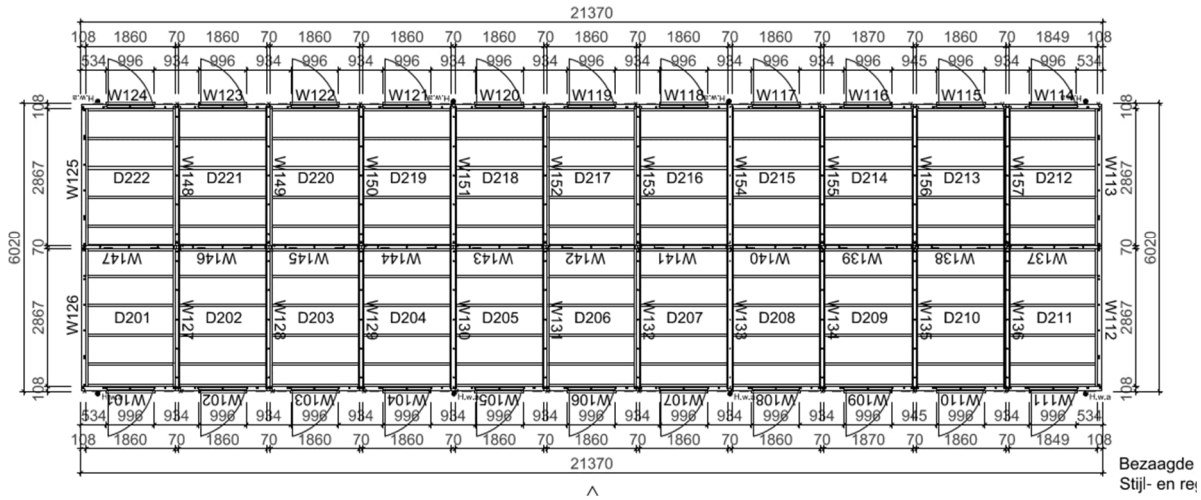


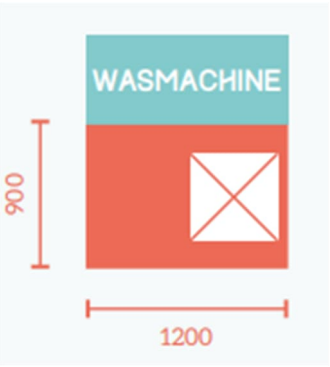
Figure 64: Existing design of the storage space, which is located at the back of the building

5.2.5 Shared Laundry Room

The Dutch building code does not require a washing machine or dryer connection in each residential unit. Therefore, a shared laundry room can be considered. Netwerk Conceptueel Bouwen (NCB) and Aedes (2023) defined in version 3.1 of De Woonstandaard that a washing machine requires a surface area of 0.9 m x 1.2 m, as visible in Figure 69. The washing machine and dryer are located in the internal storage area on the base floorplans, as visible in Figure 70. When a shared laundry room is created, the total area, equal to 23.76 m^2, can be removed to place the washing machines and dryers in the apartments, as shown in Equation 32.

Equation 32: The total decrease in UFA of the apartments, as a result applying a shared laundry room

$$UFA\ drecrease\ shared\ laundry\ room = 22 * (1.2m * 0.9m) = 23.76m^2$$



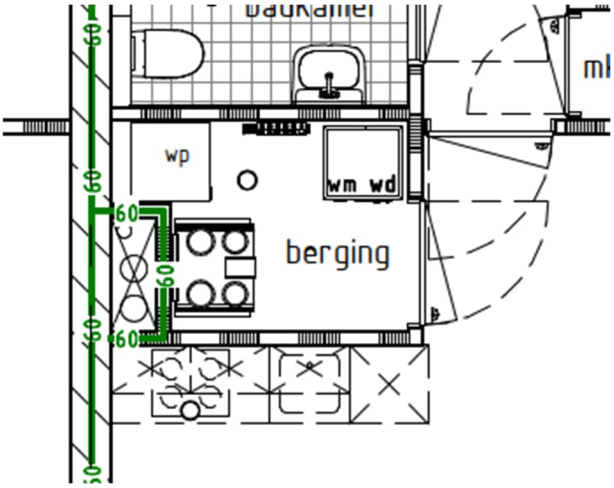


Figure 65: Design requirements for a washing machine (Netwerk Conceptueel Bouwen [NCB] & Aedes, 2023)
Figure 66: The location of the washing machine and dryer (stacked) in the existing floorplans of the apartments

De Jong from Homie Group has outlined the criteria for determining the necessary number of washing machines and dryers in a shared laundry room, as visible in Appendix 5. These criteria include the number of residents, the average frequency of laundry, and the usage distribution throughout the week. For one or two-person households, the typical laundry frequency is about 1 to 2 times per week, with usage peaking during weekends and evenings. Homie Group recommends having one washing machine and one dryer for every 10 to 12 one or two-person households, suggesting that the shared laundry facility should be equipped with two washing machines and two dryers.

Each washing machine and dryer occupies a footprint of 1.08 m², implying that 4.32 m² UFA should be created to allocate the washing machines and dryers, as shown in Equation 33.

Equation 33: UFA required for allocating the two dryers and washing machine in the shared laundry room facility

$$UFA\ washing\ machines + dryers = 4 * 1.08m^2 = 4.32m^2$$

A counter above the machines is designed for folding laundry, measuring 3.6 meters in length and 0.6 meters in depth. In addition, the shared laundry facility will establish a circulation area of 3.6 m² and an ironing area of 4.32 m². Thus, the total UFA required for the shared laundry facility equals 12.24 m², as shown in Equation 34.

Equation 34: Total UFA required for the shared laundry room facility

$$UFA\ shared\ laundry\ room = 4.32m^2 + 3.6m^2 + 4.32m^2 = 12.24m^2$$

When the dryers and washing machines would be leased from Homie Group (Homie, n.d.). The cost associated with renting two washing machines and two dryers would be €355.94 as a one-time fee and €63.96 monthly for a period of 5 years (Homie, n.d.). Resulting in total costs over the period of 5 years of €4193.54, as shown in Equation 35.

Equation 35: Costs associated with leasing 2 washing machines and 2 dryers for a period of 5 years

$$Costs\ shared\ washing\ machines\ and\ dryers\ in\ 5\ years = €355.94 + €63.96 * 12 * 5 = €4193.54$$

Table 25 presents an analysis of the costs associated with leasing two washing machines and dryers from the Homie Group (Homie, n.d.). It delineates the total monthly expenditure for leasing these appliances and the per-apartment contribution.

Table 25: Monthly and initial costs for the washing machine and dryer in the shared laundry room (Homie, n.d.)

	Energy label	Capacity	Duration contract	Amount	Costs
Homie premium washing machine	A	8 kg	5 years	2	€17.99 * 2 = €33.98 per month
Homie Dryer	A++	8 kg	5 years	2	€14.99 * 2 = €29.98 per month
Monthly costs					€63.96
Monthly costs per apartment					€2.91
Delivery and installation costs				4	€59,00 * 4 = 236,00 once
Drip tray				4	€19.99 * 4 = €79.96 once
Waterstop				2	€19.99 * 2 = €39.98 once
Total initial costs					€355.94
Total costs over 5 years					€4193,54
Total costs over 5 years per apartment					€190.62

5.2.6 Shared workspace

The floor plans of the apartment building, as shown in Appendix 1, reveal that all 22 apartments feature two bedrooms. Given that most residents are likely to be single-person or two-person households, often consisting of couples, the second bedroom may not be strictly necessary but is frequently mentioned as a desirable housing feature. With 52% of the working population in 2023 occasionally working from home, it can be surmised that this additional bedroom is increasingly favored for use as a home office. Consequently, a shared workspace is being considered, providing residents with a dedicated area to work when they work remotely and offering the possibility of removing the second bedroom.

The apartment's second bedroom has different measurements but a UFA of 5m². By eliminating this second bedroom, the overall UFA of the building can be reduced by 110m², as shown in Equation 36.

Equation 36: The total decrease in UFA of the building as a result of removing the second bedroom in each apartment

$$Decrease\ in\ UFA\ removing\ 2nd\ bedroom = 22 * 5m^2 = 110m^2$$

In addition to reducing UFA, the windows, entrance doors, and doorframes associated with the second bedroom can also be removed.

To address the need for a second bedroom that functions as a home office, the shared workspace should provide adequate facilities for the residents of the apartment building. To assess the number of required workspaces, it is considered that 11 single-person households and 11 two-person households will occupy the apartments, resulting in a total of 33 residents. According to statistics from the Centraal Bureau voor de Statistiek (2024), approximately 52% of the workforce in the Netherlands works from home, with most individuals working less than half of their hours remotely. If it is assumed that this data is applicable to the inhabitants of this building, it is calculated that 8.58 workspaces are needed, as shown in Equation 37.

Equation 37: The number of required workspaces required in the shared workspace facility

$$Required\ workplaces = 33\ inhabitants * 52\% * 50\% = 8.58\ workplaces$$

In this calculation, an even distribution of remote workdays throughout the week is assumed. Since this calculation presumes each resident works full-time, the required number of workplaces is rounded to 8 since this is probably not the case. The shared workspace, therefore, will have eight workplaces, each equipped with a desk and chair. NEN 1824 defines that each workplace must have at least 4m² of UFA (Ergonomiespecialist, 2021). Consequently, the minimum UFA for the shared workspace equals 32 m², as shown in Equation 38.

Equation 38: Required UFA to facilitate 8 workplaces

$$UFA\ workplaces = 8 * 4m^2 = 32m^2$$

To ensure adequate circulation space, this minimum is multiplied by 1.3, resulting in a required floor area of 41.6 m², as shown in Equation 39.

Equation 39: Total UFA required including circulation space for the shared workspace facility

$$UFA\ shared\ workspace = 32m^2 * 1.3 = 41.6m^2$$

Additionally, the room will feature three windows, each with a surface area of 1.6 m², to allow for ample natural light, along with an entrance door. The floor will be finished with a PVC floor, and the walls will be white.

5.3 Results

After conducting the case study it can be found that the MPG of the base design is equal to €0.86 per m2 GFA per year and that the construction costs (CC) per apartment are equal to €147,560.37, as shown in Equation 40.

Equation 40: Construction costs per apartment of the base design

$$Construction\ costs\ per\ apartment = \frac{€3{,}246{,}328.23}{22\ app} = €147{,}560.37$$

Besides the construction costs per apartment, the construction costs are also often considered per m2 GFA; for the base design, the construction costs per m2 GFA are equal to €1918.02, as shown in Equation 41.

Equation 41: Construction costs per m2 GFA of the base design

$$Construction\ costs\ per\ m2\ GFA = \frac{€3{,}246{,}328.23}{1692.54\ m2\ GFA} = €1918.02\ per\ m2\ GFA$$

Table 26 presents the average transaction prices per square meter of UFA for apartments in the third quartile of 2024. As transaction prices per square meter for newly constructed apartments are available only at the national level, the average prices for both newly constructed and existing apartments are considered for the COROP Region Arnhem-Nijmegen, where the reference project is situated, as well as for the entire Netherlands.

Table 26: Average transaction prices of apartments in the third quartile of 2024 in the Netherlands (NVM, 2024e; NVM, 2024f; NVM, 2024g)

Location	Average transaction price	Based on
Whole Netherlands	€ 5.515,00 /m2 UFA	Only newly constructed apartments
COROP Region Arnhem-Nijmegen	€ 4.388,00 /m2 UFA	Newly constructed + existing apartments
Whole Netherlands	€ 5.229,00 /m2 UFA	Newly constructed + existing apartments

The base design has a UFA of 55.22 m². Therefore, Equation 42 can be used to calculate the estimated transaction price of these apartments based on their UFA and the average transaction prices in the third quartile of 2024 in the Netherlands, as indicated in Table 26.

Equation 42: Calculation to calculate the transaction price of the base apartment

$$Estimated\ transaction\ price = \ UFA * Average\ transaction\ price\ per\ m2\ UFA$$

When equation 42 is used for the base design, it yields the estimated transaction prices for the base design, as illustrated in Table 27. This indicates that the estimated transaction price of the base design apartment is affected by the location and the average transaction prices utilized.

Table 27: Estimated transaction prices of the base design apartment

Based on Location	Transaction price of base design	Based on
Whole Netherlands	€ 304.538,30	Only newly constructed apartments
COROP Region Arnhem-Nijmegen	€ 242.305,36	Newly constructed + existing apartments
Whole Netherlands	€ 288.745,38	Newly constructed + existing apartments

To implement a shared garden/terrace and shared bike parking, the UFA of the apartment must be reduced to less than 50.00 m². Table 28 presents the reduction in UFA of apartments resulting from the implementation of the specified shared facilities. It demonstrates that the shared workspace has the biggest effect on reducing the UFA of the apartment. In contrast, both the shared garden/terrace and bike parking do not reduce the UFA. This indicates that a shared garden/terrace and shared bike parking cannot be introduced without combining these with additional shared facilities that lower the UFA. The selected shared facilities should decrease the UFA of the apartment by at least 5.23 m², as illustrated in Equation 42, to make a shared garden/terrace and bike parking possible.

Table 28: Reduction in UFA of apartments resulting from the implementation of the specified shared facilities

	Reduction in UFA per app	
Garden terrace	0	m2
Kitchen	0,96	m2
Living room	1,1	m2
Bike parking	0	m2
Laundry room	0,99	m2
Workspace	5	m2

Equation 43: Minimal decrease in UFA per apartment to make it possible to apply a shared garden/terrace and bike parking

$$Min.decrease\ in\ UFA\ per\ app. = 55.22m^2 - 49.99m^2 = 5.23m^2$$

A minimum reduction of 5.23 m² can only be achieved when at least a shared workspace is utilized in conjunction with one or more of the following shared facilities:

- Kitchen
- Living room
- Laundry room

The decision support tool, which contains the case study data for the OPUS | Tuin van Elden project, is utilized to assess the impact of various specified shared facilities and their combinations. All shared facilities and their potential combinations have been tested, with results documented in Table 29. These findings highlight the percentage reductions in the MPG and construction costs (Cc) for each shared facility or combination thereof, as compared to the base design.

Table 29: Results of the case study for all possible shared facilities and combinations of shared facilities

Cc = Construction costs	Kitchen		Living room		Laundry room		Workspace	
	MPG	**Cc**	**MPG**	**Cc**	**MPG**	**Cc**	**MPG**	**Cc**
Base	-0,05%	-0,25%	-0,26%	-0,09%	-0,53%	0,27%	-3,06%	3,93%
Kitchen			-0,31%	-0,34%	-0,58%	0,02%	-3,13%	3,67%
Living room					-0,80%	0,18%	-3,36%	3,82%
Laundry room							-3,67%	4,19%
Garden/terrace+Kitchen							-1,25%	6,22%
Garden/terrace+Living room							-1,49%	6,38%
Garden/terrace+Laundry room							-1,77%	6,75%
Kitchen+Living Room					-0,85%	-0,07%	-3,42%	3,57%
Kitchen+Bike parking							-7,22%	4,98%
Kitchen+Laundry room							-3,72%	3,94%
Living room+Bike parking							-7,48%	5,14%
Living room+Laundry room							-3,96%	4,10%
Bike parking+Laundry room							-7,83%	5,50%
Garden/terrace+Kitchen+Living room							-1,54%	6,13%
Garden/terrace+Kitchen+Bike parking							-5,25%	7,54%
Garden/terrace+Kitchen+Laundry room							-1,83%	6,50%
Garden/terrace+Living room+Bike parking							-5,51%	7,70%
Garden/terrace+Living room+Laundry room							-2,06%	6,66%
Garden/terrace+Bike parking+Laundry room							-5,84%	8,06%
Kitchen+Living Room+Bike parking							-7,55%	4,89%
Kitchen+Living Room+Laundry room							-4,02%	3,85%
Kitchen+Bike parking+Laundry room							-7,90%	5,25%
Living Room+Bike parking+Laundry room							-8,16%	5,41%
Garden/terrace+Kitchen+Living room+Bike parking							-5,57%	7,45%
Garden/terrace+Kitchen+Living room+Laundry room							-2,12%	6,41%
Garden/terrace+Kitchen+Bike parking+Laundry room							-5,90%	7,81%
Garden/terrace+Living room+Bike parking+Laundry room							-6,16%	7,97%
Kitchen+Living Room+Bike parking+Laundry room							-8,22%	5,16%
Garden/terrace+Kitchen+Living room+Bike parking+Laundry room							-6,22%	7,72%

Table 29 highlights the most significant positive effect (green square) and the most negative effect (red square) on both construction costs and MPG reductions resulting from shared facilities or combinations of shared facilities. It shows that the greatest reduction in

construction costs compared to the base design occurs when a shared workspace is implemented alongside a shared garden/terrace, bike parking, and a laundry room.

Conversely, the combination of a shared kitchen and a shared living room has the most adverse impact, increasing construction costs by 0.34%. Both the shared laundry room and shared workspace contribute to reducing construction costs, while the shared kitchen and shared living room increase the construction costs. Furthermore, Table 29 reveals that any combination of shared facilities that includes a shared workspace reduces construction costs. Notably, the seven combinations of shared facilities that demonstrate the biggest reductions in construction costs include both shared bike parking and a shared garden/terrace. In contrast, combinations lacking either shared bike parking or a garden/terrace show comparatively smaller reductions in construction costs than those that incorporate these features.

The presence of shared facilities or combinations of shared facilities increases the MPG compared to the base design, as indicated in Table 29. The biggest increase in MPG occurs when a shared workspace is utilized alongside a shared kitchen, living room, bike parking, and laundry room, leading to an increase in MPG of 8.22%. The smallest increase in MPG results from the application of a shared kitchen alone, increasing the MPG by 0.05%. It is noteworthy that the seven combinations of shared facilities demonstrating the biggest increase in MPG all incorporate shared bike parking. This trend is consistent across the board; the introduction of shared facilities featuring shared bike parking leads to a significantly stronger increase in MPG compared to combinations that exclude it. Additionally, it is observed that combinations of shared facilities, including a shared garden/terrace, result in a comparatively smaller increase in MPG than those that do not feature such elements.

5.3.1 Impact on the affordability

In Table 29, it is observed that none of the shared facilities or their combinations reduced the MPG. However, several shared facilities and combinations thereof do reduce the construction costs of the apartments. To evaluate the impact on the affordability of the apartments, the shared facilities and combinations that enhance construction costs are analyzed in relation to the estimated transaction prices of the apartments. Therefore, the adjusted transaction price is calculated in Table 30 using Equation 44.

Equation 44: Formula to calculate the adjusted estimated transaction prices

$$TP_{adjusted} = TP_{orginal} - I_{CC,SF}$$

$TP_{adjusted} = Adjusted\ transaction\ price\ of\ the\ apartment$
$TP_{orginal} = Original\ transaction\ price\ of\ the\ base\ apartment$
$I_{CC,SF} = Impact\ on\ the\ original\ construction\ costs\ per\ apartment$

The impact on the transaction price in Table 30 is calculated using Equation 45.

Equation 45: Formula to calculate the impact on the original estimated transaction price per apartment

$$I_{TP} = \frac{TP_{adjusted}}{TP_{orginal}} - 1 * 100\%$$

I_{TP} = *Percentual impact on the original estimated transaction price per apartment*

Table 30: Impact of the shared facilities on the original construction costs and the estimated transaction prices

TP = transaction price WN-NC = Whole Netherlands, Newly Constructed CRAN-NC+E = COROP Region Arnhem Nijmegen, Newly Constructed+Existing WN-NC+E = Whole Netherlands, Newly Constructed+Existing		Impact on the original construction costs	Adjusted transaction price WN-NC	Impact on TP	Adjusted transaction price CRAN-NC+E	Impact on TP	Adjusted transaction price WN-NC+E	Impact on TP
0	*Original Value*		*€ 304.538,30*		*€ 242.305,36*		*€ 288.745,38*	
1	Garden/terrace+Bike parking+Laundry room+Workspace	€ -11.893,37	€ 292.644,93	-3,91%	€ 230.411,99	-4,91%	€ 276.852,01	-4,12%
2	Garden/terrace+Living room+Bike parking+Laundry room+Workspace	€ -11.760,56	€ 292.777,74	-3,86%	€ 230.544,80	-4,85%	€ 276.984,82	-4,07%
3	Garden/terrace+Kitchen+Bike parking+Laundry room+Workspace	€ -11.524,47	€ 293.013,83	-3,78%	€ 230.780,89	-4,76%	€ 277.220,91	-3,99%
4	Garden/terrace+Kitchen+Living room+Bike parking+Laundry room+Workspace	€ -11.391,66	€ 293.146,64	-3,74%	€ 230.913,70	-4,70%	€ 277.353,72	-3,95%
5	Garden/terrace+Living room+Bike parking+Workspace	€ -11.362,15	€ 293.176,15	-3,73%	€ 230.943,21	-4,69%	€ 277.383,23	-3,94%
6	Garden/terrace+Kitchen+Bike parking+Workspace	€ -11.126,05	€ 293.412,25	-3,65%	€ 231.179,31	-4,59%	€ 277.619,33	-3,85%
7	Garden/terrace+Kitchen+Living room+Bike parking+Workspace	€ -10.993,25	€ 293.545,05	-3,61%	€ 231.312,11	-4,54%	€ 277.752,13	-3,81%
8	Garden/terrace+Laundry room+Workspace	€ -9.960,33	€ 294.577,97	-3,27%	€ 232.345,03	-4,11%	€ 278.785,05	-3,45%
9	Garden/terrace+Living room+Laundry room+Workspace	€ -9.827,52	€ 294.710,78	-3,23%	€ 232.477,84	-4,06%	€ 278.917,86	-3,40%
10	Garden/terrace+Kitchen+Laundry room+Workspace	€ -9.591,42	€ 294.946,88	-3,15%	€ 232.713,94	-3,96%	€ 279.153,96	-3,32%
11	Garden/terrace+Kitchen+Living room+Laundry room+Workspace	€ -9.458,62	€ 295.079,68	-3,11%	€ 232.846,74	-3,90%	€ 279.286,76	-3,28%
12	Garden/terrace+Living room+Workspace	€ -9.414,35	€ 295.123,95	-3,09%	€ 232.891,01	-3,89%	€ 279.331,03	-3,26%
13	Garden/terrace+Kitchen+Workspace	€ -9.178,26	€ 295.360,04	-3,01%	€ 233.127,10	-3,79%	€ 279.567,12	-3,18%
14	Garden/terrace+Kitchen+Living room+Workspace	€ -9.045,45	€ 295.492,85	-2,97%	€ 233.259,91	-3,73%	€ 279.699,93	-3,13%
15	Bike parking+Laundry room+Workspace	€ -8.115,82	€ 296.422,48	-2,66%	€ 234.189,54	-3,35%	€ 280.629,56	-2,81%
16	Living Room+Bike parking+Laundry room+Workspace	€ -7.983,02	€ 296.555,28	-2,62%	€ 234.322,34	-3,29%	€ 280.762,36	-2,76%
17	Kitchen+Bike parking+Laundry room+Workspace	€ -7.746,92	€ 296.791,38	-2,54%	€ 234.558,44	-3,20%	€ 280.998,46	-2,68%
18	Kitchen+Living Room+Bike parking+Laundry room+Workspace	€ -7.614,12	€ 296.924,18	-2,50%	€ 234.691,24	-3,14%	€ 281.131,26	-2,64%
19	Living room+Bike parking+Workspace	€ -7.584,60	€ 296.953,70	-2,49%	€ 234.720,76	-3,13%	€ 281.160,78	-2,63%
20	Kitchen+Bike parking+Workspace	€ -7.348,51	€ 297.189,79	-2,41%	€ 234.956,85	-3,03%	€ 281.396,87	-2,54%
21	Kitchen+Living Room+Bike parking+Workspace	€ -7.215,70	€ 297.322,60	-2,37%	€ 235.089,66	-2,98%	€ 281.529,68	-2,50%
22	Laundry room+Workspace	€ -6.182,78	€ 298.355,52	-2,03%	€ 236.122,58	-2,55%	€ 282.562,60	-2,14%
23	Living room+Laundry room+Workspace	€ -6.049,98	€ 298.488,32	-1,99%	€ 236.255,38	-2,50%	€ 282.695,40	-2,10%
24	Kitchen+Laundry room+Workspace	€ -5.813,88	€ 298.724,42	-1,91%	€ 236.491,48	-2,40%	€ 282.931,50	-2,01%
25	Workspace	€ -5.799,12	€ 298.739,18	-1,90%	€ 236.506,24	-2,39%	€ 282.946,26	-2,01%
26	Kitchen+Living Room+Laundry room+Workspace	€ -5.681,07	€ 298.857,23	-1,87%	€ 236.624,29	-2,34%	€ 283.064,31	-1,97%
27	Living room+Workspace	€ -5.636,81	€ 298.901,49	-1,85%	€ 236.668,55	-2,33%	€ 283.108,57	-1,95%
28	Kitchen+Workspace	€ -5.415,47	€ 299.122,83	-1,78%	€ 236.889,89	-2,23%	€ 283.329,91	-1,88%
29	Kitchen+Living Room+Workspace	€ -5.267,91	€ 299.270,39	-1,73%	€ 237.037,45	-2,17%	€ 283.477,47	-1,82%
30	Laundry room	€ -398,41	€ 304.139,89	-0,13%	€ 241.906,95	-0,16%	€ 288.346,97	-0,14%
31	Living Room+Laundry room	€ -265,61	€ 304.272,69	-0,09%	€ 242.039,75	-0,11%	€ 288.479,77	-0,09%
32	Kitchen+Laundry room	€ -29,51	€ 304.508,79	-0,01%	€ 242.275,85	-0,01%	€ 288.715,87	-0,01%

Table 30 illustrates that the initially estimated transaction price, calculated based on the average transaction price of newly constructed apartments in the Netherlands for the third quartile of 2024, can be reduced by 3.91%. This adjustment results in a revised estimated transaction price of €292,644.93 when incorporating a shared garden/terrace, bike parking, laundry room, and workspace. Furthermore, it is noted that for 13 distinct combinations of shared facilities, the estimated transaction price has decreased by at least 3%.

Additionally, Table 30 indicates that the initially estimated transaction price for apartments in the COROP Region Arnhem Nijmegen, derived from average data in the third quartile of 2024, can be reduced by 4.91%. This adjustment brings the new estimated transaction price to €230,411.99, also factoring in a shared garden/terrace, bike parking, laundry room, and workspace. It is further observed that for 9 distinct combinations of shared facilities, the estimated transaction price has decreased by at least 4%, while for 20 distinct combinations, it has decreased by a minimum of 3%.

When considering the initially estimated transaction price for apartments in the Netherlands in the third quartile of 2024, as indicated in Table 27, it can be decreased by 4.12% when a shared garden/terrace, bike parking, laundry room, and workspace are included. This results in an adjusted estimated transaction price of €276,852.01. Additionally, it is noted that for 2 distinct combinations of shared facilities, the estimated transaction price has decreased by at least 4%, and for 14 distinct combinations, it has decreased by at least 3%.

The fact that the percentual impact on the estimated transaction price differs indicates that although the impact on construction costs remains constant, the effect on affordability is contingent upon the initial height of the estimated transaction price.

Considering the initially estimated transaction prices for the apartment, as outlined in Table 27, and the willingness to pay among first-time buyers in 2023, as found in the literature & statistical data review indicate that all estimated transaction prices fall below the threshold of €323,241, which is the maximum amount that two-person first-time buyers are willing to pay. Conversely, none of the original estimated transaction prices fall below the willingness to pay for single-person first-time buyers, which stands at €240,249.

As illustrated in Table 30, when considering the adjusted transaction prices for the COROP Region Arnhem Nijmegen, the estimated transaction price for the apartment is below the willingness to pay for single-person first-time buyers in 29 out of the 32 shared facilities and their various combinations assessed. However, when the adjusted transaction prices based on the average transaction price of newly constructed apartments in the Netherlands for the third quarter of 2024, as well as the average transaction price for all apartments in the Netherlands during the same period are considered, it is found that these values still surpass the willingness to pay of single-person first-time buyers.

5.4 Adjustments

In addition to assessing the impact of shared facilities on environmental performance and construction costs, the case study also served as a validation process for the tool by actively utilizing it. Throughout the execution of the case study, several enhancements were implemented in the decision support tool.

Following the entry of project data using the “Project Data Form,” it was discovered that the delimiters applied for inputting product quantities and construction costs were incorrectly considered in the VBA coding for calculating these costs, with delimiters being misused as a thousands separators. To address this issue, the code was modified to define the Quantity variable as a double, ensuring that the value retrieved from Me.txtxQuantity is also treated as a double, as illustrated in Figure 71. After implementing this solution, a thorough review of the entire tool was conducted to confirm that all delimiters were correctly recognized and that any discrepancies were promptly resolved.

```
Private Sub CalculateMKI()

    'Calculation to calculate the MKI and MKIscaled
    Dim MKIpUnit As Double
    Dim Quantity As Double
    Dim ProductLifespan As Double
    Dim BuildingLifespan As Double
    Dim MKI As Double
    Dim NoReplacements As Double

    ' Check if txtMKIpUnit or txtQuantity is empty
    If Me.txtMKIpUnit.Value = "" Or Me.txtQuantity.Value = "" Then
        ' Clear MKI and MKIscaled fields if either input is empty
        Me.txtMKI.Value = ""
        Me.txtMKIscaled.Value = ""
        Exit Sub
    End If

    ' Retrieve the values from the text boxes
    MKIpUnit = CDbl(Me.txtMKIpUnit.Value)
    Quantity = CDbl(Me.txtQuantity.Value)
    ProductLifespan = CDbl(Me.txtLifespan.Value)
    BuildingLifespan = CDbl(Me.txtBuildinglifespan.Value)
```

Figure 67: Adjusted code to ensure that the delimiters were correctly interpreted

Upon conducting an analysis of the outcomes associated with the case study, it became evident that the calculations pertaining to the total construction costs per square meter of GFA were inaccurately determined for the designs with shared facilities. Initially, these costs were determined by dividing the construction expenses associated with the shared facilities (I56) by the GFA of the original design ($C$13), as depicted in Figure 72. This issue was addressed by incorporating the impact of the shared facilities on the GFA (Extra_Data_SF!$B$7, and others) prior to dividing the construction costs of the shared facility (I56), as illustrated in Figure 73.

```
=I56/$C$13
```

```
=I56/($C$13 +
        IF(Q$33="Yes"; Extra_data_SF!$B$7; 0) +
        IF(Q$34="Yes"; Extra_data_SF!$B$8; 0) +
        IF(Q$35="Yes"; Extra_data_SF!$B$9; 0) +
        IF(Q$36="Yes"; Extra_data_SF!$B$10; 0) +
        IF(Q$37="Yes"; Extra_data_SF!$B$11; 0) +
        IF(Q$38="Yes"; Extra_data_SF!$B$12; 0))
```

Figure 68: Original formula used to determine the construction costs per m2 GFA of the design with shared facilities
Figure 69: Updated formula used to determine the construction costs per m2 GFA of the design with shared facilities

In addition to modifying the formula for calculating the costs per square meter of GFA, the conditional formatting for the cells displaying the total construction costs and total construction costs per square meter of GFA across variants 1 to 5 has also been established, as illustrated in Figure 74. This formatting ensures that the text turns red when the value exceeds that of the base design, and green when it falls below the base design value.

Rule (applied in order shown)	Format	Applies to	Stop If True
Cell Value < $E$56	AaBbCcYyZz	=$I$56;$M$56;$Q$56;$U$56;$Y$56	☐
Cell Value > $E$56	AaBbCcYyZz	=$I$56;$M$56;$Q$56;$U$56;$Y$56	☐

Figure 70: Example of the conditional formatting that ensures that the text turns red when the value exceeds the value of the base design and turns green when the value falls below the value of the base design

It can be concluded that, as a result of the case study, the calculation and interpretation errors of the tool have been addressed, leading to improved accuracy. Additionally, the user interface has been improved through the incorporation of conditional formatting, thereby enhancing the clarity and comprehensibility of the presented outcomes.

5.5 Conclusion

The data from the selected reference project has been prepared by updating the construction costs, extracting input data, and allocating those costs to the EPD products. After entering the base design data into the decision support tool, six shared facilities were defined based on the project characteristics and subsequently incorporated into the tool. Testing all the shared facilities and their possible combinations revealed that none of them reduced the MPG. However, it was observed that most configurations led to a decrease in the construction costs of the building.

As a result of the reduced construction costs, the intended transaction price can be lowered. Since transaction prices are influenced by factors beyond just construction costs, the effect of lowering these costs on the initial transaction price varies depending on the original transaction price. An analysis of the average transaction prices for apartments in the Netherlands and in the COROP region of Arnhem Nijmegen, suggests that these prices are

subject to local influences. Given the findings that lowering construction costs contributes to lowering the transaction price and, therefore, enhances affordability, it can be concluded that the implementation of shared facilities positively contributes to making housing more affordable for first-time buyers.

Additionally, the case study was utilized in the validation process of the decision support tool. This led to the identification and correction of several aspects of the tool.

6 Validation

6.1 Expert interviews

Expert interviews were applied to gather qualitative data regarding the tool's usability and willingness to adopt the tool. Three experts, who are considered the intended users of the tool, participated in the expert interviews.

All meetings with the participants were held through Microsoft Teams (version 24295.603.3219.7719), using the transcription feature to transcribe the given answers during the interview. Table 31 outlines the participants' roles, regions of their offices in the Netherlands, job titles, and years of experience.

Table 31: The participants' roles, regions of their offices in the Netherlands, job titles, and years of experience

Participant	Role	Region	Job title	Years of experience
1	Manager	East	Ontwikkelingsmanager	28 years
2	Medior	East	Planvoorbereider (commercieel)	5 years
3	Junior	South	Gebiedsontwikkelaar	<1 year

Following a brief introduction to the decision support tool, participants engaged in the tasks outlined in the minor assignment described in Appendix 6. The version of the decision support tool that was used by the participant contained the data of the case study OPUS | de Tuin van Elden. The results were then discussed and compared against the intended objectives. It was found that Participant 1 was unable to complete the assignment independently and accurately, while Participants 2 and 3 accomplished the assignment on their own. After comparing the intended outcomes with the participants' performances, an interview consisting of six open-ended and five follow-up questions, as described in Chapter 3.4.1, was conducted. The results of the interview were analyzed using a semantic approach to carry out inductive thematic analysis (Braun & Clarke, 2006).

Table 32: The categorized interview outcomes

Question	Category	Findings
1	1.1	Participant 1 thinks he will not be able to use the decision support tool.
	1.2	Participants 2 and 3 think they will be capable of using the decision support tool, but Participant 2 thinks that more practice is required to make it familiar.
1A	1.1A	Participant 1 indicated that more technical knowledge of tool development is required.
	1.2A	Participant 1 indicated that the tool should be more intuitive.
	1.3A	Participant 3 indicated that the required input data is not yet available.
2	2.1	All participants indicated that the tool provided sufficient information concerning the impact of the six shared facilities on the MPG and construction costs so they could make informed design decisions.

	2.2	Participant 2 indicated that she found it difficult to check if everything was included in the calculation.
	2.3	Participant 3 indicated that it would be valuable to indicate the quantities of elements in the tool.
2A	2.1A	Participant 2 indicated that she needs to use the tool more than once to make suggestions.
3	3.1	Participants 2 and 3 indicated that the tool feels intuitive
	3.2	Participant 1 indicated that the tools do not feel intuitive.
	3.3	Participant 3 indicated that the tool has a recognizable structure.
	3.4	Participant 3 indicated that recognizable shared facilities are considered in the tool.
3A	3.1A	Participant 1 indicated that it would be beneficial if the data entry were more automated.
	3.2A	Participant 1 indicated that it would be nice to have a tool description guide.
	3.3A	Participant 1 indicated that it would be nice to have some more technical background as a person who uses the tool.
4	4.1	Participant 2 thinks the user-friendliness of the tool is very good
	4.2	Participant 3 thinks the user-friendliness of the tool is good.
	4.3	Participant 1 thinks the user-friendliness of the tool can be improved significantly.
	4.4	Participant 1 indicated that it would be valuable to incorporate more data sources.
	4.5	Participant 3 indicated that experience with tool development is valuable.
	4.6	Participant 3 indicated that setting the tool's language to Dutch would be beneficial.
5	5.1	All three participants indicated that they would use the tool
	5.2	Participant 1 indicated that he would not use the tool but that the technical developers in his team would use it.
	5.3	Participant 2 indicated that whether or not she would apply the tool depends on the project requirements.
	5.4	Participant 2 indicated that whether or not she would apply the tool depends on the project's location.
	5.5	Participant 3 indicated the increasing importance of the MPG as a criterion and the tool's usefulness.
	5.6	Participant 3 indicated that the tool is valuable, especially in the initial design phase.
6	6.1	Participant 1 indicated that it would be nice if the results were more graphically presented.

	6.2	Participant 2 indicated that it might be useful to implement more different shared facilities in the tool.
	6.3	Participant 3 indicated that adding basic element packages and basic design principles would be valuable.

The responses are organized and categorized, as detailed in Appendix 7, and an overview of these categorized outcomes is presented in Table 32. This is followed by summarizing the responses below and providing potential follow-up actions.

Question 1 + 1A
Two participants expressed confidence in their ability to use the tool; however, Participant 2 noted that she requires additional practice to become more familiar with it. Conversely, Participant 1 felt that he would struggle to use the tool due to his lack of technical knowledge in tool development, making the tool seem less intuitive to him. In question 5, Participant 1 also mentioned that he would not be using the tool himself, as his technical developers would handle it, indicating that this person lacks a bit of a technical background. Participant 3 also indicated that he is not currently performing these calculations since he stated, “Normally, I would ask our construction company for detailed insights regarding the elements included in the decision support tool. However, if I have the data available, I believe this tool can assist me in doing this myself.” This indicates that Participant 3 might lack the necessary input data since another company currently provides this.

Given the responses from Participants 1 and 3, it appears that these project developers were not directly involved in the MPG calculation during the initial design phase. Therefore, redefining the target group by including technical developers and individuals engaged in MPG calculations during the early design stages within construction companies is necessary.

Question 2 + 2A
All participants unanimously agreed that the tool provides essential information for making informed design decisions regarding the implementation of shared facilities. Participant 3 noted, “This is the data we are looking for in projects, the impact of choices we make, and the consequences on the MPG score. So the tool is really, really nice.” Both Participant 2 and Participant 3 suggested potential enhancements for the tool. Participant 3 proposed incorporating the quantities of elements so that when one quantity is defined, the others are automatically updated. Meanwhile, Participant 2 highlighted the need to indicate whether all necessary information is included in the tool.

Based on the feedback provided, it is concluded that a validation method to ensure the inclusion of all required data in the tool would be valuable. The certified MPG calculation tools include a completeness check that leverages the NL-SfB structure along with the classification of environmental products. In the decision support tool, preparations are made for the specification of environmental product data classification. However, due to the complexities involved in completeness validation and time constraints, this feature has yet to be integrated into the decision support tool. Nonetheless, this suggests that it would be a beneficial improvement to consider for future development of the tool, alongside the implementation of the quantities of elements system.

Question 3 + 3A
In evaluating the tool's intuitiveness, participants 2 and 3 noted that it feels intuitive, logical, and clear. Participant 3 specifically acknowledged the tool's structure and stated, "The shared facilities that are included are the shared services that are most present in the projects that we have." In contrast, Participant 1 expressed that the tool does not come across as intuitive and suggested improvements could be made by minimizing the manual data entry required, coupled with a descriptive guide and utilization by individuals with some technical knowledge. Participant 2 also emphasized her uncertainty about whether all users know where to locate the input data for the tool, a point that could be clarified in the descriptive guide. Additionally, Participant 3 mentioned, just like Participant 1, that it would be beneficial to minimize manual data entry by establishing a direct connection to the material database.

Based on the provided responses, it can be concluded that automating data entry would be highly beneficial. However, directly accessing data from the NMD database is deemed unfeasible, as this database can only be accessed via certified MPG calculation tools. Nevertheless, when further developing the tool, exploring options for automated data entry is worthwhile. Additionally, the recommendation to create a descriptive guide for the tool will be acted upon, and a concise guide will be produced.

Question 4 + 4A
According to Participants 1 and 3, the tool's user-friendliness could be enhanced. Participant 1 expressed, "I see a lot of possibilities to make it better, but I think for a student, it is way too complex to make it more incorporated with more data sources." Participant 2 remarked that the tool's user-friendliness would be significantly improved if the language were set to Dutch, as "most construction companies in the Netherlands primarily use Dutch." Additionally, while he noted that some experience with Excel would help users understand the tool better, he affirmed that the primary function of the tool is effective and expressed that it is user-friendly.

Based on the responses received, it can be concluded that the tool's user-friendliness could be enhanced further. Switching the tool's language to Dutch would likely improve its usability significantly, as all necessary input data is presented in Dutch. However, this change would restrict access for non-native speakers, so it will not be implemented now. Nevertheless, the possibility of incorporating language settings should be explored when considering future developments of the tool.

Question 5 + 5A
All three participants indicated that they or their colleagues would utilize the tool during the design phase of an apartment building aimed at first-time buyers in the Netherlands to assess the application of shared facilities. Participant 2 noted that the decision to use the tool is contingent upon specific project requirements and its location, emphasizing the critical role of location in housing development. Participant 3 highlighted the increasing focus on reducing the MPG score in current and future projects to achieve better results in tenders, stating, "Especially in the initial phase to consider the design of the building, the tool adds value." Participant 1 mentioned, as previously stated, that he would not personally use the tool, but the technical developers on his team would.

Based on these insights, it can be concluded that the tool is deemed valuable and provides the necessary information for making informed design decisions. However, as noted in previous responses, there is still potential for further improvements to the tool.

Question 6
All three participants provided valuable recommendations for enhancing the tool. Participant 3 suggested incorporating a reference project within the tool that could be easily adjusted, serving as a useful starting point. Participant 2 proposed the inclusion of additional shared facilities, while Participant 1 emphasized the benefit of visualizing outcomes graphically.

The recommendation to create a base scenario based on previous insights, which can be easily adjusted, is recognized as valuable. However, more reference data must be collected and integrated to improve the accuracy of this base scenario. The suggestion to incorporate additional shared facilities will not be pursued in the current tool, as a literature & statistical data review has already identified the facilities considered shared. Moreover, the tool's Excel-based format allows for relatively straightforward modification of the names of these shared facilities, with each already capable of being individually adapted and specified. The potential for visualizing outcomes more graphically can be considered in future tool developments but is not deemed necessary to implement now.

Other findings
In addition to the findings from the interview questions, valuable insights were gathered during the brief introduction to the tool and while participants completed the tasks. Several areas for improvement and clarification emerged, which are outlined below in conjunction with the changes implemented based on the expert interview outcomes:

1. In the NMD_DATABASE input data form, only "Environmental declaration" was visible in the explanatory text preceding the textbox for entering the environmental declaration number.
2. When a confirmation message appears, the options are displayed in Dutch; therefore, instead of "Yes" and "No," "Ja" and "Nee" are shown.

6.2 Technical validation

A summative evaluation method, noted for its more artificial approach, has been employed throughout the design process to validate the tool's accuracy and outcomes. Validating the accuracy and correctness of the outcomes is required to define potential flaws in the implemented calculation methods or the interpretation of input or output values. A comprehensive technical validation of the complete tool was conducted to conclude the design process. This involved creating a base variant, as visible in Figure 75, alongside a variant featuring a shared living room, as visible in Figure 76. The outcomes of both variants were compared to the expected results, and the discrepancies between them were calculated. The assigned construction costs were computed in this Excel file and juxtaposed against the calculated costs in the decision support tool. The MPG for each variant was determined with the MRPI MPG tool, a validated MPG calculation software, and these outcomes were then compared with those generated by the decision support tool (Stichting MRPI, n.d.-a). The results from the MRPI MPG calculations can be found in Appendix 8, while the outcomes from the decision support tool are available in the Excel document titled "Decision_Support_Tool_Technical_Validation_V1."

Function	Residential
Total GFA	100 m2
Numb of app	1

NL-SfB	EDN product name	EDN Number	Quantity	Unit	Costs/unit	Total costs	Costs in tool	MPG (MRPI)	MPG in tool
11.1	Deelproduct: Grondaanvullingen,	#nmd_27309	100	m3	€ 5,00	€ 500,00		0,00320	0,09307
16.1	Fundatiebalken, Betonhuis; beton	#nmd_27370	100	M	€ 5,00	€ 500,00	€ 1.000,00	0,08990	
23.2	Deelproduct: Afwerklagen, Kerami	#nmd_28929	100	M2	€ 5,00	€ 500,00	€ 500,00	0,05035	0,05040
31.3	Deelproduct: Buitendeuren, Onver	#nmd_30979	2	Pieces	€ 5,00	€ 10,00	€ 10,00	0,00260	0,00265

Other construction costs	€ 100,00	€ 100,00
Construction site costs	€ 200,00	€ 200,00

General costs	6%	€ 108,60	€ 108,60
Risk and profit	4%	€ 76,74	€ 76,74
Insurances	0,43%	€ 8,58	€ 8,58
Unforeseen costs	0,35%	€ 7,01	€ 7,01
Sum of the additional costs		**€ 200,94**	**€ 200,93**

					Difference			Difference
Total	**€ 2.010,94**	**€ 2.010,93**	**0,0004%**	**0,14605**	**0,14612**	**0,0479%**

Figure 71: Technical validation of the outcomes of the base scenario

Shared living room	Total increase	Decrease. per unit	Total decrease	Increase shared area
Impact on GFA	-25	30	30	5
Original GFA	100	m2		
New GFA	75	m2		

NL-SfB	*EDN product name*	*EDN Number*	*Original quantity*	*Added quantity*	*Applied quantity*	*Unit*	*Costs/unit*	*Total costs*	*Costs in tool*	*MPG (MRPI)*	*MPG in tool*
11.1	Deelproduct: Grondaanvullingen,	#nmd_27309	100	-25	75	m3	€ 5,00	€ 375,00		0,00320	0,09307
16.1	Fundatiebalken, Betonhuis; beton	#nmd_27370	100	-25	75	M	€ 5,00	€ 375,00	€ 750,00	0,08990	
23.2	Deelproduct: Afwerklagen, Kerami	#nmd_28929	100	-25	75	M2	€ 5,00	€ 375,00	€ 375,00	0,05035	0,05040
31.3	Deelproduct: Buitendeuren, Onver	#nmd_30979	2	1	3	Pieces	€ 5,00	€ 15,00	€ 15,00	0,00520	0,00531

Other construction costs	Bench	0	1	1	Pieces	€ 10,00	€ 110,00	€ 110,00	
Construction site costs							€ 200,00	€ 200,00	

General costs						6%	€ 87,00	€ 87,00
Risk and profit						4%	€ 61,48	€ 61,48
Insurances						0,43%	€ 6,87	€ 6,87
Unforeseen costs						0,35%	€ 5,62	€ 5,62
Sum of the additional costs							**€ 160,97**	**€ 160,97**

									Difference			Difference
Total							**€ 1.610,97**	**€ 1.610,97**	**0,0001%**	**0,14865**	**0,148780**	**0,0875%**

Figure 72: Technical validation of the outcomes with shared living room

Figure 75 shows that when considering the construction costs of the base variant, there is a negligible difference of 0.0004% between the outcomes. Additionally, a difference of 0.0001% is evident in the case of the shared living room, as illustrated in Figure 76. These minimal discrepancies between the calculated and expected outcomes can be attributed to the rounding of costs in the tool. In contrast, the costs in the "Total costs" column are presented without rounding. Moreover, the construction costs in the tool are based on costs per unit, which are inputted with a maximum of two decimal places, leading to the possibility of rounding in these costs per unit.

A slight discrepancy between the actual and expected outcomes is also noted concerning the MPG. Figure 75 illustrates that the difference between the actual and expected outcomes is 0.0479% for the base variant. In contrast, Figure 76 shows that for the variant with the shared living room, this difference is 0.0875%. These variations can be traced back to the fact that the NMD product data obtained from the NMD-viewer, which serves as input for the decision support tool, is presented with only two decimal places. Conversely, the input data utilized by the MRPI-MPG tool is sourced directly from the NMD database and contains more decimal

places. Consequently, Stichting Nationale Milieudatabase (n.d.-a) indicates that the data from the viewer is not considered reliable for conducting MPG calculations. However, direct access to the data from the NMD database is not available, making the viewer data the most accurate option.

Despite these minor discrepancies between the actual and expected outcomes in both MPG and construction cost calculations, it can be concluded that the decision support tool is operating as intended. The observed variances do not result from the tool but stem from the input data. While the accuracy may not be deemed perfect, the tool is specifically designed for use early in the design process, a phase characterized by numerous uncertainties and with an accuracy ranging from 10 to 30 percent (Ramos, 2020). Therefore, the minor differences between the outcomes and expected results are acceptable.

6.3 Functional validation

The decision support tool is evaluated through an ex-post analysis based on ten Boolean design requirements that are defined in Chapter 3.4.3 and visible in Table 20. Parts of the user interface are shown to indicate how the decision support tool fulfills the ten Boolean design requirements.

Figure 77 illustrates that the tool presents the construction costs and the MPG for each building element, organized according to the NL-SfB structure and for the complete building. It further reveals that costs related to the development and construction of housing, beyond the construction costs, are included in the form of construction site costs, general overhead costs, risk and profit margins, insurance, and unforeseen costs. Additionally, it highlights that the MPG and construction costs include rows labeled “Reduction compared to BASE,” where the values in these rows reflect the percentage reduction of shared facilities in relation to the base design. This fulfills Boolean design requirements one, two, nine, and ten.

MPG		MPG		
Total	9	0,98		1
Reduction compared to BASE				
1. Ground, Substructure		0,17		
2. Primary elements, Carcass		0,23		
3. Secondary elements		0,06		
4. Finishes		0,02		
5. Services mainly piped and ducted		0,30		
6. Services mainly electrical		0,16		
7. Fittings		0,01		
9. Terrain		0,01		

Construction costs		Costs	€/m2 GFA	
Total construction	10	€ 3.294.919,59	€ 1.946,73	1
Reduction compared to BASE				
1. Ground, Substructure		€ 151.053,70	€ 89,25	
2. Primary elements, Carcass		€ 994.976,86	€ 587,86	
3. Secondary elements		€ 366.124,64	€ 216,32	
4. Finishes		€ 104.761,92	€ 61,90	
5. Services mainly piped and ducted		€ 512.367,64	€ 302,72	
6. Services mainly electrical		€ 251.071,13	€ 148,34	
7. Fittings		€ 64.925,61	€ 38,36	
9. Terrain		€ -	€ -	
Other construction costs		€ 226.694,34	€ 133,94	
Construction site costs		€ 293.707,50	€ 173,53	2
General costs	6,00%	€ 177.941,00	€ 105,13	
Risk and profit	4,00%	€ 125.744,97	€ 74,29	
Insurances	0,43%	€ 14.058,29	€ 8,31	
Unforseen costs	0,35%	€ 11.492,00	€ 6,79	
Sum of the additional costs		€ 622.943,76	€ 368,05	

Figure 73: Part of the decision support tool that fulfills design requirements 1,2, 9, and 10

Figure 78 illustrates the six predefined shared facilities, along with the first of five possible variants that can be created. This suggests that multiple predefined shared facilities can be selected and applied to a variant. Up to five distinct variants can be developed for straightforward comparisons, indicating that design requirements seven and eight are met.

	Base		Variant 1		8
	Shared facilty	Shared facility		Shared facility	
1	Garden/terrace	No		Yes	9
2	Kitchen	No		No	
3	Living room	No		No	
4	Bike parking	No		Yes	
5	Laundry room	No		No	
6	Workspace	No		No	

Figure 74: Part of the decision support tool that fulfills design requirements 7 and 8

The NMD database form, as illustrated in Figure 79, allows users to enter product data into the decision support tool's database by completing all required fields and saving the information. Users can also edit or delete the stored data using the combo box and the edit and delete buttons at the bottom of the form, fulfilling design requirement three.

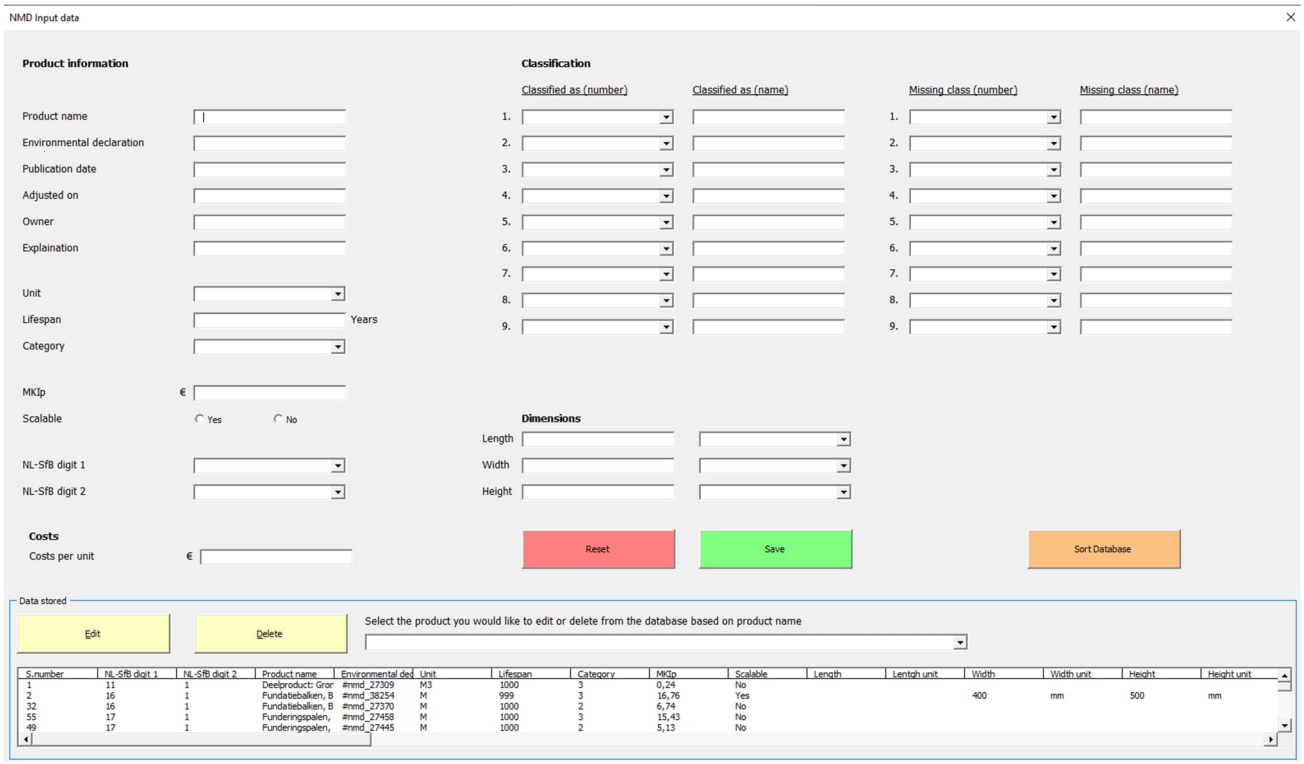


Figure 75: NMD database input form, which fulfills design requirement 3

The worksheets titled “Input_Table,” “NMD_DATABASE,” “Extra_data_SF,” and “DATA_SF” present comprehensive overviews of the data stored within the decision support tool. These worksheets are readily accessible within the tool itself, thus satisfying the stipulations of requirement four.

The project data form, illustrated in Figure 80, is used to store environmental performance and construction cost data at the product level by specifying the quantities utilized and the costs associated with each unit. This product data is also used to compute the established base design's MPG and construction costs, ensuring compliance with design requirements five and six.

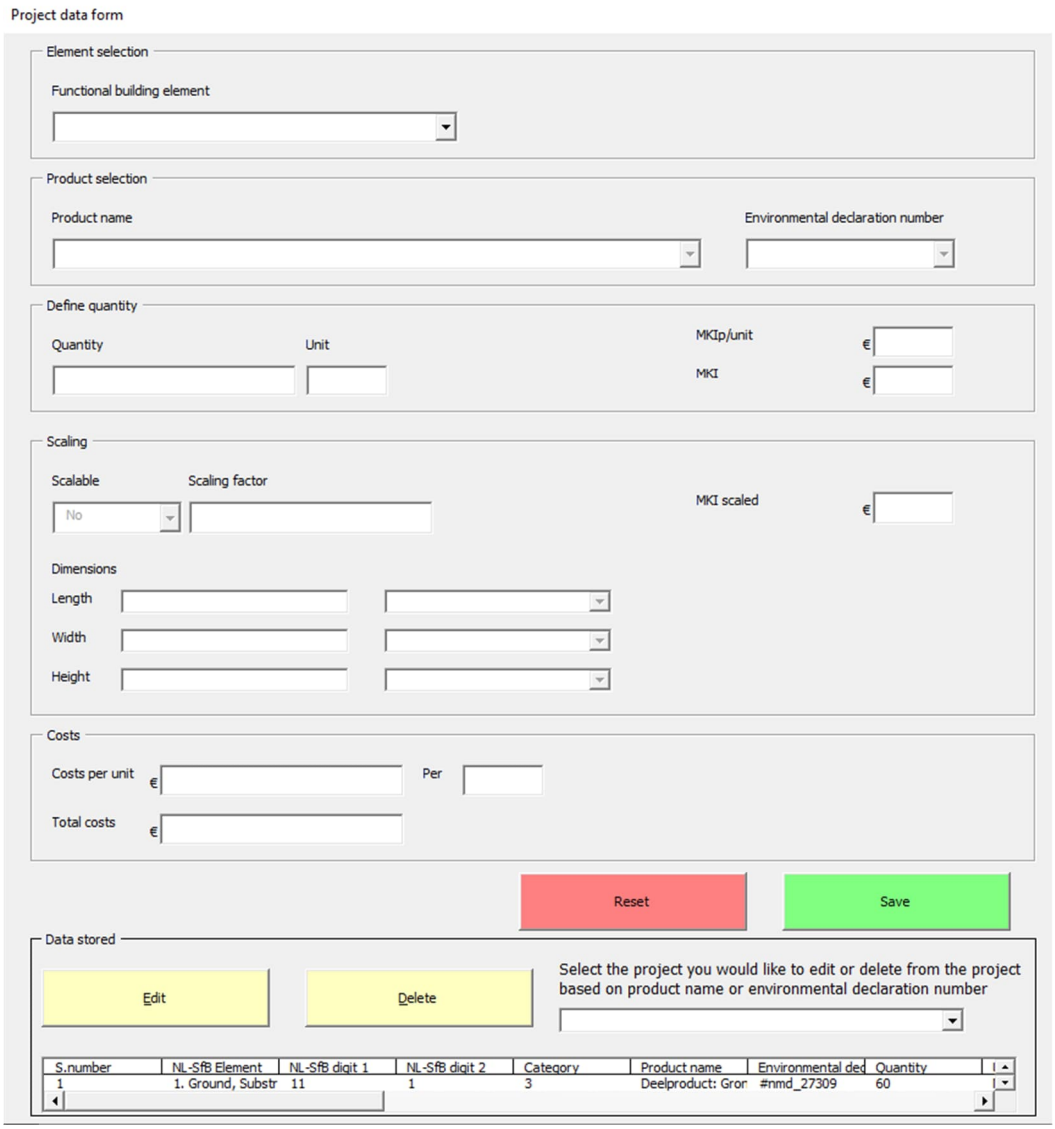


Figure 76: Project data input form, which fulfills design requirements 5 and 6

After controlling the ten Boolean requirements, it can be concluded that they are all incorporated into the decision support tool.

6.4 Adjustments

Throughout the validation process of the decision support tool, various areas requiring enhancement were identified, indicating the need for targeted modifications. Consequently, this sub-chapter delineates the specific adjustments implemented in the decision support tool.

During the expert interviews, it was discovered that the unit of products stored in the DATA_SF database was not recorded. The original VBA code for saving the unit was missing, so this code has been added, as outlined in line 1294 of Appendix 11. Additionally, it was noted that only the Environmental Declaration was visible on the NMD database form instead of the Environmental Declaration Number. This issue was addressed by expanding the textbox that holds the Environmental Declaration Number. Furthermore, the suggestion was provided to create de description guide for the decision support tool, which can be found in Appendix 12. Lastly, it was observed that the options for "Yes" or "No" in the message box were

displayed in Dutch, which is related to the device's regional settings. To resolve this, the regional setting of the device should be configured to English to ensure that "Yes" and "No" are displayed correctly (Microsoft, n.d.-c).

6.5 Conclusion

Following an expert interview, validation of the tool's outcomes, and a thorough requirements assessment, it can be concluded that the tool operates effectively and presents the necessary information for making informed design decisions. However, enhancements to the tool have also been identified. The improvements required for optimal functionality have been addressed, while additional enhancements may be explored in future research or during subsequent development of the tool.

7 Conclusion & recommendations

In this chapter, the results of this study will be concluded by answering the sub-questions to eventually answer the research question. The research question is as follows:

> What is the impact of shared facilities in apartment buildings on environmental performance and construction costs, and to what extent can this approach contribute to the development of affordable dwellings for first-time buyers in the Netherlands?

Followed by discussing the results and mentioning essential limitations. The chapter is finalized by providing recommendations for future research and professionals engaged in the development and construction stages of affordable housing for first-time buyers, where design decisions regarding the application of shared facilities are made.

7.1 Conclusion

This study assessed the impact of applying shared facilities in apartment buildings for first-time buyers in the Netherlands, with the broader goal of stimulating and ensuring the development and construction of affordable dwellings for first-time buyers in the Netherlands that meet environmental performance standards.

To answer the first sub-question: *What is the definition of an affordable and suitable dwelling for first-time buyers in the Dutch housing market?,* a literature & statistical data review has been conducted.

The shortage of affordable housing is a globally recognized issue, despite affordable housing being acknowledged as a fundamental necessity and a basic human right. The ratio approach is the most commonly used method for assessing affordability standards, with housing deemed affordable when homeowners spend no more than 40% of their disposable income on housing costs. Consequently, it can be concluded that affordability must be evaluated in relation to a household's income.

In the Netherlands, the affordability standard is set at 30% and used in calculating the maximum mortgage of households. Besides the income, the maximum mortgage is also influenced by the interest rate and housing characteristics. As a result of all these variables, defining a general definition of an affordable dwelling for first-time buyers is impossible.

There are differences in what single-person and two-person first-time buyers consider affordable and suitable housing. The definition of an affordable dwelling given by the Dutch government is not representative, to define the affordability for first-time buyers since it is solely based on two-person households. Furthermore, it is found that the value of a dwelling deemed affordable by both single-person and two-person first-time buyers is lower than the threshold set by the government. This indicates that more specific definitions, which take into account the characteristics of households, are necessary to accurately determine affordability for first-time buyers in the Netherlands.

Evaluating suitable housing options indicated that first-time buyers favor urban areas where average transaction prices for dwellings are high, and the availability of construction land is limited. Therefore, apartments are the most suitable dwelling type due to their compactness.

However, this preference diverges from that of two-person first-time buyers. When the average size of apartments bought by first-time buyers in the Netherlands is considered in relation to the high transaction prices per square meter in urban settings, it can be concluded that based on the average size of apartments bought by first-time buyers, apartments are not affordable for first-time buyers. Therefore, smaller apartments need to be constructed to ensure the construction of affordable apartments.

In conclusion, it is impossible to define a suitable and affordable dwelling for first-time buyers in the Netherlands in general. However, it can be determined that apartments represent the most viable option for this group and that the key factor in making these dwellings affordable for first-time buyers is reducing the transaction price.

A literature & statistical data review has also been performed to answer the second sub-question: *What facilities can be shared in apartment buildings for first-time buyers?*

It can be concluded that first-time buyers in the Dutch housing market are inclined to adopt shared facilities as a strategic approach to mitigate financial constraints. In alignment with the objective of lowering construction costs and optimizing the use of materials through the implementation of shared facilities, the following six facilities are proposed for shared use, ensuring compliance with the Dutch building code:

1. Garden/terrace
2. Kitchen
3. Living room
4. Bike parking
5. Laundry room
6. Workspace

To answer sub-question 3: *How is the environmental performance of dwellings in the Netherlands assessed?,* a literature & statistical data review has been performed.

In the Netherlands, the MPG serves as a localized assessment method to determine the embodied environmental impact of construction projects. This assessment utilizes environmental performance calculations aligned with the Environmental Performance Assessment Method for Construction Works and draws on Environmental Product Declarations (EPDs) stored in the NMD database.

To answer sub-question 4: *How can the impact of shared facilities on the environmental performance and construction costs of a building be determined?,* the outcomes of the literature & statistical data review were used.

There are numerous tools and methods available worldwide for evaluating the impact of shared facilities on a building's environmental performance. However, the number of tools specifically designed to assess the MPG is limited to eight certified calculation tools, of which only one is freely accessible. This particular tool does not enable users to directly evaluate the impact of shared facilities on the MPG, as a new calculation must be defined and conducted for each shared facility or combination of shared facilities.

Additionally, various tools are available to assess the impact of shared facilities on the construction costs of a building. However, none currently offers the ability to select and compare shared facilities without requiring a complete redesign.

So, there are tools that can provide insight into the environmental performance and construction costs of a building, but a tool that allows testing the impact on the MPG and construction costs of shared facilities or combinations of shared facilities compared to the base design is missing.

To answer sub-question 5: *How can the determined impact of shared facilities on the environmental performance and construction costs of a building be modeled to create a decision support tool?*, the outcomes of the literature & statistical data review in combination with the data from the tool development process are used.

A variety of software systems can be utilized to develop decision support tools. In this case, Excel has been chosen to implement a framework based on the MPG calculation method, which integrates the cost estimation approach. The input data is derived from the information available during the basic design stage of a building, as design decisions concerning the use of shared facilities are made at this stage. The tool evaluates the impact of a shared facility or combinations of shared facilities by comparing the MPG and construction costs against the baseline design. Moreover, insights from expert interviews confirm that the tool delivers the necessary information for making informed design decisions about the application of shared facilities.

The answers to the sub-questions, in combination with the outcomes of the case study, are used to answer the research question: *What is the impact of shared facilities in apartment buildings on environmental performance and construction costs, and to what extent can this approach contribute to the development of affordable dwellings for first-time buyers in the Netherlands?*

The combination of a shared workspace, kitchen, living room, bike parking, and laundry room has the biggest negative impact on reducing the MPG. It was observed that shared bike parking has the most detrimental effect on lowering the MPG, whereas having a shared garden/terrace has the least negative impact. However, none of the shared facilities analyzed resulted in a decrease in MPG.

Conversely, the integration of a shared workspace, garden/terrace, bike parking, and laundry resulted in the biggest reduction in construction costs. Notably, the inclusion of a shared garden/terrace, bike parking, and workspace contributes the most to lowering the construction costs. Therefore, to enhance affordability, the UFA of the apartments should be kept below 50 m². Furthermore it can be concluded that most shared facilities or combinations of shared facilities reduced the construction costs.

By lowering construction costs, the transaction prices of dwellings can decrease, thereby improving housing affordability. Since transaction prices are specific to their locations, it's not possible to assess how the implementation of shared facilities will affect achieving the desired

affordability thresholds of first-time buyers. Nonetheless, it can be concluded that the impact of shared facilities on the initial transaction price is bigger when the initial transaction price of dwellings is lower.

In conclusion, shared facilities can have a positive impact on construction costs but negatively impact the MPG. Therefore, the extent to which shared facilities can contribute to improving the affordability of dwellings for first-time buyers in the Netherlands depends on the financial implications associated with the supplementary measures necessary to meet the MPG standards.

7.2 Discussion

This thesis presented the results of a case study that was conducted by utilizing the decision support tool that was created. Therefore the discussion of the results will be divided into the discussion of the results of the case study and the discussion of the developed tool.

Results of the case study

Based on the findings of the case study, the influence of shared facilities on the environmental performance and construction costs of a building was assessed. The case study focused on a reference project completed in 2021, and the input data was updated to reflect the current market situation. However, to revise the construction cost data, an average indexation for newly constructed dwellings was utilized, which is less precise than implementing a product-specific indexation. Additionally, assumptions were necessary regarding the products used or the EPDs intended to represent the used products, as some data was outdated or no longer available. This negatively impacts the accuracy and representativeness of the determined MPG and construction costs.

Moreover, the standards for environmental performance were lower in 2021 compared to the present day. Consequently, there may have been less emphasis during the design process on reducing the MPG by carefully selecting materials. Additionally, the number of Environmental Product Declarations (EPDs) available in the NMD database was lower, leading to less accurate representations of the building and, therefore, less reliable MPG scores. This suggests that the MPG can be further improved by placing greater emphasis on selecting materials that are more conducive to enhancing environmental performance. This, in turn, could indirectly affect construction costs, as the costs of these materials may vary.

Excluding the impact of shared facilities on products that need to be determined by energy performance calculations leads to outcomes that are less representative and meaningful. Additionally, the furnishing costs associated with these shared facilities are omitted, which could have contributed to a more comprehensive analysis.

Since the shared facilities are defined on a project-specific basis, the generalizability of the results is constrained. Moreover, assumptions about the design of these shared facilities needed to be made, which may introduce bias. Furthermore, the majority of the data was processed manually, increasing the likelihood of human errors.

It was also not feasible to identify a suitable and affordable dwelling for first-time buyers, making it impossible to evaluate the direct impact of shared facilities on the affordability of

apartments for this demographic in the Netherlands. This is particularly relevant given that affordability is influenced by multiple variables. Therefore, future research is necessary to assess the relationship between shared facilities and affordability.

In summary, it can be concluded that the outcomes are less significant, not fully representative, not completely accurate, and not broadly applicable. However, they can serve as a valuable starting point for further research within their specific context.

Decision support tool

The developed decision support tool utilizes open-source EPD data stored in the NMD, which can be accessed through the Viewer available on the Stichting NMD website. It is important to note that Stichting NMD states that the EPD data retrieved via the Viewer is unsuitable for conducting MPG calculations, however the required data is provided. As a result, the MKI per product unit utilized for these calculations is represented with only two decimal places, which compromises the accuracy of the results. Furthermore, construction costs per unit are also entered using a limited number of decimal places, further affecting the precision of the outcomes and potentially leading to rounding errors. Nevertheless, such minor discrepancies are deemed acceptable during the initial design phase, where the accuracy of calculations tends to be relatively low.

In addition, the data entry process is manual, which increases the risk of errors due to human oversight during data processing. Although the risk of such errors is mitigated by incorporating control mechanisms within the tool, it cannot be completely eliminated. Moreover, the tool lacks a feature to confirm that all applied building elements have corresponding EPDs, which raises the risk of omitting essential product data. This issue could be addressed by implementing a control mechanism based on the NL-SfB classification, which is included in the tool's data. Additionally, there is an increased risk of relying on outdated information since all data must be updated manually. To facilitate the verification of data accuracy, the date and time of entry or modification for each product are recorded.

Consequently, it can be concluded that the outcomes generated by the tool may not be entirely accurate and that it is crucial to consider the validity of the data used to ensure the reliability of the results. However, the tool provides sufficient information for professionals involved in the design process of affordable dwellings to compare and test different variants with shared facilities to eventually make informed design decisions.

7.3 Recommendations

Drawing from the findings of this master's thesis, a series of recommendations can be articulated. These recommendations are categorized into two distinct areas: first, those pertaining to the enhancement of scientific knowledge regarding shared facilities in residential buildings, and second, those focused on the practical application and continued refinement of the decision support tool developed throughout this research.

Scientific knowledge

A limitation addressed in this research is the insufficient scientific knowledge regarding the facilities that first-time buyers are willing to share. Future studies could deepen this understanding by conducting thorough research into the facilities that first-time buyers are

willing to share. Moreover, future research should focus on defining and assessing the financial capabilities and constraints faced by first-time buyers. Assessing these topics could aid in defining what constitutes an affordable and suitable dwelling for first-time buyers. Furthermore, future research ought to examine the various factors that influence the housing preferences of first-time buyers and evaluate the extent of their impact. This would contribute to effectively evaluating the impact of shared facilities on the affordability for first-time buyers.

Furthermore, while existing scientific literature primarily emphasizes identifying the potential benefits of shared facilities, there is a notable gap in knowledge concerning the quantification of these impacts. Therefore, it would be beneficial to carry out more comprehensive research aimed at quantifying the potential advantages of shared facilities. It is particularly important to examine the variables that influence individuals' decisions to opt for or accept shared facilities.

Moreover, the robustness of the findings from the case study can be strengthened by incorporating previously excluded components in future research. By conducting additional case studies that include these elements and leverage more recent project data, the generalizability and reliability of the results can be improved.

Ultimately, the findings of this research can serve as a foundational step in understanding how shared facilities can help reduce environmental impact while enhancing housing affordability on a global scale. By omitting local components and employing a universally recognized method for assessing environmental performance, the results are anticipated to be more generalizable and robust.

Application and refinement of the decision support tool

The developed decision support tool can be used in practice by professionals involved in the design process of affordable housing to make informed decisions regarding the application of shared facilities to enhance the affordability of housing. While the tool already offers essential data for making these informed decisions, there remains potential for further enhancement.

The practical relevance of the tool can be enhanced by incorporating the capability to connect to software utilized for determining products based on energy performance calculations. In addition to facilitating this integration, it would be advantageous to incorporate a wider range of data sources into the tool to improve the representativeness and comprehensiveness of the results. Moreover, automating data entry would help minimize the risk of errors associated with manual processing. The reliability of the outcomes can be further strengthened by implementing a system that verifies whether all necessary products are included in the calculations.

To optimize user-friendliness, creating a Dutch version of the tool would be beneficial. Additionally, enhancing usability and addressing data dependencies can be achieved by linking the tool directly to a cost database and establishing a baseline scenario along with various shared facilities that can serve as a foundation for customization in individual projects. Furthermore, the tool would benefit from the ability to integrate additional data regarding shared facilities, such as the social benefits of specific shared facilities.

This tool has been developed using a nationally recognized environmental performance assessment method. To tackle the global issue of housing affordability and sustainability, a tool could be created based on an internationally accepted environmental performance assessment framework, making it more widely accessible.

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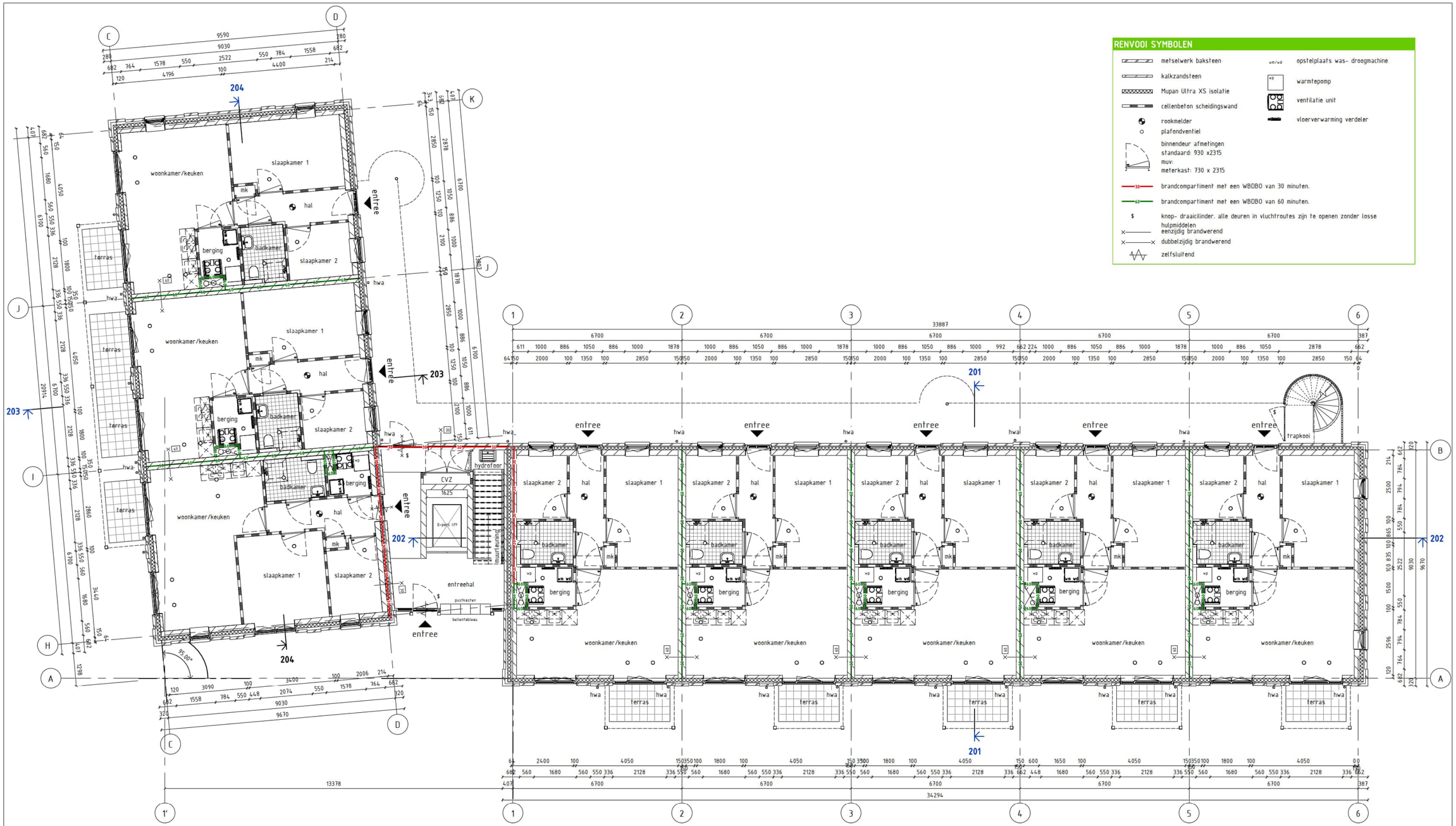


RENVOOI BOUWBESLUIT

- Voor constructies zie de statische berekeningen van Aveco de Bondt
- Voor de toetsing bouwbesluit zie de bouwbesluit rapporten van BouwVisie
- Elektrotechnische installatie minimaal volgens NEN 1010
- Elke woonfunctie is een brandcompartiment; de woningscheidende wanden uitvoeren met een brandwerendheid van 60 minuten
- Binnen-en buitendeur kozijnen met een minimale dagmaat van 850x2300 mm
- De sanitaire ruimte word betegeld. De vloeren worden waterdicht betegeld met keramische vloertegels. De wanden worden waterdicht betegeld met keramische wandtegels tot aan plafond.
- Ter wering van ratten en muizen zullen alle uitwendige scheidingsconstructies geen bredere openingen aanwezig zijn dan 10 mm
- Deuren, ramen en kozijnen en daarmee gelijk te stellen constructie-onderdelen en een uitwendige scheidingsconstructie van een niet gemeenschappelijke ruimte, die volgens de NEN 5087 bereikbaar zijn voor inbraak, hebben een volgens NEN 5096 bepaalde inbraakwerendheid die voldoet aan de in de norm aangegeven weerstandklasse 2.

RENVOOI BRANDVEILIGHEID

- Er is geen verplichting tot het aanbrengen van brandslanghaspels
- Voor het bouwplan geldt geen verplichting tot het aanbrengen van een brandmeldinstallatie en een ontruimingsalarminstallatie.
- Conform artikel 2.56 tot en met 2.60 in het bouwbesluit zullen er enkel materialen (schachten/kokers/kanalen en afvoervoorzieningen) worden toegepast die tenminste voldoen aan de brandvoortplantingsklasse als gesteld in de voorgenoemde artikelen van het bouwbesluit.
- Conform artikel 2.66 tot en met 2.72 in het bouwbesluit zullen er enkel materialen worden toegepast die ten minste voldoen aan de rookproductie of brandklasse als gesteld in de voorgenoemde artikelen van het bouwbesluit. Dit geldt voor zowel constructieonderdelen grenzend aan het binnen- en buitenopervlak en het beloopbare vlak.
- Conform aritkel 2.71 in het bouwbesluit en de NEN6063 is het dak niet brandgevaarlijk uitgevoerd.
- De bereikbaarheid voor hulpdiensten voldoet aan het gestelde in artikel 6.37 van het bouwbesluit.
- Weerstand m.b.t. bezwijken: vloeren, trappen en hellingbanen waarover gevlucht wordt, moeten ten minste 30 minuten bestand zijn tegen bezwijken bij brand in een subbrandcompartiment waarin de vluchtroute niet ligt. Hoofddraagconstructie van het gehele pand: 60 minuten.

opdrachtgever

projectomschrijving
22 appartementen - Tuin van Elden

bladomschrijving
PLATTEGROND BEGANE GROND

projectnummer: 20026 | Nº: 06 | fase omschrijving: Omgevingsvergunning (OV)

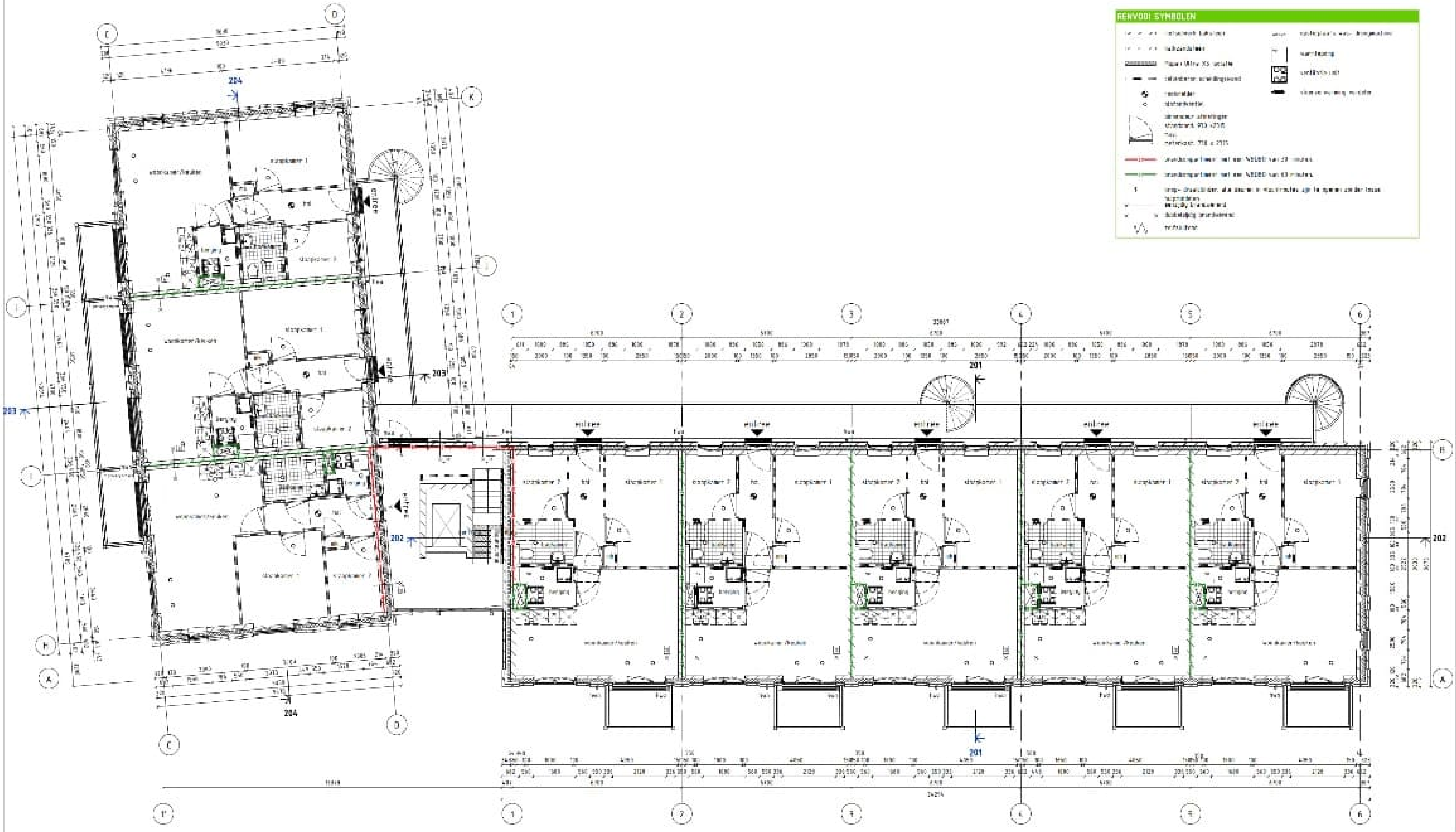
datum | Nº : gewijzigd: B : 03-11-2020

status: DEFINITIEF | schaal: 1:100 | formaat: A2.L

bouwblok | bouwsegment

bladnr.: OV-L(--)100

www.burobim.nl



RENVOOI BOUWBESLUIT

RENVOOI BRANDVEILIGHEID

B : 03-11-2020

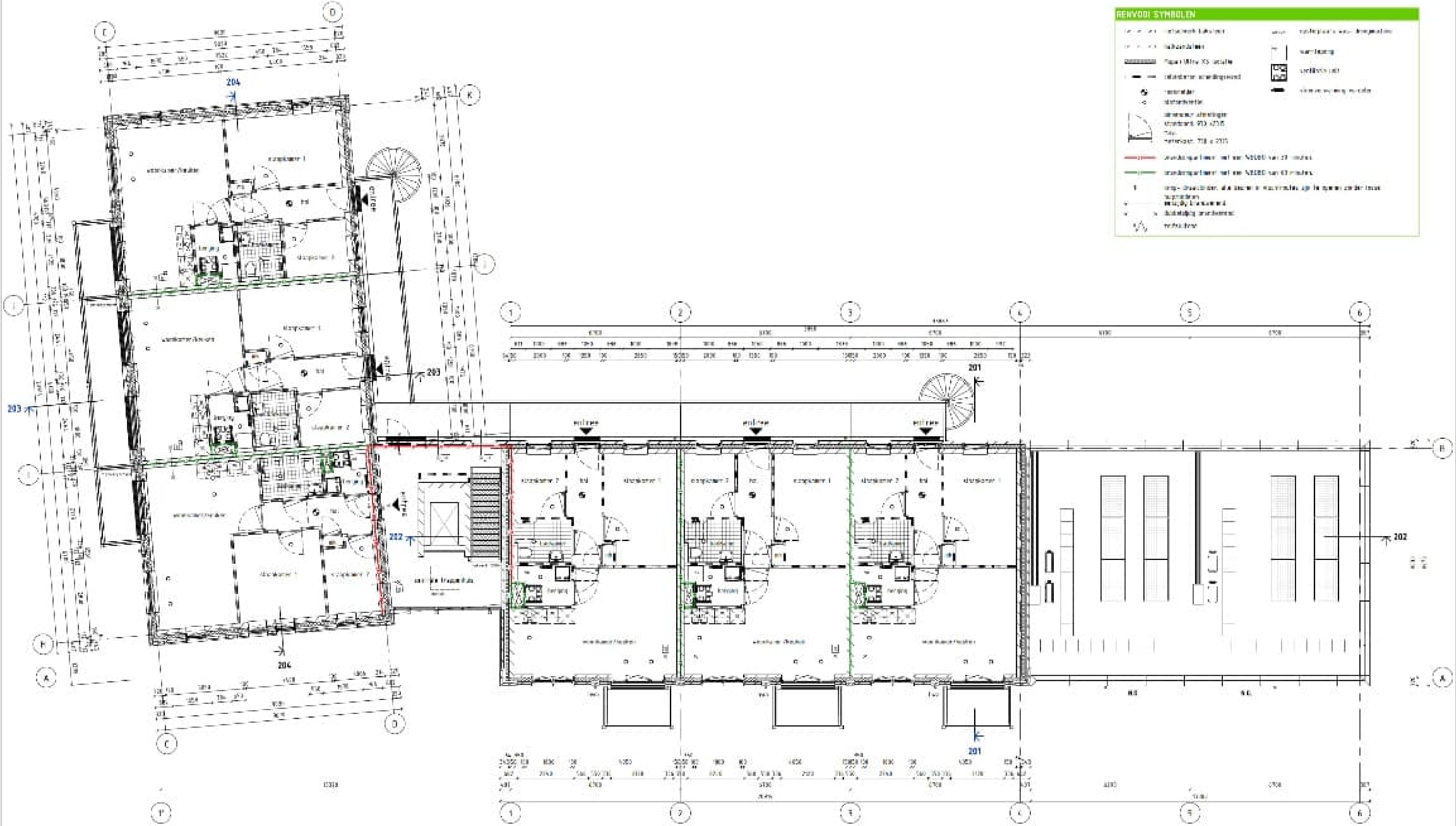
22 appartementen - Tuin van Elden

1:100

PLATTEGROND 1E VERDIEPING

20026 06 Omgevingsvergunning (OV)

OV-L(--)101



RENVOOI BOUWBESLUIT

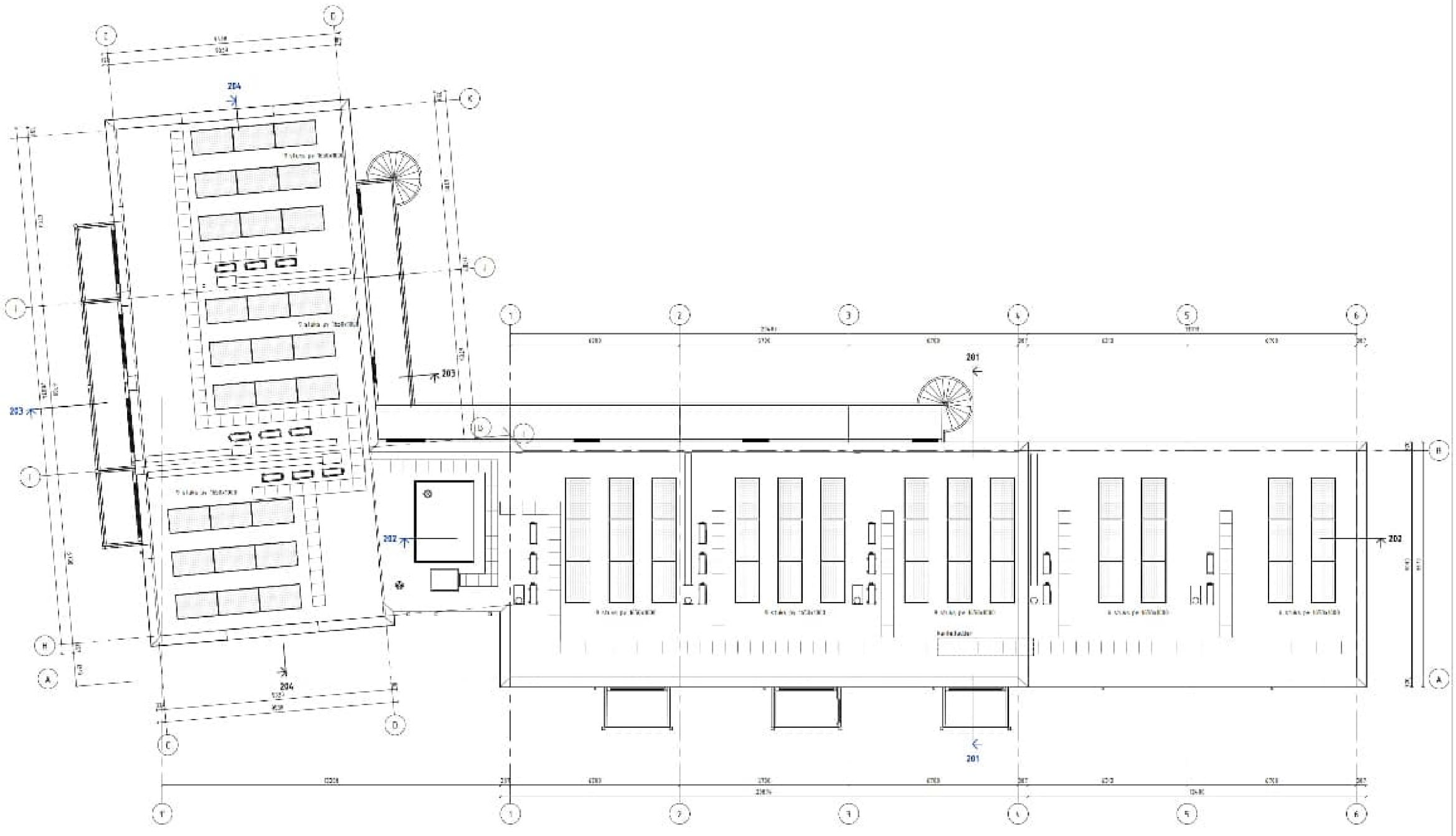
RENVOOI BRANDVEILIGHEID

22 appartementen - Tuin van Elden

PLATTEGROND 2E VERDIEPING

20026 06 Omgevingsvergunning (OV)

OV-L(--)102



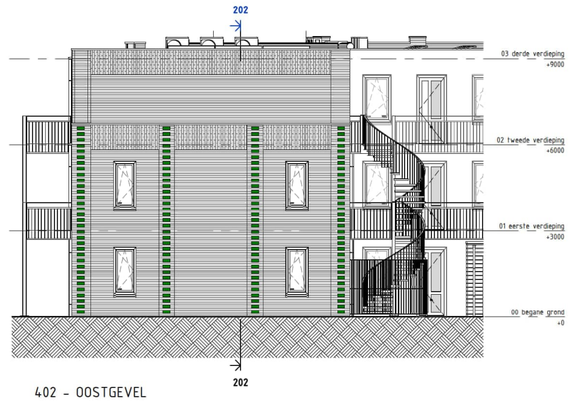
22 appartementen - Tuin van Elden

PLATTEGROND DAKVERDIEPING

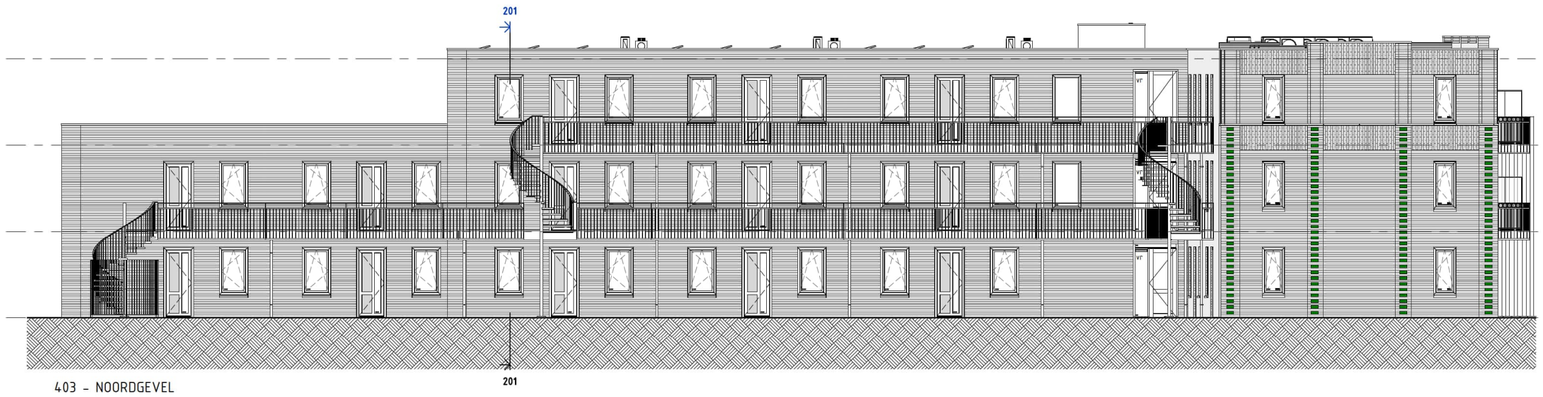
20026 05 Omgevingsvergunning (OV)

OV-L(--)103

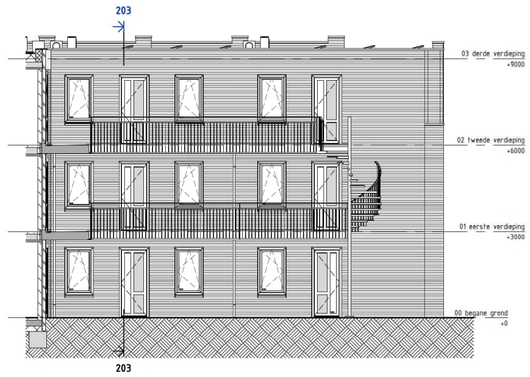
401 - ZUIDGEVEL



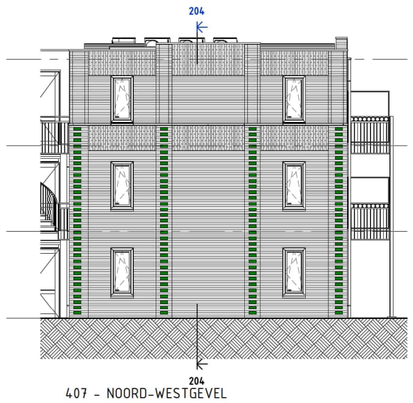
402 - OOSTGEVEL



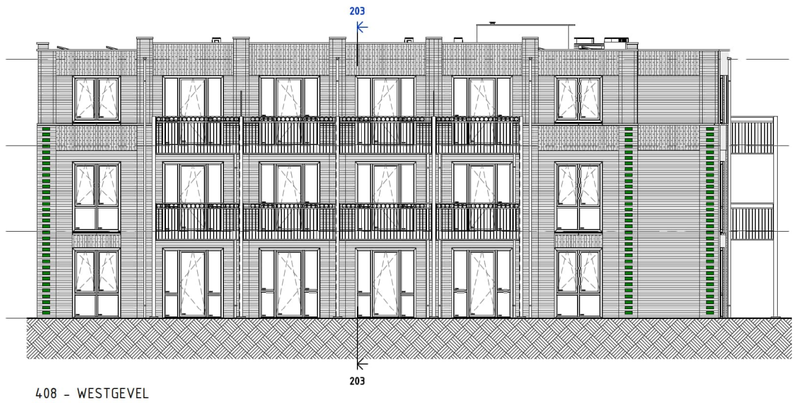
403 - NOORDGEVEL



406 - NOORD-OOSTGEVEL



407 - NOORD-WESTGEVEL

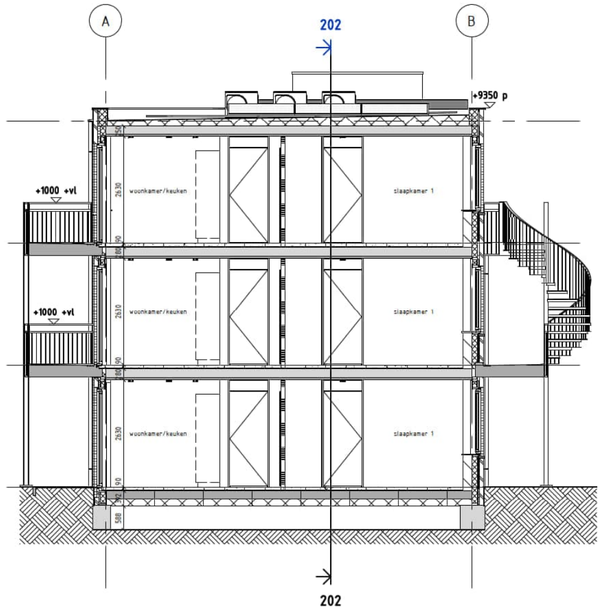


408 - WESTGEVEL

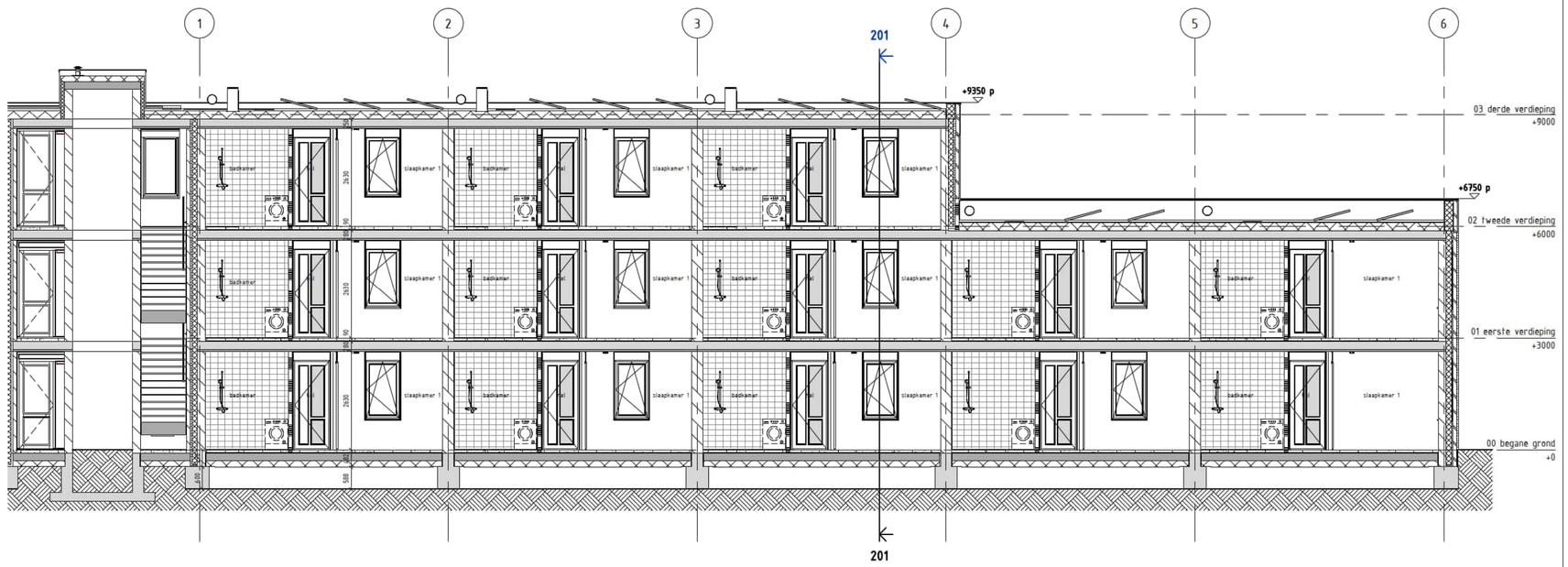
405 - ZUID-OOSTGEVEL

verticale begroeiing

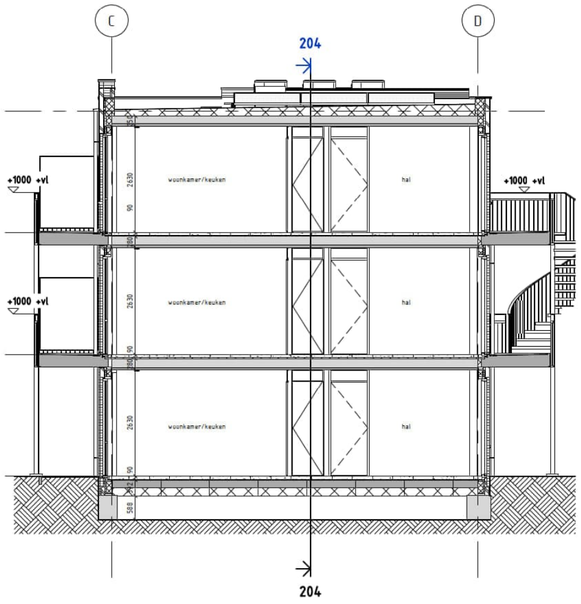
BOUW-INFORMATIE MANAGEMENT
opdrachtgever
datum
Nº - gewijzigd
projectomschrijving
22 appartementen - Tuin van Elden
status DEFINITIEF
schaal 1:100
formaat A1 L
bladomschrijving
GEVELAANZICHTEN
bouwblok
bouwsegment
projectnummer 20026
Nº 06
fase omschrijving Omgevingsvergunning (OV)
bladnr. OV-L(--)401
www.burobim.nl



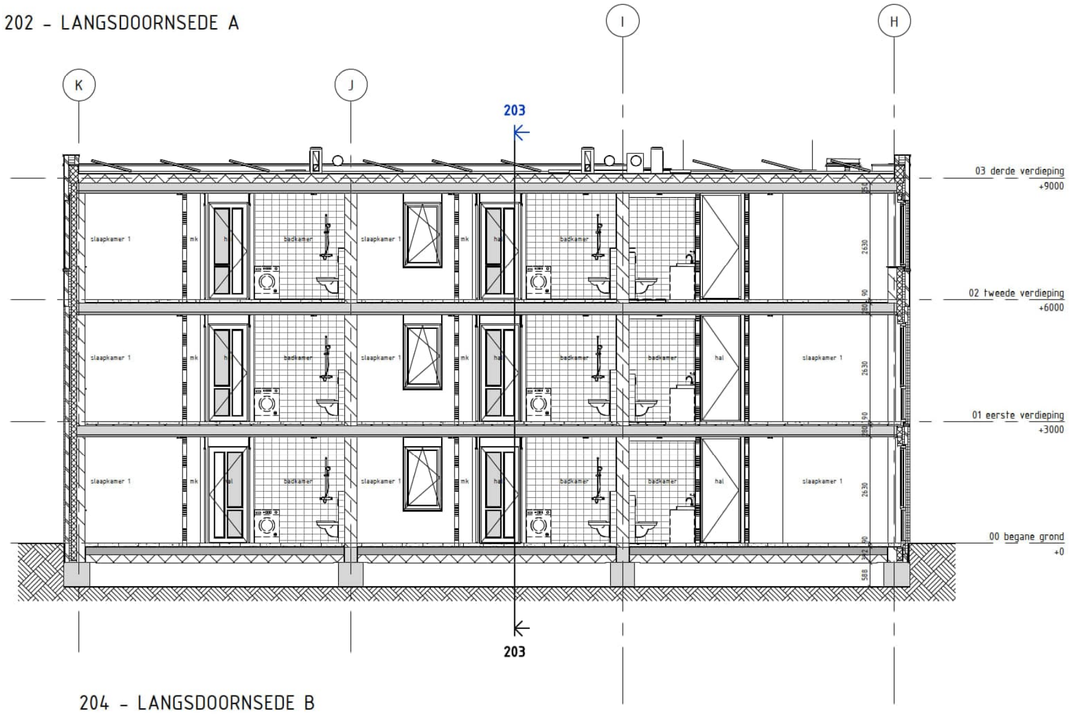
201 - DWARSDOORSNEDE A



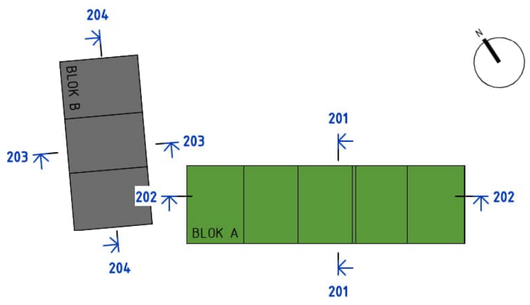
202 - LANGSDOORNSEDE A



203 - DWARSDOORSNEDE B



204 - LANGSDOORNSEDE B



BOUW INFORMATIE MANAGEMENT

opdrachtgever

datum: 03-07-2020

Nº : gewijzigd

projectomschrijving: 22 appartementen - Tuin van Elden

status: DEFINITIEF | schaal: 1:100 | formaat: A2.L

bladomschrijving: DOORSNEDEN

bouwblok | bouwsegment

projectnummer: 20026 | Nº: 06 | fase omschrijving: Omgevingsvergunning (OV)

bladnr.: OV-L(--)201

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opdrachtgever

datum | Nº : gewijzigd

projectomschrijving
22 appartementen - Tuin van Elden

status: DEFINITIEF | schaal: NVT | formaat: A3.P

bladomschrijving
3D AANZICHTEN

bouwblok | bouwsegment

projectnummer: 20026 | Nº: 06 | fase omschrijving: Omgevingsvergunning (OV)

bladnr.
OV-L(--)301

www.burobim.nl

Appendix 2

Gebouwinformatie

Gebruiksfunctie:	Woongebouw			
Levensduur	75 jaar			
Type	Appartement			
Totaal BVO	1692,54 m2			
Totaal GO	1214,94 m2	3202982,874	43339,19631	3246322,07
Aantal woningen/eenheden	22			

Materialisering — Inflation correction — 123,19% BDB sept 2020 = 98,57; BDB sept 2024 = 121,43

Fundering				Quantity	Unit	Scaling	Construction costs	Construction costs corrected for inflation	Construction costs/unit	Comment MPG	Comment costs
Bodemvoorzieningen											
Grondaanvullingen	Zand	Deelproduct: Grondaanvullingen, Zand	#nmd_27309	6	m3		€9.622,95	€11.854,67	€197,58		Costs for Grondwerk
Fundering											
Funderingsbalken	funderingsbalk ihwg, 450x600	Fundatiebalken, Beton,in het werk gestort, C20/25; incl.wapening + eps	#nmd_38254	59,	m	1	€11.981,54	€14.760,26	€248,38	Including EPS C20/25; c3037 assumed of Betonhuis	
	funderingsbalk ihwg, 600x600	Fundatiebalken, Beton,in het werk gestort, C20/25; incl.wapening + eps	#nmd_38254	111,	m	1	€22.533,97	€27.759,97	€248,38	Including EPS C20/25; c3037 assumed of Betonhuis	
	funderingsbalk ihwg, 650x600	Fundatiebalken, Beton,in het werk gestort, C20/25; incl.wapening + eps	#nmd_38254	35,	m	1	€7.060,49	€8.697,93	€248,38	Including EPS C20/25; c3037 assumed of Betonhuis	
Funderingspalen	funderingpalen_mortelschroefpaal_rond:schr	Funderingspalen, Betonhuis; schroefpaal; beton,in het werk gestort, C20/25,CEMIII; incl.wapen	#nmd_27445	995,18	m		€ 35.920,00	€ 44.250,44	€ 44,46	C30/37 not available in NMD	
Vloeren											
Vloeren, begane grond											
Vloeren vrijdragend	VBI isolatieplaatvloer 200; rc 5	VBI Isolatieplaatvloer 200 Groen	#nmd_20101	47	m2	1	€40.108,73	€49.410,60	€104,21	Scaled in database: eps 3.7 m2/k -> 5m2/k; MKI eps = €0,49; MKI	
Dekvloeren	zwevende cementdekvloer, d=90	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	4	m2		€5.694,64	€7.015,31	€15,64	Product not scalable	Same costs as cementdekvloer
Dekvloeren	verende cementdekvloer, d=62	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	6	m2		€83,15	€102,43	€15,64	Product not scalable	Same costs as cementdekvloer
Dekvloeren	Cementdekvloer d=80	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	2	m2		€298,95	€368,28	€15,64	Product not scalable	Same costs as cementdekvloer
				478	m			€7.486,03			
Vloeren, verdieping											
Vloeren vrijdragend	Van Nieuwpoort BPV 50mm breedplaatvloer	Van Nieuwpoort Breedplaatvloer Bpv 50 mm	#nmd_20115	9	m2		€102.351,18	€126.088,10	€136,01	C30/37	Includes costs for druklaag;
	Druklaag; c30/37; 230mm	Deelproduct: Vrijdragende Vloeren, Betonhuis; druklaag breedplaatvloer; betonmortel	#nmd_29055	944,2	m2		0,00	€ -	€ -	Product not scalable	Included in vloeren,
Dekvloeren	zwevende cementdekvloer, d=90	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	778,5	m2		€ 9.882,46	€ 12.174,37	€ 15,64	Product not scalable	Same costs as cementdekvloer with other thickness
Dekvloeren	verende cementdekvloer, d=62	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	11,46	m2		€ 145,48	€ 179,21	€ 15,64	Product not scalable	Same costs as cementdekvloer with other thickness
Dekvloeren	Cementdekvloer d=80	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	36,44	m2		€ 462,58	€ 569,86	€ 15,64	Product not scalable	Same costs as cementdekvloer with other thickness
				1250,4	m			€ 12.920,44			
Afwerklagen, vloer	Verglaasde klei, tegels 150x150 7 mm	Deelproduct: Afwerklagen, Keramische tegels, geglazuurd/gelijmd	#nmd_28929	65,01	m2		€ 30.768,30	€ 37.903,97	€ 583,05		Also includes wandtegels
Afwerklagen, plafond	Spuitpleister	Deelproduct: Afwerklagen, Spuitpleister	#nmd_28558	944,2	m2		€ 12.012,90	€ 14.798,89	€ 8,69		Costs combined with spuitplaster wanden
Vloeren, balkon- en galerij											
Vloeren vrijdragend	buiten_prefab_galerij, d=300	Balkon-/galerijvloer, beton, prefab, 250 mm, Betonhuis	#nmd_10812	130,35	m2	1,2	€	€	€527,66	C30/37; no other product available	Gallerij + Balkon combined into one
Vloeren vrijdragend	buiten_prefab_balkon, d=300	Balkon-/galerijvloer, beton, prefab, 250 mm, Betonhuis	#nmd_10812	80,59	m2	1,2	99.250	111.204	C45/55; no other product available	Gallerij + Balkon combined into	
Ballustrades	balustrade, h=1000; staal; spijlen	Balustrades, Staal; gepoedercoat; spijlen	#nmd_31897	139,	m		€50.823,00	€62.609,69	€448,65		
Draagconstructie											
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=100	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	9	m2		€4.009,69	€4.939,60	€51,40	Reference thickness= 100mm	In costs estimation as 120mm,
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=120	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	18	m2	1	€7.787,39	€9.593,42	€51,40	Reference thickness= 100mm	
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=214	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	52	m2	2	€29.878,58	€36.807,92	€70,55	Reference thickness= 100mm	Costs combined with other
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=300	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	39	m2		€26.363,95	€32.478,18	€82,64	Reference thickness= 100mm	
Dragende wanden, massief	Calduran Kalkzandsteen CS20, d=214	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	6	m3	2	€3.996,03	€4.922,77	€70,55	Reference thickness= 100mm	Costs combined with other
Dragende wanden, niet	Vuren framewerk voor buiten en binnen wanden	Houtskeletbouw frame voor dragende en niet-dragende binnenwand. Representatief voor	#nmd_92900	290,15	m2		€ -	€ -	€ -		Included in bergingen
Gevels											
Spouwwanden, buitenblad	Wienerberger Teunisbloem 50mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	1	m2	0	€2.349,54	€2.894,43	€279,39	Assumed the thickness =	
	Wienerberger Teunisbloem 100mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	78	m2		€178.877,88	€220.362,60	€279,39	Assumed the thickness =	
	Wienerberger Teunisbloem 112mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	1	m2	1	€317,51	€391,14	€279,39	Assumed the thickness =	
	Gevelsteen 100 mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	8	m2		€19.639,96	€24.194,79	€279,39	Assumed the thickness =	
Isolatielagen	Isolatie minerale wol, Mupan Ultra XS, d=138	Isover Mupan Ultra XS	#nmd_45415	83	m2		€40.983,61	€50.488,38	€60,11	Thickness=131 mm	
Bekledingen	Vuren geimpregneerde rabatdelen 19x130mm	Deelproduct: Bekledingen, Europees naaldhouten delen, wax impregnatie; duurzame	#nmd_31985	9	m2		0	€-	€-		Included in Spaanplaat 18mm
Kozijnen	PVC	Kunststof raamkozijn, vleugeldeel, met VKG keurmerk	#nmd_30559	35	m2		€130.368,75	€160.603,40	€457,90	Splitted into frames and glass	
	Beglazing	Isolatieglas, driedubbelglas, ongecoat, Bouwend Nederland Vakgroep GLAS	#nmd_91482	280,	m2		€-	€-	€-	Triple glass; 80% of the surface area of the frames	
Kozijnen	Kozijnen bergingen vuren met aflaklaag	Deelproduct: Buitenkozijnen, Europees naaldhout; geschilderd, acryl; duurzame bosbouw	#nmd_30512	48,513	m2			€-	€-		
Kozijnen	Kozijnen gezamenlijke ruimtes mahonihout	Deelproduct: Buitenkozijnen, Tropisch loofhout; geschilderd, acryl; duurzame bosbouw	#nmd_30979	5	m2		€30.721,65	€37.846,50	€655,46		Including Flowcoat, P-A deur de
Deuren	Flowcoat, P-A deur de Mors (hout met glas)	Deelproduct: Buitendeuren, Onverduurzaamd hout; geschilderd:alkyd; glasopening:0.85m2	#nmd_30459		piec		€3.301,00	€4.066,56	€580,94		Only labour and small material
	Deuren Bergingen	HOUT100% kozijn met deur, kleiner dan 3,6 m2, inclusief NBVT massief houten buitendeur tot	#nmd_92815	48,4	m2		€ -	€ -	€ -		Included in Spaanplaat 18mm met vuren balklaag
Stelkozijnen	Verduurzaamd hout	Deelproduct: Stelkozijnen, Onverduurzaamd hout; geverfd	#nmd_30902	118	pieces		€ 49.379,60	€ 60.831,54	€ 515,52		
Lateien	Stalen latei h=120	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_91230	1,88	m		€ 335,80	€ 413,68	€ 14,70	15 kg/m	
	Stalen latei h=50	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_91230	1,924	m		€ 344,39	€ 424,27	€ 14,70	15 kg/m	
	Stalen latei h=60	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_91230	7,194	m		€ 1.287,72	€ 1.586,36	€ 14,70	15 kg/m	
	Stalen latei h=70	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_91230	15,386	m		€ 2.754,08	€ 3.392,80	€ 14,70	15 kg/m	
	Stalen latei h=90	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_91230	4,856	m		€ 869,22	€ 1.070,81	€ 14,70	15 kg/m	
	Stalen latei h=100	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_91230	13,51	m		€ 2.418,28	€ 2.979,12	€ 14,70	15 kg/m	
Waterslagen	Betonnen waterslagen	Deelproduct: Waterslagen, Beton	#nmd_30955	167	m		€ 8.401,71	€ 10.350,20	€ 61,98	not	accessible in
Waterkeringen	EPDM; folie [50, 1]	Deelproduct: Waterkeringen, EPDM; folie	#nmd_32284	500	m			€ -	€ -	Not in model	included in waterslagen
Daken											
Daken,plat		Deelproduct: Platte daken, Europees naaldhouten balken met europees naaldhouten	#nmd_29276	1	m2		€46.217,00	€56.935,48	€454,39		Includes all the costs for the
Daken	Hoeslagen (delen) voor dak vuren aflaklaag	Plat dakbedekking, Stg. Dak en Milieu, Bitumen gemod. eenlaags 4,3 mm, 5,3 kg per m2, volledi	#nmd_90716	125,3	m2						
Daken	Van Nieuwpoort BPV 50mm breedplaatvloer	Van Nieuwpoort Breedplaatvloer Bpv 50 mm	#nmd_201159	364,85	m2		€ 42.171,70	€ 51.952,01	€ 136,01	C30/37	Includes costs for druklaag: cost/m2 combined with othet Breedplaatvloer
	Druklaag; c30/37; 200mm	Deelproduct: Vrijdragende Vloeren, Druklaag breedplaatvloer; betonmortel C30/37; incl. waper	#nmd_29081	364,85	m2		0	€ -	€ -	Product not scalable	included Van Nieuwpoort BPV 50MM breedplaatvloer
Isolatielagen	EPS 100	Deelproduct: Isolatielagen plat dak, EPS	#nmd_32316	503,63	m2		€ 48.150,00	€ 59.316,77	€ 117,78		Including the costs of bedekkingen
Bedekkingen	APP gemodificeerde gebitumineerde onderlaag, b	Plat dakbedekking, Stg. Dak en Milieu, Bitumen gemod. tweelaags 6,6 mm, 8,1 kg per m2, loslig	#nmd_90722	503,	m2		€-	€-	€-		Included in
Waterkeringen	Lood slab	Deelproduct: Waterkeringen, Combinatie PVC/Lood	#nmd_32386	1	m		€28.879,00	€35.576,51	€197,65	Not in model	
Afwerkingen, plafond	Spuitpleister	Deelproduct: Afwerklagen, Spuitpleister	#nmd_32172	9	m2			€-	€-	Removed, was duplicate	
Aftimmering, buiten	Aftimmering bergingen	Deelproduct: Bekledingen, Europees naaldhouten delen, wax impregnatie; duurzame	#nmd_31985	5	m			€-	€-		Removed not in real design
Installaties											
Warmtelevering											
Warmteopwekkingsinstallaties	Lucht water warmtepomp MetroTherm MetroAir L	Lucht-water warmtepomp, solo, koudemiddel R410a, Vereniging Warmtepompen (3,4 - 12 kW)	#nmd_95894	22	pieces	0,9996	€ 116.600,00	€ 143.641,45	€ 6.529,16	1 unit per app, wasn't available then in database; scaled with packhunt	
Warmteopwekkingsinstallaties	MetroTherm SHK200S binnenunit	Buffervat	#nmd_93832	22	pieces	0,9589	€ 49.500,00	€ 60.979,86	€ 2.771,81	Scaling, original 315 liter should be 180 liter; scaled using packhunt	
Warmtedistributiesystemen	Polyetheen/polybuteen, cv-leidingen; incl. koppelingen + verdeling	Warmtedistributiesystemen, Polyetheen/polybuteen; cv-leidingen; incl. koppelingen + verdeling	#nmd_32893	1214,94	m2		€ 19.800,00	€ 24.391,94	€ 20,08		
Warmteafgiftesystemen	Vloerverwarming; leidingen:polybuteen+toebehor	Warmteafgiftesystemen, Vloerverwarming; leidingen:polybuteen+toebehoren	#nmd_32894	1214,94	m2		€ 39.050,00	€ 48.106,34	€ 39,60		
Elektrische installaties											
Elektriciteitsleidingen	Geisoleerde installatiedraad + mantelbuis:pvc	Deelproduct: Elektriciteitsleidingen, Geisoleerde installatiedraad + mantelbuis:pvc	#nmd_32999	1214,94	m2		€ 122.341,50	€ 150.714,50	€ 124,05		
Elektriciteitsopwekkingsysteme	AM60S10 340/PR pv panelen + sunbeam NOVA s	PV paneel – polykristallijn / plat dak	#nmd_93723	54	pieces	0,91	€ 34.193,00	€ 42.122,92	€ 780,05	1,68m2; 330 wp, so scaling from 1,	Includes costs for
Elektriciteitsopwekkingsysteme	SAJ R5-1,5K-S1 omvormer	Omvormer – 2500 W	#nmd_93729	23	pieces		€ -	€ -	€ -	1,5 kw	Included in pv panels
Luchtbehandeling											
Luchtbehandelingssytemen	DucoBox Energy Comfort WTW box type 325	Deelproduct: Luchtdistributiesystemen, WTW-unit	#nmd_32915	2	piec		€48.400,00	€59.624,75		should be inserted in m2 gbo	Included in distributiesystem
Luchtdistributiesystemen	Mechanische aan- en afvoer; verzinkt staal,	Mechanische aan- en afvoer; verzinkt staal, incl. roosters	#nmd_32909	1214,94	m2		€ 65.400,00	€ 80.567,33	€ 115,39		
Water- en gasdistributie											

Waterleidingen	Polyetheen; leiding+mantelbuis	Deelproduct: Waterleidingen, Polyetheen; leiding+mantelbuis	#nmd_32834	121	m2		€18.250,00	€22.482,47	€18,51			
Afvoeren												
Buitenrioleringen	Pvc; gerecycled; leiding	Deelproduct: Buitenrioleringen kavel, Pvc; gerecycled; leiding	#nmd_32744	121	m2		€5.000,00	€6.159,58	€5,07			
Binnenrioleringen	Pvc; gerecycled; leiding	Deelproduct: Binnenrioleringen, Pvc; gerecycled; leiding	#nmd_36236	121	m2		47	€58.269,65	€47,96			
Hemelwaterafvoeren	Hemelwaterafvoeren diameter 80mm	Deelproduct: Hemelwaterafvoeren, Pvc; grecycled; diameter:80mm; d:1.8mm	#nmd_32790	6	m		€6.600,00	€8.130,65	€117,18			
Inbouw												
Binnenwanden												
Niet dragende wanden,	Ytongpan. 10cm G4/600	Massieve wanden, niet dragend, cellenbeton blokken, Xella-Ytong	#nmd_38859	91	m2		€40.564,12	€49.971,61	€54,70			lafond
Niet dragende wanden,	Ytongpan. 10cm G5/800	Massieve wanden, niet dragend, cellenbeton blokken, Xella-Ytong	#nmd_38859	18	m2		€8.399,38	€10.347,33	€54,70			
Plinten	Plinten	Deelproduct: Bekledingen, Plint Gegoten Composietsteen	#nmd_28552	1	m		54	€6.750,41	€6,02	Not in model		
Afwerklagen	Spuitpleister appartementen	Deelproduct: Afwerklagen, Spuitpleister	#nmd_28558	3	m2		€18.408,42	€22.677,63	€8,69	Not in model	Costs combined with	
Afwerklagen	Behang; vinyl (openbare ruimte)	Deelproduct: Afwerklagen, Behang; vinyl	#nmd_28416	2	m2		392	€4.829,17	€16,77	Not in model		
Niet dragende wanden, niet	Scheidingswanden bergingen Spaanplaat 11mm	Deelproduct: Bekledingen systeemwanden niet dragend, Spaanplaat	#nmd_28447	78,494	m2		0	€ -	€ -		Costs included in bergingen	
Binnenwandopeningen												
Binnenkozijnen	Montage kozijn Reinaerdt 930x2315 plaatstaal	Deelproduct: Binnenkozijnen, Staal; verzinkt+gemoffeld	#nmd_31609	236,8	m2		€-	€-	€-	opp = 2,153m2	Costs are incorporated in the	ndeuren
Binnenkozijnen	Montage kozijn Reinaerdt 730x2315 plaatstaal	Deelproduct: Binnenkozijnen, Staal; verzinkt+gemoffeld	#nmd_31609	37,1	m2		€-	€-	€-	opp = 1,690 m2	Costs are incorporated in the	ndeuren
Binnendeuren	R1 opdekdeur Reinaerdt 930x2315	Deelproduct: Binnendeuren, Hout; geschilderd:alkyd	#nmd_31621	1	piec		€19.749,58	€24.329,84	€221,18			
	R1 opdekdeur Reinaerdt 730x2315	Deelproduct: Binnendeuren, Hout; geschilderd:alkyd	#nmd_31621	2	piec		€3.949,92	€4.865,97	€221,18			
Binnendorpels	Binnendorpel 7 cm diep, 2 cm hoog 91 cm	Deelproduct: Binnendorpels, Gegoten Composietsteen badceldorpel	#nmd_31639	20,02	m		503,8	€ 620,64	€ 31,00			
Trappen en liften												
Centrale trappen	Prefab betontrap	Trap, beton, prefab, Betonhuis	#nmd_10813	2	pieces		€ 8.000,24	€ 9.855,63	€ 4.927,81			osts from another project considered; also includes costs for Aanrechtblad and is up to date
	Spiltrap	Deelproduct: Interne trappen, Staal met Meranti treden: duurzame bosbouw	#nmd_29172	3	pieces		€ 28.142,00	€ 34.668,59	€ 11.556,20			kast
balustrades	Opgenomen in vloeren, balkon- galerij; ballustrad	n.a.	n.a.					€-		Is considered in other chapter		
Liftcabines	Otis personenlift	Liftcabines, Staal; personenlift; gemoffeld	#nmd_33020		piec		35	€43.117,07	€43.117,07	Per level so scaling in NMD at 3 to correct		
Liftinstallaties	Otis hefconstructie+contragewicht	Liftinstallaties, Staal; hefconstructie+contragewicht; 1 bouwlaag	#nmd_33021		piec		€12.271,97	€15.118,04	€15.118,04			
Keukenkasten		Deelproduct: Keukenkasten, Multiplex; geschilderd:alkyd	#nmd_33023	5	m		€39.008,64	€39.008,64	€738,80		Not included in project,	
Aanrechtbladen		Deelproduct: Aanrechtbladen Kunsthars composiet; massief	#nmd_33027	3	m2		€-	€ -	€ -	Not data availble, no need to scale	Symbolic 1 euro included in	
Toiletten	Keramiek; toiletpot+reservoir	Deelproduct: Toiletten, Wandcloset + fontein, porselein; incl. kunststof reservoir	#nmd_33033	2	piec							
Wasvoorzieningen	Keramiek; wastafel			2	piec							
Douchevoorzieningen	Keramiek; tegels			2	piec		€ 21.039,70	€ 25.919,15	€ 1.178,14			
Additional costs												
Additional costs W-	Engineering costs + additional costs in Werkbegroting			2	piec		€54.175,00	€66.739,07	€3.033,59			
Additional costs Facade	Steal columns for the facade of the shared area				piec		€3.400,00	€4.188,52	€4.188,52			
Additional costs beweegbare	Costs for movable stairs				piec		€118,25	€145,67	€145,67			
Additional costs	Costs for the house numbers			4	piec		€1.164,88	€1.435,03	€32,61			
Additional costs diverse	Diverse finishing materials				piec		€7.150,00	€8.808,20	€8.808,20			
Additional costs Postkasten	Costs for the shared letterboxes at the common entrance area				piec		€4.853,00	€5.978,49	€5.978,49			
Additional costs	Costs for the floor covering				piec		€5.615,00	€6.917,21	€6.917,21			
Additional costs common	Costs for making the energylabel, projectmanagement, bim modeller, cleaning etc				piec		€107.541,50	€132.482,14	€132.482,14			
Additional costs				**1**	**piece**		**€184.017,63**	**€226.694,34**				
Construction site costs												
Construction site costs					piec		€238.415,12	€293.707,50	€293.707,50			

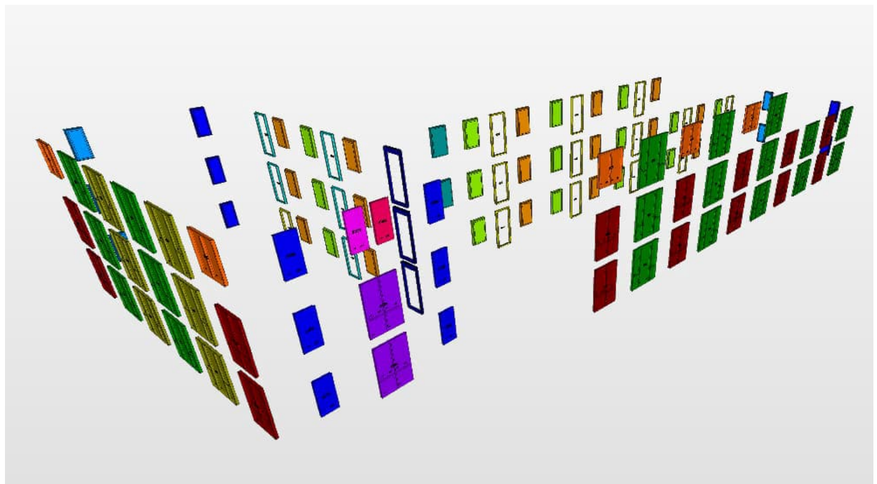
Vaste voorzieningen

Terreinvoorzieningen

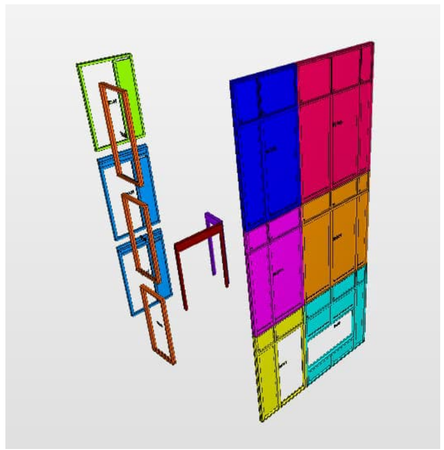
Verhardingen Straatstenen tpv bergingen en terrassen begane g

€	**2.379.209,58**	**€ 2.942.350,03**
€	**2.340.201,94**	As in Werkbegroting
€	39.007,64	**Costs for kitchens

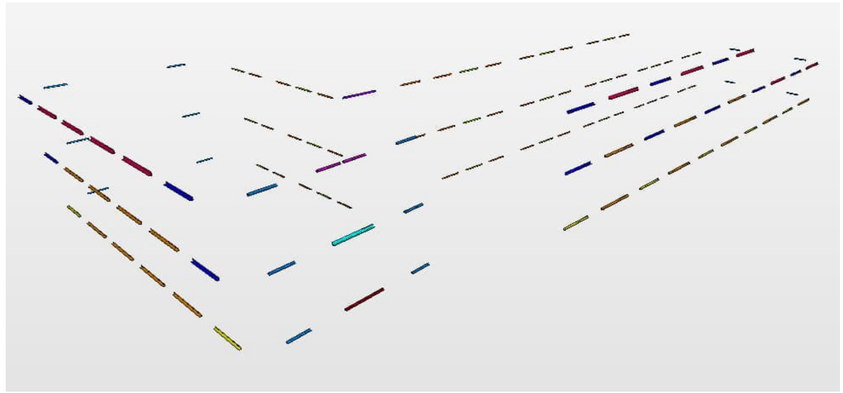
Uniformat Classification	Component	Type	Bounding Box Height	Bounding Box Length	Count	Area	Total area	Color
31.40	Window	31.40 kozijn K.01	2454	1064	11	2,61	28,71	
31.40	Window	31.40 kozijn K.01	2516	1064	3	2,68	8,04	
31.40	Window	31.40 kozijn K.02	2454	1064	5	2,61	13,05	
31.40	Window	31.40 kozijn K.03a	1686	738	1	1,24	1,24	
31.40	Window	31.40 kozijn K.03b	1686	770	11	1,3	14,3	
31.40	Window	31.40 kozijn K.03d	1624	976	17	1,58	26,86	
31.40	Window	31.40 kozijn K.04a	1686	738	1	1,24	1,24	
31.40	Window	31.40 kozijn K.04b	1686	770	5	1,3	6,5	
31.40	Window	31.40 kozijn K.04d	1624	976	16	1,59	25,44	
31.40	Window	31.40 kozijn K.05	1686	1656	5	2,79	13,95	
31.40	Window	31.40 kozijn K.06a	2501	1602	2	4,01	8,02	
31.40	Window	31.40 kozijn K.06b	2501	1656	14	4,14	57,96	
31.40	Window	31.40 kozijn K.07	2529	2104	6	5,32	31,92	
31.40	Window	31.40 kozijn K.08	2529	2104	19	5,32	101,08	
31.40	Window	31.40 kozijn K.09	1624	976	2	1,58	3,16	
31.40	Window	31.40 spouwlat 01, deur	2776	1112	3	3,09	9,27	



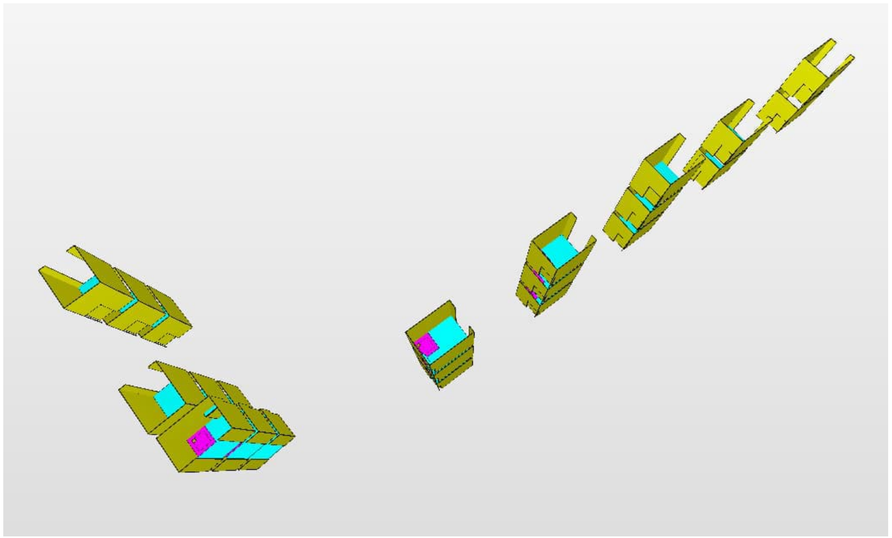
Uniformat Classification	Type	Count	Dimensions.Width	Area	Dimensions.Height	Color
31.40	31.40 kozijn H.01	1	1680	5,11	2985	
31.40	31.40 kozijn H.02	1	2560	7,96	2985	
31.40	31.40 kozijn H.03a	1	1680	5,06	3010	
31.40	31.40 kozijn H.03b	1	1680	5,63	3350	
31.40	31.40 kozijn H.04a	1	2560	7,71	3010	
31.40	31.40 kozijn H.04b	1	2560	8,58	3350	
31.40	31.40 kozijn H.05	2	1560	4,25	2667	
31.40	31.40 kozijn H.06	1	1560	3,87	2480	
31.40	31.40 kozijn H.07	3	1034	2,54	2454	
31.40	32.40 kozijn H.03	1	880	2,31	2620	
31.40	32.40 kozijn H.03	1	1800	4,72	2620	



Uniformat Classification	Name	Type	Bounding Box Height	Bounding Box Length	Count	Color
31.20	LATEIEN:L10:14145927	L10	120	1876	1	
31.20	LATEIEN:L11:14145928	L11	50	962	1	
31.20	LATEIEN:L11:14147241	L11	50	962	1	
31.20	LATEIEN:L1:14134416	L1	70	1930	1	
31.20	LATEIEN:L1:14135517	L1	70	1930	1	
31.20	LATEIEN:L1:14135534	L1	70	1930	1	
31.20	LATEIEN:L1:14135545	L1	70	1930	1	
31.20	LATEIEN:L1:14135554	L1	70	1930	1	
31.20	LATEIEN:L1:14144617	L1	70	1930	1	
31.20	LATEIEN:L1:14144846	L1	70	1930	1	
31.20	LATEIEN:L2:14135119	L2	100	1930	1	
31.20	LATEIEN:L2:14135120	L2	100	1930	1	
31.20	LATEIEN:L2:14135518	L2	100	1930	1	
31.20	LATEIEN:L2:14135519	L2	100	1930	1	
31.20	LATEIEN:L2:14135535	L2	100	1930	1	
31.20	LATEIEN:L2:14135536	L2	100	1930	1	
31.20	LATEIEN:L2:14144673	L2	100	1930	1	
31.20	LATEIEN:L3:14136087	L3	90	2428	1	
31.20	LATEIEN:L3:14144235	L3	90	2428	1	
31.20	LATEIEN:L5:14137449	L5	60	994	1	
31.20	LATEIEN:L6:14138739	L6	60	1300	1	
31.20	LATEIEN:L6:14142360	L6	60	1300	1	
31.20	LATEIEN:L7:14140206	L7	60	1200	1	
31.20	LATEIEN:L7:14142092	L7	60	1200	1	
31.20	LATEIEN:L7:14142356	L7	60	1200	1	
31.20	LATEIEN:L9:14145442	L9	70	1876	1	



Uniformat Classification	Type	Name	Material	Count	Area	Color
42.12	Basic Wall:42.12 wandtegels, 150x200	Basic Wall:42.12 w	g3 Verglaasde klei, tegels 150x200 10 mm	135	396,15	
42.12	Floor:42.12 wandtegels, 150x150	Floor:42.12 wandte	g3 Verglaasde klei, tegels 150x150 7 mm,<Unnamed> 3 mm	44	65,01	
43.22	43.22 douchehoek	43.22 douchehoek:	g3 Verglaasde klei, tegels 150x150 0 mm	22	17,33	



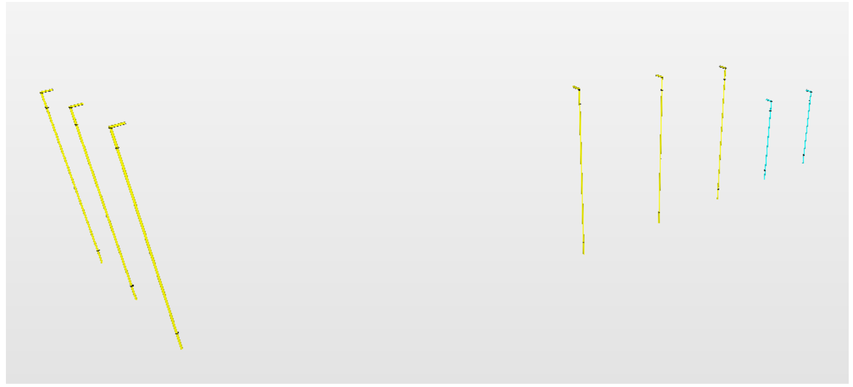
103.6 - NL-73.11_vast	Type	Bounding Box Lengt	Count	Color
	73.11 keuk	52800	22	

103.6 - NL-22.11_binn	Type	Area	Count	Color
	Basic Wall:22.11 cellenbeton seperatiepaneel G4/600, d=100	913,63	270	
22.11_binn	Basic Wall:22.11 cellenbeton seperatiepaneel G5/800, d=100	189,18	28	

103.6 - NL-	Type	Name	Material	Count	Color
24.11_trappen en helling		24.11 prefab betontrap bgg:24.11 prefab betontr		2	
24.13_trap	CHS 101.6x5	Kolom staa	h3 RAL 7022 0 mm	8	
24.13_trappen en helling		Stair:24.13 spiltrap:1493734, Stair:24.13 spiltrap3			

103.6 - NL-SfB	Type	Name	Material	Area	Count	Color
32.40_binnenwandopeningen - gevuld met puien, algemeen (verzamelniveau)	32.40 kozijn P.03	32.40 kozijn P.03:32	o1 Doorzic	292,19	110	
32.40_binnenwandopeningen - gevuld met puien, algemeen (verzamelniveau)	32.40 kozijn P.03 o730x2315 ROD=28	32.40 kozijn P.03:32	o1 Doorzic	46,87	22	

Uniformat Classification	Type	Name	Bounding Box Height	Material	Count	Color
52.12	52.12 RWA ø80	52.12 afvoer:52.12 RWA ø80:2084630, 52.12 afvoer:52.12 RWA ø80:2085156, 52.12 afvoer:52.12 RWA ø80:2085188, 52.12 afvoer:52.12 RWA ø80:2086378, 52.12 afvoer:52.12 RWA ø80:2086494, 52.12 afvoer:52.12 RWA ø80:2086530	9427 n6	RAL 7039 0 mm	6	
52.12	52.12 RWA ø80	52.12 afvoer:52.12 RWA ø80:2085219, 52.12 afvoer:52.12 RWA ø80:2085255	6411 n6	RAL 7039 0 mm	2	



103.6 - NL- Type	Pset_Manu	Pset_Manu	Count	Color	
UnclassifieNIB#H202:	Nibe	HK 200S t.	11		
UnclassifieNIB#H202:	Nibe	HK 200S t.	3		Not considered
UnclassifieNIB#L208:	Nibe	Split AMS 122			

	Name	Material.Name	Area	Count	Color
103.6 - NL-47.11_dak	Basic Roof:47.11 dak-afschotisolatie gecacheerd EPS, d=160:105616	n1 Op basis van bitumen, n7 Kunststof met cellenstructuur, n8 Kunststof met wapening	116,46	1	
47.11_dak	Basic Roof:47.11 dak-afschotisolatie gecacheerd EPS, d=160:1101913	n1 Op basis van bitumen, n7 Kunststof met cellenstructuur, n8 Kunststof met wapening	178,74	1	
47.11_dak	Basic Roof:47.11 dak-afschotisolatie gecacheerd EPS, d=160:1503089		5,93		1
47.11_dak	Basic Roof:47.11 dak-afschotisolatie gecacheerd EPS, d=160:851163	n1 Op basis van bitumen, n7 Kunststof met cellenstructuur, n8 Kunststof met wapening	202,49	1	
Unclassifie	Basic Roof:47.11 dak-afschotisolatie gecacheerd EPS, d=160:1503089		0,01	1	

Appendix 3

Gebouwinformatie

Gebruiksfunctie:	Woongebouw
Levensduur	75 jaar
Type	Appartement
Totaal BVO	1692,54 m2
Totaal GO	1214,94 m2
Aantal woningen/eenheden	22

3202982,874 43339,19631 3246322,07

Inflation correction 123,19% BDB sept 2020 = 98,57; BDB sept 2024 = 121,43

Materialisering				Quantity	Unit	Scaling	Construction costs	Construction costs corrected for inflation	Construction costs/unit	Comment MPG	Comment costs
Fundering											
Bodemvoorzieningen											
Grondaanvullingen	Zand	Deelproduct: Grondaanvullingen, Zand	#nmd_27309	6	m3		€9.622,95	€11.854,67	€197,58		Costs for Grondwerk
Fundering											
Funderingsbalken	funderingsbalk ihwg, 450x600	Fundatiebalken, Beton,in het werk gestort, C20/25; incl.wapening + eps	#nmd_38254	59,	m	1	€11.981,54	€14.760,26	€248,38	Including EPS C20/25; c3037 assumed of Betonhuis	
	funderingsbalk ihwg, 600x600	Fundatiebalken, Beton,in het werk gestort, C20/25; incl.wapening + eps	#nmd_38254	111,	m	1	€22.533,97	€27.759,97	€248,38	Including EPS C20/25; c3037 assumed of Betonhuis	
	funderingsbalk ihwg, 650x600	Fundatiebalken, Beton,in het werk gestort, C20/25; incl.wapening + eps	#nmd_38254	35,	m	1	€7.060,49	€8.697,93	€248,38	Including EPS C20/25; c3037 assumed of Betonhuis	
Funderingspalen	funderingpalen_mortelschroefpaal_rond:schro	Funderingspalen, Betonhuis; schroefpaal; beton,in het werk gestort, C20/25,CEMIII; incl.wapenin	#nmd_27445	995,18	m		€ 35.920,00	€ 44.250,44	€ 44,46	C30/37 not available in NMD	
Vloeren											
Vloeren, begane grond											
Vloeren vrijdragend	VBI isolatieplaatvloer 200; rc 5	VBI Isolatieplaatvloer 200 Groen	#nmd_20101	474	m2	1	€40.108,73	€49.410,60	€104,21	Scaled in database: eps 3.7 m2/k -> 5m2/k; MKI eps = €0,49; MKI floor	
Dekvloeren	zwevende cementdekvloer, d=90	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	44	m2		€5.694,64	€7.015,31	€15,64	Product not scalable	Same costs as cementdekvloer
Dekvloeren	verende cementdekvloer, d=62	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	6	m2		€83,15	€102,43	€15,64	Product not scalable	Same costs as cementdekvloer
Dekvloeren	Cementdekvloer d=80	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	23	m2		€298,95	€368,28	€15,64	Product not scalable	Same costs as cementdekvloer
				478	m			€7.486,03			
Vloeren, verdieping											
Vloeren vrijdragend	Van Nieuwpoort BPV 50mm breedplaatvloer	Van Nieuwpoort Breedplaatvloer Bpv 50 mm	#nmd_20115	94	m2		€102.351,18	€126.088,10	€136,01	C30/37	Includes costs for druklaag;
	Druklaag; c30/37; 230mm	Deelproduct: Vrijdragende Vloeren, Betonhuis; druklaag breedplaatvloer; betonmortel	#nmd_29055	944,2	m2		0,00	€ -	€ -	Product not scalable	Included in vloeren vrijdragend
Dekvloeren	zwevende cementdekvloer, d=90	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	778,5	m2		€ 9.882,46	€ 12.174,37	€ 15,64	Product not scalable	Same costs as cementdekvloer with other thickness
~~Dekvloeren~~	~~verende cementdekvloer, d=62~~	~~Deelproduct: Dekvloeren, Zandcement~~	~~#nmd_28904~~	~~11,46~~	~~m2~~		~~€ 145,48~~	~~€ 179,21~~	~~€ 15,64~~	~~Product not scalable~~	~~Same costs as cementdekvloer with other thickness~~
~~Dekvloeren~~	~~Cementdekvloer d=80~~	~~Deelproduct: Dekvloeren, Zandcement~~	~~#nmd_28904~~	~~36,44~~	~~m2~~		~~€ 462,58~~	~~€ 569,86~~	~~€ 15,64~~	~~Product not scalable~~	~~Same costs as cementdekvloer with other thickness~~
				~~826,1~~	~~m~~			~~€ 12.923,14~~			
~~Afwerklagen, vloer~~	~~Verglaasde klei, tegels 150x150 7 mm~~	~~Deelproduct: Afwerklagen, Keramische tegels, geglazuurd/gefijnd~~	~~#nmd_28929~~	~~65,01~~	~~m2~~		~~€ 30.768,30~~	~~€ 37.903,97~~	~~€ 583,05~~		~~Also includes wandtegels~~
Afwerklagen, plafond	Spuitpleister	Deelproduct: Afwerklagen, Spuitpleister	#nmd_28558	944,2	m2		€ 12.012,90	€ 14.798,89	€ 8,69		Costs combined with spuitplaster wanden
Vloeren, balkon- en galerij											
Vloeren vrijdragend	buiten_prefab_galerij, d=300	Balkon-/galerijvloer, beton, prefab, 250 mm, Betonhuis	#nmd_10812	130,35	m2	1,2	€	€111.304,32	€527,66	C30/37, no other product available	Gallerij + Balkon combined into one
~~Vloeren vrijdragend~~	~~buiten_prefab_balkon, d=300~~	~~Balkon-/galerijvloer, beton, prefab, 250 mm, Betonhuis~~	~~#nmd_10812~~	~~90,59~~	~~m2~~	~~1,2~~	~~99.350~~			~~C45/55; no other product available~~	~~Gallerij + Balkon combined into~~
Ballustrades	balustrade, h=1000; staal; spijlen	Balustrades, Staal; gepoedercoat; spijlen	#nmd_31897	139,	m		€50.823,00	€62.609,69	€448,65		
Draagconstructie											
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=100	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	9	m2		€4.009,69	€4.939,60	€51,40	Reference thickness= 100mm	In costs estimation as 120mm,
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=120	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	186	m2	1	€7.787,39	€9.593,42	€51,40	Reference thickness= 100mm	
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=214	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	521	m2	2	€29.878,58	€36.807,92	€70,55	Reference thickness= 100mm	Costs combined with other
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=300	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	392	m2		€26.363,95	€32.478,18	€82,64	Reference thickness= 100mm	
Dragende wanden, massief	Calduran Kalkzandsteen CS20, d=214	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	69	m3	2	€3.996,03	€4.922,77	€70,55	Reference thickness= 100mm	Costs combined with other
Dragende wanden, niet	Vuren framewerk voor buiten en binnen wanden	Houtskeletbouw frame voor dragende en niet-dragende binnenwand. Representatief voor leden	#nmd_92900	290,15	m2		€ -	€ -	€ -		Included in bergingen
Gevels											
Spouwwanden, buitenblad	Wienerberger Teunisbloem 50mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	10	m2	0	€2.349,54	€2.894,43	€279,39	Assumed the thickness =	
	Wienerberger Teunisbloem 100mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	788	m2		€178.877,88	€220.362,60	€279,39	Assumed the thickness =	
	Wienerberger Teunisbloem 112mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	1	m2	1	€317,51	€391,14	€279,39	Assumed the thickness =	
	Gevelsteen 100 mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	8	m2		€19.639,96	€24.194,79	€279,39	Assumed the thickness =	
Isolatielagen	Isolatie minerale wol, Mupan Ultra XS, d=138	Isover Mupan Ultra XS	#nmd_45415	839	m2		€40.983,61	€50.488,38	€60,11	Thickness=131 mm	
Bekledingen	Vuren geimpregneerde rabatdelen 19x130mm	Deelproduct: Bekledingen, Europees naaldhouten delen, wax impregnatie; duurzame bosbouw	#nmd_31985	93	m2		0	€-	€-		Included in Spaanplaat 18mm
Kozijnen	PVC	Kunststof raamkozijn, vleugeldeel, met VKG keurmerk	#nmd_30559	350	m2		€130.368,75	€160.603,40	€457,90	Splitted into frames and glass	
	Beglazing	Isolatieglas, driedubbelglas, ongecoat, Bouwend Nederland Vakgroep GLAS	#nmd_91482	280,	m2		€-	€-	€-	Triple glass; 80% of the surface area of the frames	
Kozijnen	Kozijnen bergingen vuren met aflaklaag	Deelproduct: Buitenkozijnen, Europees naaldhout; geschilderd, acryl; duurzame bosbouw	#nmd_30512	48,513	m2			€-	€-		
Kozijnen	Kozijnen gezamenlijke ruimtes mahonihout	Deelproduct: Buitenkozijnen, Tropisch loofhout; geschilderd, acryl; duurzame bosbouw	#nmd_30979	57	m2		€30.721,65	€37.846,50	€655,46		Including Flowcoat, P-A deur de
Deuren	Flowcoat, P-A deur de Mors (hout met glas)	Deelproduct: Buitendeuren, Onverduurzaamd hout; geschilderd:alkyd; glasopening:0.85m2	#nmd_30459		piec		€3.301,00	€4.066,56	€580,94		Only labour and small material
	Deuren Bergingen	HOUT100% kozijn met deur, kleiner dan 3,6 m2, inclusief NBVT massief houten buitendeur tot	#nmd_92815	48,4	m2		€ -	€ -	€ -		Included in Spaanplaat 18mm met vuren balklaag
Stelkozijnen	Verduurzaamd hout	Deelproduct: Stelkozijnen, Onverduurzaamd hout; geverfd	#nmd_30902	118	pieces		€ 49.379,60	€ 60.831,54	€ 515,52		
Lateien	Stalen latei h=120	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_91230	1,88	m		€ 335,80	€ 413,68	€ 14,70	15 kg/m	
	Stalen latei h=50	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_91230	1,924	m		€ 344,39	€ 424,27	€ 14,70	15 kg/m	
	~~Stalen latei h=60~~	~~Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)~~	~~#nmd_91230~~	~~7,194~~	~~m~~		~~€ 1.287,72~~	~~€ 1.586,36~~	~~€ 14,70~~	~~15 kg/m~~	
	~~Stalen latei h=70~~	~~Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)~~	~~#nmd_91230~~	~~15,366~~	~~m~~		~~€ 2.754,00~~	~~€ 3.392,00~~	~~€ 14,70~~	~~15 kg/m~~	
	~~Stalen latei h=90~~	~~Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)~~	~~#nmd_91230~~	~~4,856~~	~~m~~		~~€ 869,22~~	~~€ 1.070,81~~	~~€ 14,70~~	~~15 kg/m~~	
	Stalen latei h=100	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_91230	13,51	m		€ 2.418,28	€ 2.979,12	€ 14,70	15 kg/m	
Waterslagen	Betonnen waterslagen	Deelproduct: Waterslagen, Beton	#nmd_30955	167	m		€ 8.401,71	€ 10.350,20	€ 61,98	not	accessible in model
Waterkeringen	EPDM; folie [50, 1]	Deelproduct: Waterkeringen, EPDM; folie	#nmd_32284	500	m			€ -	€ -	Not in model	included in waterslagen
Daken											
Daken,plat		Deelproduct: Platte daken, Europees naaldhouten balken met europees naaldhouten multiplex;	#nmd_29276	12	m2		€46.217,00	€56.935,48	€454,39		Includes all the costs for the
Daken	~~APP gemodificeerde gebitumineerde onderlaag, ty~~ Plat dakbedekking, Stg. Dak en Milieu, Bitumen gemod. eenlaags 4,3 mm, 5,3 kg per m2, volledig		#nmd_90716	125,3	m2						
Daken	Van Nieuwpoort BPV 50mm breedplaatvloer	Van Nieuwpoort Breedplaatvloer Bpv 50 mm	#nmd_201159	364,85	m2		€ 42.171,70	€ 51.952,01	€ 136,01	C30/37	Includes costs for druklaag; cost/m2 combined with othet Breedplaatvloer
	Druklaag; c30/37; 200mm	Deelproduct: Vrijdragende Vloeren, Druklaag breedplaatvloer; betonmortel C30/37; incl. wapenin	#nmd_29081	364,85	m2			0 €	€ -	Product not scalable	included Van Nieuwpoort BPV 50MM breedplaatvloer
Isolatielagen	EPS 100	Deelproduct: Isolatielagen plat dak, EPS	#nmd_32316	503,63	m2		€ 48.150,00	€ 59.316,77	€ 117,78		Including the costs of bedekkingen
Bedekkingen	APP gemodificeerde gebitumineerde onderlaag, ty	Plat dakbedekking, Stg. Dak en Milieu, Bitumen gemod. tweelaags 6,6 mm, 8,1 kg per m2, losligge	#nmd_90722	503,	m2		€-	€-	€-		Included in
Waterkeringen	Lood slab	Deelproduct: Waterkeringen, Combinatie PVC/Lood	#nmd_32386	1	m		€28.879,00	€35.576,51	€197,65	Not in model	
Afwerkingen, plafond	Spuitpleister	Deelproduct: Afwerklagen, Spuitpleister	#nmd_32172	90	m2			€-	€-	Removed, was duplicate	
Aftimmering, buiten	Aftimmering bergingen	Deelproduct: Bekledingen, Europees naaldhouten delen, wax impregnatie; duurzame bosbouw	#nmd_31985	5	m			€-	€-		Removed not in real design
Installaties											
Warmtelevering											
Warmteopwekkingsinstallati	Lucht water warmtepomp MetroTherm MetroAir L-G	Lucht-water warmtepomp, solo, koudemiddel R410a, Vereniging Warmtepompen (3,4 - 12 kW)	#nmd_95894	22	pieces	0,9996	€ 116.600,00	€ 143.641,45	€ 6.529,16	1 unit per app, wasn't available then in database; scaled with packhunt	
Warmteopwekkingsinstallaties	MetroTherm SHK200S binnenunit	Buffervat	#nmd_93832	2	piec	0,9	€49.500,00	€60.979,86	€2.771,81	Scaling, original 315 liter should be 180 liter; scaled using packhunt	
Warmtedistributiesystemen	Polyetheen/polybuteen; cv-leidingen; incl. koppelingen + verdeling	Warmtedistributiesystemen, Polyetheen/polybuteen; cv-leidingen; incl. koppelingen + verdeling	#nmd_32893	1214,	m2		€19.800,00	€24.391,94	€20,08		
Warmteafgiftesystemen	Vloerverwarming;	Warmteafgiftesystemen, Vloerverwarming; leidingen:polybuteen+toebehoren	#nmd_32894	1214	m2		€39.050,00	€48.106,34	€39,60		
Elektrische installaties											
Elektriciteitsleidingen	Geisoleerde installatiedraad + mantelbuis:pvc	Deelproduct: Elektriciteitsleidingen, Geisoleerde installatiedraad + mantelbuis:pvc	#nmd_32999	1214	m2		€122.341,50	€150.714,50	€124,05		
Elektriciteitsopwekkingsyste	JAM60S10 340/PR pv panelen + sunbeam NOVA	PV paneel – polykristallijn / plat dak	#nmd_93723	54	pieces	0,91	€ 34.193,00	€ 42.122,92	€ 780,05	1.68m2; 330 wp, so scaling from 1.	Includes costs for omvormer
Elektriciteitsopwekkingssystem	SAJ R5-1.5K-S1 omvormer	Omvormer – 2500 W	#nmd_93729	23	pieces		€ -	€ -	€ -	1,5 kw	Included in pv panels
Luchtbehandeling											
Luchtbehandelingssystemen	DucoBox Energy Comfort WTW box type 325	Deelproduct: Luchtdistributiesystemen, WTW-unit	#nmd_32915	22	pieces		€ 48.400,00	€ 59.624,75		should be inserted in m2 gbo	Included in distributiesystem with distributie
Luchtdistributiesystemen	Mechanische aan- en afvoer; verzinkt staal, incl. ro	Mechanische aan- en afvoer; verzinkt staal, incl. roosters	#nmd_32909	1214	m2		€65.400,00	€80.567,33	€		

cost since same product in NMD
efore costs of 120mm blocks
thicknes
thicknes
Gevels, dicht
uren balklaag
Gevels, open
rs (hout met glas)
s+ binnendeuren hout
en
00 = €2.86
other thickness
other thickness
other thickness
combined with othet Breedplaatvloer
vrijdragend
Same costs as cementdekvloer with other thickness
Same costs as cementdekvloer with other thickness
Same costs as cementdekvloer with other thickness
costs of bedekkingen
Hoofdraagconstructie
ost since same product in NMD

Water- en gasdistributie												
Waterleidingen	Polyetheen; leiding+mantelbuis	Deelproduct: Waterleidingen, Polyetheen; leiding+mantelbuis	#nmd_32834	1214	m2		€18.250,00	€22.482,47	€18,51			
Afvoeren												
Buitenrioleringen	Pvc; gerecycled; leiding	Deelproduct: Buitenrioleringen kavel, Pvc; gerecycled; leiding	#nmd_32744	1214	m2		€5.000,00	€6.159,58	€5,07			
Binnenrioleringen	Pvc; gerecycled; leiding	Deelproduct: Binnenrioleringen, Pvc; gerecycled; leiding	#nmd_36236	1214	m2		47	€58.269,65	€47,96			
Hemelwaterafvoeren	Hemelwaterafvoeren diameter 80mm	Deelproduct: Hemelwaterafvoeren, Pvc; grecycled; diameter:80mm; d:1.8mm	#nmd_32790	69	m		€6.600,00	€8.130,65	€117,18			
Inbouw												
Binnenwanden												
Niet dragende wanden,	Ytongpan. 10cm G4/600	Massieve wanden, niet dragend, cellenbeton blokken, Xella-Ytong	#nmd_38859	913	m2		€40.564,12	€49.971,61	€54,70			afond
Niet dragende wanden,	Ytongpan. 10cm G5/800	Massieve wanden, niet dragend, cellenbeton blokken, Xella-Ytong	#nmd_38859	189	m2		€8.399,38	€10.347,33	€54,70			
Plinten	Plinten	Deelproduct: Bekledingen, Plint Gegoten Composietsteen	#nmd_28552	1	m		547	€6.750,41	€6,02	Not in model		
Afwerklagen	Spuitpleister appartementen	Deelproduct: Afwerklagen, Spuitpleister	#nmd_28558	3	m2		€18.408,42	€22.677,63	€8,69	Not in model	Costs combined with	
Afwerklagen	Behang; vinyl (openbare ruimte)	Deelproduct: Afwerklagen, Behang; vinyl	#nmd_28416	2	m2		3920	€4.829,17	€16,77	Not in model		
Niet dragende wanden, niet	Scheidingswanden bergingen Spaanplaat 11mm	Deelproduct: Bekledingen systeemwanden niet dragend, Spaanplaat	#nmd_28447	78,494	m2		0	€ -	€ -		Costs included in bergingen	
Binnenwandopeningen												
Binnenkozijnen	Montage kozijn Reinaerdt 930x2315 plaatstaal	Deelproduct: Binnenkozijnen, Staal; verzinkt+gemoffeld	#nmd_31609	236,8	m2		€-	€-	€-	opp = 2,153m2	Costs are incorporated in the	deuren
Binnenkozijnen	Montage kozijn Reinaerdt 730x2315 plaatstaal	Deelproduct: Binnenkozijnen, Staal; verzinkt+gemoffeld	#nmd_31609	37,1	m2		€-	€-	€-	opp = 1,690 m2	Costs are incorporated in the	deuren
Binnendeuren	R1 opdekdeur Reinaerdt 930x2315	Deelproduct: Binnendeuren, Hout; geschilderd:alkyd	#nmd_31621	1	piec		€19.749,58	€24.329,84	€221,18			
	R1 opdekdeur Reinaerdt 730x2315	Deelproduct: Binnendeuren, Hout; geschilderd:alkyd	#nmd_31621	2	piec		€3.949,92	€4.865,97	€221,18			
Binnendorpels	Binnendorpel 7 cm diep, 2 cm hoog 91 cm breed,	Deelproduct: Binnendorpels, Gegoten Composietsteen badceldorpel	#nmd_31639	20,02	m		503,8	€ 620,64	€ 31,00			
Centrale trappen	Prefab betontrap	Trap, beton, prefab, Betonhuis	#nmd_10813		piec		€8.000,24	€9.855,63	€4.927,81			
	Spiltrap	Deelproduct: Interne trappen, Staal met Meranti treden; duurzame bosbouw	#nmd_29172		piec		€28.142,00	€34.668,59	€11.556,20			
balustrades	Opgenomen in vloeren, balkon- galerij;	n.a.	n.a.					€-		Is considered in other chapter		
Liftcabines	Otis personenlift	Liftcabines, Staal; personenlift; gemoffeld	#nmd_33020		piec		35	€43.117,07	€43.117,07	Per level so scaling in NMD at 3 to correct		
Liftinstallaties	Otis hefconstructie+contragewicht	Liftinstallaties, Staal; hefconstructie+contragewicht; 1 bouwlaag	#nmd_33021		piec		€12.271,97	€15.118,04	€15.118,04			
Keukenkasten		Deelproduct: Keukenkasten, Multiplex; geschilderd:alkyd	#nmd_33023	5	m		€39.008,64	€39.008,64	€738,80		Not included in project, therefore	
Aanrechtbladen		Deelproduct: Aanrechtbladen, Kunstharsgebonden; massief	#nmd_33027	3	m		€-	€-	€-		Symbolic 1 euro included in	
Toiletten	Keramiek; toiletpot+reservoir			2	piec							
Wasvoorzieningen	Keramiek; wastafel			2	piec							
Douchevoorzieningen	Keramiek; tegels	Deelproduct: Toiletten, Wandcloset + fontein, porselein; incl. kunststof reservoir	#nmd_33033	2	piec		€ 21.039,70	€ 25.919,15	€ 1.178,14			
Terreinvoorzieningen												
Verhardingen	Straatstenen tpv bergingen en terrassen begane gr	Betonstraatsteen (210x105x80mm) door en door grijs	#nmd_37007	200	m2			€ -	€ -	Not data availble, no need to scale		
Additional costs												
Additional costs W-	Engineering costs + additional costs in Werkbegroting			1	piec		€54.175,00	€66.739,07	€3.033,59			
Additional costs Facade	Steal columns for the facade of the shared area				piec		€3.400,00	€4.188,52	€4.188,52			
Additional costs beweegbare	Costs for movable stairs				piec		€118,25	€145,67	€145,67			
Additional costs	Costs for the house numbers			4	piec		€1.164,88	€1.435,03	€32,61			
Additional costs diverse	Diverse finishing materials				piec		€7.150,00	€8.808,20	€8.808,20			
Additional costs Postkasten	Costs for the shared letterboxes at the common entrance area				piec		€4.853,00	€5.978,49	€5.978,49			
Additional costs	Costs for the floor covering				piec		€5.615,00	€6.917,21	€6.917,21			
Additional costs common	Costs for making the energylabel, projectmanagement, bim modeller, cleaning etc				piec		€107.541,50	€132.482,14	€132.482,14			
Additional costs				**1**	**piece**		**€184.017,63**	**€226.694,34**				
Construction site costs												
Construction site costs					piec		€238.415,12	€293.707,50	€293.707,50			

€ 2.379.209,58 € 2.942.350,03

€ 2.340.201,94 As in Werkbegroting

€ 39.007,64 **Costs for kitchens

Trappen en liften

Vaste voorzieningen

sts from another project considered; also includes costs for Aanrechtblad and is up to date kast

Appendix 4

Gebouwinformatie

Gebruiksfunctie:	Woongebouw
Levensduur	75 jaar
Type	Appartement
Totaal BVO	1692,54 m2
Totaal GO	1214,94 m2
Aantal woningen/eenheden	22

Shared garden/terrace

Increase in Building UFA	0	m2
Percentual increase	0,00%	
Decrease in Building UFA	0	m2
Percentual decrease	0,00%	
Change in UFA	0	m2

Added		Envrionemtnal Product name	ED number	Corrected amount	Unit	Scaling NMD	Construction costs		Construction costs/unit		Explaination	Cost explaination
Grondaanvullingen	Zand	Deelproduct: Grondaanvullingen, Zand	#nmd_273	3	m							
Verhardingen	Betontegels	Betontegels (300x300x60mm) grijs	#nmd_370	2	m		€	1.791,80	€	81,45	Sand 150 mm thick (Bestratingsweb.nl, n.d.) Concrete pavement tiles	per meter concrete band, labour €30 per m2 of pavement (Grondverzet.nu, 2024 ;Karsten, 2024) and calculated per m2, so assigned to betontegels
Verhardingen	Betonbanden	Betonband, 250mm hoog, CEM I, schaalbaar	#nmd_665	2	m						Concrete bands to keep the pavement in place (Bestratingsweb.nl, n.d.)	
Spouwwanden, buitenblad	Wienerberger Teunisbloem 100mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_108	13	m		€3.710,24		€279,39		Facade finishing at location of balconies	Balcony depth = 1820 mm, thickness = 300mm

Removed										
Vloeren vrijdragend	buiten_prefab_balkon, d=300	Balkon-/galerijvloer, beton, prefab, 250 mm, Betonhuis	#nmd_1081	-	m	1	€-42.524,12	€527,66		All balconies are removed
Ballustrades	balustrade, h=1000; staal; spijlen	Balustrades, Staal; gepoedercoat; spijlen	#nmd_3189	-	m		€-37.731,54	€448,65		The fencing is calculated based on drawings in Appendix XX
Verhardingen	Straatstenen tpv bergingen en terrassen begane	Betonstraatsteen (210x105x80mm) door en door grijs Deelproduct: Dekvloeren, Zandcement	#nmd_37007	-44,83	m2				Surface area of the "balconies" on the ground floor	

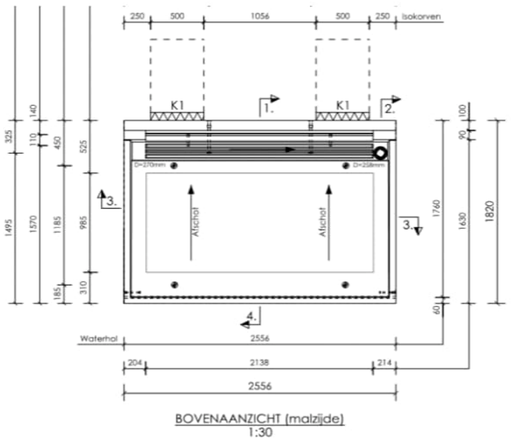
*Difference excluding additional costs

Extra

N.a.	€	-
Total	**€**	-

Difference € -74.753,62 costs

Design of a balcony



BOVENAANZICHT (malzijde)
1:30

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Gebouwinformatie

Gebruiksfunctie:	Woongebouw	
Levensduur	75 jaar	
Type	Appartement	
Totaal GFA	1692,54	m2
Totaal UFA	1214,94	m2
Aantal woningen/eenheden	22	

Shared Kitchen

Increase in Building UFA	20	m2
Percentual increase	1,65%	
Decrease in Building UFA	21,12	m2
Percentual decrease	1,74%	
Change in UFA	-1,12	m2

Changed	Envrionmental Product name	EDN	Added	Unit	Removed	Unit				Corrected		Construction	Construction costs/unit	Explaination	Comment MPG	Cost explaination
Materialisering																
Fundering																
Bodemvoorzieningen																
Grondaanvullingen	Zand	Deelproduct: Grondaanvullingen, Zand	#nmd_27309	0,99	m3	1,04	m3	Removed	-0,055	0	€ -10,93	€ 197,58	UFA increase -UFA decrease			Costs for Grondwerk
Fundering																
Funderingsbalken	funderingsbalk ihwg, 450x600	Fundatiebalken, Betonhuis; beton,in het werk gestort, C30/37,CEMIII; incl.wapening+eps	#nmd_27370	0	m	1	m	Remo	-	1	€-13,61	€248,38	UFA increase -UFA decrease	Including EPS C20/25; c3037 assumed of		
	funderingsbalk ihwg, 600x600	Fundatiebalken, Betonhuis; beton,in het werk gestort, C30/37,CEMIII; incl.wapening+eps	#nmd_27370	1,	m	1,	m	Remove	-	1	€-25,59	€248,38	UFA increase -UFA decrease	Including EPS C20/25; c3037 assumed of		
	funderingsbalk ihwg, 650x600	Fundatiebalken, Betonhuis; beton,in het werk gestort, C30/37,CEMIII; incl.wapening+eps	#nmd_27370	0,	m	0,	m	Remove	-	1,	€-8,02	€248,38	UFA increase -UFA decrease	Including EPS C20/25; c3037 assumed of		
Funderingspalen	funderingpalen_mortelschroefpaal_rond:schroefpaal_rond_400	Funderingspalen, Betonhuis; schroefpaal; beton,in het werk gestort, C20/25,CEMIII; incl.wapening	#nmd_27372	16,38	m	17,30	m	Removed	-0,917	0	€ -40,79	€ 44,46	UFA increase -UFA decrease	C30/37 not available in NMD		
Vloeren																
Vloeren, begane grond																
Vloeren vrijdragend	VBI isolatieplaatvloer 200; rc 5	VBI Isolatieplaatvloer 200 Groen	#nmd_27309	7,81	m2	8,24	m2	Removed	-0,437	1,0483	€ -45,55	€ 104,21	UFA increase -UFA decrease	Scaled in database: eps 3.7 m2/k -> 5m2/k; MKI eps = €0,49; MKI floor 200 = €2.86		
Dekvloeren	zwevende cementdekvloer, d=90	Deelproduct: Dekvloeren, Zandcement	#nmd_27309	7	m2	7	m2	Remo	-		€-6,47	€15,64	UFA increase -UFA decrease	Product not scalable		Same costs as cementdekvloer with other thickness
Dekvloeren	verende cementdekvloer, d=62	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0	m2	0	m2	Remo	-		€-0,09	€15,64	UFA increase -UFA decrease	Product not scalable		Same costs as cementdekvloer with other thickness
Dekvloeren	Cementdekvloer d=80	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0	m2	0	m2	Remo	-		€-0,34	€15,64	UFA increase -UFA decrease	Product not scalable		Same costs as cementdekvloer with other thickness
Vloeren, verdieping																
Vloeren vrijdragend	Van Nieuwpoort BPV 50mm breedplaatvloer	Van Nieuwpoort Breedplaatvloer Bpv 50 mm	#nmd_20115	15	m2	16	m2	Remo	-		€-118,38	€136,01	UFA increase -UFA decrease	C30/37		Includes costs for druklaag; cost/m2 combined with other Breedplaatvloer
	Druklaag: c30/37; 230mm	Deelproduct: Vrijdragende Vloeren, Betonhuis; druklaag breedplaatvloer; betonmortel C30/37,CEMIII; incl. wapening	#nmd_29055	15,	m2	16,	m2	Remove	-	0	€-	€-	UFA increase -UFA decrease	Product not scalable		Included in vloeren,
Dekvloeren	zwevende cementdekvloer, d=90	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	12	m2	13	m2	Remo	-		€-11,22	€15,64	UFA increase -UFA decrease	Product not scalable		Same costs as cementdekvloer with other thickness
Dekvloeren	verende cementdekvloer, d=62	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0	m2	0	m2	Remo	-		€-0,17	€15,64	UFA increase -UFA decrease	Product not scalable		Same costs as cementdekvloer with other thickness
Dekvloeren	Cementdekvloer d=80	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0,	m2	0,	m2	Remove	-	0	€-0,53	€15,64	UFA increase -UFA decrease	Product not scalable		Same costs as cementdekvloer with other
Afwerklagen, plafond	Spuitpleister	Deelproduct: Afwerklagen, Spuitpleister	#nmd_28558	20	m2	21	m2	Remo	-		€-9,74	€8,69	UFA shared kitchen added -UFA decrease (0,96m2 per app)			Costs combined with spuitplaster wanden
Vloeren, balkon- en galerij																
Vloeren vrijdragend	buiten_prefab_galerij, d=300	Balkon-/galerijvloer, beton, prefab, 250 mm, Betonhuis	#nmd_10812	2	m2	2	m2	Removed	-0,1	1	€-63,41	€527,66	UFA increase -UFA decrease	C30/37; no other product available so therefore this option		Gallerij + Balkon combined into one cost since same product in NMD
Ballustrades	balustrade, h=1000; staal; spijlen	Balustrades, Staal; gepoedercoat; spijlen	#nmd_31897	2	m	2	m	Remo	-		€-57,72	€448,65	UFA increase -UFA decrease			
Draagconstructie																
Hoofddraagconstructie																
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=100	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	1,58	m2	1,67	m2	Removed	-0,089	0	€ -4,55	€ 51,40	UFA increase -UFA decrease	Reference thickness= 100mm		In costs estimation as 120mm, therefore costs of 120mm blocks
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=120	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	3,07	m2	3,24	m2	Removed	-0,172	1,2	€ -8,84	€ 51,40	UFA increase -UFA decrease	Reference thickness= 100mm		
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=214	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	8,59	m2	9,07	m2	Removed	-0,481	2,14	€ -33,93	€ 70,55	UFA increase -UFA decrease	Reference thickness= 100mm		Costs combined with other 214mm thicknes Dragende
wanden, massief	Calduran Kalkzandsteen CS12, d=300	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	6,47	m2	6,83	m2	Removed	-0,362	3	€ -29,94	€ 82,64	UFA increase -UFA decrease	Reference thickness= 100mm		
Dragende wanden, massief	Calduran Kalkzandsteen CS20, d=214	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	1,15	m3	1,21	m3	Removed	-0,064	2,14	€ -4,54	€ 70,55	UFA increase -UFA decrease	Reference thickness= 100mm		Costs combined with other 214mm thicknes
Gevels																
Gevels, dicht																
Spouwwanden, buitenblad	Wienerberger Teunisbloem 50mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	0,17	m2	0,18	m2	Removed	-0,010	0,5	€ -2,67	€ 279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm		
	Wienerberger Teunisbloem 100mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	12,98	m2	13,71	m2	Removed	-0,727	0	€ 203,14	€ 279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm		
	Wienerberger Teunisbloem 112mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	0,02	m2	0,02	m2	Removed	-0,001	1,12	€ -0,36	€ 279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm		
	Gevelsteen 100 mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	1,43	m2	1,51	m2	Removed	-0,080	0	€ 22,30	€ 279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm		
Isolatielagen	Isolatie minerale wol, Mupan Ultra XS, d=138	Isover Mupan Ultra XS	#nmd_45415	13,83	m2	14,60	m2	Removed	-0,774	0	€ -46,54	€ 60,11	UFA increase -UFA decrease	Thickness=131 mm		
Gevels, open																
Kozijnen	PVC	Kunststof raamkozijn, vleugeldeel, met VKG keurmerk	#nmd_30559	3	m2		m2	Added	3,		€1.465,28	€457,90	2 windows 1.6 m2 added - none removed	Splitted into frames and glass		
	Beglazing	Isolatieglas, driedubbelglas, ongecoat, Bouwend Nederland Vakgroep GLAS	#nmd_91482	2	m2	0	m2	Added	2,		€-	€-	2 windows 1.6 m2 added - none removed	Triple glass; 80% of the surface area of the frames		
Kozijnen	Kozijnen gezamenlijke ruimtes mahonihout	Deelproduct: Buitenkozijnen, Tropisch loofhout; geschilderd, acryl; duurzame bosbouw	#nmd_30979	2,	m2		m2	Added	2,3	0	€1.507,57	€655,46	Door frame			Including Flowcoat, P-A deur de Mors (hout met
Deuren	Flowcoat, P-A deur de Mors (hout met glas)	Deelproduct: Buitendeuren, Onverduurzaamd hout; geschilderd:alkyd; glasopening:0.85m2	#nmd_30459	1	piec		piec	Added	1,		€580,94	€580,94	Entrance door			Only labour and small material costs+ binnendeuren hout
Stelkozijnen	Verduurzaamd hout	Deelproduct: Stelkozijnen, Onverduurzaamd hout; geverfd	#nmd_30902	3	piec		piec	Added	3,		€1.546,56	€515,52	1 entrance door and 2 window frames	door area =		
	Stalen latei h=70	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_91230	4	m		m	Added	4,		€69,09	€14,70	1 entrance door (1.1m) and 2 window frames (1.8m x2)	15 kg/m		
Waterslagen	Betonnen waterslagen	Deelproduct: Waterslagen, Beton	#nmd_30955	3	m		m	Added	3,		€198,33	€61,98	2 window frames 1.6 m	not accessible in model		
Waterkeringen	EPDM; folie [50, 1]	Deelproduct: Waterkeringen, EPDM; folie	#nmd_32284	8	m	8	m	Remo	-		€-	€-	UFA increase -UFA decrease	Not in model		included in waterslagen
Daken																
Daken,plat																

Daken	Van Nieuwpoort BPV 50mm breedplaatvloer	Van Nieuwpoort Breedplaatvloer Bpv 50 mm	#nmd_20115	6	m2	6	m2	Remo	-		€-45,74	€136,01	UFA increase -UFA decrease	C30/37	Includes costs for druklaag; cost/m2 combined with othet Breedplaatvloer
	Druklaag; c30/37; 200mm	Deelproduct: Vrijdragende Vloeren, Druklaag breedplaatvloer; betonmortel C30/37; incl. wapening	#nmd_29081	6,	m2	6,	m2	Remove	-	0	€-	€-	UFA increase -UFA decrease	Product not scalable	included Van Nieuwpoort BPV 50MM
Isolatielagen	EPS 100	Deelproduct: Isolatielagen plat dak, EPS	#nmd_32316	8	m2	8	m2	Remo	-		€-54,68	€117,78	UFA increase -UFA decrease		Including the costs of bedekkingen
Bedekkingen	APP gemodificeerde gebitumineerde onderlaag type 490P60 toplaag van APPgemodificeerde gebitumineerde dakbedekking voorzien van een inlage van polyester/glasvlies, type 470K 14	Plat dakbedekking, Stg. Dak en Milieu, Bitumen gemod. tweelaags 6,6 mm, 8,1 kg per m2, losliggend incl. ballast (system 07, incl. 1x overlagen)	#nmd_90722	8,	m2	8,	m2	Remove	-	0	€-	€-	UFA increase -UFA decrease		Included in
Waterkeringen	Lood slab	Deelproduct: Waterkeringen, Combinatie PVC/Lood	#nmd_32386	2	m	3	m	Remo	-		€-32,80	€197,65	UFA increase -UFA decrease	Not in model	
Installaties															

Warmtelevering

Warmteopwekkingsinstallati	Lucht water warmtepomp MetroTherm MetroAir L-	Lucht-water warmtepomp, solo, koudemiddel R410a, Vereniging Warmtepompen (3,4 - 12 kW)	#nmd_95894		piec		piec	Added	0,	0,9	€-	€6.529,16	Not included	1 unit per app, wasn't available then in database; scaled with packhunt	
Warmteopwekkingsinstallati	MetroTherm SHK200S binnenunit	Buffervat	#nmd_93832		piec		piec	Added	0,	0,9	€-	€2.771,81	Not included	Scaling, original 315 liter should be 180 liter; scaled using packhunt	
Warmtedistributiesystemen	Polyetheen/polybuteen; cv-leidingen; incl. koppelingen + verdeling	Warmtedistributiesystemen, Polyetheen/polybuteen; cv-leidingen; incl. koppelingen +	#nmd_32893	20	m2	21	m2	Remo	-		€-22,49	€20,08	UFA increase -UFA decrease		
Warmteafgiftesystemen	Vloerverwarming; leidingen:polybuteen+toebehoren	Warmteafgiftesystemen, Vloerverwarming; leidingen:polybuteen+toebehoren	#nmd_32894	20	m2	21	m2	Remo	-		€-44,35	€39,60	UFA increase -UFA decrease		
Elektrische installaties															
Elektriciteitsleidingen	Geisoleerde installatiedraad + mantelbuis:pvc	Deelproduct: Elektricteitsleidingen, Geisoleerde installatiedraad + mantelbuis:pvc	#nmd_32999	20,00	m2	21,12	m2	Removed	-1,120	0	€ -138,94	€ 124,05	UFA increase -UFA decrease		
Elektriciteitsopwekkingsysteme	JAM60S10 340/PR pv panelen + sunbeam NOVA steun	PV paneel – polykristallijn / plat dak	#nmd_93723		piece		piece	Added	0,0	0,90	€-	€780,05	Not included	1,68m2; 330 wp, so scaling from 1,85m2 to 1,68m2	Includes costs for
Elektriciteitsopwekkingsyste	SAJ R5-1,5K-S1 omvormer	Omvormer – 2500 W	#nmd_93729		piec		piec	Added	0,		€-	€-	Not included	1,5 kw	Included in pv panels
Luchtbehandeling															
Luchtbehandelingssytemen	DucoBox Energy Comfort WTW box type 325	Deelproduct: Luchtdistributiesystemen, WTW-unit	#nmd_32915		piec		piec	Added	0,			Not included		should be inserted in m2 gbo	Included in distributiesystem with distributie
Luchtdistributiesystemen	Mechanische aan- en afvoer; verzinkt staal, incl. roosters	Mechanische aan- en afvoer; verzinkt staal, incl. roosters	#nmd_32909	20,00	m2	21,12	m2	Removed	-1,120	€ -138,94		UFA increase -UFA decrease			
Water- en gasdistributie															
Waterleidingen	Polyetheen; leiding+mantelbuis	Deelproduct: Waterleidingen, Polyetheen; leiding+mantelbuis	#nmd_32834	20,00	m2	21,12	m2	Removed	-1,120	0	€ -20,73	€ 18,51	UFA increase -UFA decrease		
Afvoeren															
Buitenrioleringen	Pvc; gerecycled; leiding	Deelproduct: Buitenrioleringen kavel, Pvc; gerecycled; leiding	#nmd_32744	20	m2	21	m2	Remo	-		€-5,68	€5,07	UFA increase -UFA decrease		
Binnenrioleringen	Pvc; gerecycled; leiding	Deelproduct: Binnenrioleringen, Pvc; gerecycled; leiding	#nmd_36236	20	m2	21	m2	Remo	-		€-53,72	€47,96	UFA increase -UFA decrease		
Inbouw															
Binnenwanden															
Niet dragende wanden,	Ytongpan. 10cm G4/600	Massieve wanden, niet dragend, cellenbeton blokken, Xella-Ytong	#nmd_38859	15	m2	15	m2	Remo	-		€-46,07	€54,70	UFA increase -UFA decrease		
Niet dragende wanden,	Ytongpan. 10cm G5/800	Massieve wanden, niet dragend, cellenbeton blokken, Xella-Ytong	#nmd_38859	3	m2	3	m2	Remo	-		€-9,54	€54,70	UFA increase -UFA decrease		
Plinten	Plinten	Deelproduct: Bekledingen, Plint Gegoten Composietsteen	#nmd_28552	18	m	19	m	Remo	-		€-6,22	€6,02	UFA increase -UFA decrease	Not in model	
Afwerklagen	Spuitpleister appartementen	Deelproduct: Afwerklagen, Spuitpleister	#nmd_28558	55	m2	58	m2	Remo	-		€-26,98	€8,69	UFA increase -UFA decrease	Not in model	Costs combined with spuitplaster plafond
Afwerklagen	Behang; vinyl (openbare ruimte)	Deelproduct: Afwerklagen, Behang; vinyl	#nmd_28416	0	m2	0	m2	Added	0,		€-	€16,77	Not Influenced	Not in model	
Niet dragende wanden, niet	Scheidingswanden bergingen Spaanplaat 11mm	Deelproduct: Bekledingen systeemwanden niet dragend, Spaanplaat	#nmd_28447		m2		m2	Added	0,000		€ -	€ -	Not Influenced		
Binnenwandopeningen															
Trappen en liften															
Vaste voorzieningen															
Keukenkasten		Deelproduct: Keukenkasten, Multiplex; geschilderd:alkyd	#nmd_33023	4	m	13	m	Remo	-		€-	€738,80	4 meter shared kitchen; -0.6m per app		
Aanrechtbladen		Deelproduct: Aanrechtbladen, Kunstharsgebonden; massief	#nmd_33027	3	m	0	m	Added	3,		€2.511,92	€738,80			
Terreinvoorzieningen															

Difference **€ -333,50** *Difference excluding additional costs

Extra costs

Kitchen	€	5.690,08	Offerte Keukenconcurrent
Floor surface PVC	€	1.074,38	(*PVC Vloer Inclusief Leggen? All-in Prijzen Bij Het Vloeren Magazijn!* , 2024)
Total	**€**	**1.074,38**	

Design of the Kitchen in the shared area

RECHTE OPSTELLING
400 cm

References

PVC Vloer inclusief leggen? All-in prijzen bij Het Vloeren Magazijn! (2024, August 10). Het Vloeren Magazijn. https://hetvloerenmagazijn.nl/all-in-prijs-pvc-vloer/

Gebouwinformatie

Gebruiksfunctie:	Woongebouw	
Levensduur	75 jaar	
Type	Appartement	
Totaal GFA	1692,54	m2
Totaal UFA	1214,94	m2
Aantal woningen/eenheden	22	

Shared Living room

Increase in Building UFA	20,4	m2
Percentual increase	1,68%	
Decrease in Building UFA	24,2	m2
Percentual decrease	1,99%	
Change in UFA	-3,8	m2

Changed	Environmental Product name	EDN	Added	Unit	Removed	Unit		Corrected		Construction	Construction costs/unit	Explaination	Comment MPG	Cost explaination
Fundering														
Bodemvoorzieningen														
Grondaanvullingen	Zand	Deelproduct: Grondaanvullingen, Zand	#nmd_27309	1,01	m3	1,20	m3	Removed	-0,188	0	€ -37,08	€ 197,58	UFA increase -UFA decrease		Costs for Grondwerk
Fundering														
Funderingsbalken	funderingsbalk ihwg, 450x600	Fundatiebalken, Betonhuis; beton,in het werk gestort, C30/37,CEMIII; incl.wapening+eps	#nmd_27370	1	m	1	m	Remov	-	1	€-46,17	€248,38	UFA increase -UFA decrease	Including EPS C20/25; c3037 assumed of	
	funderingsbalk ihwg, 600x600	Fundatiebalken, Betonhuis; beton,in het werk gestort, C30/37,CEMIII; incl.wapening+eps	#nmd_27370	1,	m	2,	m	Remove	-	1	€-86,83	€248,38	UFA increase -UFA decrease	Including EPS C20/25; c3037 assumed of	
	funderingsbalk ihwg, 650x600	Fundatiebalken, Betonhuis; beton,in het werk gestort, C30/37,CEMIII; incl.wapening+eps	#nmd_27370	0,	m	0,	m	Remove	-	1,	€-27,20	€248,38	UFA increase -UFA decrease	Including EPS C20/25; c3037 assumed of	
Funderingspalen	funderingpalen_mortelschroefpaal_rond:schroefpaal_rond_400	Funderingspalen, Betonhuis; schroefpaal; beton,in het werk gestort, C20/25,CEMIII; incl.wapening	#nmd_27309	16,71	m	19,82	m	Removed	-3,113	0	€ -138,40	€ 44,46	UFA increase -UFA decrease	C30/37 not available in NMD	
Vloeren														
Vloeren, begane grond														
Vloeren vrijdragend	VBI isolatieplaatvloer 200; rc 5	VBI Isolatieplaatvloer 200 Groen	#nmd_27309	7,96	m2	9,44	m2	Removed	-1,483	1,0483	€ -154,54	€ 104,21	UFA increase -UFA decrease	Scaled in database: eps 3.7 m2/k -> 5m2/k; MKI eps = €0,49; MKI floor 200 = €2.86	
Dekvloeren	zwevende cementdekvloer, d=90	Deelproduct: Dekvloeren, Zandcement	#nmd_27309	7	m2	8	m2	Remov	-		€-21,94	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other thickness
Dekvloeren	verende cementdekvloer, d=62	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0	m2	0	m2	Remov	-		€-0,32	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other thickness
Dekvloeren	Cementdekvloer d=80	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0	m2	0	m2	Remov	-		€-1,15	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other thickness
Vloeren, verdieping														
Vloeren vrijdragend	Van Nieuwpoort BPV 50mm breedplaatvloer	Van Nieuwpoort Breedplaatvloer Bpv 50 mm	#nmd_20115	15	m2	18	m2	Remov	-		€-401,66	€136,01	UFA increase -UFA decrease	C30/37	Includes costs for druklaag; cost/m2 combined with othet Breedplaatvloer
	Druklaag: c30/37: 230mm	Deelproduct: Vrijdragende Vloeren, Betonhuis; druklaag breedplaatvloer; betonmortel C30/37,CEMIII; incl. wapening	#nmd_29055	15,	m2	18,	m2	Remove	-	0	€-	€-	UFA increase -UFA decrease	Product not scalable	Included in vloeren,
Dekvloeren	zwevende cementdekvloer, d=90	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	13	m2	15	m2	Remov	-		€-38,08	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other thickness
Dekvloeren	verende cementdekvloer, d=62	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0	m2	0	m2	Remov	-		€-0,56	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other thickness
Dekvloeren	Cementdekvloer d=80	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0,	m2	0,	m2	Remove	-	0	€-1,78	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other
Afwerklagen, plafond	Spuitpleister	Deelproduct: Afwerklagen, Spuitpleister	#nmd_28558	20	m2	24	m2	Remov	-		€-33,04	€8,69	UFA shared living room added -UFA decrease (1.1 m2 per app)		Costs combined with spuitplaster wanden
Vloeren, balkon- en galerij														
Vloeren vrijdragend	buiten_prefab_galerij, d=300	Balkon-/galerijvloer, beton, prefab, 250 mm, Betonhuis	#nmd_10812	2,	m2	2,	m2	Removed	-0,4	1,	€-215,13	€527,66	UFA increase -UFA decrease	C30/37; no other product available so therefore this option	Gallerij + Balkon combined into one cost since same product in NMD
Ballustrades	balustrade, h=1000; staal; spijlen	Balustrades, Staal; gepoedercoat; spijlen	#nmd_31897	2	m	2	m	Remov	-		€-195,83	€448,65	UFA increase -UFA decrease		
Draagconstructie														
Hoofddraagconstructie														
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=100	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	1,61	m2	1,91	m2	Removed	-0,301	0	€ -15,45	€ 51,40	UFA increase -UFA decrease	Reference thickness= 100mm	In costs estimation as 120mm, therefore costs of 120mm blocks
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=120	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	3,13	m2	3,72	m2	Removed	-0,584	1,2	€ -30,01	€ 51,40	UFA increase -UFA decrease	Reference thickness= 100mm	
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=214	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	8,76	m2	10,39	m2	Removed	-1,632	2,14	€ -115,13	€ 70,55	UFA increase -UFA decrease	Reference thickness= 100mm	Costs combined with other 214mm thicknes Dragende
wanden, massief	Calduran Kalkzandsteen CS12, d=300	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	6,60	m2	7,83	m2	Removed	-1,229	3	€ -101,58	€ 82,64	UFA increase -UFA decrease	Reference thickness= 100mm	
Dragende wanden, massief	Calduran Kalkzandsteen CS20, d=214	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	1,17	m3	1,39	m3	Removed	-0,218	2,14	€ -15,40	€ 70,55	UFA increase -UFA decrease	Reference thickness= 100mm	Costs combined with other 214mm thicknes
Gevels														
Gevels, dicht														
Spouwwanden, buitenblad	Wienerberger Teunisbloem 50mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	0	m2	0	m2	Remov	-	0	€-9,05	€279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm	
	Wienerberger Teunisbloem 100mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	13	m2	15	m2	Remov	-		€-689,23	€279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm	
	Wienerberger Teunisbloem 112mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	0	m2	0	m2	Remov	-	1	€-1,22	€279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm	
	Gevelsteen 100 mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	1	m2	1	m2	Remov	-		€-75,67	€279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm	
Isolatielagen	Isolatie minerale wol, Mupan Ultra XS, d=138	Isover Mupan Ultra XS	#nmd_45415	14	m2	16	m2	Remov	-		€-157,91	€60,11	UFA increase -UFA decrease	Thickness=131 mm	
Gevels, open														
Kozijnen	PVC	Kunststof raamkozijn, vleugeldeel, met VKG keurmerk	#nmd_30559	3	m2		m2	Added	3,		€1.465,28	€457,90	2 windows 1.6 m2 added - none removed	Splitted into frames and glass	
	Beglazing	Isolatieglas, driedubbelglas, ongecoat, Bouwend Nederland Vakgroep GLAS	#nmd_91482	2	m2	5	m2	Remov	-		€-	€-	2 windows 1.6 m2 added - none removed	Triple glass; 80% of the surface area of the frames	
Kozijnen	Kozijnen gezamenlijke ruimtes mahonihout	Deelproduct: Buitenkozijnen, Tropisch loofhout; geschilderd, acryl; duurzame bosbouw	#nmd_30979	2	m2		m2	Added	2,		€1.507,57	€655,46	Door frame		Including Flowcoat, P-A deur de Mors (hout met glas)
Deuren	Flowcoat, P-A deur de Mors (hout met glas)	Deelproduct: Buitendeuren, Onverduurzaamd hout; geschilderd:alkyd; glasopening:0.85m2	#nmd_30459	1	piec		piec	Added	1,		€580,94	€580,94	Entrance door		Only labour and small material costs+ binnendeuren hout
Stelkozijnen	Verduurzaamd hout	Deelproduct: Stelkozijnen, Onverduurzaamd hout; geverfd	#nmd_30902	3	piec		piec	Added	3,		€1.546,56	€515,52	1 entrance door and 2 window frames	door area =	
	Stalen latei h=70	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_91230	4	m		m	Added	4,		€69,09	€14,70	1 entrance door (1.1m) and 2 window frames (1.8m x2)	15 kg/m	
Waterslagen	Betonnen waterslagen	Deelproduct: Waterslagen, Beton	#nmd_30955	3	m		m	Added	3,		€198,33	€61,98	2 window frames 1.6 m	not accessible in model	
Waterkeringen	EPDM; folie [50, 1]	Deelproduct: Waterkeringen, EPDM; folie	#nmd_32284	8	m	9	m	Remov	-		€-	€-	UFA increase -UFA decrease	Not in model	included in waterslagen
Daken														
Daken,plat														
~~Daken~~	~~Van Nieuwpoort BPV 50mm breedplaatvloer~~	~~Van Nieuwpoort Breedplaatvloer Bpv 50 mm~~	~~#nmd_201159~~	~~6,13~~	~~m2~~	~~7,27~~	~~m2~~	~~Removed~~	~~-1,141~~	~~0~~	~~€ -155,20~~	~~€ 136,01~~	~~UFA increase -UFA decrease~~	~~C30/37~~	~~Includes costs for druklaag; cost/m2 combined with othet Breedplaatvloer~~
	~~Druklaag: c30/37: 230mm~~	~~Deelproduct: Vrijdragende Vloeren, Druklaag breedplaatvloer; betonmortel C30/37; incl. wapening~~	~~#nmd_29081~~	~~6,13~~	~~m2~~	~~7,27~~	~~m2~~	~~Removed~~	~~-1,141~~	~~0~~	~~€ -~~	~~€ -~~	~~UFA increase -UFA decrease~~	~~Product not scalable~~	~~included Van Nieuwpoort BPV 50MM breedplaatvloer~~
~~Isolatielagen~~	~~EPS 100~~	~~Deelproduct: Isolatielagen plat dak; EPS~~	~~#nmd_32316~~	~~8,46~~	~~m2~~	~~10,03~~	~~m2~~	~~Removed~~	~~-1,575~~	~~0~~	~~€ -185,53~~	~~€ 117,78~~	~~UFA increase -UFA decrease~~		~~Including the costs of bedekkingen~~
~~Bedekkingen~~	~~APP gemodificeerde gebitumineerde onderlaag, type 490P60 toplaag van APPgemodificeerde gebitumineerde dakbedekking voorzien van een inlage van polyester/glasvlies, type 470K 14~~	~~Plat dakbedekking, Stg. Dak en Milieu, Bitumen gemod. tweelaags 6,6 mm, 8,1 kg per m2, losliggend incl. ballast (system 07, incl. 1x overlagen)~~	~~#nmd_90722~~	~~8,46~~	~~m2~~	~~10,03~~	~~m2~~	~~Removed~~	~~-1,575~~	~~0~~	~~€ -~~	~~€ -~~	~~UFA increase -UFA decrease~~		~~Included in isolatielagen~~
~~Waterkeringen~~	~~Lood slab~~	~~Deelproduct: Waterkeringen, Combinatie PVC/Lood~~	~~#nmd_32386~~	~~3,02~~	~~m~~	~~3,59~~	~~m~~	~~Removed~~	~~-0,563~~	~~0~~	~~€ -111,27~~	~~€ 197,65~~	~~UFA increase -UFA decrease~~	~~Not in~~	~~model~~
Installaties														

Warmtelevering

Warmteopwekkingsinstallati	Lucht water warmtepomp MetroTherm MetroAir L-6	Lucht-water warmtepomp, solo, koudemiddel R410a, Vereniging Warmtepompen (3,4 - 12 kWt)	#nmd_95894		pieces		pieces	Added	0,000	0,9996	€ -	€ 6.529,16	Not included	1 unit per app, wasn't available then in database; scaled with packhunt	

Warmteopwekkingsinstallati	MetroTherm SHK200S binnenunit	Buffervat	#nmd_93832		piec		piec	Added	0,	0,9	€-	€2.771,81	Not included	Scaling, original 315 liter should be 180 liter; scaled using packhunt	
Warmtedistributiesystemen	Polyetheen/polybuteen; cv-leidingen; incl. koppelingen + verdeling	Warmtedistributiesystemen, Polyetheen/polybuteen; cv-leidingen; incl. koppelingen +	#nmd_32893	20	m2	24	m2	Remov	-		€-76,29	€20,08	UFA increase -UFA decrease		
Warmteafgiftesystemen	Vloerverwarming; leidingen:polybuteen+toebehoren	Warmteafgiftesystemen, Vloerverwarming; leidingen:polybuteen+toebehoren	#nmd_32894	20	m2	24	m2	Remov	-		€-150,46	€39,60	UFA increase -UFA decrease		
Elektrische installaties															
Elektriciteitsleidingen	Geisoleerde installatiedraad + mantelbuis:pvc	Deelproduct: Elektricteitsleidingen, Geisoleerde installatiedraad + mantelbuis:pvc	#nmd_32999	20,40	m2	24,20	m2	Removed	-3,800	0	€ -471,39	€ 124,05	UFA increase -UFA decrease		
Elektriciteitsopwekkingsysteme	JAM60S10 340/PR pv panelen + sunbeam NOVA steun	PV paneel – polykristallijn / plat dak	#nmd_93723		piece		piece	Added	0,0	0,90	€-	€780,05	Not included	1,68m2; 330 wp, so scaling from 1,85m2 to 1,68m2	Includes costs for
Elektriciteitsopwekkingsyste	SAJ R5-1,5K-S1 omvormer	Omvormer – 2500 W	#nmd_93729		piec		piec	Added	0,		€-	€-	Not included	1,5 kw	Included in pv panels
Luchtbehandeling															
Luchtbehandelingssytemen	DucoBox Energy Comfort WTW box type 325	Deelproduct: Luchtdistributiesystemen, WTW-unit	#nmd_32915		piec		piec	Added	0,			Not included		should be inserted in m2 gbo	Included in distributiesystem with distributie
Luchtdistributiesystemen	Mechanische aan- en afvoer; verzinkt staal, incl. roosters	Mechanische aan- en afvoer; verzinkt staal, incl. roosters	#nmd_32909	20,40	m2	24,20	m2	Removed	-3,800		€ -438,48	UFA increase -UFA decrease			
Water- en gasdistributie															
Waterleidingen	Polyetheen; leiding+mantelbuis	Deelproduct: Waterleidingen, Polyetheen; leiding+mantelbuis	#nmd_32834	20,40	m2	24,20	m2	Removed	-3,800	0	€ -70,32	€ 18,51	UFA increase -UFA decrease		
Afvoeren															
Buitenrioleringen	Pvc; gerecycled; leiding	Deelproduct: Buitenrioleringen kavel, Pvc; gerecycled; leiding	#nmd_32744	20	m2	24	m2	Remov	-		€-19,27	€5,07	UFA increase -UFA decrease		
Binnenrioleringen	Pvc; gerecycled; leiding	Deelproduct: Binnenrioleringen, Pvc; gerecycled; leiding	#nmd_36236	20	m2	24	m2	Remov	-		€-182,25	€47,96	UFA increase -UFA decrease		
Inbouw															
Binnenwanden															
Niet dragende wanden,	Ytongpan. 10cm G4/600	Massieve wanden, niet dragend, cellenbeton blokken, Xella-Ytong	#nmd_38859	15	m2	18	m2	Remov	-		€-156,30	€54,70	UFA increase -UFA decrease		
Niet dragende wanden,	Ytongpan. 10cm G5/800	Massieve wanden, niet dragend, cellenbeton blokken, Xella-Ytong	#nmd_38859	3	m2	3	m2	Remov	-		€-32,36	€54,70	UFA increase -UFA decrease		
Plinten	Plinten	Deelproduct: Bekledingen, Plint Gegoten Composietsteen	#nmd_28552	18	m	22	m	Remov	-		€-21,11	€6,02	UFA increase -UFA decrease	Not in model	
Afwerklagen	Spuitpleister appartementen	Deelproduct: Afwerklagen, Spuitpleister	#nmd_28558	56	m2	67	m2	Remov	-		€-91,54	€8,69	UFA increase -UFA decrease	Not in model	Costs combined with spuitplaster plafond

Binnenwandopeningen
Trappen en liften
Vaste voorzieningen
Terreinvoorzieningen

Difference **€ 595,62** *Difference excluding additional costs

Extra costs

Floor surface PVC	€	1.095,87	(*PVC Vloer Inclusief Leggen? All-in Prijzen Bij Het Vloeren Magazijn!* , 2024)
Total	**€**	**1.095,87**	

References

PVC Vloer inclusief leggen? All-in prijzen bij Het Vloeren Magazijn! (2024, August 10). Het Vloeren Magazijn. https://hetvloerenmagazijn.nl/all-in-prijs-pvc-vloer/

Gebouwinformatie

Gebruiksfunctie:	Woongebouw	
Levensduur	75 jaar	
Type	Appartement	
Totaal GFA storage	128,65	m2
Totaal UFA storage	117,32	m2
Aantal woningen/eenheden	22	

Shared Bike parking

Increase in storage GFA	0	m2
Percentual increase	0,00%	
Decrease in storage GFA	79,14	m2
Percentual decrease	67,46%	
Impact on GFA	-79,143472	m2

Changed		Environmental Product name	EDN	Added	Unit	Removed	Unit		Corrected amount	Scaling	Construction costs	Construction costs/unit	Explaination	Comment MPG	Cost explaination
Fundering															
Bodemvoorzieningen															
Fundering															
Vloeren															
Vloeren, begane grond															
Vloeren, verdieping															
Vloeren, balkon- en galerij															
Draagconstructie															
Hoofddraagconstructie															
Dragende wanden, niet	Vuren framewerk voor buiten en binnen wanden	Houtskeletbouw frame voor dragende en niet-dragende binnenwand. Representatief voor leden van de NBvT	#nmd_92900	75	m2	290	m2	Remo	-		€-	€-	Only externall walls added, all other walls removed	Thickness=70 mm	Costs combined in bergingen
Gevels															
Gevels, dicht															
Bekledingen	Vuren geimpregneerde rabatdelen 19x130mm	Deelproduct: Bekledingen, Europees naaldhouten delen, wax impregnatie; duurzame bosbouw	#nmd_31985	75	m2	93	m2	Remo	-		€-	€-	Recalculated l=11m; w = 4,2m		Included in Spaanplaat 18mm met vuren balklaag
Gevels, open															
Kozijnen	Kozijnen bergingen vuren met aflaklaag	Deelproduct: Buitenkozijnen, Europees naaldhout; geschilderd, acryl; duurzame bosbouw	#nmd_30512	4	m2	48	m2	Remo	-		€-	€-	2 doors added with a surface area of 2.205m2, existing doors removed		
	Deuren Bergingen	HOUT100% kozijn met deur, kleiner dan 3,6 m2, inclusief NBVT massief houten buitendeur tot 3,6m2, inclusief aflak en onderhoud	#nmd_92815	4	m2	48	m2	Remo	-		€-	€-	2 doors added with a surface area of 2.2m2, existing doors removed		Included in Spaanplaat 18mm met vuren balklaag
Daken															
Daken,plat															
Daken	Houtskelet (balken) voor dak vuren + multiplex dakplaat	Deelproduct: Platte daken, Europees naaldhouten balken met europees naaldhouten multiplex;	#nmd_29276	0	m2	84	m2	Remo	-		€ -	€454,39	GFA increase -GFA decrease		Includes all the costs for the bergingen
	APPgemodificeerde gebitumineerde dakbedekking voorzien van een inlage van polyester/glasvlies, type 470K 14	Plat dakbedekking, Stg. Dak en Milieu, Bitumen gemod. eenlaags 4,3 mm, 5,3 kg per m2, volledig gekleefd brandmethode (system 01, incl. 1x overlagen)	#nmd_90716	0	m2	84	m2	Remo	-		€-	€-	GFA increase -GFA decrease		costs included in houtskelet
Installaties															
Warmtelevering															
Elektrische installaties															
Luchtbehandeling															
Water- en gasdistributie															
Afvoeren															
Inbouw															
Binnenwanden															
Niet dragende wanden, niet	Scheidingswanden bergingen Spaanplaat	Deelproduct: Bekledingen systeemwanden niet dragend, Spaanplaat	#nmd_28447	0	m2	78	m2	Remo	-		€-	€-	Not Influenced		
Binnenwandopeningen															
Trappen en liften															
Vaste voorzieningen															
Terreinvoorzieningen															
Verhardingen	Straatstenen tpv bergingen en terrassen begane grond	Betonstraatsteen (210x105x80mm) door en door grijs	#nmd_37007	79	m2		m2	Added	79,		€-	€-	To correct for the flooring in the storage areas	Not data availble	
											€	**-38.409,16**			
											Difference		*Difference excluding additional costs		

Extra		**costs**
N.a.	€	-
Total	**€**	**-**

Gebouwinformatie

Gebruiksfunctie:	Woongebouw	
Levensduur	75 jaar	
Type	Appartement	
Totaal GFA	1692,54	m2
Totaal UFA	1214,94	m2
Aantal woningen/eenheden	22	

Shared laundry room

Increase in Building UFA	12,24	m2
Percentual increase	1,01%	
Decrease in Building UFA	23,76	m2
Percentual decrease	1,96%	
Change in UFA	-11,52	m2

Changed		Environmental Product name	EDN	Added	Unit	Removed	Unit		Corrected		Construction	Construction costs/unit	Explaination	Comment MPG	Cost explaination
Fundering															
Bodemvoorzieningen															
Grondaanvullingen	Zand	Deelproduct: Grondaanvullingen, Zand	#nmd_27309	0,60	m3	1,17	m3	Removed	-0,569	0	€ -112,41	€ 197,58	UFA increase -UFA decrease		Costs for Grondwerk
Fundering															
Funderingsbalken	funderingsbalk ihwg, 450x600	Fundatiebalken, Betonhuis; beton,in het werk gestort, C30/37,CEMIII; incl.wapening+eps	#nmd_273	0	m	1	m	Remo	-	1	€-139,96	€248,38	UFA increase -UFA decrease	Including EPS C20/25; c3037 assumed of	
	funderingsbalk ihwg, 600x600	Fundatiebalken, Betonhuis; beton,in het werk gestort, C30/37,CEMIII; incl.wapening+eps	#nmd_27370	1,	m	2,	m	Remove	-	1	€-263,22	€248,38	UFA increase -UFA decrease	Including EPS C20/25; c3037 assumed of	
	funderingsbalk ihwg, 650x600	Fundatiebalken, Betonhuis; beton,in het werk gestort, C30/37,CEMIII; incl.wapening+eps	#nmd_273	0	m	0	m	Remo	-	1	€-82,47	€248,38	UFA increase -UFA decrease	Including EPS C20/25; c3037 assumed of	
Funderingspalen	funderingpalen_mortelschroefpaal_rond:schro	Funderingspalen, Betonhuis; schroefpaal; beton,in het werk gestort, C20/25,CEMIII; incl.wapenin	#nmd_27309	10,03	m	19,46	m	Removed	-9,436	0	€ -419,58	€ 44,46	UFA increase -UFA decrease	C30/37 not available in NMD	
Vloeren															
Vloeren, begane grond															
Vloeren vrijdragend	VBI isolatieplaatvloer 200; rc 5	VBI Isolatieplaatvloer 200 Groen	#nmd_27309	4,78	m2	9,27	m2	Removed	-4,496	1,0483	€ -468,51	€ 104,21	UFA increase -UFA decrease	Scaled in database: eps 3.7 m2/k -> 5m2/k; MKI eps = €0,49; MKI floor 200 = €2.86	
Dekvloeren	zwevende cementdekvloer, d=90	Deelproduct: Dekvloeren, Zandcement	#nmd_273	4	m2	8	m2	Remo	-		€-66,52	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other thickness
Dekvloeren	verende cementdekvloer, d=62	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0,	m2	0,	m2	Remove	-	0	€-0,97	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other
Dekvloeren	Cementdekvloer d=80	Deelproduct: Dekvloeren, Zandcement	#nmd_289	0	m2	0	m2	Remo	-		€-3,49	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other thickness
Vloeren, verdieping															
Vloeren vrijdragend	Van Nieuwpoort BPV 50mm breedplaatvloer	Van Nieuwpoort Breedplaatvloer Bpv 50 mm	#nmd_201	9	m2	18	m2	Remo	-		€-	€136,01	UFA increase -UFA decrease	C30/37	Includes costs for druklaag; cost/m2 combined with othet Breedplaatvloer
	Druklaag: c30/37; 230mm	Deelproduct: Vrijdragende Vloeren, Betonhuis; druklaag breedplaatvloer; betonmortel C30/37,CE	#nmd_29055	9,	m2	18,	m2	Remove	-	0	€-	€-	UFA increase -UFA decrease	Product not scalable	Included in vloeren,
Dekvloeren	zwevende cementdekvloer, d=90	Deelproduct: Dekvloeren, Zandcement	#nmd_289	7	m2	15	m2	Remo	-		€-115,44	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other thickness
Dekvloeren	verende cementdekvloer, d=62	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0,	m2	0,	m2	Remove	-	0	€-1,70	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other
Dekvloeren	Cementdekvloer d=80	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0,	m2	0,	m2	Remove	-	0	€-5,40	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other
Afwerklagen, plafond	Spuitpleister	Deelproduct: Afwerklagen, Spuitpleister	#nmd_285	12	m2	23	m2	Remo	-		€-100,16	€8,69	UFA shared laundry room added -UFA decrease (1.08 m2 per app)		Costs combined with spuitplaster wanden
Vloeren, balkon- en galerij															
Vloeren vrijdragend	buiten_prefab_galerij, d=300	Balkon-/galerijvloer, beton, prefab, 250 mm, Betonhuis	#nmd_10812	1,	m2	2,	m2	Removed	-1,2	1	€-652,17	€527,66	UFA increase -UFA decrease	C30/37; no other product available so therefore this option	Gallerij + Balkon combined into one cost since same product in NMD
Ballustrades	balustrade, h=1000; staal; spijlen	Balustrades, Staal; gepoedercoat; spijlen	#nmd_318	1	m	2	m	Remo	-		€-593,66	€448,65	UFA increase -UFA decrease		
Draagconstructie															
Hoofddraagconstructie															
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=100	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	0,97	m2	1,88	m2	Removed	-0,911	0	€ -46,84	€ 51,40	UFA increase -UFA decrease	Reference thickness= 100mm	In costs estimation as 120mm, therefore costs of 120mm blocks
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=120	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	1,88	m2	3,65	m2	Removed	-1,770	1,2	€ -90,96	€ 51,40	UFA increase -UFA decrease	Reference thickness= 100mm	
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=214	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	5,26	m2	10,20	m2	Removed	-4,947	2,14	€ -349,01	€ 70,55	UFA increase -UFA decrease	Reference thickness= 100mm	Costs combined with other 214mm thicknes Dragende
wanden, massief	Calduran Kalkzandsteen CS12, d=300	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	3,96	m2	7,69	m2	Removed	-3,720	3	€ -307,96	€ 82,04	UFA increase -UFA decrease	Reference thickness= 100mm	
Dragende wanden, massief	Calduran Kalkzandsteen CS20, d=214	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	0,70	m3	1,36	m3	Removed	-0,662	2,14	€ -46,68	€ 70,55	UFA increase -UFA decrease	Reference thickness= 100mm	Costs combined with other 214mm thicknes
Gevels															
Gevels, dicht															
Spouwwanden, buitenblad	Wienerberger Teunisbloem 50mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_108	0	m2	0	m2	Remo	-	0	€-27,44	€279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm	
	Wienerberger Teunisbloem 100mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_108	7	m2	15	m2	Remo	-		€-	€279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm	
	Wienerberger Teunisbloem 112mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_108	0	m2	0	m2	Remo	-	1	€-3,71	€279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm	
	Gevelsteen 100 mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_108	0	m2	1	m2	Remo	-		€-229,41	€279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm	
Isolatielagen	Isolatie minerale wol, Mupan Ultra XS, d=138	Isover Mupan Ultra XS	#nmd_454	8	m2	16	m2	Remo	-		€-478,73	€60,11	UFA increase -UFA decrease	Thickness=131 mm	
Gevels, open															
Kozijnen	PVC	Kunststof raamkozijn, vleugeldeel, met VKG keurmerk	#nmd_305	1	m2		m2	Added	1,		€732,64	€457,90	1 window 1.6 m2 added - none removed	Splitted into frames and glass	
	Beglazing	Isolatieglas, driedubbelglas, ongecoat, Bouwend Nederland Vakgroep GLAS	#nmd_914	1	m2		m2	Added	1,		€-	€-	1 window 1.6 m2 added - none removed	Triple glass; 80% of the surface area of the frames	
Kozijnen	Kozijnen gezamenlijke ruimtes mahonihout	Deelproduct: Buitenkozijnen, Tropisch loofhout; geschilderd, acryl; duurzame bosbouw	#nmd_309	2	m2		m2	Added	2,		€1.507,57	€655,46	Door frame		Including Flowcoat, P-A deur de Mors (hout met glas)
Deuren	Flowcoat, P-A deur de Mors (hout met glas)	Deelproduct: Buitendeuren, Onverduurzaamd hout; geschilderd:alkyd; glasopening:0.85m2	#nmd_304	1	piec		piec	Added	1,		€580,94	€580,94	Entrance door		Only labour and small material costs+ binnendeuren hout
Stelkozijnen	Verduurzaamd hout	Deelproduct: Stelkozijnen, Onverduurzaamd hout; geverfd	#nmd_309	2	piec		piec	Added	2,		€1.031,04	€515,52	1 entrance door and 1 window frame	door area =	
	Stalen latei h=70	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_912	2	m		m	Added	2,		€639,49	€14,70	1 entrance door (1.1m) and 1 window frames (1.8m)	15 kg/m	
Waterslagen	Betonnen waterslagen	Deelproduct: Waterslagen, Beton	#nmd_309	1	m		m	Added	1,		€99,16	€61,98	1 window frame 1.6 m	not accessible in model	
Waterkeringen	EPDM; folie [50, 1]	Deelproduct: Waterkeringen, EPDM; folie	#nmd_322	5	m	9	m	Remo	-		€-	€-	UFA increase -UFA decrease	Not in model	included in waterslagen
Daken															
Daken,plat															
Daken	Van Nieuwpoort BPV 50mm breedplaatvloer	Van Nieuwpoort Breedplaatvloer Bpv 50 mm	#nmd_201	3	m2	7	m2	Remo	-		€-470,52	€136,01	UFA increase -UFA decrease	C30/37	Includes costs for druklaag; cost/m2 combined with othet Breedplaatvloer
	Druklaag: c30/37; 200mm	Deelproduct: Vrijdragende Vloeren, Druklaag breedplaatvloer; betonmortel C30/37; incl. wapenin	#nmd_29061	3,68	m2	7,14	m2	Removed	-3,459	0	€ -	€ -	UFA increase -UFA decrease	Product not scalable	included Van Nieuwpoort BPV 50MM breedplaatvloer
Isolatielagen	EPS 100	Deelproduct: Isolatielagen plat dak, EPS	#nmd_32316	5,07	m2	9,85	m2	Removed	-4,775	0	€ -562,44	€ 117,78	UFA increase -UFA decrease		Including the costs of bedekkingen
Bedekkingen	APP gemodificeerde gebitumineerde onderlaag, ty	Plat dakbedekking, Stg. Dak en Milieu, Bitumen gemod. tweelaags 6,6 mm, 8,1 kg per m2, losligge	#nmd_90722	5,07	m2	9,85	m2	Removed	-4,775	0	€ -	€ -	UFA increase -UFA decrease		Included in isolatielagen
Waterkeringen	Lood slab	Deelproduct: Waterkeringen, Combinatie PVC/Lood	#nmd_32386	1,81	m	3,52	m	Removed	-1,707	0	€ -337,33	€ 197,65	UFA increase -UFA decrease	Not in model	
Installaties															
Warmtelevering															
Warmteopwekkingsinstallaties	Lucht water warmtepomp MetroTherm MetroAir L-6	Lucht-water warmtepomp, solo, koudemiddel R410a, Vereniging Warmtepompen (3,4 - 12 kW)	#nmd_95894		pieces		pieces	Added	0,000	0,9996	€ -	€ 6.529,16	Not included	1 unit per app, wasn't available then in database;	
Warmteopwekkingsinstallaties	MetroTherm SHK200S binnenunit	Buffervat	#nmd_93832		pieces		pieces	Added	0,000	0,9589	€ -	€ 2.771,81	Not included	Scaling, original 315 liter should be 180 liter; scaled using packhunt	
Warmtedistributiesystemen	Polyetheen/polybuteen; cv-leidingen; incl. koppelingen + verdeling	Warmtedistributiesystemen, Polyetheen/polybuteen; cv-leidingen; incl. koppelingen + verdeling	#nmd_32893	12,24	m2	23,76	m2	Removed	-11,520	0	€ -231,28	€ 20,08	UFA increase -UFA decrease		

Warmteafgiftesystemen	Vloerverwarming; leidingen:polybuteen+toebehoreWarmteafgiftesystemen, Vloerverwarming; leidingen:polybuteen+toebehoren	#nmd_32894	12,24 m2	23,76 m2	Removed	-11,520	0 €	-456,14 €	39,60	UFA increase -UFA decrease		
Elektrische installaties												

Elektriciteitsleidingen	Geisoleerde installatiedraad + mantelbuis;pvc	Deelproduct: Elektriciteitsleidingen, Geisoleerde installatiedraad + mantelbuis;pvc	#nmd_32999	12,24	m2	23,76	m2	Removed	-11,520	0	€ -1.429,07	€ 124,05	UFA increase -UFA decrease			
Elektriciteitsopwekkingssysteme,1	AM60S10.340/PR pv panelen + sunbeam NOVA st	PV paneel – polykristallijn / plat dak	#nmd_937		piec		piec	Added	0,	0,9	€-	€780,05	Not included		1,68m2; 330 wp, so scaling from 1,85m2 to 1,68m2	Includes costs for omvormer
Elektriciteitsopwekkingsyste	SAJ R5-1,5K-S1 omvormer	Omvormer – 2500 W	#nmd_937		piec		piec	Added	0,		€-	€-	Not included		1,5 kw	Included in pv panels
Luchtbehandeling																
Luchtbehandelingssytemen	DucoBox Energy Comfort WTW box type 325	Deelproduct: Luchtdistributiesystemen, WTW-unit	#nmd_329		piec		piec	Added	0,			€ 115,39	Not included		should be inserted in m2 gbo	Included in distributiesystem with distributie
Luchtdistributiesystemen	Mechanische aan- en afvoer; verzinkt staal, incl.	Mechanische aan- en afvoer; verzinkt staal, incl. roosters	#nmd_32909	12,24	m2	23,76	m2	Removed	-11,520		€ -1.329,29		UFA increase -UFA decrease			
Water- en gasdistributie																
Waterleidingen	Polyetheen; leiding+mantelbuis	Deelproduct: Waterleidingen, Polyetheen; leiding+mantelbuis	#nmd_32834	12,24	m2	23,76	m2	Removed	-11,520	0	€ -213,18	€ 18,51	UFA increase -UFA decrease			
Afvoeren																
Buitenrioleringen	Pvc; gerecycled; leiding	Deelproduct: Buitenrioleringen kavel, Pvc; gerecycled; leiding	#nmd_327	12	m2	23	m2	Remo	-		€-58,40	€5,07	UFA increase -UFA decrease			
Binnenrioleringen	Pvc; gerecycled; leiding	Deelproduct: Binnenrioleringen, Pvc; gerecycled; leiding	#nmd_362	12	m2	23	m2	Remo	-		€-552,51	€47,96	UFA increase -UFA decrease			
Inbouw																
Binnenwanden																
Niet dragende wanden,	Ytongpan. 10cm G4/600	Massieve wanden, niet dragend, cellenbeton blokken, Xella-Ytong	#nmd_388	9	m2	17	m2	Remo	-		€-473,83	€54,70	UFA increase -UFA decrease			
Niet dragende wanden,	Ytongpan. 10cm G5/800	Massieve wanden, niet dragend, cellenbeton blokken, Xella-Ytong	#nmd_388	1	m2	3	m2	Remo	-		€-98,11	€54,70	UFA increase -UFA decrease			
Plinten	Plinten	Deelproduct: Bekledingen, Plint Gegoten Composietsteen	#nmd_285	11	m	21	m	Remo	-		€-64,01	€6,02	UFA increase -UFA decrease		Not in model	
Afwerklagen	Spuitpleister appartementen	Deelproduct: Afwerklagen, Spuitpleister	#nmd_285	33	m2	65	m2	Remo	-		€-277,51	€8,69	UFA increase -UFA decrease		Not in model	Costs combined with spuitplaster plafond
Binnenwandopeningen																
Trappen en liften																
Vaste voorzieningen																
Aanrechtbladen		Deelproduct: Aanrechtbladen, Kunstharsgebonden; massief	#nmd_330	3	m	0	m	Added	3,		€-	€-	The counter on top of the laundry machines			~~Https://www.keukenervaringen.nl/wat-kost-een-aanrechtblad-de-kosten-op-een-rij/~~
Terreinvoorzieningen																

Difference € -9.876,31 *Difference excluding additional costs

Extra costs

Floor surface PVC	€	657,52	(*PVC Vloer Inclusief Leggen? All-in Prijzen Bij Het Vloeren Magazijn!* , 2024)
Total	**€**	**657,52**	

References

PVC Vloer inclusief leggen? All-in prijzen bij Het Vloeren Magazijn! (2024, August 10). Het Vloeren Magazijn. https://hetvloerenmagazijn.nl/all-in-prijs-pvc-vloer/

Gebouwinformatie

Gebruiksfunctie:	Woongebouw	
Levensduur	75 jaar	
Type	Appartement	
Totaal GFA	1692,54	m2
Totaal UFA	1214,94	m2
Aantal woningen/eenheden	22	

Shared Workspace

Increase in Building UFA	41,6	m2
Percentual increase	3,42%	
Decrease in Building UFA	110	m2
Percentual decrease	9,05%	
Change in UFA	-68,4	m2

Changed	Environmental Product name	EDN	Added	Unit	Removed	Unit		Corrected		Construction	Construction costs/unit	Explaination	Comment MPG	Cost explaination
Fundering														
Bodemvoorzieningen														
Grondaanvullingen	Zand	Deelproduct: Grondaanvullingen, Zand	#nmd_27309	2,05	m3	5,43	m3	Removed	-3,378	0	€ -667,41	€ 197,58	UFA increase -UFA decrease		Costs for Grondwerk
Fundering														
Funderingsbalken	funderingsbalk ihwg, 450x600	Fundatiebalken, Betonhuis; beton,in het werk gestort, C30/37,CEMIII; incl.wapening+eps	#nmd_27370	2	m	5	m	Remo	-	1	€-830,99	€248,38	UFA increase -UFA decrease	Including EPS C20/25; c3037 assumed of	
	funderingsbalk ihwg, 600x600	Fundatiebalken, Betonhuis; beton,in het werk gestort, C30/37,CEMIII; incl.wapening+eps	#nmd_27370	3,	m	10,	m	Remove	-	1	€-1.562,86	€248,38	UFA increase -UFA decrease	Including EPS C20/25; c3037 assumed of	
	funderingsbalk ihwg, 650x600	Fundatiebalken, Betonhuis; beton,in het werk gestort, C30/37,CEMIII; incl.wapening+eps	#nmd_27370	1,	m	3,	m	Remove	-	1,	€-489,69	€248,38	UFA increase -UFA decrease	Including EPS C20/25; c3037 assumed of	
Funderingspalen	funderingpalen_mortelschroefpaal_rond:schroefpaal_rond_400	Funderingspalen, Betonhuis; schroefpaal; beton,in het werk gestort, C20/25,CEMIII; incl.wapening	#nmd_27309	34,08	m	90,10	m	Removed	-56,028	0	€ -2.491,26	€ 44,46	UFA increase -UFA decrease	C30/37 not available in NMD	
Vloeren														
Vloeren, begane grond														
Vloeren vrijdragend	VBI isolatieplaatvloer 200; rc 5	VBI Isolatieplaatvloer 200 Groen	#nmd_27309	16,24	m2	42,93	m2	Removed	-26,695	1,0483	€ -2.781,77	€ 104,21	UFA increase -UFA decrease	Scaled in database: eps 3.7 m2/k -> 5m2/k; MKI eps = €0,49; MKI floor 200 = €2.86	
Dekvloeren	zwevende cementdekvloer, d=90	Deelproduct: Dekvloeren, Zandcement	#nmd_27309	15	m2	40	m2	Remo	-		€-394,96	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other thickness
Dekvloeren	verende cementdekvloer, d=62	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0,	m2	0,	m2	Remove	-	0	€-5,77	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other
Dekvloeren	Cementdekvloer d=80	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0	m2	2	m2	Remo	-		€-20,73	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other thickness
Vloeren, verdieping														
Vloeren vrijdragend	Van Nieuwpoort BPV 50mm breedplaatvloer	Van Nieuwpoort Breedplaatvloer Bpv 50 mm	#nmd_20115	32	m2	85	m2	Remo	-		€-7.229,81	€136,01	UFA increase -UFA decrease	C30/37	Includes costs for druklaag; cost/m2 combined with othet Breedplaatvloer
	Druklaag; c30/37; 230mm	Deelproduct: Vrijdragende Vloeren, Betonhuis; druklaag breedplaatvloer; betonmortel C30/37,CEMIII; incl. wapening	#nmd_29055	32,	m2	85,	m2	Remove	-	0	€-	€-	UFA increase -UFA decrease	Product not scalable	Included in vloeren,
Dekvloeren	zwevende cementdekvloer, d=90	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	26,	m2	70,	m2	Remove	-	0	€-685,41	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other
Dekvloeren	verende cementdekvloer, d=62	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	0,	m2	1,	m2	Remove	-	0	€-10,09	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other
Dekvloeren	Cementdekvloer d=80	Deelproduct: Dekvloeren, Zandcement	#nmd_28904	1,	m2	3,	m2	Remove	-	0	€-32,08	€15,64	UFA increase -UFA decrease	Product not scalable	Same costs as cementdekvloer with other
Afwerklagen, plafond	Spuitpleister	Deelproduct: Afwerklagen, Spuitpleister	#nmd_28558	41	m2	110	m2	Remo	-		€-594,73	€8,69	UFA shared laundry room added -UFA decrease (1.08 m2 per app)		Costs combined with spuitplaster wanden
Vloeren, balkon- en galerij														
Vloeren vrijdragend	buiten_prefab_galerij, d=300	Balkon-/galerijvloer, beton, prefab, 250 mm, Betonhuis	#nmd_10812	4 ,	m2	11 ,8	m2	Removed	- 7,3	1 ,	€-3.872,27	€527,66	UFA increase -UFA decrease	C30/37; no other product available so therefore this option	Gallerij + Balkon combined into one cost since same product in NMD
Ballustrades	balustrade, h=1000; staal; spijlen	Balustrades, Staal; gepoedercoat; spijlen	#nmd_31897	4	m	12	m	Remo	-		€-3.524,87	€448,65	UFA increase -UFA decrease		
Draagconstructie														
Hoofddraagconstructie														
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=100	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	3,29	m2	8,70	m2	Removed	-5,410	0	€ -278,09	€ 51,40	UFA increase -UFA decrease	Reference thickness= 100mm	In costs estimation as 120mm, therefore costs of 120mm blocks
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=120	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	6,39	m2	16,90	m2	Removed	-10,508	1,2	€ -540,10	€ 51,40	UFA increase -UFA decrease	Reference thickness= 100mm	
Dragende wanden, massief	Calduran Kalkzandsteen CS12, d=214	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	17,86	m2	47,24	m2	Removed	-29,374	2,14	€ -2.072,25	€ 70,55	UFA increase -UFA decrease	Reference thickness= 100mm	Costs combined with other 214mm thicknes Dragende
wanden, massief	Calduran Kalkzandsteen CS12, d=300	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	13,46	m2	35,58	m2	Removed	-22,125	3	€ -1.828,49	€ 82,64	UFA increase -UFA decrease	Reference thickness= 100mm	
Dragende wanden, massief	Calduran Kalkzandsteen CS20, d=214	Binnenwanden, constructief: Calduran kalkzandsteen elementen CS12 of CS20	#nmd_92787	2,39	m3	6,32	m3	Removed	-3,929	2,14	€ -277,15	€ 70,55	UFA increase -UFA decrease	Reference thickness= 100mm	Costs combined with other 214mm thicknes
Gevels														
Gevels, dicht														
Spouwwanden, buitenblad	Wienerberger Teunisbloem 50mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	0	m2	0	m2	Remo	-	0	€-162,95	€279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm	
	Wienerberger Teunisbloem 100mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	27	m2	71	m2	Remo	-		€-12.406,21	€279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm	
	Wienerberger Teunisbloem 112mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	0	m2	0	m2	Remo	-	1	€-22,02	€279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm	
	Gevelsteen 100 mm	Baksteenmetselwerk buitenwanden constructief KNB	#nmd_10881	2	m2	7	m2	Remo	-		€-1.362,14	€279,39	UFA increase -UFA decrease	Assumed the thickness = 100mm	
Isolatielagen	Isolatie minerale wol, Mupan Ultra XS, d=138	Isover Mupan Ultra XS	#nmd_45415	28	m2	76	m2	Remo	-		€-2.842,45	€60,11	UFA increase -UFA decrease	Thickness=131 mm	
Gevels, open														
Kozijnen	PVC	Kunststof raamkozijn, vleugeldeel, met VKG keurmerk	#nmd_30559	4	m2	34	m2	Remo	-		€-13.769,26	€457,90	3 windows 1.6 m2 added - none removed	Splitted into frames and glass	
	Beglazing	Isolatieglas, driedubbelglas, ongecoat, Bouwend Nederland Vakgroep GLAS	#nmd_91482	3	m2	27	m2	Remo	-		€-	€-	1 windows 1.6 m2 added - none removed	Triple glass; 80% of the surface area of the frames	
Kozijnen	Kozijnen gezamenlijke ruimtes mahonihout	Deelproduct: Buitenkozijnen, Tropisch loofhout; geschilderd, acryl; duurzame bosbouw	#nmd_30979	2,	m2		m2	Added	2,3	0	€1.507,57	€655,46	Door frame		Including Flowcoat, P-A deur de Mors (hout met
Deuren	Flowcoat, P-A deur de Mors (hout met glas)	Deelproduct: Buitendeuren, Onverduurzaamd hout; geschilderd:alkyd; glasopening:0.85m2	#nmd_30459	1	piec		piec	Added	1,		€580,94	€580,94	Entrance door		Only labour and small material costs+ binnendeuren hout
Stelkozijnen	Verduurzaamd hout	Deelproduct: Stelkozijnen, Onverduurzaamd hout; geverfd	#nmd_30902	4,00	pieces	22,00	pieces	Removed	-18,000	0	€ -9.279,39	€ 515,52	1 entrance door and 3 window frame; removed 22 windows	door area =	
	Staven latei h=70	Zwaar constructiestaal GWW (7820 kg/m3, incl. conservering)	#nmd_91230	6,50	m	26,40	m	Removed	-19,900	0	€ -292,55	€ 14,70	1 entrance door (1.1m) and 3 window frames (1.8m); 1.2m	15 kg/m	
Waterslagen	Betonnen waterslagen	Deelproduct: Waterslagen, Beton	#nmd_30955	4	m	22	m	Remo	-		€-1.066,01	€61,98	3 window frames 1.6 m; 1m removed all app	not accessible in model	
Waterkeringen	EPDM; folie [50, 1]	Deelproduct: Waterkeringen, EPDM; folie	#nmd_32284	17	m	45	m	Remo	-		€-	€-	UFA increase -UFA decrease	Not in model	included in waterslagen
Daken														
Daken,plat														
~~Daken~~	~~Van Nieuwpoort BPV 50mm breedplaatvloer~~	~~Van Nieuwpoort Breedplaatvloer Bpv 50 mm~~	~~#nmd_201159~~	~~12,49~~	~~m2~~	~~33,03~~	~~m2~~	~~Removed~~	~~-20,541~~	~~0~~	~~€ -2.793,68~~	~~€ 136,01~~	~~UFA increase -UFA decrease~~	~~C30/37~~	~~Includes costs for druklaag; cost/m2 combined with othet Breedplaatvloer~~
	~~Druklaag; c30/37; 200mm~~	~~Deelproduct: Vrijdragende Vloeren, Druklaag breedplaatvloer; betonmortel C30/37; incl. wapening~~	~~#nmd_29081~~	~~12,49~~	~~m2~~	~~33,03~~	~~m2~~	~~Removed~~	~~-20,541~~	~~0~~	~~€ -~~	~~€ -~~	~~UFA increase -UFA decrease~~	~~Product not scalable~~	~~included Van Nieuwpoort BPV 50MM breedplaatvloer~~
Isolatielagen	EPS 100	Deelproduct: Isolatielagen plat dak, EPS	#nmd_32316	17,24	m2	45,60	m2	Removed	-28,354	0	€ -3.339,48	€ 117,78	UFA increase -UFA decrease		Including the costs of bedekkingen
Bedekkingen	APP gemodificeerde gebitumineerde onderlaag, type 490P60 toplaag van APPgemodificeerde gebitumineerde dakbedekking voorzien van een inlage van polyester/glasvlies, type 470K 14	Plat dakbedekking, Stg. Dak en Milieu, Bitumen gemod. tweelaags 6,6 mm, 8,1 kg per m2, losliggend incl. ballast (system 07, incl. 1x overlagen)	#nmd_90722	17,24	m2	45,60	m2	Removed	-28,354	0	€ -	€ -	UFA increase -UFA decrease		Included in isolatielagen
Waterkeringen	Lood slab	Deelproduct: Waterkeringen, Combinatie PVC/Lood	#nmd_32386	6,16	m	16,30	m	Removed	-10,134	0	€ -2.002,92	€ 197,65	UFA increase -UFA decrease	Not in	model
Installaties														

Warmtelevering

Warmteopwekkingsinstallati	Lucht water warmtepomp MetroTherm MetroAir L-6	Lucht-water warmtepomp, solo, koudemiddel R410a, Vereniging Warmtepompen (3,4 - 12 kWt)	#nmd_95894		pieces		pieces	Added		0,9996	€ -	€ 6.529,16	Not included	1 unit per app, wasn't available then in database; scaled with packhunt	

Warmteopwekkingsinstallati	MetroTherm SHK200S binnenunit	Buffervat	#nmd_93832		piec		piec	Added		0,9	€-	€2.771,81	Not included	Scaling, original 315 liter should be 180 liter; scaled using packhunt	
Warmtedistributiesystemen	Polyetheen/polybuteen; cv-leidingen; incl. koppelingen + verdeling	Warmtedistributiesystemen, Polyetheen/polybuteen; cv-leidingen; incl. koppelingen +	#nmd_32893	41	m2	110	m2	Remo	-		€-1.373,24	€20,08	UFA increase -UFA decrease		
Warmteafgiftesystemen	Vloerverwarming; leidingen:polybuteen+toebehoren	Warmteafgiftesystemen, Vloerverwarming; leidingen:polybuteen+toebehoren	#nmd_32894	41	m2	110	m2	Remo	-		€-2.708,34	€39,60	UFA increase -UFA decrease		
Elektrische installaties															
Elektriciteitsleidingen	Geisoleerde installatiedraad + mantelbuis:pvc	Deelproduct: Elektricteitsleidingen, Geisoleerde installatiedraad + mantelbuis:pvc	#nmd_32999	41	m2	110	m2	Remo	-		€-8.485,09	€124,05	UFA increase -UFA decrease		
Elektriciteitsopwekkingsyste	JAM60S10 340/PR pv panelen + sunbeam NOVA steun	PV paneel – polykristallijn / plat dak	#nmd_93723		pieces		pieces	Added	0,000	0,9081	€ -	€ 780,05	Not included	1,68m2; 330 wp, so scaling from 1,85m2 to 1,68m2	Includes costs for omvormer
Luchtbehandeling															
Luchtbehandelingssytemen	DucoBox Energy Comfort WTW box type 325	Deelproduct: Luchtdistributiesystemen, WTW-unit	#nmd_32915		piec		piec	Added	0,		Not included			should be inserted in m2 gbo	Included in distributiesystem with distributie
Luchtdistributiesystemen	Mechanische aan- en afvoer; verzinkt staal, incl. roosters	Mechanische aan- en afvoer; verzinkt staal, incl. roosters	#nmd_32909	41,60	m2	110,00	m2	Removed	-68,400		€ -7.892,69		UFA increase -UFA decrease		
Water- en gasdistributie															
Waterleidingen	Polyetheen; leiding+mantelbuis	Deelproduct: Waterleidingen, Polyetheen; leiding+mantelbuis	#nmd_32834	41,60	m2	110,00	m2	Removed	-68,400	0	€ -1.265,74	€ 18,51	UFA increase -UFA decrease		
Afvoeren															
Buitenrioleringen	Pvc; gerecycled; leiding	Deelproduct: Buitenrioleringen kavel, Pvc; gerecycled; leiding	#nmd_32744	41	m2	110	m2	Remo	-		€-346,78	€5,07	UFA increase -UFA decrease		
Binnenrioleringen	Pvc; gerecycled; leiding	Deelproduct: Binnenrioleringen, Pvc; gerecycled; leiding	#nmd_36236	41	m2	110	m2	Remo	-		€-3.280,53	€47,96	UFA increase -UFA decrease		
Inbouw															
Binnenwanden															
Niet dragende wanden,	Ytongpan. 10cm G4/600	Massieve wanden, niet dragend, cellenbeton blokken, Xella-Ytong	#nmd_38859	31	m2	82	m2	Remo	-		€-2.813,36	€54,70	UFA increase -UFA decrease		
Niet dragende wanden,	Ytongpan. 10cm G5/800	Massieve wanden, niet dragend, cellenbeton blokken, Xella-Ytong	#nmd_38859	6	m2	17	m2	Remo	-		€-582,55	€54,70	UFA increase -UFA decrease		
Plinten	Plinten	Deelproduct: Bekledingen, Plint Gegoten Composietsteen	#nmd_28552	38	m	101	m	Remo	-		€-380,04	€6,02	UFA increase -UFA decrease	Not in model	
Afwerklagen	Spuitpleister appartementen	Deelproduct: Afwerklagen, Spuitpleister	#nmd_28558	115	m2	304	m2	Remo	-		€-1.647,70	€8,69	UFA increase -UFA decrease	Not in model	Costs combined with spuitplaster plafond
Binnenwandopeningen															
Binnenkozijnen	Montage kozijn Reinaerdt 930x2315 plaatstaal	Deelproduct: Binnenkozijnen, Staal; verzinkt+gemoffeld	#nmd_31609	0	m2	47	m2	Remo	-		€-	€-	Removed indoor doorframes; 22 app	opp = 2,153m2	Costs are incorporated in the binnendeuren
Binnendeuren	R1 opdekdeur Reinaerdt 930x2315	Deelproduct: Binnendeuren, Hout; geschilderd:alkyd	#nmd_31621	0	piec	22	piec	Remo	-		€-4.865,97	€221,18	Removed indoor doors; 22 app		

Trappen en liften

Vaste voorzieningen

Terreinvoorzieningen

Difference € -113.083,341 *Difference excluding additional costs

Extra costs

Floor surface PVC	€	2.234,71 (*PVC Vloer Inclusief Leggen? All-in Prijzen Bij Het Vloeren Magazijn!* , 2024)
Total	**€**	**2.234,71**

References

PVC Vloer inclusief leggen? All-in prijzen bij Het Vloeren Magazijn! (2024, August 10). Het Vloeren Magazijn. https://hetvloerenmagazijn.nl/all-in-prijs-pvc-vloer/

Appendix 5

Outlook

RE: Gedeelde Wasmachines en drogers in appartementencomplex voor koopstarters

Van stefan.dejong@homiegroup.com <stefan.dejong@homiegroup.com>
Datum Di 29/10/2024 8:57
Tot Slot, Deon <d.slot@student.tue.nl>

U ontvangt niet vaak e-mail van stefan.dejong@homiegroup.com. Ontdek waarom dit belangrijk is

Goedendag Deon,

Bedankt voor uw bericht en ons telefoongesprek van eerder. Graag geef ik u meer inzicht in het bepalen van het aantal benodigde wasmachines en drogers voor een appartementencomplex, specifiek gericht op de gedeelde faciliteiten voor koopstarters in een gebouw met 22 appartementen.

Voor het vaststellen van de benodigde capaciteit maken wij doorgaans gebruik van een combinatie van richtlijnen en ervaringsdata. Factoren die hierbij worden meegenomen zijn onder andere:

1. **Aantal bewoners per appartement**: In uw geval betreft het één- en tweepersoonshuishoudens, wat de gemiddelde gebruiksfrequentie verlaagt.
2. **Gemiddelde wasfrequentie**: Voor één- en tweepersoonshuishoudens ligt de wasfrequentie gemiddeld op 1-2 keer per week.
3. **Gebruiksspreiding**: Het gebruik van gedeelde wasvoorzieningen wordt vaak gespreid over de week, met pieken in het weekend en avonduren.

Als richtlijn adviseren wij vaak één wasmachine en één droger per 10-12 huishoudens voor kleine huishoudens. Voor uw complex met 22 appartementen zouden **twee wasmachines en twee drogers** doorgaans voldoende capaciteit bieden. Indien het mogelijk is om de apparaten in een reserveringssysteem op te nemen, kan dit het gebruik verder optimaliseren en wachttijden beperken.
Mocht u verdere vragen hebben of specifieke informatie nodig hebben voor uw onderzoek naar betaalbaarheid en duurzaamheid, laat het gerust weten. Wij denken graag met u mee.

Met vriendelijke groet | With refreshing regards,

Stefan de Jong
Planning
Homie B.V.

015-7601615

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Wagenmakersweg 3,
Woerden

Van: Slot, Deon <d.slot@student.tue.nl>
Verzonden: maandag 28 oktober 2024 16:03
Aan: info@homiegroup.com
Onderwerp: Gedeelde Wasmachines en drogers in appartementencomplex voor koopstarters

Goedemiddag,

Zojuist heb ik al even telefonisch contact gehad met jullie over het aantal wasmachines en drogers welke nodig zijn in een appartementencomplex voor koopstarters.
Mijn vraag is of jullie kan toelichten op welke wijze ik het aantal benodigde wasmachines en drogers kan vaststellen en of jullie hier een specifieke methode voor gebruiken om dit te bepalen, dit omdat ik onderzoek doe naar de invloed van gedeelde faciliteiten in een appartementencomplex op de betaalbaarheid en duurzaamheid.
In dit geval gaat het om gedeelde was voorzieningen in een appartementencomplex bestaande uit 22 appartementen voor voornamelijk een a twee persoonshuishoudens.

Ik kijk uit naar jullie reactie en alvast vriendelijk bedankt voor de gedane moeite

Met vriendelijke groeten,
Deon Slot

Appendix 6

Decision support tool testing assignment

Data related to the reference project Opus | de Tuin van Elden has been loaded into the decision support tool. However, during a review of the input values, it was discovered that one NMD product is not present in the NMD_DATABASE of the decision support tool. This product is:

Product name	EDN	Quantity	Unit	Costs/unit
DKG Groep B2B Standard Kitchen Set-up 780BK	#nmd_96282	1	M2	€2000

It has been discovered that the base design incorrectly includes two types of pile foundations. Specifically, the currently assigned pile foundation "Funderingspalen, Schroefpaal; beton,in het werk gestort, C20/25; incl.wapening, diameter 400" should be removed.

Additionally, it has come to our attention that the shared facility labeled "Kitchen" does not have a kitchen assigned. To rectify this, the DKG standard kitchen set-up should be incorporated into the shared facility.

After removing the incorrect foundation piles in the base design and assigning the kitchen group to the shared facility "Kitchen," we can proceed to create different variants. The objective is to:

- Highlight the shared facility with the most significant positive impact on the MPG in Variant 1
- Showcase a combination of shared facilities—including a shared garden/terrace, bike parking, and workspace—in Variant 2.

Appendix 7

Expert interviews

Thematic analysis

The interview experts are transcribed and the outcomes are categorized using inductive thematic analysis.

Question	Categories
1	N
	Y
1A	More technical knowledge about tool development is requir
	More intuitive
	Input
2	Y
	Indicates the impact of choices
	DiU'icult to estimate if everything is included
	Element quantity
2A	N
	More experience
3	Y
	N
	Recognizable structure and layout
	Recognizable shared facilities
3A	More automated data entry
	Description
	User with technical ckground
4	Very
	Can be improved significantly
	Incorporate more sources
	Experience with excel required
	Go
	Main
5	Y
	Usage by technical developers
	Dependent on
	Dependent on project requirements
	Increasing MPG
	Especially in the design phase
6	Add more shared
	Visualization of the outcomes
	Add basic element packages/basic design principles

Interview participant 1

1 november 2024, 08:23a.m.

Participant 1 has a management function at a project development company in the East of the Netherlands

SD Slot, Deon 35:25

Q1: “Do you think that with the knowledge you have right now, you will be capable of using the decision support tool on your own projects?”

Participant 1 35:56

No.

SD Slot, Deon 35:58

Q1A: “What do you need to make you capable of using the decision support tool on your own projects?”

Participant 1 36:06

Well, I think that as a person, you have to be more of a technical developer.
You have to have some technical knowledge which I don't have.
I think the tool works well, but maybe it could be more intuitive.
And you have to do a lot of manual copy-paste work, that's a lot of work.

SD Slot, Deon 36:33

Q2: “Does the tool provide you with sufficient information concerning the impacts of the six considered shared facilities on the MPG and construction costs to make informed design decisions regarding the application of shared facilities?”

Participant 1 36:54

It is, yes. This is the data we are looking for in projects, the impact of choices we make, and the consequences on the MPG score. So the tool is really, really nice.

SD Slot, Deon 37:13

Q3: “Does the tool feel intuitive to use and can you explain why?”

Participant 1 37:19

No, however, this is the first time that I have used the tool.

SD Slot, Deon 37:25

Q3A: “Do you have any suggestions to improve the intuitiveness of the tool?”

Participant 1 37:31

Yeah, it would be nice if you didn't have to copy-paste a lot, but I think that it is very complex to make the connection to the database. So with a good guide/description how it works, and someone who has some technical background I think that it will work

SD Slot, Deon 38:25

Q4: “What do you think about the user-friendliness of the tool?’’

Participant 1 38:38

Yeah, I see a lot of possibilities to make it better, but I think for a student, it is way too complex to make it more incorporated with more data sources.

SD Slot, Deon 38:57

Q5: ‘’Would you use this tool during the initial design phases of an apartment building for first time buyers in the Dutch housing market to consider the application of shared facilities?’’

Participant 1 39:17

Yes. Personally, I won't, but our technical developers will do.

Slot, Deon 39:25

Q6: ‘’Do you have any other recommendations or points of improvement regarding the decision support tool and/or the way it is intended to be used?’’

Participant 1 39:45

No. Maybe you can visualize the outcome in a kind of graphic.

That would be nice. So, you can see directly the impact of the choices you make.

Interview Participant 2

1 november 2024, 12:38p.m.

Participant 2 has a medior role in a project development company in the East of the Netherlands

SD Slot, Deon 34:50

Q1: ”Do you think that with the knowledge you have right now, you are capable of using the decision support tool on your own projects?”

Participant 2 34:57

Mmm, I have to practice some more times, I guess, but it is clear how it works. However, I need to practice more times than once to be capable of doing it all by myself and the fact that this is in English makes it more difficult. But.
I have no complaints about how it works, it is very clear to me.

SD Slot, Deon 35:45

Q2: “Does the tool provide you with sufficient information concerning the impacts of the six considered shared facilities on the MPG and construction costs to make informed design decisions regarding the application of shared facilities?”

Participant 2 36:31

I think that with the variants you can easily test the shared facilities negative or positive impact. So, I think that the information it contains is good. but it's a lot of i data, so I can’t make a proper estimation if it kept the total part or if it is missing something.

SD

Slot, Deon 38:11

Q2A: “Do you have any suggestions on which data should be added to make informed design decisions regarding the application of shared facilities? “

Participant 2 38:33

That's a difficult question because I saw this tool once, and I didn't work with it in a project where I've been working on myself. I find it difficult to make a suggestion for something you can add to be honest. S I really need to work more with t

make a suggestion for you.

SD Slot, Deon 39:35

Q3: “Does the tool feel intuitive to use and can you explain why?”

Participant 2 39:47

The tool shows a lot of information but the launch buttons on the bottom makes it very easy to add something. Well, I have no questions about the tool, the tool is really clear. I have no complaints.

SD Slot, Deon 41:27

Q3A: “Do you have any suggestions to improve the intuitiveness of the tool?”

Participant 2 41:45

I don't know if everyone knows where to find the information to put in the NMD database of the tool. Which I found on the website.

SD Slot, Deon 42:26

Q4: “What do you think about the user-friendliness of the tool?”

Participant 2 42:49

I think the question looks like the question you asked me two questions ago. It is very friendly

SD Slot, Deon 44:00

Q5: “Would you use this tool during the initial design phases of an apartment building for first time buyers in the Dutch housing market to consider the application of shared facilities?”

Participant 2 44:23

This depends on the project requirements. In a highly urbanized area like Utrecht, I would use , but in a less urbanized area like Zevenaar, it seems less

SD Slot, Deon 46:43

Q6: “Do you have any other recommendations or points of improvement regarding the decision support tool and or the way it is intended to be used?”

Participant 2 47:06

Improvements, I guess not. I don't know if there are more shared facilities that you can possibly add.

Interview Participant 3

4 november 2024, 02:14p.m.

Participant 3 has a junior function at a project development company in the South of the Netherlands

SD Slot, Deon 23:52

Q1: “Do you think that with the knowledge you have right now, you will be capable of using the decision support tool on your own projects?”

Participant 3 23:54

Yeah, I think so.

SD Slot, Deon 23:52

Q1A: “What do you need to make you capable of using the decision support tool on your own projects?”

Participant 3 23:59

But as I already said to you, we are like project developers. So, we have the construction companies incorporated into our design teams. So as we do our processes now. We normally I would ask our construction company to provide detailed insights into the aspects that are in the decision support tool.

But yeah, if I have the data available, I think this tool can help me to do this myself.

Yeah, it provides more insights into project development than I currently have.

So I do think it's an added value.

SD Slot, Deon 24:51

Q2: “Does the tool provide you with sufficient information concerning the impacts of the six considered shared facilities on the MPG and construction costs to make informed design decisions regarding the application of shared facilities?”

Participant 3 25:09

Yeah. So it's possible to compare the different options with each other, so you can immediately see what the MPG does in relation to the base design.

So yeah, I do think it has an explanatory value. There is already an option to attach building costs to it, but I do think that it would be valuable to apply the quantity number to the tool to show the total number of things that you apply.

So, I do think it provides the basic insights and perhaps added value is to include the the quantities of elements and what it does in the costs in total, so that there's an option to maximize the insights.

SD Slot, Deon 26:10

Q3: “Does the tool feel intuitive to use and can you explain why?”

Participant 3 26:23

Yeah. So the the basic layout is actually quite comparable to like the bases basic business case approach that we have in our company? So yeah, the cost of the elements are structured the same and the shared facilities that are included are the shared services that are most present in the projects that we have. So that's all logical.

SD Slot, Deon 26:44

Q3A: “Do you have any suggestions to improve the intuitiveness of the tool?”

Participant 3 26:50

Maybe. In the future, that also depends on whether the tool on which you base this tool expands. But it could be interesting to see whether there's a complete database that directly provides you the insights of elements without using the external website. But, the current tool is also quite, yeah, easy to use once you've done it once, then I think, yeah, it becomes easier. Just as that the amount of data you need to add in the

next project decreases when you incorporate more projects. So I think it's a learning curve, but I think it's quite yeah. There's a good overview as it is.

SD Slot, Deon 27:32

Q4: “What do you think about the user-friendliness of the tool?’’

Participant 3 27:37

I do think that you need some experience in Excel, so for me I built some Excel tools myself, so I think it's quite easy to work with. But on the other hand, most of the building companies in the Netherlands have Dutch as the main language, so of course, yeah, it's now in English because of the studies. But the database that you use as in Dutch, making the use in English a bit more difficult, but yeah, translating it to Dutch can also be an expansion. The main function is good. So yeah, I I do think that once you have an overview of what elements are relevant in the calculation, then I think it's easier to gather all the required insights, but as a first insight, yeah, it seems quite a lot. But once you've done it once, also in the example exercise, it's quite easy to fill in all the required details. So I think overall it's a good tool.

SD Slot, Deon 28:44

Q5: ''Would you use this tool during the initial design phases of an apartment building for first time buyers in the Dutch housing market to consider the application of shared facilities?''

Participant 3 28:58

Yes. So. in the current projects and also the projects that are in the near future, there is quite an emphasis on the MPG score. Implying that you will receive a higher value if you have a lower MPG score then they require. So yeah, by adding or removing shared facilities, you can quite easily see what costs do for your overall business case, but also how the score that you have in MPG is influenced. So you can actually gain insights into whether you have an added value by reducing the MPG score and what that does for your financial business case. So you can also determine whether you think it has an added value to lower your MPG score and what the financial consequences are for that. So I think especially in the initial phase to consider the design of the building, the tool adds value.

SD Slot, Deon 30:02

Q6: ''Do you have any other recommendations or points of improvement regarding the decision support tool and/or the way it is intended to be used?''

Participant 3 30:13

Yeah, I do think that. Because there are no, like basic packages on build ups that now can be considered, quite detailed inside input data is required and quite specific elements. Maybe it could be expanded by making your own package of like a simple building that you can implement and change based on future and past insights. By that I mean that there could be for example a reference project within your tool that you can simply adjust, but that the basic elements such as wooden door frames or frames or stuff like that are already filled in in the tool. Such that you only need to indicate whether you apply other materials or quantities. In the basis, it would be the same, but a reference project would make it easier to from a starting point adjust insights also because there might be some project developers that have less data about specific elements and then it can be more difficult to fill in such an Excel tool.

Appendix 8

Rapportage Freetool MRPI Milieuprestatie Gebouw

In deze rapportage zijn de resultaten en de invoer opgenomen van de milieuprestatieberekening gebouw van Technical Validation Shared Living Room. De resultaten zijn verdeeld naar de verplichte milieuprestatieberekening voor het bouwbesluit op basis van afdeling 5.2 en naar de MPG score. Tot slot is een verantwoording voor de berekening opgenomen.

Algemene gegevens

Naam project	**Technical Validation Shared Living Room**
Organisatie	TU/e
Gebruiksfunctie	woongebouw
BVO	75.0 m²
Levensduur	75.0 jaar
Datum rapportage	3 november 2024

Resultaat MPG-score

Naam project	**Technical Validation Shared Living Room**
MKI module A	836.19
MKI module B	117.83
MKI module C	120.47
MKI module D	-26.84
MKI totaal	836.19
MPG totaal	**0.15 € / m² BVO**

In bijlage I zijn overzichten opgenomen van de geselecteerde producten inclusief hoeveelheden en eventuele dimensies van het product.

De berekende resultaten zijn direct gekoppeld aan de in bijlage I opgenomen producten, een afwijkende materialisatie of productkeuze heeft invloed op de berekening. Indien in het verdere ontwerp- en bouwproces andere materiaalkeuzes worden gemaakt dient de milieuprestatie opnieuw berekend te worden.

Verantwoording

Deze berekening is gemaakt met de Freetool MRPI-MPG, er is voor de berekening gebruik gemaakt van versie 3.0 van de productendatabase van de nationale milieudatabase, hieraan is versie 1.1.6 van de basisprofielendatabase gekoppeld.

Disclaimer

De Stichting Milieu Relevante Product Informatie (MRPI) en haar software ontwikkelaar White Lioness technologies aanvaarden geen enkele aansprakelijkheid voor fouten in de berekeningen welke worden/zijn gemaakt met de door de Stichting Nationale Milieu Database (NMD) gevalideerde milieuprestatie berekeningstools MRPI Free tool en MRPI Pro tool, mede omdat deze resultaten enerzijds afhankelijk zijn van correcte invoer en anderzijds omdat de resultaten door ons niet worden gecontroleerd of goedgekeurd.

Deze gevalideerde tools worden daarom beschikbaar gesteld “as-is”, derhalve zonder garantie op functioneren, resultaat of anderszins. De tools leveren een berekeningsresultaat conform de in de wetgeving aangewezen bepalingsmethode materiaalgebonden milieuprestatie gebouwen en GWW werken (MPG) indien daarbij gebruik gemaakt wordt van de productmilieudata zoals die is opgenomen in de Nationale Milieu Database van de Stichting NMD.

Het is verplicht om elementen af te dekken maar het is op dit moment vaak niet mogelijk omdat er geen deelproducten in de Milieudatabase voorhanden zijn. Voor het gebruiksgemak is het toch mogelijk om een MPG berekeningsrapport te genereren. Het is de verantwoordelijkheid van de gebruiker om een dergelijke berekening in te dienen voor de omgevingsvergunning.

Bijlage voor Technical Validation Shared Living Room

Getoetst

Product is getoetst

Product is ongetoetst: deze merkongebonden producten van van stichting NMD krijgen automatisch een toeslag van 30%

Gebouwelementen

b&u: 11.1 Bodemvoorzieningen; grond

Productnaam	Getoetst	Hoeveelheid	Dimensies	MPG waarde
Deelproduct: Grondaanvullingen, Zand		75.0 m3	0	0.00320 €/m2 BVO

b&u: 16.1 Funderingsconstructies; voetenenbalken

Productnaam	Getoetst	Hoeveelheid	Dimensies	MPG waarde
Fundatiebalken, Betonhuis; beton,in het werk gestort, C3037,CEMIII; incl.wapening+eps		75.0 m	0	0.08990 €/m2 BVO

b&u: 23.2 Vloeren; constructief

Productnaam	Getoetst	Hoeveelheid	Dimensies	MPG waarde
Deelproduct: Afwerklagen, Keramische tegels; geglazuurd/gelijmd		75.0 m2	11 mm	0.05035 €/m2 BVO

b&u: 31.3 Buitenwandopeningen; gevuld met deuren

Productnaam	Getoetst	Hoeveelheid	Dimensies	MPG waarde
Deelproduct: Buitendeuren, Onverduurzaamd hout; geschilderd:alkyd; glasopening:0.85m2		3.0 stuk(s)	0	0.00520 €/m2 BVO

Rapportage Freetool MRPI Milieuprestatie Gebouw

In deze rapportage zijn de resultaten en de invoer opgenomen van de milieuprestatieberekening gebouw van Technical Validation Base. De resultaten zijn verdeeld naar de verplichte milieuprestatieberekening voor het bouwbesluit op basis van afdeling 5.2 en naar de MPG score. Tot slot is een verantwoording voor de berekening opgenomen.

Algemene gegevens

Naam project	**Technical Validation Base**
Organisatie	TU/e
Gebruiksfunctie	woongebouw
BVO	100.0 m²
Levensduur	75.0 jaar
Datum rapportage	3 november 2024

Resultaat MPG-score

Naam project	**Technical Validation Base**
MKI module A	1095.41
MKI module B	141.49
MKI module C	161.56
MKI module D	-35.48
MKI totaal	1095.41
MPG totaal	**0.15 € / m² BVO**

In bijlage I zijn overzichten opgenomen van de geselecteerde producten inclusief hoeveelheden en eventuele dimensies van het product.

De berekende resultaten zijn direct gekoppeld aan de in bijlage I opgenomen producten, een afwijkende materialisatie of productkeuze heeft invloed op de berekening. Indien in het verdere ontwerp- en bouwproces andere materiaalkeuzes worden gemaakt dient de milieuprestatie opnieuw berekend te worden.

Verantwoording

Deze berekening is gemaakt met de Freetool MRPI-MPG, er is voor de berekening gebruik gemaakt van versie 3.0 van de productendatabase van de nationale milieudatabase, hieraan is versie 1.1.6 van de basisprofielendatabase gekoppeld.

Disclaimer

De Stichting Milieu Relevante Product Informatie (MRPI) en haar software ontwikkelaar White Lioness technologies aanvaarden geen enkele aansprakelijkheid voor fouten in de berekeningen welke worden/zijn gemaakt met de door de Stichting Nationale Milieu Database (NMD) gevalideerde milieuprestatie berekeningstools MRPI Free tool en MRPI Pro tool, mede omdat deze resultaten enerzijds afhankelijk zijn van correcte invoer en anderzijds omdat de resultaten door ons niet worden gecontroleerd of goedgekeurd.

Deze gevalideerde tools worden daarom beschikbaar gesteld “as-is”, derhalve zonder garantie op functioneren, resultaat of anderszins. De tools leveren een berekeningsresultaat conform de in de wetgeving aangewezen bepalingsmethode materiaalgebonden milieuprestatie gebouwen en GWW werken (MPG) indien daarbij gebruik gemaakt wordt van de productmilieudata zoals die is opgenomen in de Nationale Milieu Database van de Stichting NMD.

Het is verplicht om elementen af te dekken maar het is op dit moment vaak niet mogelijk omdat er geen deelproducten in de Milieudatabase voorhanden zijn. Voor het gebruiksgemak is het toch mogelijk om een MPG berekeningsrapport te genereren. Het is de verantwoordelijkheid van de gebruiker om een dergelijke berekening in te dienen voor de omgevingsvergunning.

Bijlage voor Technical Validation Base

Getoetst

Product is getoetst

Product is ongetoetst: deze merkongebonden producten van van stichting NMD krijgen automatisch een toeslag van 30%

Gebouwelementen

b&u: 11.1 Bodemvoorzieningen; grond

Productnaam	Getoetst	Hoeveelheid	Dimensies	MPG waarde
Deelproduct: Grondaanvullingen, Zand		100.0 m3	0	0.00320 €/m2 BVO

b&u: 16.1 Funderingsconstructies; voetenenbalken

Productnaam	Getoetst	Hoeveelheid	Dimensies	MPG waarde
Fundatiebalken, Betonhuis; beton,in het werk gestort, C3037,CEMIII; incl.wapening+eps		100.0 m	0	0.08990 €/m2 BVO

b&u: 23.2 Vloeren; constructief

Productnaam	Getoetst	Hoeveelheid	Dimensies	MPG waarde
Deelproduct: Afwerklagen, Keramische tegels; geglazuurd/gelijmd		100.0 m2	11 mm	0.05035 €/m2 BVO

b&u: 31.3 Buitenwandopeningen; gevuld met deuren

Productnaam	Getoetst	Hoeveelheid	Dimensies	MPG waarde
Deelproduct: Buitendeuren, Onverduurzaamd hout; geschilderd:alkyd; glasopening:0.85m2		2.0 stuk(s)	0	0.00260 €/m2 BVO

Appendix 9

VBA Coding of the NMD_DATABASE entry form in the decision support tool

```
'NMD_DATABASE entry
'Stored in NMDForm
Private Sub cmdDelete_Click()
    Dim ws          As Worksheet
    Dim lastRow     As Long
    Dim i           As Long
    Dim found       As Boolean

    If Me.cmbProductName.Value = "" Then
        MsgBox "No product Is selected.", vbOKOnly + vbInformation, "Delete"
        Exit Sub
    End If

    Dim response    As VbMsgBoxResult
    response = MsgBox("Do you want To delete the selected product from the database?", vbYesNo + vbQuestion, "Confirmation")

    If response = vbNo Then Exit Sub

    Set ws = ThisWorkbook.Sheets("NMD_Database")
    lastRow = ws.Cells(ws.Rows.Count, "D").End(xlUp).Row
    found = FALSE

    For i = 2 To lastRow
        If ws.Cells(i, 4).Value = Me.cmbProductName.Value Then
            ws.Rows(i).Delete
            found = TRUE
            Exit For
        End If
    Next i

    If Not found Then
        MsgBox "Product Not found.", vbExclamation
    Else
        Call Reset_NMDForm
        MsgBox "Selected product has been deleted.", vbOKOnly + vbInformation, "Deleted"
    End If
End Sub

Private Sub cmdEdit_Click()
    Dim ws          As Worksheet
    Dim lastRow     As Long
    Dim i           As Long
    Dim found       As Boolean
    Dim MKIpValue   As Variant
    Dim costUnit    As Variant

    If Me.cmbProductName.Value = "" Then
        MsgBox "No product Is selected.", vbOKOnly + vbInformation, "Edit"
        Exit Sub
    End If

    Set ws = ThisWorkbook.Sheets("NMD_Database")
    lastRow = ws.Cells(ws.Rows.Count, "D").End(xlUp).Row
    found = FALSE

    For i = 2 To lastRow
        If ws.Cells(i, 4).Value = Me.cmbProductName.Value Then
            ' Populate the fields with the data from the selected row
            Me.txtRowNumber.Value = i
            Me.cmbNLSfBDigit1.Value = ws.Cells(i, 2).Value
            Me.cmbNLSfBDigit2.Value = ws.Cells(i, 3).Value
            Me.txtProductName.Value = ws.Cells(i, 4).Value
```

```
            Me.txtEnvironmentalDeclarationNumber.Value = ws.Cells(i, 5).Value
            Me.cmbUnit.Value = ws.Cells(i, 6).Value
            Me.txtLifespan.Value = ws.Cells(i, 7).Value
            Me.cmbCategory.Value = ws.Cells(i, 8).Value

            ' Retrieve the MKIp value
            MKIpValue = ws.Cells(i, 9).Value

            ' Convert MKIp value to string and replace periods with commas
            Me.txtMKIp.Value = Replace(CStr(MKIpValue), ".", ",")

            Me.optYes.Value = (ws.Cells(i, 10).Value = "Yes")
            Me.optNo.Value = (ws.Cells(i, 10).Value = "No")
            Me.txtLength.Value = ws.Cells(i, 11).Value
            Me.cmbLengthUnit.Value = ws.Cells(i, 12).Value
            Me.txtWidth.Value = ws.Cells(i, 13).Value
            Me.cmbWidthUnit.Value = ws.Cells(i, 14).Value
            Me.txtHeight.Value = ws.Cells(i, 15).Value
            Me.cmbHeightUnit.Value = ws.Cells(i, 16).Value
            Me.txtPublicationdate.Value = ws.Cells(i, 17).Value
            Me.txtAdjustedon.Value = ws.Cells(i, 18).Value
            Me.txtOwner.Value = ws.Cells(i, 19).Value
            Me.txtExplaination.Value = ws.Cells(i, 20).Value
            Me.cmbClass1.Value = ws.Cells(i, 21).Value
            Me.txtNameClass1.Value = ws.Cells(i, 22).Value
            Me.cmbClass2.Value = ws.Cells(i, 23).Value
            Me.txtNameClass2.Value = ws.Cells(i, 24).Value
            Me.cmbClass3.Value = ws.Cells(i, 25).Value
            Me.txtNameClass3.Value = ws.Cells(i, 26).Value
            Me.cmbClass4.Value = ws.Cells(i, 27).Value
            Me.txtNameClass4.Value = ws.Cells(i, 28).Value
            Me.cmbClass5.Value = ws.Cells(i, 29).Value
            Me.txtNameClass5.Value = ws.Cells(i, 30).Value
            Me.cmbClass6.Value = ws.Cells(i, 31).Value
            Me.txtNameClass6.Value = ws.Cells(i, 32).Value
            Me.cmbClass7.Value = ws.Cells(i, 33).Value
            Me.txtNameClass7.Value = ws.Cells(i, 34).Value
             Me.cmbClass8.Value = ws.Cells(i, 35).Value
             Me.txtNameClass8.Value = ws.Cells(i, 36).Value
             Me.cmbClass9.Value = ws.Cells(i, 37).Value
             Me.txtNameClass9.Value = ws.Cells(i, 38).Value

             Me.cmbMissingClass1.Value = ws.Cells(i, 39).Value
             Me.txtNameMissingClass1.Value = ws.Cells(i, 40).Value
             Me.cmbMissingClass2.Value = ws.Cells(i, 41).Value
             Me.txtNameMissingClass2.Value = ws.Cells(i, 42).Value
             Me.cmbMissingClass3.Value = ws.Cells(i, 43).Value
             Me.txtNameMissingClass3.Value = ws.Cells(i, 44).Value
             Me.cmbMissingClass4.Value = ws.Cells(i, 45).Value
             Me.txtNameMissingClass4.Value = ws.Cells(i, 46).Value
             Me.cmbMissingClass5.Value = ws.Cells(i, 47).Value
             Me.txtNameMissingClass5.Value = ws.Cells(i, 48).Value
             Me.cmbMissingClass6.Value = ws.Cells(i, 49).Value
             Me.txtNameMissingClass6.Value = ws.Cells(i, 50).Value
             Me.cmbMissingClass7.Value = ws.Cells(i, 51).Value
             Me.txtNameMissingClass7.Value = ws.Cells(i, 52).Value
             Me.cmbMissingClass8.Value = ws.Cells(i, 53).Value
             Me.txtNameMissingClass8.Value = ws.Cells(i, 54).Value
             Me.cmbMissingClass9.Value = ws.Cells(i, 55).Value
             Me.txtNameMissingClass9.Value = ws.Cells(i, 56).Value

             ' Retrieve the costunitr value
             costUnit = ws.Cells(i, 57).Value

             ' Convert MKIp value to string and replace periods with commas
             Me.txtcostUnit.Value = Replace(CStr(costUnit), ".", ",")
```

```
129
130             found = TRUE
131             Exit For
132         End If
133     Next i
134
135     If Not found Then
136         MsgBox "Product Not found.", vbExclamation
137     Else
138         MsgBox "Please make the required changes And click On the        'Save' button to update", vbOKOnly + vbInformation, "Edit"
139     End If
140End Sub
141
142Private Sub cmdReset_Click()
143
144     Dim msgValue    As VbMsgBoxResult
145
146     msgValue = MsgBox("Do you want To reset the form?", vbYesNo + vbInformation, "Confirmation")
147
148     If msgValue = vbNo Then Exit Sub
149
150     Call Reset_NMDForm
151
152End Sub
153
154Private Sub cmdSortdatabase_Click()
155
156     Call SortData
157
158End Sub
159Private Sub cmdsave_Click()
160
161     Dim msgValue    As VbMsgBoxResult
162     Dim ws          As Worksheet
163     Dim lastRow     As Long
164     Dim i           As Long
165     Dim isDuplicate As Boolean
166     Dim envNumber   As String
167     Dim rowToUpdate As Long
168
169     ' Check if all required comboboxes are filled
170     If Not Completeness_check_Comboboxes() Then
171         MsgBox "Please fill in all required comboboxes", vbExclamation
172         Exit Sub
173     End If
174
175     ' Check if at least one option button is selected
176     If Not Completeness_check_OptionButtons() Then
177         Exit Sub
178     End If
179
180     ' Check if all required textboxes are filled
181     If Not Completeness_check_Textboxes() Then
182         Exit Sub
183     End If
184
185     ' Get the value from the textbox
186     envNumber = Me.txtEnvironmentalDeclarationNumber.Value
187
188     ' Set the worksheet
189     Set ws = ThisWorkbook.Sheets("NMD_DATABASE")
190
191     ' Get the last row with data in column E
192     lastRow = ws.Cells(ws.Rows.Count, "E").End(xlUp).Row
193
194     ' Initialize the duplicate flag
```

```
    isDuplicate = FALSE

    ' Loop through column E to check for duplicates
    For i = 2 To lastRow        ' Assuming the first row is headers
        If ws.Cells(i, 5).Value = envNumber Then
            isDuplicate = TRUE
            rowToUpdate = i
            Exit For
        End If
    Next i

    ' If duplicate is found, ask if the user wants to update the data
    If isDuplicate Then
        msgValue = MsgBox("This data Is already saved in the NMD_DATABASE. Do you want To update the existing data?", vbYesNo + vbInformation, "Confirmation")
        If msgValue = vbNo Then Exit Sub

        ' Update the existing row
        Call UpdateRow(ws, rowToUpdate)
    Else
        msgValue = MsgBox("Do you want To save the data?", vbYesNo + vbInformation, "Confirmation")        'pop up a message with the question if the person wants to save the
data
        If msgValue = vbNo Then Exit Sub

        ' Add a new row
        Call Submit_NMDForm
    End If

    Call Reset_NMDForm

End Sub

Private Sub SortData()
    Dim ws          As Worksheet
    Dim lastRow     As Long

    Set ws = ThisWorkbook.Sheets("NMD_DATABASE")

    ' Selecteer de laatste rij met gegevens in kolom A
    lastRow = ws.Cells(ws.Rows.Count, "A").End(xlUp).Row

    ' Sorteren op kolom B en vervolgens op kolom C
    With ws.Sort
        .SortFields.Clear
        .SortFields.Add Key:=ws.Range("B2:B" & lastRow), Order:=xlAscending
        .SortFields.Add Key:=ws.Range("C2:C" & lastRow), Order:=xlAscending
        .SetRange ws.Range("A1:BG" & lastRow)
        .Header = xlYes
        .Apply
    End With

End Sub

Private Sub UserForm_Initialize()

    Dim ws          As Worksheet
    Dim lastRow     As Long
    Dim i           As Long

    Set ws = ThisWorkbook.Sheets("NMD_Database")        ' define the place of the database
    lastRow = ws.Cells(ws.Rows.Count, "D").End(xlUp).Row

    For i = 2 To lastRow
        Me.cmbProductName.AddItem ws.Cells(i, 4).Value
    Next i

    Me.lst_database.ColumnCount = 59
```

```
260
261    Call Reset_NMDForm        'Ensure that the data in the form is deleted and the form is empty
262
263End Sub
264
265Private Sub txtPublicationdate_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)
266    If Me.txtPublicationdate.Text <> "" Then        ' only validate if data is entered in the textbox
267    Date_validation Me.txtPublicationdate, Cancel
268End If
269End Sub
270
271Private Sub txtAdjustedon_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)
272    If Me.txtAdjustedon.Text <> "" Then        ' only validate if data is entered in the textbox
273    Date_validation Me.txtAdjustedon, Cancel
274End If
275End Sub
276
277Private Sub txtLifespan_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)
278    If Me.txtLifespan.Text <> "" Then        ' only validate if data is entered in the textbox
279    Integer_validation Me.txtLifespan, Cancel
280End If
281End Sub
282
283Private Sub txtMKIp_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)
284    If Me.txtMKIp.Text <> "" Then        ' only validate if data is entered in the textbox
285    Currency_validation Me.txtMKIp, Cancel
286End If
287End Sub
288
289Private Sub txtCostunit_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)
290    If Me.txtcostUnit.Text <> "" Then        ' only validate if data is entered in the textbox
291    Currency_validation Me.txtMKIp, Cancel
292End If
293End Sub
294
295Private Sub txtLength_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)
296    If Me.txtLength.Text <> "" Then        ' only validate if data is entered in the textbox
297    Number_validation Me.txtLength, Cancel
298End If
299End Sub
300
301Private Sub txtWidth_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)
302    If Me.txtWidth.Text <> "" Then        ' only validate if data is entered in the textbox
303    Number_validation Me.txtWidth, Cancel
304End If
305End Sub
306
307Private Sub txtHeight_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)
308    If Me.txtHeight.Text <> "" Then        ' only validate if data is entered in the textbox
309    Number_validation Me.txtHeight, Cancel
310End If
311End Sub
312
313Private Sub Date_validation(txtBox As MSForms.TextBox, ByRef Cancel As MSForms.ReturnBoolean)
314    Dim userInput   As String
315    userInput = txtBox.Text
316
317    If Not IsDate(Replace(userInput, "-", "/")) Then        ' check if the input is a valid date
318    MsgBox "Please enter a valid Date in the format D-M-YYYY.", vbExclamation
319    Cancel = TRUE
320End If
321End Sub
322
323Private Sub Integer_validation(txtBox As MSForms.TextBox, ByRef Cancel As MSForms.ReturnBoolean)
324    Dim userInput   As String
325    userInput = txtBox.Text
```

```
326
327    If Not IsNumeric(userInput) Or InStr(userInput, ".") > 0 Or InStr(userInput, ",") > 0 Then        ' check if the input is an integer
328    MsgBox "Please enter a valid integer.", vbExclamation
329    Cancel = TRUE
330End If
331End Sub
332
333Private Sub Currency_validation(txtBox As MSForms.TextBox, ByRef Cancel As MSForms.ReturnBoolean)
334    Dim userInput   As String
335    Dim regex       As Object
336    Set regex = CreateObject("VBScript.RegExp")
337
338    userInput = txtBox.Text
339
340    ' Regular expression pattern for currency with 2 decimal places
341    regex.Pattern = "^\d+(\,\d{2})?$"
342    regex.IgnoreCase = TRUE
343    regex.Global = TRUE
344
345    If Not regex.Test(userInput) Then
346        MsgBox "Please enter a valid financial value With 2 decimal places (e.g., 123,45).", vbExclamation
347        Cancel = TRUE
348    End If
349End Sub
350
351Private Sub Number_validation(txtBox As MSForms.TextBox, ByRef Cancel As MSForms.ReturnBoolean)
352    Dim userInput   As String
353    userInput = txtBox.Text
354
355    If Not IsNumeric(userInput) Then        ' check if the input is a number
356    MsgBox "Please enter a number.", vbExclamation
357    Cancel = TRUE
358End If
359End Sub
360
361Private Sub UpdateRow(ws As Worksheet, rowToUpdate As Long)
362    ' Replace commas with periods in txtMKIp
363    Dim convertedMKIp As String
364
365    convertedMKIp = Replace(Me.txtMKIp.Value, ",", ".")
366
367    ' Update the row with the new data
368    ws.Cells(rowToUpdate, 2).Value = Me.cmbNLSfBDigit1.Value
369    ws.Cells(rowToUpdate, 3).Value = Me.cmbNLSfBDigit2.Value
370    ws.Cells(rowToUpdate, 4).Value = Me.txtProductName.Value
371    ws.Cells(rowToUpdate, 5).Value = Me.txtEnvironmentalDeclarationNumber.Value
372    ws.Cells(rowToUpdate, 6).Value = Me.cmbUnit.Value
373    ws.Cells(rowToUpdate, 7).Value = Me.txtLifespan.Value
374    ws.Cells(rowToUpdate, 8).Value = Me.cmbCategory.Value
375    ws.Cells(rowToUpdate, 9).Value = convertedMKIp
376    ws.Cells(rowToUpdate, 10).Value = IIf(Me.optYes.Value, "Yes", "No")
377    ws.Cells(rowToUpdate, 11).Value = Me.txtLength.Value
378    ws.Cells(rowToUpdate, 12).Value = Me.cmbLengthUnit.Value
379    ws.Cells(rowToUpdate, 13).Value = Me.txtWidth.Value
380    ws.Cells(rowToUpdate, 14).Value = Me.cmbWidthUnit.Value
381    ws.Cells(rowToUpdate, 15).Value = Me.txtHeight.Value
382    ws.Cells(rowToUpdate, 16).Value = Me.cmbHeightUnit.Value
383    ws.Cells(rowToUpdate, 17).Value = Me.txtPublicationdate.Value
384    ws.Cells(rowToUpdate, 18).Value = Me.txtAdjustedon.Value
385    ws.Cells(rowToUpdate, 19).Value = Me.txtOwner.Value
386    ws.Cells(rowToUpdate, 20).Value = Me.txtExplaination.Value
387    ws.Cells(rowToUpdate, 21).Value = Me.cmbClass1.Value
388    ws.Cells(rowToUpdate, 22).Value = Me.txtNameClass1.Value
389    ws.Cells(rowToUpdate, 23).Value = Me.cmbClass2.Value
390    ws.Cells(rowToUpdate, 24).Value = Me.txtNameClass2.Value
391    ws.Cells(rowToUpdate, 25).Value = Me.cmbClass3.Value
```

```
    ws.Cells(rowToUpdate, 26).Value = Me.txtNameClass3.Value
    ws.Cells(rowToUpdate, 27).Value = Me.cmbClass4.Value
    ws.Cells(rowToUpdate, 28).Value = Me.txtNameClass4.Value
    ws.Cells(rowToUpdate, 29).Value = Me.cmbClass5.Value
    ws.Cells(rowToUpdate, 30).Value = Me.txtNameClass5.Value
    ws.Cells(rowToUpdate, 31).Value = Me.cmbClass6.Value
    ws.Cells(rowToUpdate, 32).Value = Me.txtNameClass6.Value
    ws.Cells(rowToUpdate, 33).Value = Me.cmbClass7.Value
    ws.Cells(rowToUpdate, 34).Value = Me.txtNameClass7.Value
    ws.Cells(rowToUpdate, 35).Value = Me.cmbClass8.Value
    ws.Cells(rowToUpdate, 36).Value = Me.txtNameClass8.Value
    ws.Cells(rowToUpdate, 37).Value = Me.cmbClass9.Value
    ws.Cells(rowToUpdate, 38).Value = Me.txtNameClass9.Value

    ws.Cells(rowToUpdate, 39).Value = Me.cmbMissingClass1.Value
    ws.Cells(rowToUpdate, 40).Value = Me.txtNameMissingClass1.Value
    ws.Cells(rowToUpdate, 41).Value = Me.cmbMissingClass2.Value
    ws.Cells(rowToUpdate, 42).Value = Me.txtNameMissingClass2.Value
    ws.Cells(rowToUpdate, 43).Value = Me.cmbMissingClass3.Value
    ws.Cells(rowToUpdate, 44).Value = Me.txtNameMissingClass3.Value
    ws.Cells(rowToUpdate, 45).Value = Me.cmbMissingClass4.Value
    ws.Cells(rowToUpdate, 46).Value = Me.txtNameMissingClass4.Value
    ws.Cells(rowToUpdate, 47).Value = Me.cmbMissingClass5.Value
    ws.Cells(rowToUpdate, 48).Value = Me.txtNameMissingClass5.Value
    ws.Cells(rowToUpdate, 49).Value = Me.cmbMissingClass6.Value
    ws.Cells(rowToUpdate, 50).Value = Me.txtNameMissingClass6.Value
    ws.Cells(rowToUpdate, 51).Value = Me.cmbMissingClass7.Value
    ws.Cells(rowToUpdate, 52).Value = Me.txtNameMissingClass7.Value
    ws.Cells(rowToUpdate, 53).Value = Me.cmbMissingClass8.Value
    ws.Cells(rowToUpdate, 54).Value = Me.txtNameMissingClass8.Value
    ws.Cells(rowToUpdate, 55).Value = Me.cmbMissingClass9.Value
    ws.Cells(rowToUpdate, 56).Value = Me.txtNameMissingClass9.Value
    ws.Cells(rowToUpdate, 57).Value = Me.txtcostUnit.Value

    MsgBox "Data successfully updated!", vbInformation
End Sub

Private Function Completeness_check_Textboxes() As Boolean

    Dim ctrl        As Control
    Dim emptyTextBox As Control
    Dim allFilled   As Boolean
    allFilled = TRUE

    ' Loop through all controls on the form
    For Each ctrl In Me.Controls

        ' Check if the control is a TextBox and not one of the excluded ones
        If TypeName(ctrl) = "TextBox" And _
        ctrl.Name <> "txtAdjustedon" And _
        ctrl.Name <> "txtExplaination" And _
        ctrl.Name <> "txtNameClass2" And _
        ctrl.Name <> "txtNameClass3" And _
        ctrl.Name <> "txtNameClass4" And _
        ctrl.Name <> "txtNameClass5" And _
        ctrl.Name <> "txtNameClass6" And _
        ctrl.Name <> "txtNameClass7" And _
        ctrl.Name <> "txtNameClass8" And _
        ctrl.Name <> "txtNameClass9" And _
        ctrl.Name <> "txtNameMissingClass1" And _
        ctrl.Name <> "txtNameMissingClass2" And _
        ctrl.Name <> "txtNameMissingClass3" And _
        ctrl.Name <> "txtNameMissingClass4" And _
        ctrl.Name <> "txtNameMissingClass5" And _
        ctrl.Name <> "txtNameMissingClass6" And _
        ctrl.Name <> "txtNameMissingClass7" And _
```

```
        ctrl.Name <> "txtNameMissingClass8" And _
        ctrl.Name <> "txtNameMissingClass9" And _
        ctrl.Name <> "txtLength" And _
        ctrl.Name <> "txtWidth" And _
        ctrl.Name <> "txtRowNumber" And _
        ctrl.Name <> "txtcostUnit" And _
        ctrl.Name <> "txtHeight" Then

        ' Check if the TextBox is empty
        If ctrl.Text = "" Then
            allFilled = FALSE
            Set emptyTextBox = ctrl
            Exit For
        End If
    End If
Next ctrl

' If not all TextBoxes are filled, show a message and set focus to the empty TextBox
If Not allFilled Then
    MsgBox "Please fill in all required fields.", vbExclamation
    emptyTextBox.SetFocus
    Completeness_check_Textboxes = FALSE
Else
    Completeness_check_Textboxes = TRUE
End If

End Function

Private Function Completeness_check_OptionButtons() As Boolean

    Dim option1Selected As Boolean
    Dim option2Selected As Boolean

    ' controlling the status of the optionbuttons
    option1Selected = Me.optYes.Value
    option2Selected = Me.optNo.Value

    ' controlling if at least one optionbutton is selected
    If Not option1Selected And Not option2Selected Then
        MsgBox "Please Select If the product Is scalable.", vbExclamation
        ' set focus on the first option button if none is selected
        Me.optYes.SetFocus
        Completeness_check_OptionButtons = FALSE
    Else
        Completeness_check_OptionButtons = TRUE
    End If

End Function

Private Function Completeness_check_Comboboxes() As Boolean
    Dim ctrl        As Control
    Dim allFilled   As Boolean
    allFilled = TRUE

    For Each ctrl In Me.Controls
        If TypeName(ctrl) = "ComboBox" Then
            Select Case ctrl.Name        'Do not control the following comboboxes
                Case "cmbClass2", "cmbClass3", "cmbClass4", "cmbClass5", "cmbClass6", "cmbClass7", "cmbClass8", "cmbClass9", _
                 "cmbMissingClass1", "cmbMissingClass2", "cmbMissingClass3", "cmbMissingClass4", "cmbMissingClass5", "cmbMissingClass6", "cmbMissingClass7", "cmbMissingClass8",
"cmbMissingClass9", _
                     "cmbLengthUnit", "cmbWidthUnit", "cmbHeightUnit", "cmbProductName"
                    ' Do nothing for these comboboxes
                Case Else
                    If IsNull(ctrl.Value) Or ctrl.Value = "" Then        'check for all the other comboboxes if they are empty
                    allFilled = FALSE        'when they are empty the boolean is false
                    Exit For
```

```
523                End If
524            End Select
525        End If
526Next ctrl
527
528Completeness_check_Comboboxes = allFilled
529End Function
530
531Private Sub cmbProductName_Change()
532    Dim i           As Integer
533    Dim productName As String
534
535    ' get the name of the selected product from the combobox
536    productName = cmbProductName.Value
537
538    ' run through the items in the listbox
539    For i = 0 To lst_database.ListCount - 1
540        ' check if the current row is in line with the selected row from the combobox
541        If lst_database.List(i, 3) = productName Then
542            ' select and highlight the row
543            lst_database.Selected(i) = TRUE
544            Exit For
545        End If
546    Next i
547End Sub
548
549'Stored in module 1
550
551Sub Reset_NMDForm()
552
553    Dim iRow        As Long
554
555    iRow = [Counta(NMD_DATABASE!A:A)]        ' identifying the last row of the database
556
557    With NMDForm
558
559        'reset the input data
560
561        .cmbNLSfBDigit1.Clear
562        .cmbNLSfBDigit2.Clear
563        .txtProductName.Value = ""
564        .txtEnvironmentalDeclarationNumber.Value = ""
565        .cmbUnit.Clear
566        .txtLifespan.Value = ""
567        .cmbCategory.Clear
568        .txtMKIp.Value = ""
569        .optNo.Value = FALSE
570        .optYes.Value = FALSE
571        .txtLength.Value = ""
572        .cmbLengthUnit.Clear
573        .txtWidth.Value = ""
574        .cmbWidthUnit.Clear
575        .txtHeight.Value = ""
576        .cmbHeightUnit.Clear
577        .txtPublicationdate.Value = ""
578        .txtAdjustedon.Value = ""
579        .txtOwner.Value = ""
580        .txtExplaination.Value = ""
581
582        .cmbClass1.Clear
583        .txtNameClass1.Value = ""
584        .cmbClass2.Clear
585        .txtNameClass2.Value = ""
586        .cmbClass3.Clear
587        .txtNameClass3.Value = ""
588        .cmbClass4.Clear
```

```
589         .txtNameClass4.Value = ""
590         .cmbClass5.Clear
591         .txtNameClass5.Value = ""
592         .cmbClass6.Clear
593         .txtNameClass6.Value = ""
594         .cmbClass7.Clear
595         .txtNameClass7.Value = ""
596         .cmbClass8.Clear
597         .txtNameClass8.Value = ""
598         .cmbClass9.Clear
599         .txtNameClass9.Value = ""
600
601         .cmbMissingClass1.Clear
602         .txtNameMissingClass1.Value = ""
603         .cmbMissingClass2.Clear
604         .txtNameMissingClass2.Value = ""
605         .cmbMissingClass3.Clear
606         .txtNameMissingClass3.Value = ""
607         .cmbMissingClass4.Clear
608         .txtNameMissingClass4.Value = ""
609         .cmbMissingClass5.Clear
610         .txtNameMissingClass5.Value = ""
611         .cmbMissingClass6.Clear
612         .txtNameMissingClass6.Value = ""
613         .cmbMissingClass7.Clear
614         .txtNameMissingClass7.Value = ""
615         .cmbMissingClass8.Clear
616         .txtNameMissingClass8.Value = ""
617         .cmbMissingClass9.Clear
618         .txtNameMissingClass9.Value = ""
619
620         .txtcostUnit.Value = ""
621
622         .txtRowNumber.Value = ""
623
624         'Add items to the different combo boxes
625
626         ' Add items to the combobox "NL-SfB digit 1"
627         .cmbNLSfBDigit1.AddItem "11"
628         .cmbNLSfBDigit1.AddItem "13"
629         .cmbNLSfBDigit1.AddItem "16"
630         .cmbNLSfBDigit1.AddItem "17"
631         .cmbNLSfBDigit1.AddItem "21"
632         .cmbNLSfBDigit1.AddItem "22"
633         .cmbNLSfBDigit1.AddItem "23"
634         .cmbNLSfBDigit1.AddItem "24"
635         .cmbNLSfBDigit1.AddItem "27"
636         .cmbNLSfBDigit1.AddItem "28"
637         .cmbNLSfBDigit1.AddItem "31"
638         .cmbNLSfBDigit1.AddItem "32"
639         .cmbNLSfBDigit1.AddItem "33"
640         .cmbNLSfBDigit1.AddItem "34"
641         .cmbNLSfBDigit1.AddItem "37"
642         .cmbNLSfBDigit1.AddItem "41"
643         .cmbNLSfBDigit1.AddItem "42"
644         .cmbNLSfBDigit1.AddItem "43"
645         .cmbNLSfBDigit1.AddItem "45"
646         .cmbNLSfBDigit1.AddItem "47"
647         .cmbNLSfBDigit1.AddItem "52"
648         .cmbNLSfBDigit1.AddItem "53"
649         .cmbNLSfBDigit1.AddItem "54"
650         .cmbNLSfBDigit1.AddItem "55"
651         .cmbNLSfBDigit1.AddItem "56"
652         .cmbNLSfBDigit1.AddItem "57"
653         .cmbNLSfBDigit1.AddItem "58"
654         .cmbNLSfBDigit1.AddItem "61"
```

```
655         .cmbNLSfBDigit1.AddItem "62"
656         .cmbNLSfBDigit1.AddItem "63"
657         .cmbNLSfBDigit1.AddItem "64"
658         .cmbNLSfBDigit1.AddItem "65"
659         .cmbNLSfBDigit1.AddItem "66"
660         .cmbNLSfBDigit1.AddItem "71"
661         .cmbNLSfBDigit1.AddItem "73"
662         .cmbNLSfBDigit1.AddItem "74"
663         .cmbNLSfBDigit1.AddItem "75"
664         .cmbNLSfBDigit1.AddItem "76"
665         .cmbNLSfBDigit1.AddItem "80"
666         .cmbNLSfBDigit1.AddItem "83"
667         .cmbNLSfBDigit1.AddItem "90"
668
669         ' Add items to the combobox "NL-SfB digit 1"
670         .cmbNLSfBDigit2.AddItem "0"
671         .cmbNLSfBDigit2.AddItem "1"
672         .cmbNLSfBDigit2.AddItem "2"
673         .cmbNLSfBDigit2.AddItem "3"
674         .cmbNLSfBDigit2.AddItem "4"
675         .cmbNLSfBDigit2.AddItem "5"
676         .cmbNLSfBDigit2.AddItem "6"
677         .cmbNLSfBDigit2.AddItem "7"
678         .cmbNLSfBDigit2.AddItem "20"
679         .cmbNLSfBDigit2.AddItem "22"
680         .cmbNLSfBDigit2.AddItem "24"
681         .cmbNLSfBDigit2.AddItem "40"
682
683         ' Add items to the combobox "Unit"
684         .cmbUnit.AddItem "M"
685         .cmbUnit.AddItem "M2"
686         .cmbUnit.AddItem "M3"
687         .cmbUnit.AddItem "Piece(s)"
688         .cmbUnit.AddItem "Kg"
689         .cmbUnit.AddItem "kW"
690
691         ' Add items to the combobox "Category"
692         .cmbCategory.AddItem "1"
693         .cmbCategory.AddItem "2"
694         .cmbCategory.AddItem "3"
695
696         ' Add items to the combobox "Length Unit"
697         .cmbLengthUnit.AddItem "mm"
698         .cmbLengthUnit.AddItem "cm"
699         .cmbLengthUnit.AddItem "dm"
700         .cmbLengthUnit.AddItem "m"
701
702         ' Add items to the combobox "Width Unit"
703         .cmbWidthUnit.AddItem "mm"
704         .cmbWidthUnit.AddItem "cm"
705         .cmbWidthUnit.AddItem "dm"
706         .cmbWidthUnit.AddItem "m"
707
708         ' Add items to the combobox "Height Unit"
709         .cmbHeightUnit.AddItem "mm"
710         .cmbHeightUnit.AddItem "cm"
711         .cmbHeightUnit.AddItem "dm"
712         .cmbHeightUnit.AddItem "m"
713
714         ' Add items to the combobox "Class 1"
715         .cmbClass1.AddItem "1"
716         .cmbClass1.AddItem "2"
717         .cmbClass1.AddItem "3"
718         .cmbClass1.AddItem "4"
719         .cmbClass1.AddItem "5"
720         .cmbClass1.AddItem "6"
```

```
721         .cmbClass1.AddItem "7"
722         .cmbClass1.AddItem "8"
723         .cmbClass1.AddItem "9"
724         .cmbClass1.AddItem "10"
725         .cmbClass1.AddItem "11"
726         .cmbClass1.AddItem "12"
727         .cmbClass1.AddItem "13"
728         .cmbClass1.AddItem "14"
729
730         ' Add items to the combobox "Class 2"
731         .cmbClass2.AddItem ""
732         .cmbClass2.AddItem "2"
733         .cmbClass2.AddItem "3"
734         .cmbClass2.AddItem "4"
735         .cmbClass2.AddItem "5"
736         .cmbClass2.AddItem "6"
737         .cmbClass2.AddItem "7"
738         .cmbClass2.AddItem "8"
739         .cmbClass2.AddItem "9"
740         .cmbClass2.AddItem "10"
741         .cmbClass2.AddItem "11"
742         .cmbClass2.AddItem "12"
743         .cmbClass2.AddItem "13"
744         .cmbClass2.AddItem "14"
745
746         ' Add items to the combobox "Class 3"
747         .cmbClass3.AddItem ""
748         .cmbClass3.AddItem "3"
749         .cmbClass3.AddItem "4"
750         .cmbClass3.AddItem "5"
751         .cmbClass3.AddItem "6"
752         .cmbClass3.AddItem "7"
753         .cmbClass3.AddItem "8"
754         .cmbClass3.AddItem "9"
755         .cmbClass3.AddItem "10"
756         .cmbClass3.AddItem "11"
757         .cmbClass3.AddItem "12"
758         .cmbClass3.AddItem "13"
759         .cmbClass3.AddItem "14"
760
761         ' Add items to the combobox "Class 4"
762         .cmbClass4.AddItem ""
763         .cmbClass4.AddItem "4"
764         .cmbClass4.AddItem "5"
765         .cmbClass4.AddItem "6"
766         .cmbClass4.AddItem "7"
767         .cmbClass4.AddItem "8"
768         .cmbClass4.AddItem "9"
769         .cmbClass4.AddItem "10"
770         .cmbClass4.AddItem "11"
771         .cmbClass4.AddItem "12"
772         .cmbClass4.AddItem "13"
773         .cmbClass4.AddItem "14"
774
775         ' Add items to the combobox "Class 5"
776         .cmbClass5.AddItem ""
777         .cmbClass5.AddItem "5"
778         .cmbClass5.AddItem "6"
779         .cmbClass5.AddItem "7"
780         .cmbClass5.AddItem "8"
781         .cmbClass5.AddItem "9"
782         .cmbClass5.AddItem "10"
783         .cmbClass5.AddItem "11"
784         .cmbClass5.AddItem "12"
785         .cmbClass5.AddItem "13"
786         .cmbClass5.AddItem "14"
```

```
787
788         ' Add items to the combobox "Class 6"
789         .cmbClass6.AddItem ""
790         .cmbClass6.AddItem "6"
791         .cmbClass6.AddItem "7"
792         .cmbClass6.AddItem "8"
793         .cmbClass6.AddItem "9"
794         .cmbClass6.AddItem "10"
795         .cmbClass6.AddItem "11"
796         .cmbClass6.AddItem "12"
797         .cmbClass6.AddItem "13"
798         .cmbClass6.AddItem "14"
799
800         ' Add items to the combobox "Class 7"
801         .cmbClass7.AddItem ""
802         .cmbClass7.AddItem "7"
803         .cmbClass7.AddItem "8"
804         .cmbClass7.AddItem "9"
805         .cmbClass7.AddItem "10"
806         .cmbClass7.AddItem "11"
807         .cmbClass7.AddItem "12"
808         .cmbClass7.AddItem "13"
809         .cmbClass7.AddItem "14"
810
811         ' Add items to the combobox "Class 8"
812         .cmbClass8.AddItem ""
813         .cmbClass8.AddItem "8"
814         .cmbClass8.AddItem "9"
815         .cmbClass8.AddItem "10"
816         .cmbClass8.AddItem "11"
817         .cmbClass8.AddItem "12"
818         .cmbClass8.AddItem "13"
819         .cmbClass8.AddItem "14"
820
821         ' Add items to the combobox "Class 9"
822         .cmbClass9.AddItem ""
823         .cmbClass9.AddItem "9"
824         .cmbClass9.AddItem "10"
825         .cmbClass9.AddItem "11"
826         .cmbClass9.AddItem "12"
827         .cmbClass9.AddItem "13"
828         .cmbClass9.AddItem "14"
829
830         ' Add items to the combobox "Missing Class 1"
831         .cmbMissingClass1.AddItem ""
832         .cmbMissingClass1.AddItem "1"
833         .cmbMissingClass1.AddItem "2"
834         .cmbMissingClass1.AddItem "3"
835         .cmbMissingClass1.AddItem "4"
836         .cmbMissingClass1.AddItem "5"
837         .cmbMissingClass1.AddItem "6"
838         .cmbMissingClass1.AddItem "7"
839         .cmbMissingClass1.AddItem "8"
840         .cmbMissingClass1.AddItem "9"
841         .cmbMissingClass1.AddItem "10"
842         .cmbMissingClass1.AddItem "11"
843         .cmbMissingClass1.AddItem "12"
844         .cmbMissingClass1.AddItem "13"
845         .cmbMissingClass1.AddItem "14"
846
847         ' Add items to the combobox "Missing Class 2"
848         .cmbMissingClass2.AddItem ""
849         .cmbMissingClass2.AddItem "2"
850         .cmbMissingClass2.AddItem "3"
851         .cmbMissingClass2.AddItem "4"
852         .cmbMissingClass2.AddItem "5"
```

```
853         .cmbMissingClass2.AddItem "6"
854         .cmbMissingClass2.AddItem "7"
855         .cmbMissingClass2.AddItem "8"
856         .cmbMissingClass2.AddItem "9"
857         .cmbMissingClass2.AddItem "10"
858         .cmbMissingClass2.AddItem "11"
859         .cmbMissingClass2.AddItem "12"
860         .cmbMissingClass2.AddItem "13"
861         .cmbMissingClass2.AddItem "14"
862
863         ' Add items to the combobox "Missing Class 3"
864         .cmbMissingClass3.AddItem ""
865         .cmbMissingClass3.AddItem "3"
866         .cmbMissingClass3.AddItem "4"
867         .cmbMissingClass3.AddItem "5"
868         .cmbMissingClass3.AddItem "6"
869         .cmbMissingClass3.AddItem "7"
870         .cmbMissingClass3.AddItem "8"
871         .cmbMissingClass3.AddItem "9"
872         .cmbMissingClass3.AddItem "10"
873         .cmbMissingClass3.AddItem "11"
874         .cmbMissingClass3.AddItem "12"
875         .cmbMissingClass3.AddItem "13"
876         .cmbMissingClass3.AddItem "14"
877
878         ' Add items to the combobox "Missing Class 4"
879         .cmbMissingClass4.AddItem ""
880         .cmbMissingClass4.AddItem "4"
881         .cmbMissingClass4.AddItem "5"
882         .cmbMissingClass4.AddItem "6"
883         .cmbMissingClass4.AddItem "7"
884         .cmbMissingClass4.AddItem "8"
885         .cmbMissingClass4.AddItem "9"
886         .cmbMissingClass4.AddItem "10"
887         .cmbMissingClass4.AddItem "11"
888         .cmbMissingClass4.AddItem "12"
889         .cmbMissingClass4.AddItem "13"
890         .cmbMissingClass4.AddItem "14"
891
892         ' Add items to the combobox "Missing Class 5"
893         .cmbMissingClass5.AddItem ""
894         .cmbMissingClass5.AddItem "5"
895         .cmbMissingClass5.AddItem "6"
896         .cmbMissingClass5.AddItem "7"
897         .cmbMissingClass5.AddItem "8"
898         .cmbMissingClass5.AddItem "9"
899         .cmbMissingClass5.AddItem "10"
900         .cmbMissingClass5.AddItem "11"
901         .cmbMissingClass5.AddItem "12"
902         .cmbMissingClass5.AddItem "13"
903         .cmbMissingClass5.AddItem "14"
904
905         ' Add items to the combobox "Missing Class 6"
906         .cmbMissingClass6.AddItem ""
907         .cmbMissingClass6.AddItem "6"
908         .cmbMissingClass6.AddItem "7"
909         .cmbMissingClass6.AddItem "8"
910         .cmbMissingClass6.AddItem "9"
911         .cmbMissingClass6.AddItem "10"
912         .cmbMissingClass6.AddItem "11"
913         .cmbMissingClass6.AddItem "12"
914         .cmbMissingClass6.AddItem "13"
915         .cmbMissingClass6.AddItem "14"
916
917         ' Add items to the combobox "Missing Class 7"
918         .cmbMissingClass7.AddItem ""
```

```
        .cmbMissingClass7.AddItem "7"
        .cmbMissingClass7.AddItem "8"
        .cmbMissingClass7.AddItem "9"
        .cmbMissingClass7.AddItem "10"
        .cmbMissingClass7.AddItem "11"
        .cmbMissingClass7.AddItem "12"
        .cmbMissingClass7.AddItem "13"
        .cmbMissingClass7.AddItem "14"

        ' Add items to the combobox "Missing Class 8"
        .cmbMissingClass8.AddItem ""
        .cmbMissingClass8.AddItem "8"
        .cmbMissingClass8.AddItem "9"
        .cmbMissingClass8.AddItem "10"
        .cmbMissingClass8.AddItem "11"
        .cmbMissingClass8.AddItem "12"
        .cmbMissingClass8.AddItem "13"
        .cmbMissingClass8.AddItem "14"

        ' Add items to the combobox "Missing Class 9"
        .cmbMissingClass9.AddItem ""
        .cmbMissingClass9.AddItem "9"
        .cmbMissingClass9.AddItem "10"
        .cmbMissingClass9.AddItem "11"
        .cmbMissingClass9.AddItem "12"
        .cmbMissingClass9.AddItem "13"
        .cmbMissingClass9.AddItem "14"

        'Define the number of columns of the database and state that the database has headers
        .lst_database.ColumnCount = 59
        .lst_database.ColumnHeads = TRUE

        If iRow > 1 Then
            .lst_database.RowSource = "NMD_DATABASE!A2:BF3" & iRow        ' BF is the 58th column
        Else
            .lst_database.RowSource = "NMD_DATABASE!A2:BF3"
        End If

    End With

End Sub

Sub Submit_NMDForm()

    'Submit the form
    Dim sh          As Worksheet
    Dim iRow        As Long

    Set sh = ThisWorkbook.Sheets("NMD_DATABASE")

    If NMDForm.txtRowNumber.Value = "" Then
        iRow = Application.WorksheetFunction.CountA(sh.Range("A:A")) + 1
    Else
        iRow = NMDForm.txtRowNumber.Value
    End If

    ' Define the column(s) of the database in which the information needs to be stored
    With sh
        .Cells(iRow, 1) = iRow - 1
        .Cells(iRow, 2) = NMDForm.cmbNLSfBDigit1.Value
        .Cells(iRow, 3) = NMDForm.cmbNLSfBDigit2.Value
        .Cells(iRow, 4) = NMDForm.txtProductName.Value
        .Cells(iRow, 5) = NMDForm.txtEnvironmentalDeclarationNumber.Value
        .Cells(iRow, 6) = NMDForm.cmbUnit.Value
        .Cells(iRow, 7) = NMDForm.txtLifespan.Value
        .Cells(iRow, 8) = NMDForm.cmbCategory.Value
```

```
985         .Cells(iRow, 9) = NMDForm.txtMKIp.Value
986         .Cells(iRow, 10) = IIf(NMDForm.optYes.Value = True, "Yes", "No")
987         .Cells(iRow, 11) = NMDForm.txtLength.Value
988         .Cells(iRow, 12) = NMDForm.cmbLengthUnit.Value
989         .Cells(iRow, 13) = NMDForm.txtWidth.Value
990         .Cells(iRow, 14) = NMDForm.cmbWidthUnit.Value
991         .Cells(iRow, 15) = NMDForm.txtHeight.Value
992         .Cells(iRow, 16) = NMDForm.cmbHeightUnit.Value
993         .Cells(iRow, 17) = NMDForm.txtPublicationdate.Value
994         .Cells(iRow, 18) = NMDForm.txtAdjustedon.Value
995         .Cells(iRow, 19) = NMDForm.txtOwner.Value
996         .Cells(iRow, 20) = NMDForm.txtExplaination.Value
997         .Cells(iRow, 21) = NMDForm.cmbClass1.Value
998         .Cells(iRow, 22) = NMDForm.txtNameClass1.Value
999         .Cells(iRow, 23) = NMDForm.cmbClass2.Value
1000         .Cells(iRow, 24) = NMDForm.txtNameClass2.Value
1001         .Cells(iRow, 25) = NMDForm.cmbClass3.Value
1002         .Cells(iRow, 26) = NMDForm.txtNameClass3.Value
1003         .Cells(iRow, 27) = NMDForm.cmbClass4.Value
1004         .Cells(iRow, 28) = NMDForm.txtNameClass4.Value
1005         .Cells(iRow, 29) = NMDForm.cmbClass5.Value
1006         .Cells(iRow, 30) = NMDForm.txtNameClass5.Value
1007         .Cells(iRow, 31) = NMDForm.cmbClass6.Value
1008         .Cells(iRow, 32) = NMDForm.txtNameClass6.Value
1009         .Cells(iRow, 33) = NMDForm.cmbClass7.Value
1010         .Cells(iRow, 34) = NMDForm.txtNameClass7.Value
1011         .Cells(iRow, 35) = NMDForm.cmbClass8.Value
1012         .Cells(iRow, 36) = NMDForm.txtNameClass8.Value
1013         .Cells(iRow, 37) = NMDForm.cmbClass9.Value
1014         .Cells(iRow, 38) = NMDForm.txtNameClass9.Value
1015         .Cells(iRow, 39) = NMDForm.cmbMissingClass1.Value
1016         .Cells(iRow, 40) = NMDForm.txtNameMissingClass1.Value
1017         .Cells(iRow, 41) = NMDForm.cmbMissingClass2.Value
1018         .Cells(iRow, 42) = NMDForm.txtNameMissingClass2.Value
1019         .Cells(iRow, 43) = NMDForm.cmbMissingClass3.Value
1020         .Cells(iRow, 44) = NMDForm.txtNameMissingClass3.Value
1021         .Cells(iRow, 45) = NMDForm.cmbMissingClass4.Value
1022         .Cells(iRow, 46) = NMDForm.txtNameMissingClass4.Value
1023         .Cells(iRow, 47) = NMDForm.cmbMissingClass5.Value
1024         .Cells(iRow, 48) = NMDForm.txtNameMissingClass5.Value
1025         .Cells(iRow, 49) = NMDForm.cmbMissingClass6.Value
1026         .Cells(iRow, 50) = NMDForm.txtNameMissingClass6.Value
1027         .Cells(iRow, 51) = NMDForm.cmbMissingClass7.Value
1028         .Cells(iRow, 52) = NMDForm.txtNameMissingClass7.Value
1029         .Cells(iRow, 53) = NMDForm.cmbMissingClass8.Value
1030         .Cells(iRow, 54) = NMDForm.txtNameMissingClass8.Value
1031         .Cells(iRow, 55) = NMDForm.cmbMissingClass9.Value
1032         .Cells(iRow, 56) = NMDForm.txtNameMissingClass9.Value
1033         .Cells(iRow, 57) = NMDForm.txtcostUnit.Value
1034         .Cells(iRow, 58) = Application.UserName        'add user name
1035         .Cells(iRow, 59) = [Text(Now(), "DD-MM-YYYY HH:MM:SS")]        'add date and time of adjustment
1036     End With
1037
1038End Sub
1039
1040Private Sub SortData()
1041     Dim ws          As Worksheet
1042     Dim lastRow     As Long
1043
1044     Set ws = ThisWorkbook.Sheets("NMD_DATABASE")
1045
1046     ' select the last row with data in column a
1047     lastRow = ws.Cells(ws.Rows.Count, "A").End(xlUp).Row
1048
1049     ' sort on column b and then on column c
1050     With ws.Sort
```

```
        .SortFields.Clear
        .SortFields.Add Key:=ws.Range("B2:B" & lastRow), Order:=xlAscending
        .SortFields.Add Key:=ws.Range("C2:C" & lastRow), Order:=xlAscending
        .SetRange ws.Range("A1:C" & lastRow)
        .Header = xlYes
        .Apply
    End With

End Sub

Sub Show_NMDForm()
    'show the form
    NMDForm.Show
End Sub

Function Selected_List() As Long
    Dim i           As Long

    Selected_List = 0

    For i = 0 To NMDForm.lst_database.ListCount - 1

        If NMDForm.lst_database.Selected(i) = TRUE Then

            Selected_List = i + 1
            Exit For

        End If

    Next i
End Function
```

Appendix 10

VBA Coding of the Project Data entry form in the decision support tool

```
'Base design data entry form
'Stored in Inputform

Private Sub cmdReset_Click()

    'Define the code for the reset button
    Dim msgValue    As VbMsgBoxResult

    msgValue = MsgBox("Do you want To reset the form?", vbYesNo + vbInformation, "Confirmation")

     If msgValue = vbNo Then Exit Sub

     Call Reset_Inputform        'Ensure that the data in the inputform is deleted
     Call UserForm_Initialize        'Ensure that the inputform is initialized

End Sub

Private Sub cmdsave_Click()
    ' Define the code for the save button
    Dim msgValue    As VbMsgBoxResult
    Dim ws          As Worksheet
    Dim wsDatabase  As Worksheet
    Dim lastRow     As Long
    Dim i           As Long
    Dim isDuplicate As Boolean
    Dim envNumber   As String
    Dim rowToUpdate As Long
    Dim Scalingfactor As Double
    Dim isScaledDuplicate As Boolean
    Dim storedScalingFactor As Double
    Dim tolerance   As Double
    Dim isScalable  As Boolean

    ' Set the tolerance for comparison
    tolerance = 0.0001

    ' Check if all required comboboxes are filled
    If Not Completeness_check_Comboboxes() Then
        MsgBox "Please fill in all required comboboxes", vbExclamation
        Exit Sub
    End If

    ' Check if all required textboxes are filled
    If Not Completeness_check_Textboxes() Then
        Exit Sub
    End If

    ' Validate units
    If Not ValidateUnits() Then
        Exit Sub
    End If

    ' Get the values from the textboxes
    envNumber = Me.cmbEDN.Value

    ' Replace comma with dot and convert to double
    Scalingfactor = Val(Replace(Me.txtScalingfactor.Value, ",", "."))

    ' Set the worksheets
    Set ws = ThisWorkbook.Sheets("Input_Table")
    Set wsDatabase = ThisWorkbook.Sheets("NMD_DATABASE")

```

```
    ' Get the last row with data in column G
    lastRow = ws.Cells(ws.Rows.Count, "G").End(xlUp).Row

    ' Initialize the duplicate flags
    isDuplicate = FALSE
    isScaledDuplicate = FALSE

    ' Check if the product is scalable
    isScalable = FALSE
    For i = 2 To wsDatabase.Cells(wsDatabase.Rows.Count, "A").End(xlUp).Row
        If wsDatabase.Cells(i, "A").Value = envNumber Then
            If wsDatabase.Cells(i, "J").Value = "Yes" Then
                isScalable = TRUE
            End If
            Exit For
        End If
    Next i

    ' Loop through column G to check for duplicates
    For i = 2 To lastRow        ' The first row is headers
        If ws.Cells(i, 7).Value = envNumber Then
            storedScalingFactor = Val(Replace(ws.Cells(i, 14).Value, ",", "."))

            ' Set default value to 1 if empty
            If storedScalingFactor = 0 Then storedScalingFactor = 1
            If Scalingfactor = 0 Then Scalingfactor = 1

            If isScalable And Abs(storedScalingFactor - Scalingfactor) >= tolerance Then
                isScaledDuplicate = TRUE
                rowToUpdate = i
                Exit For
            ElseIf Abs(storedScalingFactor - Scalingfactor) < tolerance Then
                isDuplicate = TRUE
                rowToUpdate = i
                Exit For
            End If
        End If
     Next i

    ' If a scaled duplicate is found, ask if the user wants to add the scaled data to the database
    If isScaledDuplicate Then
        msgValue = MsgBox("This data Is already saved in the Database at a different scale, would you Like To add this scaled data To the database?", vbYesNo + vbInformation,
"Confirmation")
        If msgValue = vbNo Then Exit Sub

        ' If "Yes" add a new row with the scaled data
        Call Submit_Inputform

        ' If a duplicate is found, ask if the user wants to update the existing data
    ElseIf isDuplicate Then
        msgValue = MsgBox("This data Is already saved in the Input_Table. Do you want To update the existing data?", vbYesNo + vbInformation, "Confirmation")
        If msgValue = vbNo Then Exit Sub

        ' If "Yes" update the data in the existing row
        Call UpdateRow(ws, rowToUpdate)

        ' If no duplicate is found, ask if the user wants to add the data to the database
    Else
        msgValue = MsgBox("Do you want To save the data?", vbYesNo + vbInformation, "Confirmation")        ' Pop up a message with the question if the person wants to save the
data
        If msgValue = vbNo Then Exit Sub

        ' Add a new row
        Call Submit_Inputform
    End If

```

```
    SortData        ' Sort the data in the database & listbox
    Reset_Inputform        ' Reset the input form
    UserForm_Initialize        ' Initialize the input form

End Sub

Private Sub cmdEdit_Click()

    'Define the code for the edit button
    If Me.cmbProductNameChange.Value = "" Then        'Check if a product is selected to edit
    MsgBox "No product Is selected To edit.", vbOKOnly + vbInformation, "Edit"        'If no product is selected, inform the user that no product is selected to edit
    Exit Sub
End If

' Call the subroutine to fill the form fields with the selected product name
FillFormFields Me.cmbProductNameChange.Value

MsgBox "Please make the required changes And click On the        'Save' button to update", vbOKOnly + vbInformation, "Edit"
End Sub

Private Sub cmdDelete_Click()

    'Define the code for the delete button
    Dim ws          As Worksheet
    Dim lastRow     As Long
    Dim i           As Long
    Dim found       As Boolean

    If Me.cmbProductNameChange.Value = "" Then        'Check if a product is selected to delete
    MsgBox "No product Is selected.", vbOKOnly + vbInformation, "Delete"        'If no product is selected, inform the user that no product is selected to delete
    Exit Sub
End If

Dim response        As VbMsgBoxResult
response = MsgBox("Do you want To delete the selected product from the database?", vbYesNo + vbQuestion, "Confirmation")        'Ensure that the used really want to delete the
data

If response = vbNo Then Exit Sub

' Set the worksheets
Set ws = ThisWorkbook.Sheets("Input_Table")
lastRow = ws.Cells(ws.Rows.Count, "F").End(xlUp).Row
found = FALSE

'Define the data that the user would like to delete in from the database
For i = 2 To lastRow
    If ws.Cells(i, 6).Value = Me.cmbProductNameChange.Value Then        'delete the data from which the name in the cmb productnamechange equals the name in kolom 6 of the
selected row in the database
    ws.Rows(i).Delete
    found = TRUE
    Exit For
End If
Next i

If Not found Then
    MsgBox "Product Not found.", vbExclamation
Else
    Call Reset_Inputform        'reset the input form
    MsgBox "Selected product has been deleted.", vbOKOnly + vbInformation, "Deleted"
End If

Call FillProductNameChange        'ensure that the cmbbox productnamechange is filled
Call SortData        'Sort the data in the database & listbox
Call Reset_Inputform        'reset the input form
Call UserForm_Initialize        'Initialize the input form

```

```
End Sub

Private Sub UserForm_Initialize()

    ' Initialize cmbElementSelection with options
    With Me.cmbElementSelection
        .Clear
        .AddItem "1. Ground, Substructure"
        .AddItem "2. Primary elements, Carcass"
        .AddItem "3. Secondary elements"
        .AddItem "4. Finishes"
        .AddItem "5. Services mainly piped And ducted"
        .AddItem "6. Services mainly electrical"
        .AddItem "7. Fittings"
        .AddItem "9. Terrain"
        .Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
    End With

    ' Initialize cmbScalable with options
    With Me.cmbScalable
        .Clear
        .AddItem "Yes"
        .AddItem "No"
        .Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
        .Value = "No"        'Set default value to "No"
    End With

    ' Initialize cmbLengthUnit with options
    With Me.cmbLengthUnit
        .Clear
        .AddItem "mm"
        .AddItem "cm"
        .AddItem "dm"
        .AddItem "m"
        .Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
    End With

    ' Initialize cmbWidthUnit with options
    With Me.cmbWidthUnit
        .Clear
        .AddItem "mm"
        .AddItem "cm"
        .AddItem "dm"
        .AddItem "m"
        .Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
    End With

    ' Initialize cmbHeightUnit with options
    With Me.cmbHeightUnit
        .Clear
        .AddItem "mm"
        .AddItem "cm"
        .AddItem "dm"
        .AddItem "m"
        .Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
    End With

    ' Lock and disable the specified textboxes
    Me.txtUnit.Locked = TRUE
    Me.txtUnit.Enabled = FALSE
    Me.txtMKIpUnit.Locked = TRUE
    Me.txtMKIpUnit.Enabled = FALSE
    Me.txtMKI.Locked = TRUE
    Me.txtMKI.Enabled = FALSE
    Me.txtMKIscaled.Locked = TRUE
    Me.txtMKIscaled.Enabled = FALSE
```

```
    Me.txtScalingfactor.Locked = TRUE        ' Lock txtScalingfactor by default
    Me.txtcostunit.Locked = TRUE
    Me.txtcostunit.Enabled = FALSE
    Me.txtTotalcosts.Locked = TRUE
    Me.txtTotalcosts.Enabled = FALSE

    ' Disable cmbProductName and cmbEDN initially
    Me.cmbProductName.Enabled = FALSE
    Me.cmbEDN.Enabled = FALSE

    ' Disable txtQuantity and cmbScalable initially
    Me.txtQuantity.Enabled = FALSE
    Me.cmbScalable.Enabled = FALSE

    ' Disable txtQuantity, cmbScalable, and other fields initially
    Me.txtQuantity.Enabled = FALSE
    Me.cmbScalable.Enabled = FALSE
    Me.txtLength.Enabled = FALSE
    Me.txtWidth.Enabled = FALSE
    Me.txtHeight.Enabled = FALSE
    Me.cmbLengthUnit.Enabled = FALSE
    Me.cmbWidthUnit.Enabled = FALSE
    Me.cmbHeightUnit.Enabled = FALSE
    Me.txtcosts.Enabled = FALSE

    ' Fill the combobox with product names
    FillProductNameChange

    ' Fill the listbox with data
    FillListBox

End Sub

Private Sub cmbElementSelection_Change()

    'Ensure that from the cmb ElementSelection options can be selected and that based on the selected option the correct options in cmb ProductName and EDN are selected to be
displayed
    Dim ws          As Worksheet
    Dim i           As Integer
    Dim selectedCode As String
    Dim productCode As String

    ' Clear the cmbProductName combobox
    Me.cmbProductName.Clear

    ' Clear the cmbEDN combobox
    Me.cmbEDN.Clear

    ' Get the selected code from cmbElementSelection
    selectedCode = Left(Me.cmbElementSelection.Value, 1)

    ' Set the worksheet containing the database
    Set ws = ThisWorkbook.Sheets("NMD_DATABASE")

    ' Loop through the database and add matching products to cmbProductName and cmbEDN
    For i = 2 To ws.Cells(ws.Rows.Count, "B").End(xlUp).Row        ' Define that the data in the NMD_DATABASE starts from row 2
        productCode = Left(ws.Cells(i, "B").Value, 1)
        If productCode = selectedCode Then
               Me.cmbProductName.AddItem ws.Cells(i, "D").Value         'if the requirement is set, data from column D from the NMD_DATABASE is shown in the dropdownlist
cmbProductName
            Me.cmbEDN.AddItem ws.Cells(i, "E").Value        'if the requirement is set, data from column E from the NMD_DATABASE is shown in the dropdownlist cmbEDN
        End If
    Next i

    ' Ensure cmbProductName and cmbEDN are dropdown lists
    Me.cmbProductName.Style = fmStyleDropDownList
```

```
    Me.cmbEDN.Style = fmStyleDropDownList

    ' Enable cmbProductName and cmbEDN if cmbElementSelection has a value
    If Me.cmbElementSelection.Value <> "" Then
        Me.cmbProductName.Enabled = TRUE
        Me.cmbEDN.Enabled = TRUE
    Else
        Me.cmbProductName.Enabled = FALSE
        Me.cmbEDN.Enabled = FALSE
    End If
End Sub

Private Sub cmbProductName_Change()
    Debug.Print "cmbProductName_Change triggered"

    'Ensure that when a Product Name is selected, it automatically selects the correct environmental declaration number in the cmbbox "cmbEDN" and loads the data stored in the
NMD_DATABASE
    Dim ws          As Worksheet
    Dim basews      As Worksheet
    Dim i           As Integer
    Dim cellValue   As Double

    ' Set the worksheet containing the database
    Set ws = ThisWorkbook.Sheets("NMD_DATABASE")

    'Set the worksheet containing the project data
    Set basews = ThisWorkbook.Sheets("Overview")

    ' Loop through the database to find the matching EDN value, MKIpUnit value, and Unit value
    For i = 2 To ws.Cells(ws.Rows.Count, "D").End(xlUp).Row        ' Define that the data in the NMD_DATABASE starts from row 2
        If ws.Cells(i, "D").Value = Me.cmbProductName.Value Then
            Me.cmbEDN.Value = ws.Cells(i, "E").Value
            Me.txtMKIpUnit.Value = Format(ws.Cells(i, "I").Value, "#,##0.00")        ' Set the MKIpUnit value with comma as decimal separator
            Me.txtUnit.Value = ws.Cells(i, "F").Value        ' Set the Unit value for the mki
            Me.txtcategory.Value = ws.Cells(i, "H").Value        'Define the category
            Me.txtNLSfB1.Value = ws.Cells(i, "B").Value        'Define the NL-SfB1 digit
            Me.txtNLSfB2.Value = ws.Cells(i, "C").Value        'Define the NL-SfB2 digit
            Me.txtLifespan.Value = ws.Cells(i, "G").Value        'Define the lifespan of the product
            Me.txtcosts.Value = ws.Cells(i, "BE").Value        'Define the costs per unit of the material
            Me.txtcostunit.Value = ws.Cells(i, "F").Value        ' Set the Unit value for the costs

            ' Define the lifespan of the entire building
            cellValue = CDbl(basews.Range("C14").Value)
            Me.txtBuildinglifespan = cellValue

            ' Check if the product is scalable
            If ws.Cells(i, "J").Value = "Yes" Then
                Me.cmbScalable.Enabled = TRUE
                Me.txtScalingfactor.Enabled = TRUE
            Else
                Me.cmbScalable.Enabled = FALSE
                Me.txtScalingfactor.Enabled = FALSE
            End If

            Exit For
        End If
    Next i

    ' Clear txtMKI and txtTotalcosts value
    Me.txtMKI.Value = ""
    Me.txtTotalcosts.Value = ""

    ' Call CalculateMKI & CalculateCosts subroutines
    CalculateMKI
    CalculateCosts

```

```
    ' Check if txtQuantity and cmbScalable should be enabled
    CheckEnableControls

End Sub

Private Sub cmbEDN_Change()
    Debug.Print "cmbEDN_Change triggered"

     'Ensure that when an Environmental declaration number is selected, it automatically selects the correct product name in the cmbbox "cmbProductName" and loads the data
stored in the NMD_DATABASE
    Dim ws          As Worksheet
    Dim basews      As Worksheet
    Dim i           As Integer
    Dim cellValue   As Double

    ' Set the worksheet containing the database
    Set ws = ThisWorkbook.Sheets("NMD_DATABASE")

    'Set the worksheet containing the project data
    Set basews = ThisWorkbook.Sheets("Overview")

    ' Loop through the database to find the matching ProductName value, MKIpUnit value, and Unit value
    For i = 2 To ws.Cells(ws.Rows.Count, "E").End(xlUp).Row        ' Define that the data in the NMD_DATABASE starts from row 2
        If ws.Cells(i, "E").Value = Me.cmbEDN.Value Then
            Me.cmbProductName.Value = ws.Cells(i, "D").Value
            Me.txtMKIpUnit.Value = Format(ws.Cells(i, "I").Value, "#,##0.00")        ' Set the MKIpUnit value with comma as decimal separator
            Me.txtUnit.Value = ws.Cells(i, "F").Value        ' Set the Unit value
            Me.txtcategory.Value = ws.Cells(i, "H").Value        'Define the category
            Me.txtNLSfB1.Value = ws.Cells(i, "B").Value        'Define the NL-SfB1 digit
            Me.txtNLSfB2.Value = ws.Cells(i, "C").Value        'Define the NL-SfB2 digit
            Me.txtLifespan.Value = ws.Cells(i, "G").Value        'Define the lifespan of the product
            Me.txtcostunit.Value = ws.Cells(i, "F").Value        ' Set the Unit value for the costs

            ' Define the lifespan of the entire building
            cellValue = CDbl(basews.Range("C14").Value)
            Me.txtBuildinglifespan = cellValue

            ' Check if the product is scalable
            If ws.Cells(i, "J").Value = "Yes" Then
                Me.cmbScalable.Enabled = TRUE
                Me.txtScalingfactor.Enabled = TRUE
            Else
                Me.cmbScalable.Enabled = FALSE
                Me.txtScalingfactor.Enabled = FALSE
            End If

            Exit For
        End If

        ' Check if txtMKIpUnit contains a valid number
        If IsNumeric(Me.txtMKIpUnit.Value) And Me.txtMKIpUnit.Value <> "" Then
            MKIpUnit = CDbl(Me.txtMKIpUnit.Value)
        Else
            Exit Sub
        End If
    Next i

    ' Clear txtMKI and txtTotalcosts value
    Me.txtMKI.Value = ""
    Me.txtTotalcosts.Value = ""

    ' Call CalculateMKI & CalculateCosts subroutines
    CalculateMKI
    CalculateCosts

    ' Check if txtQuantity and cmbScalable should be enabled
```

```
    CheckEnableControls

End Sub

Private Sub cmbScalable_Change()
    Debug.Print "cmbScalable_Change triggered"

    ' Lock or unlock txtScalingfactor based on the value of cmbScalable
    If Me.cmbScalable.Value = "Yes" Then        'Ensure that when the product is scalable txtscalingfactor is unlocked and enabled
    Me.txtScalingfactor.Locked = FALSE
    Me.txtScalingfactor.Enabled = TRUE
Else
    Me.txtScalingfactor.Locked = TRUE        'Ensure that when the product is not scalable txtscalingfactor keeps locked and will not be enabled
    Me.txtScalingfactor.Enabled = FALSE
    Me.txtScalingfactor.Value = ""        ' Clear the value if not scalable
End If
End Sub

Private Sub cmbProductNameChange_Change()

    'Ensure that that the correct data from the selected product in the ProductNamechange combobox is loaded
    Dim ws          As Worksheet
    Dim lastRow     As Long
    Dim i           As Long
    Dim found       As Boolean

    Set ws = ThisWorkbook.Sheets("Input_Table")
    lastRow = ws.Cells(ws.Rows.Count, "A").End(xlUp).Row
    found = FALSE

    For i = 2 To lastRow
        If ws.Cells(i, 6).Value = Me.cmbProductNameChange.Value Then
            found = TRUE
            Exit For
        End If
    Next i

    If found Then
        ' Highlight the selected product in the listbox
        HighlightListBoxItem Me.cmbProductNameChange.Value
    Else
        MsgBox "Product Not found.", vbExclamation
    End If
End Sub

Private Sub FillProductNameChange()

    'Ensure that the products stored in the Input_Table are selecteable based on the product name in the combobox
    Dim ws          As Worksheet
    Dim lastRow     As Long
    Dim i           As Long

    Set ws = ThisWorkbook.Sheets("Input_Table")
    lastRow = ws.Cells(ws.Rows.Count, "A").End(xlUp).Row

    ' Fill the combobox with product names from the table
    With Me.cmbProductNameChange
        .Clear
        For i = 2 To lastRow        ' Assuming the first row is headers
            If ws.Cells(i, 6).Value <> "" Then        ' Check if the cell is not empty
            .AddItem ws.Cells(i, 6).Value        ' Column 6 contains the product names
        End If
    Next i
End With
End Sub

```

```
Private Sub FillListBox()

    Dim ws          As Worksheet
    Dim lastRow     As Long

    Set ws = ThisWorkbook.Sheets("Input_Table")
    lastRow = ws.Cells(ws.Rows.Count, "A").End(xlUp).Row

    ' Fill the listbox with data from the table
    With Me.lst_Inputdatabase
        .RowSource = ""        ' Clear the listbox by setting RowSource to an empty string
        .ColumnCount = 23
        .ColumnHeads = TRUE
        If lastRow > 1 Then
            .RowSource = "Input_Table!A2:W" & lastRow
        Else
            .RowSource = "Input_Table!A2:W2"
        End If
    End With
End Sub

Private Sub HighlightListBoxItem(productName As String)

    'Ensure that when a user select a product in the productnamechange combobox, the product is highlighted in the list
    Dim i           As Integer

    ' Loop through the items in the listbox
    For i = 0 To Me.lst_Inputdatabase.ListCount - 1
        ' Check if the current row matches the selected product name
        If Me.lst_Inputdatabase.List(i, 5) = productName Then        ' Column 5 is the product name
        ' Select and highlight the row
        Me.lst_Inputdatabase.Selected(i) = TRUE
        Exit For
    End If
Next i
End Sub

Private Sub CheckEnableControls()

    'Define the settings for disabling and locking textboxes and comboboxes
    If Me.cmbProductName.Value <> "" Or Me.cmbEDN.Value <> "" Then
        Me.txtQuantity.Enabled = TRUE
        Me.txtcosts.Locked = FALSE
        Me.txtcosts.Enabled = TRUE

        ' Check if the product is scalable
        Dim ws      As Worksheet
        Set ws = ThisWorkbook.Sheets("NMD_DATABASE")
        Dim i       As Integer
        For i = 2 To ws.Cells(ws.Rows.Count, "D").End(xlUp).Row
            If ws.Cells(i, "D").Value = Me.cmbProductName.Value Or ws.Cells(i, "E").Value = Me.cmbEDN.Value Then
                If ws.Cells(i, "J").Value = "Yes" Then
                    Me.cmbScalable.Enabled = TRUE
                    Me.txtScalingfactor.Enabled = TRUE
                    Me.txtLength.Enabled = TRUE
                    Me.txtWidth.Enabled = TRUE
                    Me.txtHeight.Enabled = TRUE
                    Me.cmbLengthUnit.Enabled = TRUE
                    Me.cmbWidthUnit.Enabled = TRUE
                    Me.cmbHeightUnit.Enabled = TRUE
                Else
                    Me.cmbScalable.Enabled = FALSE
                    Me.txtScalingfactor.Enabled = FALSE
                    Me.cmbScalable.Value = "No"        ' Set cmbScalable to "No" if the product is not scalable
                    Me.txtScalingfactor.Value = ""        ' Clear the value if not scalable
                    Me.txtLength.Enabled = FALSE
```

```
                    Me.txtWidth.Enabled = FALSE
                    Me.txtHeight.Enabled = FALSE
                    Me.cmbLengthUnit.Enabled = FALSE
                    Me.cmbWidthUnit.Enabled = FALSE
                    Me.cmbHeightUnit.Enabled = FALSE
                    Me.txtLength.Value = ""        ' Clear the value if not scalable
                    Me.txtWidth.Value = ""        ' Clear the value if not scalable
                    Me.txtHeight.Value = ""        ' Clear the value if not scalable
                    Me.cmbLengthUnit.Value = ""        ' Clear the value if not scalable
                    Me.cmbWidthUnit.Value = ""        ' Clear the value if not scalable
                    Me.cmbHeightUnit.Value = ""        ' Clear the value if not scalable
                End If
                Exit For
            End If
        Next i
    Else
        Me.txtQuantity.Enabled = FALSE
        Me.txtcosts.Locked = TRUE
        Me.txtcosts.Enabled = FALSE
        Me.cmbScalable.Enabled = FALSE
        Me.txtScalingfactor.Enabled = FALSE
        Me.cmbScalable.Value = "No"        ' Set cmbScalable to "No" if no product is selected
        Me.txtScalingfactor.Value = ""        ' Clear the value if no product is selected
        Me.txtLength.Enabled = FALSE
        Me.txtWidth.Enabled = FALSE
        Me.txtHeight.Enabled = FALSE
        Me.cmbLengthUnit.Enabled = FALSE
        Me.cmbWidthUnit.Enabled = FALSE
        Me.cmbHeightUnit.Enabled = FALSE
        Me.txtLength.Value = ""        ' Clear the value if no product is selected
        Me.txtWidth.Value = ""        ' Clear the value if no product is selected
        Me.txtHeight.Value = ""        ' Clear the value if no product is selected
        Me.cmbLengthUnit.Value = ""        ' Clear the value if no product is selected
        Me.cmbWidthUnit.Value = ""        ' Clear the value if no product is selected
        Me.cmbHeightUnit.Value = ""        ' Clear the value if no product is selected
    End If
End Sub

Private Sub CalculateMKI()

    'Calculation to calculate the MKI and MKIscaled
    Dim MKIpUnit    As Double
    Dim Quantity    As Double
    Dim ProductLifespan As Double
    Dim BuildingLifespan As Double
    Dim MKI         As Double
    Dim NoReplacements As Double

    ' Check if txtMKIpUnit or txtQuantity is empty
    If Me.txtMKIpUnit.Value = "" Or Me.txtQuantity.Value = "" Then
        ' Clear MKI and MKIscaled fields if either input is empty
        Me.txtMKI.Value = ""
        Me.txtMKIscaled.Value = ""
        Exit Sub
    End If

    ' Retrieve values from text boxes
    MKIpUnit = Me.txtMKIpUnit.Value
    Quantity = Me.txtQuantity.Value
    ProductLifespan = Me.txtLifespan.Value
    BuildingLifespan = Me.txtBuildinglifespan.Value

    ' Calculate the number of product replacements during the lifespan of the building
    NoReplacements = BuildingLifespan / ProductLifespan

    ' Ensure NoReplacements is at least 1
```

```
649    If NoReplacements < 1 Then
650        NoReplacements = 1
651    End If
652
653    ' Calculate MKI
654    MKI = MKIpUnit * Quantity * NoReplacements
655
656    ' Set MKI value as currency
657    Me.txtMKI.Value = MKI
658
659    ' Calculate MKIscaled if applicable
660    If Me.cmbScalable.Value = "Yes" And Me.txtScalingfactor.Value <> "" Then
661        Me.txtMKIscaled.Value = MKI * CDbl(Me.txtScalingfactor.Value)
662    Else
663        Me.txtMKIscaled.Value = ""
664    End If
665
666End Sub
667
668Private Sub CalculateCosts()
669
670    'Calculation to calculate the construction costs
671    Dim Costsunit   As Double
672    Dim Quantity    As Double
673    Dim totalcosts  As Double
674
675    ' Check if txtcosts or txtQuantity is empty
676    If Me.txtcosts.Value = "" Or Me.txtQuantity.Value = "" Then
677        ' Clear Totalcosts field if either input is empty
678        Me.txtTotalcosts.Value = ""
679        Exit Sub
680    End If
681
682    ' Retrieve values from text boxes
683    Costsunit = CDbl(Me.txtcosts.Value)
684    Quantity = CDbl(Me.txtQuantity.Value)
685
686    ' Calculate total costs
687    totalcosts = Costsunit * Quantity
688
689    ' Set Totalcosts value as currency
690    Me.txtTotalcosts.Value = totalcosts
691
692End Sub
693
694Private Function ValidateUnits() As Boolean
695
696    ' Validate Length Unit
697    If Me.txtLength.Value <> "" And Me.cmbLengthUnit.Value = "" Then
698        MsgBox "Please enter the unit in which the length of the product Is measured", vbExclamation
699        ValidateUnits = FALSE
700        Exit Function
701    End If
702
703    ' Validate Width Unit
704    If Me.txtWidth.Value <> "" And Me.cmbWidthUnit.Value = "" Then
705        MsgBox "Please enter the unit in which the width of the product Is measured", vbExclamation
706        ValidateUnits = FALSE
707        Exit Function
708    End If
709
710    ' Validate Height Unit
711    If Me.txtHeight.Value <> "" And Me.cmbHeightUnit.Value = "" Then
712        MsgBox "Please enter the unit in which the height of the product Is measured", vbExclamation
713        ValidateUnits = FALSE
714        Exit Function
```

```
    End If

    ValidateUnits = TRUE

End Function

Private Sub txtQuantity_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)

    'Ensure that the data entered in txtQuantity is numeric and has maximal 4 decimal places
    If Me.Visible = FALSE Then Exit Sub        ' Check if the form is being closed

    ' Check if txtQuantity contains a valid number
    If IsNumeric(Me.txtQuantity.Value) And Me.txtQuantity.Value <> "" Then
    Else
        MsgBox "Please enter a number With up To 4 decimal places.", vbExclamation
        Cancel = TRUE
        Exit Sub
    End If

    ' Clear txtMKI and txtTotalcosts value
    Me.txtMKI.Value = ""
    Me.txtTotalcosts.Value = ""

    ' Call CalculateMKI & CalculateCosts subroutines
    CalculateMKI
    CalculateCosts
End Sub

Private Sub txtcosts_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)

    'Ensure that the data entered in txtcosts is a financial value
    Dim userInput   As String
    Dim regex       As Object
    Set regex = CreateObject("VBScript.RegExp")

    userInput = txtcosts.Text

    ' Check if the form is being closed
    If Me.Visible = FALSE Then Exit Sub

    ' Regular expression pattern for currency with 2 decimal places
    regex.Pattern = "^\d+(\,\d{2})?$"
    regex.IgnoreCase = TRUE
    regex.Global = TRUE

    If Not regex.Test(userInput) Then
        MsgBox "Please enter a valid financial value With 2 decimal places (e.g., 123,45).", vbExclamation
        Cancel = TRUE
    End If

    ' Clear txtTotalcosts value
    Me.txtTotalcosts.Value = ""

    ' Call CalculateCosts subroutines
    CalculateCosts
End Sub

Private Sub txtScalingfactor_AfterUpdate()
    ' Ensure the data in txtScalingfactor is a number with up to 4 decimals
    If Me.Visible = FALSE Then Exit Sub        ' Check if the form is being closed

    Dim Scalingfactor As Double
    Dim inputValue  As String
    inputValue = Me.txtScalingfactor.Value

    ' Replace comma with dot if necessary
```

```
    inputValue = Replace(inputValue, ",", ".")

    ' Check if the input value is numeric after replacing the comma
    If IsNumeric(inputValue) Then
        ' Valid input, proceed with further actions
    Else
        MsgBox "Please enter a valid scaling factor With up To 4 decimal places.", vbExclamation
        Me.txtScalingfactor.Value = ""
    End If

    ' Clear txtMKI value
    Me.txtMKI.Value = ""

    ' Call CalculateMKI subroutine
    CalculateMKI
End Sub

Private Sub txtLength_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)

    'Ensure that the data entere in txtlength is entered in the correct way
    Static isHandlingErrorLength As Boolean
    If isHandlingErrorLength Then Exit Sub

    ' Check if the form is being unloaded
    If Me.Visible = FALSE Then Exit Sub

    Dim Length      As String
    Dim regex       As Object
    Set regex = CreateObject("VBScript.RegExp")

    ' Get the value from the textbox
    Length = Me.txtLength.Value

    ' Define the regular expression pattern for a number with up to 4 decimal places
    With regex
        .Pattern = "^\d+(\.\d{1,4})?$"
        .IgnoreCase = TRUE
        .Global = FALSE
    End With

    ' Check if the textbox is not empty and does not match the pattern
    If Length <> "" And Not regex.Test(Length) Then
        isHandlingErrorLength = TRUE
        MsgBox "Please enter a number With up To 4 decimal places.", vbExclamation
        Cancel = TRUE
        isHandlingErrorLength = FALSE
    End If
End Sub

Private Sub txtWidth_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)

    'Ensure that the data entere in txtwidth is entered in the correct way
    Static isHandlingErrorWidth As Boolean
    If isHandlingErrorWidth Then Exit Sub

    ' Check if the form is being unloaded
    If Me.Visible = FALSE Then Exit Sub

    Dim Width       As String
    Dim regex       As Object
    Set regex = CreateObject("VBScript.RegExp")

    ' Get the value from the textbox
    Width = Me.txtWidth.Value

    ' Define the regular expression pattern for a number with up to 4 decimal places
```

```
    With regex
        .Pattern = "^\d+(\.\d{1,4})?$"
        .IgnoreCase = TRUE
        .Global = FALSE
    End With

    ' Check if the textbox is not empty and does not match the pattern
    If Width <> "" And Not regex.Test(Width) Then
        isHandlingErrorWidth = TRUE
        MsgBox "Please enter a number With up To 4 decimal places.", vbExclamation
        Cancel = TRUE
        isHandlingErrorWidth = FALSE
    End If

End Sub

Private Sub txtHeight_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)

    'Ensure that the data entere in txtWidth is entered in the correct way
    Static isHandlingErrorHeight As Boolean
    If isHandlingErrorHeight Then Exit Sub

    ' Check if the form is being unloaded
    If Me.Visible = FALSE Then Exit Sub

    Dim Height      As String
    Dim regex       As Object
    Set regex = CreateObject("VBScript.RegExp")

    ' Get the value from the textbox
    Height = Me.txtHeight.Value

    ' Define the regular expression pattern for a number with up to 4 decimal places
    With regex
        .Pattern = "^\d+(\.\d{1,4})?$"
        .IgnoreCase = TRUE
        .Global = FALSE
    End With

    ' Check if the textbox is not empty and does not match the pattern
    If Height <> "" And Not regex.Test(Height) Then
        isHandlingErrorHeight = TRUE
        MsgBox "Please enter a number With up To 4 decimal places.", vbExclamation
        Cancel = TRUE
        isHandlingErrorHeight = FALSE
    End If

End Sub

Private Function Completeness_check_Textboxes() As Boolean

    'Ensure that all the required textboxes are filled with data
    Dim ctrl        As Control
    Completeness_check_Textboxes = TRUE

    ' Loop through all controls in the form
    For Each ctrl In Me.Controls
        ' Check if the control is a TextBox and not in the excluded list
        If TypeName(ctrl) = "TextBox" Then
            Select Case ctrl.Name
                 Case "txtcategory", "txtNLSfB1", "txtNLSfB2", "txtUnit", "txtMKIpUnit", "txtMKI", "txtLength", "txtWidth", "txtHeight", "txtLifespan", "txtBuildinglifespan",
"txtRowNumber", "txtMKIscaled", "txtScalingfactor"
                    ' Do nothing, these textboxes are excluded
                Case Else
                    ' Check if the TextBox is empty
                    If ctrl.Value = "" Then
```

```
                        MsgBox "Please fill in all required fields.", vbExclamation
                        Completeness_check_Textboxes = FALSE
                        Exit Function
                    End If
            End Select
        End If
    Next ctrl

    ' Additional check for txtScalingfactor based on cmbScalable
    If Me.cmbScalable.Value = "Yes" Then
        If Me.txtScalingfactor.Value = "" Then
            MsgBox "Please indicate the scaling factor.", vbExclamation
            Completeness_check_Textboxes = FALSE
            Exit Function
        End If
    End If

End Function

Private Function Completeness_check_Comboboxes() As Boolean

    'Ensure that all the required comboboxes are filled with data
    Dim ctrl        As Control
    Dim allFilled   As Boolean
    allFilled = TRUE

    For Each ctrl In Me.Controls
        If TypeName(ctrl) = "ComboBox" Then
            Select Case ctrl.Name        'Do not control the following comboboxes
                Case "cmbProductNameChange", "cmbLengthUnit", "cmbWidthUnit", "cmbHeightUnit"
                    ' Do nothing for these comboboxes
                Case Else
                    If ctrl.Value = "" Then        'check for all the other comboboxes if they are empty
                    allFilled = FALSE        'when they are empty the boolean is false
                    Exit For
                End If
        End Select
    End If
Next ctrl

Completeness_check_Comboboxes = allFilled

End Function

Private Sub UpdateRow(ws As Worksheet, rowToUpdate As Long)
    ' Ensure that after adjusting data in the forms that the data that is stored in the database at row i is updated correctly
    Dim convertedScalingFactor As String
    Dim Scalingfactor As Double
    Dim MKIpUnit    As Double
    Dim MKI         As Double
    Dim MKIscaled   As Double
    Dim totalcosts  As Double
    Dim Quantity    As Double

    convertedScalingFactor = Replace(Me.txtScalingfactor.Value, ",", ".")
    Quantity = Val(Replace(Inputform.txtQuantity.Value, ",", "."))
    MKIpUnit = Val(Replace(Inputform.txtMKIpUnit.Value, ",", "."))
    MKI = Val(Replace(Inputform.txtMKI.Value, ",", "."))
    MKIscaled = Val(Replace(Inputform.txtMKIscaled.Value, ",", "."))
    totalcosts = Val(Replace(Inputform.txtTotalcosts.Value, ",", "."))

    ' Update the row with the new data
    ws.Cells(rowToUpdate, 2).Value = Me.cmbElementSelection.Value
    ws.Cells(rowToUpdate, 3).Value = Me.txtNLSfB1.Value
    ws.Cells(rowToUpdate, 4).Value = Me.txtNLSfB2.Value
    ws.Cells(rowToUpdate, 5).Value = Me.txtcategory.Value
```

```
978    ws.Cells(rowToUpdate, 6).Value = Me.cmbProductName.Value
979    ws.Cells(rowToUpdate, 7).Value = Me.cmbEDN.Value
980    ws.Cells(rowToUpdate, 8).Value = Quantity
981    ws.Cells(rowToUpdate, 9).Value = Me.txtUnit.Value
982    ws.Cells(rowToUpdate, 10).Value = MKIpUnit
983    ws.Cells(rowToUpdate, 11).Value = MKI
984    ws.Cells(rowToUpdate, 12).Value = MKIscaled
985    ws.Cells(rowToUpdate, 13).Value = Me.cmbScalable.Value
986    ws.Cells(rowToUpdate, 14).Value = convertedScalingFactor        ' Store the converted scaling factor
987    ws.Cells(rowToUpdate, 15).Value = totalcosts
988    ws.Cells(rowToUpdate, 16).Value = Me.txtLength.Value
989    ws.Cells(rowToUpdate, 17).Value = Me.cmbLengthUnit.Value
990    ws.Cells(rowToUpdate, 18).Value = Me.txtWidth.Value
991    ws.Cells(rowToUpdate, 19).Value = Me.cmbWidthUnit.Value
992    ws.Cells(rowToUpdate, 20).Value = Me.txtHeight.Value
993    ws.Cells(rowToUpdate, 21).Value = Me.cmbHeightUnit.Value
994    ws.Cells(rowToUpdate, 22).Value = Me.txtLifespan.Value
995    ws.Cells(rowToUpdate, 23).Value = Me.txtBuildinglifespan.Value
996
997    MsgBox "Data successfully updated!", vbInformation
998
999End Sub
1000
1001Private Sub SortData()
1002
1003    'Ensure that the data that is stored in the database is sorted
1004    Dim ws          As Worksheet
1005    Dim lastRow     As Long
1006
1007    Set ws = ThisWorkbook.Sheets("Input_Table")
1008
1009    ' Select the last row with data in column A
1010    lastRow = ws.Cells(ws.Rows.Count, "A").End(xlUp).Row
1011
1012    ' Sort on column B, then on column C, then on column D, and finally on column G
1013    With ws.Sort
1014        .SortFields.Clear
1015        .SortFields.Add Key:=ws.Range("B2:B" & lastRow), Order:=xlAscending        ' First sort the data in the database in ascending order by the data stored in column B
1016        .SortFields.Add Key:=ws.Range("C2:C" & lastRow), Order:=xlAscending        ' Next sort the data in the database in ascending order by the data stored in column C
1017        .SortFields.Add Key:=ws.Range("D2:D" & lastRow), Order:=xlAscending        ' Next sort the data in the database in ascending order by the data stored in column D
1018        .SortFields.Add Key:=ws.Range("G2:G" & lastRow), Order:=xlAscending        ' Finally sort the data in the database in ascending order by the stored in column G
1019        .SetRange ws.Range("A1:Y" & lastRow)
1020        .Header = xlYes
1021        .Apply
1022    End With
1023
1024End Sub
1025
1026Private Sub FillFormFields(productName As String)
1027
1028    'Ensure that the fields in the Inputform are filled with the correct data from the NMD_DATABASE
1029    Dim ws          As Worksheet
1030    Dim lastRow     As Long
1031    Dim i           As Long
1032    Dim found       As Boolean
1033    Dim elementValue As String
1034    Dim itemExists  As Boolean
1035    Dim j           As Long
1036    Dim loadedScalingFactor As String
1037    Dim loadedTotalCosts As String
1038    Dim loadedQuantity As String
1039
1040    Set ws = ThisWorkbook.Sheets("Input_Table")
1041    lastRow = ws.Cells(ws.Rows.Count, "F").End(xlUp).Row
1042    found = FALSE
1043
```

```
    For i = 2 To lastRow
        If ws.Cells(i, 6).Value = productName Then
            ' Populate the fields with the data from the selected row
            Me.txtRowNumber.Value = i

            ' Get the value for cmbElementSelection
            elementValue = ws.Cells(i, 2).Value

            ' Check if the value exists in the combobox
            itemExists = FALSE
            For j = 0 To Me.cmbElementSelection.ListCount - 1
                If Me.cmbElementSelection.List(j) = elementValue Then
                    itemExists = TRUE
                    Exit For
                End If
            Next j

            ' Add the value to the combobox if it doesn't exist
            If Not itemExists Then
                Me.cmbElementSelection.AddItem elementValue
            End If

            ' Set the value of the combobox
            Me.cmbElementSelection.Value = elementValue

            Me.txtNLSfB1.Value = ws.Cells(i, 3).Value
            Me.txtNLSfB2.Value = ws.Cells(i, 4).Value
            Me.txtcategory.Value = ws.Cells(i, 5).Value
            Me.cmbProductName.Value = ws.Cells(i, 6).Value
            Me.cmbEDN.Value = ws.Cells(i, 7).Value

            Me.txtUnit.Value = ws.Cells(i, 9).Value
            Me.txtMKIpUnit.Value = ws.Cells(i, 10).Value
            Me.txtMKI.Value = ws.Cells(i, 11).Value
            Me.txtMKIscaled.Value = ws.Cells(i, 12).Value
            Me.cmbScalable.Value = ws.Cells(i, 13).Value

            ' Load the value from cells i,8; i,14 & i 15 and convert it
            loadedQuantity = ws.Cells(i, 8).Value
            loadedScalingFactor = ws.Cells(i, 14).Value
            loadedTotalCosts = ws.Cells(i, 15).Value
            ' Replace periods with commas
            Me.txtQuantity.Value = Replace(loadedQuantity, ".", ",")
            Me.txtScalingfactor.Value = Replace(loadedScalingFactor, ".", ",")
            Me.txtTotalcosts.Value = Replace(loadedTotalCosts, ".", ",")

            Me.txtLength.Value = ws.Cells(i, 16).Value
            Me.cmbLengthUnit.Value = ws.Cells(i, 17).Value
            Me.txtWidth.Value = ws.Cells(i, 18).Value
            Me.cmbWidthUnit.Value = ws.Cells(i, 19).Value
            Me.txtHeight.Value = ws.Cells(i, 20).Value
            Me.cmbHeightUnit.Value = ws.Cells(i, 21).Value
            Me.txtLifespan.Value = ws.Cells(i, 22).Value
            Me.txtBuildinglifespan.Value = ws.Cells(i, 23).Value

            Me.txtcosts = loadedTotalCosts / loadedQuantity

            found = TRUE
            Exit For
        End If
    Next i

    If Not found Then
        MsgBox "Product Not found.", vbExclamation
    End If
End Sub
```

```
1110
1111'Stored in module 2
1112
1113Sub Show_Inputform()
1114    'show the form
1115    Inputform.Show
1116End Sub
1117
1118Sub Reset_Inputform()
1119
1120    Dim skipBeforeUpdate As Boolean
1121    skipBeforeUpdate = TRUE
1122    Debug.Print "Reset_Inputform called"
1123
1124    Dim iRow        As Long
1125
1126    iRow = [Counta(Input_Table!A:A)]        ' identifying the last row of the database
1127
1128    With Inputform
1129        ' Reset the input data
1130        .cmbElementSelection.Clear
1131        .cmbProductName.Clear
1132        .cmbEDN.Clear
1133        .txtQuantity.Value = ""
1134        .txtUnit.Value = ""
1135        .txtMKIpUnit.Value = ""
1136        .txtMKI.Value = ""
1137        .cmbScalable.Clear
1138        .txtScalingfactor.Value = ""
1139        Debug.Print "txtScalingfactor cleared. Value: " & .txtScalingfactor.Value
1140        .txtMKIscaled.Value = ""
1141        .cmbProductNameChange.Clear
1142
1143        .txtcategory.Value = ""
1144        .txtNLSfB1.Value = ""
1145        .txtNLSfB2.Value = ""
1146        .txtRowNumber.Value = ""
1147        .txtLifespan.Value = ""
1148        .txtBuildinglifespan.Value = ""
1149        .txtTotalcosts.Value = ""
1150
1151        .txtLength.Value = ""
1152        .txtWidth.Value = ""
1153        .txtHeight.Value = ""
1154        .cmbLengthUnit.Clear
1155        .cmbWidthUnit.Clear
1156        .cmbHeightUnit.Clear
1157
1158        ' Define the number of columns of the database and state that the database has headers
1159        .lst_Inputdatabase.ColumnCount = 25
1160        .lst_Inputdatabase.ColumnHeads = TRUE
1161
1162        If iRow > 1 Then
1163            .lst_Inputdatabase.RowSource = "Input_Table!A2:X" & iRow        ' X is the 24th column
1164        Else
1165            .lst_Inputdatabase.RowSource = "Input_Table!A2:X2"
1166        End If
1167    End With
1168
1169    skipBeforeUpdate = FALSE
1170End Sub
1171Sub Submit_Inputform()
1172
1173    'Submit the form
1174    Dim sh          As Worksheet
1175    Dim iRow        As Long
```

```
    Dim Scalingfactor As Double
    Dim convertedScalingFactor As String
    Dim MKIpUnit    As Double
    Dim MKI         As Double
    Dim MKIscaled   As Double
    Dim totalcosts  As Double
    Dim Quantity    As Double

    Set sh = ThisWorkbook.Sheets("Input_Table")

    If Inputform.txtRowNumber.Value = "" Then
        iRow = Application.WorksheetFunction.CountA(sh.Range("A:A")) + 1
    Else
        iRow = Inputform.txtRowNumber.Value
    End If

    ' Convert MKI and MKIscaled to numbers
    Quantity = Val(Replace(Inputform.txtQuantity.Value, ",", "."))
    MKIpUnit = Val(Replace(Inputform.txtMKIpUnit.Value, ",", "."))
    MKI = Val(Inputform.txtMKI.Value)
    MKIscaled = Val(Replace(Inputform.txtMKIscaled.Value, ",", "."))
    totalcosts = Val(Replace(Inputform.txtTotalcosts.Value, ",", "."))

    ' Define the column(s) of the database in which the information needs to be stored
    With sh
        .Cells(iRow, 1) = iRow - 1
        .Cells(iRow, 2) = Inputform.cmbElementSelection.Value
        .Cells(iRow, 3) = Inputform.txtNLSfB1.Value
        .Cells(iRow, 4) = Inputform.txtNLSfB2.Value
        .Cells(iRow, 5) = Inputform.txtcategory.Value
        .Cells(iRow, 6) = Inputform.cmbProductName.Value
        .Cells(iRow, 7) = Inputform.cmbEDN.Value
        .Cells(iRow, 8) = Quantity        ' Store quantity as a number
        .Cells(iRow, 9) = Inputform.txtUnit.Value
        .Cells(iRow, 10) = MKIpUnit        'Store the MKIpUnit as number
        .Cells(iRow, 11) = MKI        ' Store MKI as a number
        .Cells(iRow, 12) = MKIscaled        ' Store MKIscaled as a number
        .Cells(iRow, 13) = Inputform.cmbScalable.Value

        ' Replace commas with periods in txtScalingfactor
        convertedScalingFactor = Replace(Inputform.txtScalingfactor.Value, ",", ".")
        .Cells(iRow, 14) = convertedScalingFactor        ' Store the converted scaling factor

        .Cells(iRow, 15) = totalcosts        ' Store Totalcosts as a number

        .Cells(iRow, 16) = Inputform.txtLength.Value
        .Cells(iRow, 17) = Inputform.cmbLengthUnit.Value
        .Cells(iRow, 18) = Inputform.txtWidth.Value
        .Cells(iRow, 19) = Inputform.cmbWidthUnit.Value
        .Cells(iRow, 20) = Inputform.txtHeight.Value
        .Cells(iRow, 21) = Inputform.cmbHeightUnit.Value
        .Cells(iRow, 22) = Inputform.txtLifespan.Value
        .Cells(iRow, 23) = Inputform.txtBuildinglifespan.Value
        .Cells(iRow, 24) = Application.UserName        'add user name
        .Cells(iRow, 25) = [Text(Now(), "DD-MM-YYYY HH:MM:SS")]        'add date and time of adjustment
    End With

End Sub
```

Appendix 11

VBA Coding of the Shared Facilities entry form in the decision support tool

```
'Shared facilities design data entry form
'Stored in Inputform

Private Sub cmdReset_Click()

    'Define the code for the reset button
    Dim msgValue    As VbMsgBoxResult

    msgValue = MsgBox("Do you want To reset the form?", vbYesNo + vbInformation, "Confirmation")

     If msgValue = vbNo Then Exit Sub

     Call Reset_SharedFacility        'Ensure that the data in the inputform is deleted
     Call UserForm_Initialize        'Ensure that the inputform is initialized

End Sub

Private Sub cmdsave_Click()

    'Define the code for the save button
    Dim msgValue    As VbMsgBoxResult
    Dim ws          As Worksheet
    Dim wsDatabase  As Worksheet
    Dim wsSF        As Worksheet
    Dim lastRow     As Long
    Dim i           As Long
    Dim isDuplicate As Boolean
    Dim envNumber   As String
    Dim rowToUpdate As Long
    Dim Scalingfactor As Double
    Dim isScaledDuplicate As Boolean
    Dim storedScalingFactor As Double
    Dim tolerance   As Double
    Dim isScalable  As Boolean

    ' Set the tolerance for comparison
    tolerance = 0.0001

    ' Check if all required comboboxes are filled
    If Not Completeness_check_Comboboxes1() Then
        MsgBox "Please fill in all required comboboxes", vbExclamation
        Exit Sub
    End If

    ' Check if all required textboxes are filled
    If Not Completeness_check_Textboxes1() Then
        Exit Sub
    End If

    ' Validate units
    If Not ValidateUnits1() Then
        Exit Sub
    End If

    ' Get the values from the textboxes
    envNumber = Me.cmbEDN1.Value

    ' Replace comma with dot and convert to double
    Scalingfactor = Val(Replace(Me.txtScalingfactor1.Value, ",", "."))

    ' Set the worksheets
    Set ws = ThisWorkbook.Sheets("Input_Table")
```

```
    Set wsDatabase = ThisWorkbook.Sheets("NMD_DATABASE")
    Set wsSF = ThisWorkbook.Sheets("DATA_SF")

    ' Get the last row with data in column G
    lastRow = ws.Cells(ws.Rows.Count, "G").End(xlUp).Row

    ' Initialize the duplicate flags
    isDuplicate = FALSE
    isScaledDuplicate = FALSE

    ' Check if the product is scalable
    isScalable = FALSE
    For i = 2 To wsDatabase.Cells(wsDatabase.Rows.Count, "A").End(xlUp).Row
        If wsDatabase.Cells(i, "A").Value = envNumber Then
            If wsDatabase.Cells(i, "J").Value = "Yes" Then
                isScalable = TRUE
            End If
            Exit For
        End If
    Next i

    ' Loop through DATA_SF worksheet to check for duplicates
    For i = 2 To wsSF.Cells(wsSF.Rows.Count, "G").End(xlUp).Row
        If wsSF.Cells(i, 7).Value = envNumber Then
            storedScalingFactor = Val(Replace(wsSF.Cells(i, 14).Value, ",", "."))

            ' Set default value to 1 if empty
            If storedScalingFactor = 0 Then storedScalingFactor = 1
            If Scalingfactor = 0 Then Scalingfactor = 1

            If isScalable And Abs(storedScalingFactor - Scalingfactor) >= tolerance Then
                isScaledDuplicate = TRUE
                rowToUpdate = i
                Exit For
            ElseIf Abs(storedScalingFactor - Scalingfactor) < tolerance Then
                isDuplicate = TRUE
                rowToUpdate = i
                 Exit For
             End If
        End If
    Next i

    ' If a scaled duplicate is found, ask if the user wants to add the scaled data to the database
    If isScaledDuplicate Then
        msgValue = MsgBox("This data Is already saved in the Database at a different scale, would you Like To add this scaled data To the database?", vbYesNo + vbInformation,
"Confirmation")
        If msgValue = vbNo Then Exit Sub

        ' If "Yes" add a new row with the scaled data
        Call Submit_Sharedfacility

        ' If a duplicate is found, ask if the user wants to update the existing data
    ElseIf isDuplicate Then
        msgValue = MsgBox("This data Is already saved in the DATA_SF. Do you want To update the existing data?", vbYesNo + vbInformation, "Confirmation")
        If msgValue = vbNo Then Exit Sub

        ' If "Yes" Update the data in the existing row
        Call UpdateRow1(wsSF, rowToUpdate)

        ' If no duplicate is found, ask if the user wants to add the data to the database
    Else
        msgValue = MsgBox("Do you want To save the data?", vbYesNo + vbInformation, "Confirmation")
        If msgValue = vbNo Then Exit Sub

        ' Add a new row
        Call Submit_Sharedfacility
```

```
    End If

    SortAndInsertRows1        ' Sort the data in the database & listbox
    Reset_SharedFacility        ' Reset the input form
    UserForm_Initialize        ' Initialize the input form
End Sub

Private Sub cmdEdit_Click()

    'Define the code for the edit button
    If Me.cmbProductNameChange1.Value = "" Then        'Check if a product is selected to edit
    MsgBox "No product Is selected To edit.", vbOKOnly + vbInformation, "Edit"        'If no product is selected, inform the user that no product is selected to edit
    Exit Sub
End If

' Call the subroutine to fill the form fields with the selected product name
FillFormFields1 Me.cmbProductNameChange1.Value

MsgBox "Please make the required changes And click On the        'Save' button to update", vbOKOnly + vbInformation, "Edit"
End Sub

Private Sub cmdDelete_Click()

    'Define the code for the delete button
    Dim wsSF        As Worksheet
    Dim lastRow     As Long
    Dim i           As Long
    Dim found       As Boolean
    Dim rowsToDelete As Collection
    Dim rowNum      As Variant

    If Me.cmbProductNameChange1.Value = "" Then        'Check if a product is selected to delete
    MsgBox "No product Is selected.", vbOKOnly + vbInformation, "Delete"        'If no product is selected, inform the user that no product is selected to delete
    Exit Sub
End If

' Load the form fields with the selected product name
FillFormFields1 Me.cmbProductNameChange1.Value

Dim response        As VbMsgBoxResult
response = MsgBox("Do you want To delete the selected product from the database?", vbYesNo + vbQuestion, "Confirmation")        'Ensure that the user really wants to delete
the data

If response = vbNo Then
    Call Reset_SharedFacility       'reset the input form if the user chooses not to delete
    Call UserForm_Initialize       'Initialize the input form
    Call FillProductNameChange1       'ensure that the cmbbox productnamechange1 is filled
    Exit Sub
End If

' Set the worksheet
Set wsSF = ThisWorkbook.Sheets("DATA_SF")
found = FALSE
Set rowsToDelete = New Collection

' Get the last row in the worksheet
lastRow = wsSF.Cells(wsSF.Rows.Count, 1).End(xlUp).Row

'Define the data that the user would like to delete from the database
For i = lastRow To 2 Step -1

    If wsSF.Cells(i, 7).Value = Me.cmbProductNameChange1.Value And _
       wsSF.Cells(i, 2).Value = Me.CmbSharedFacility.Value And _
       wsSF.Cells(i, 3).Value = Me.cmbAdded.Value Then        'delete the data from which the name in the cmb productnamechange1 equals the name in column 7 of the selected
row in the database, the name in cmgsharedfacility equals the name of column 2 and the name in cmbadded equals the name in column 3

```

```
    rowsToDelete.Add i
    found = TRUE
End If
Next i

' Delete the marked rows
If found Then
    For Each rowNum In rowsToDelete
        wsSF.Rows(rowNum).Delete
    Next rowNum
    MsgBox "Selected product has been deleted.", vbOKOnly + vbInformation, "Deleted"
Else
    MsgBox "Product Not found.", vbExclamation
End If

Call FillProductNameChange1        'ensure that the cmbbox productnamechange1 is filled
Call SortAndInsertRows1        'Sort the data in the database & listbox
Call Reset_SharedFacility        'reset the input form
Call UserForm_Initialize        'Initialize the input form

End Sub

Private Sub UserForm_Initialize()

    ' Initialize cmbSharedFacility with options
    With Me.CmbSharedFacility
        .Clear
        .AddItem "Garden/terrace"
        .AddItem "Kitchen"
        .AddItem "Living room"
        .AddItem "Bike parking"
        .AddItem "Laundry room"
        .AddItem "Workspace"
        .Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
    End With

    ' Initialize cmbAdded with options
    With Me.cmbAdded
        .Clear
        .AddItem "Added"
        .AddItem "Removed"
        .Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
    End With

    ' Initialize cmbElementSelection with options
    With Me.cmbElementSelection1
        .Clear
        .AddItem "1. Ground, Substructure"
        .AddItem "2. Primary elements, Carcass"
        .AddItem "3. Secondary elements"
        .AddItem "4. Finishes"
        .AddItem "5. Services mainly piped And ducted"
        .AddItem "6. Services mainly electrical"
        .AddItem "7. Fittings"
        .AddItem "9. Terrain"
        .Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
    End With

    ' Initialize cmbScalable with options
    With Me.cmbScalable1
        .Clear
        .AddItem "Yes"
        .AddItem "No"
        .Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
        .Value = "No"        'Set default value to "No"
    End With
```

```
258
259     ' Initialize cmbLengthUnit with options
260     With Me.cmbLengthUnit1
261         .Clear
262         .AddItem "mm"
263         .AddItem "cm"
264         .AddItem "dm"
265         .AddItem "m"
266         .Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
267     End With
268
269     ' Initialize cmbWidthUnit with options
270     With Me.cmbWidthUnit1
271         .Clear
272         .AddItem "mm"
273         .AddItem "cm"
274         .AddItem "dm"
275         .AddItem "m"
276         .Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
277     End With
278
279     ' Initialize cmbHeightUnit with options
280     With Me.cmbHeightUnit1
281         .Clear
282         .AddItem "mm"
283         .AddItem "cm"
284         .AddItem "dm"
285         .AddItem "m"
286         .Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
287     End With
288
289     ' Lock and disable the specified textboxes
290     Me.txtUnit1.Locked = TRUE
291     Me.txtUnit1.Enabled = FALSE
292     Me.txtMKIpUnit1.Locked = TRUE
293     Me.txtMKIpUnit1.Enabled = FALSE
294     Me.txtMKI1.Locked = TRUE
295     Me.txtMKI1.Enabled = FALSE
296     Me.txtMKIscaled1.Locked = TRUE
297     Me.txtMKIscaled1.Enabled = FALSE
298     Me.txtScalingfactor1.Locked = TRUE        ' Lock txtScalingfactor by default
299     Me.txtcostunit1.Locked = TRUE
300     Me.txtcostunit1.Enabled = FALSE
301     Me.txtTotalcosts1.Locked = TRUE
302     Me.txtTotalcosts1.Enabled = FALSE
303
304     ' Disable cmbProductName and cmbEDN initially
305     Me.cmbProductName1.Enabled = FALSE
306     Me.cmbEDN1.Enabled = FALSE
307
308     ' Disable txtQuantity and cmbScalable initially
309     Me.txtQuantity1.Enabled = FALSE
310     Me.cmbScalable1.Enabled = FALSE
311
312     ' Disable txtQuantity, cmbScalable, and other fields initially
313     Me.txtQuantity1.Enabled = FALSE
314     Me.cmbScalable1.Enabled = FALSE
315     Me.txtLength1.Enabled = FALSE
316     Me.txtWidth1.Enabled = FALSE
317     Me.txtHeight1.Enabled = FALSE
318     Me.cmbLengthUnit1.Enabled = FALSE
319     Me.cmbWidthUnit1.Enabled = FALSE
320     Me.cmbHeightUnit1.Enabled = FALSE
321     Me.txtcosts1.Enabled = FALSE
322
323     ' Fill the combobox with product names
```

```
    FillProductNameChange1

    ' Fill the listbox with data
    FillListBox1

End Sub
Private Sub FillProductNameChange1()

    'Ensure that the products stored in the DATA_SF worksheet are selectable based on the product name in the combobox
    Dim ws          As Worksheet
    Dim lastRow     As Long
    Dim i           As Long

    Set ws = ThisWorkbook.Sheets("DATA_SF")
    lastRow = ws.Cells(ws.Rows.Count, 1).End(xlUp).Row

    ' Fill the combobox with product names from the worksheet
    With Me.cmbProductNameChange1
        .Clear
        For i = 2 To lastRow        ' Assuming the first row in the worksheet is headers
            If ws.Cells(i, 7).Value <> "" Then        ' Check if the cell is not empty
            .AddItem ws.Cells(i, 7).Value        ' Column 7 contains the product names
        End If
    Next i
End With
End Sub

Private Sub FillListBox1()

    Dim ws          As Worksheet
    Dim lastRow     As Long
    Dim i           As Long

    Set ws = ThisWorkbook.Sheets("DATA_SF")
    lastRow = ws.Cells(ws.Rows.Count, 1).End(xlUp).Row

    ' Fill the listbox with data from the worksheet
    With Me.lst_Inputdatabase1
        .RowSource = ""        ' Clear the listbox by setting RowSource to an empty string
        .ColumnCount = 20
        .ColumnHeads = TRUE
        If lastRow > 1 Then
            .RowSource = "DATA_SF!A2:T" & lastRow
        Else
            ' Voeg een lege rij toe als er geen data is
            .AddItem " "
            For i = 1 To 19
                .List(0, i) = " "
            Next i
        End If
    End With
End Sub

Private Function Completeness_check_Comboboxes1() As Boolean

    'Ensure that all the required comboboxes are filled with data
    Dim ctrl        As Control
    Dim allFilled   As Boolean
    allFilled = TRUE

    For Each ctrl In Me.Controls
        If TypeName(ctrl) = "ComboBox" Then
            Select Case ctrl.Name        'Do not control the following comboboxes
                Case "cmbProductNameChange1", "cmbLengthUnit1", "cmbWidthUnit1", "cmbHeightUnit1"
                    ' Do nothing for these comboboxes
                Case Else
```

```
                    If ctrl.Value = "" Then        'check for all the other comboboxes if they are empty
                    allFilled = FALSE        'when they are empty the boolean is false
                    Exit For
                End If
        End Select
    End If
Next ctrl

Completeness_check_Comboboxes1 = allFilled

End Function

Private Function Completeness_check_Textboxes1() As Boolean

    'Ensure that all the required textboxes are filled with data
    Dim ctrl        As Control
    Completeness_check_Textboxes1 = TRUE

    ' Loop through all controls in the form
    For Each ctrl In Me.Controls
        ' Check if the control is a TextBox and not in the excluded list
        If TypeName(ctrl) = "TextBox" Then
            Select Case ctrl.Name
                     Case "txtNlsfb11", "txtNlsfb21", "txtUnit", "txtQuantity", "txtUnit1", "txtMKIpUnit", "txtMKIpUnit1", "txtMKI", "txtMKI1", "txtLength1", "txtWidth1",
"txtHeight1", "txtLifespan1", "txtBuildinglifespan1", "txtRowNumber1", "txtMKIscaled1", "txtTotalcosts1", "txtcostunit1", "txtScalingfactor1"
                    ' Do nothing, these textboxes are excluded
                Case Else
                    ' Check if the TextBox is empty
                    If ctrl.Value = "" Then
                        MsgBox "Please fill in all required fields.", vbExclamation
                        ctrl.SetFocus        ' Select the empty TextBox
                        Completeness_check_Textboxes1 = FALSE
                        Exit Function
                    End If
            End Select
        End If
    Next ctrl

    ' Additional check for txtScalingfactor based on cmbScalable
    If Me.cmbScalable1.Value = "Yes" Then
        If Me.txtScalingfactor1.Value = "" Then
            MsgBox "Please indicate the scaling factor.", vbExclamation
            Me.txtScalingfactor1.SetFocus        ' Select the txtScalingfactor1 TextBox
            Completeness_check_Textboxes1 = FALSE
            Exit Function
        End If
    End If

End Function

Private Function ValidateUnits1() As Boolean

    ' Validate Length Unit
    If Me.txtLength1.Value <> "" And Me.cmbLengthUnit1.Value = "" Then
        MsgBox "Please enter the unit in which the length of the product Is measured", vbExclamation
        ValidateUnits1 = FALSE
        Exit Function
    End If

    ' Validate Width Unit
    If Me.txtWidth1.Value <> "" And Me.cmbWidthUnit1.Value = "" Then
        MsgBox "Please enter the unit in which the width of the product Is measured", vbExclamation
        ValidateUnits1 = FALSE
        Exit Function
    End If

```

```
    ' Validate Height Unit
    If Me.txtHeight1.Value <> "" And Me.cmbHeightUnit1.Value = "" Then
        MsgBox "Please enter the unit in which the height of the product Is measured", vbExclamation
        ValidateUnits1 = FALSE
        Exit Function
    End If

    ValidateUnits1 = TRUE

End Function

Private Sub UpdateRow1(ws As Worksheet, rowToUpdate As Long)

    'Ensure that after adjusting data in the forms that the data that is stored in the database at row i is updated correctly
    Dim convertedScalingFactor As String
    Dim MKI1        As Double
    Dim MKIscaled1  As Double
    Dim totalcosts1 As Double
    Dim Quantity1   As Double
    Dim convertedScalingFactor1 As Double
    Dim MKIpUnit1   As Double

    Set sh = ThisWorkbook.Sheets("DATA_SF")

    If Sharedfacility.txtRowNumber1.Value = "" Then
        iRow = Application.WorksheetFunction.CountA(sh.Range("A:A")) + 1
    Else
        iRow = Sharedfacility.txtRowNumber1.Value
    End If

    Quantity1 = Val(Replace(Sharedfacility.txtQuantity1.Value, ",", "."))
    MKIpUnit1 = Val(Replace(Sharedfacility.txtMKIpUnit1.Value, ",", "."))
    MKI1 = Val(Replace(Sharedfacility.txtMKI1.Value, ",", "."))
    MKIscaled1 = Val(Replace(Sharedfacility.txtMKIscaled1.Value, ",", "."))
    totalcosts1 = Val(Replace(Sharedfacility.txtTotalcosts1.Value, ",", "."))
    convertedScalingFactor1 = Val(Replace(Sharedfacility.txtScalingfactor1.Value, ",", "."))

    ' Update the row with the new data
    With ws
        .Cells(rowToUpdate, 2).Value = Me.CmbSharedFacility.Value
        .Cells(rowToUpdate, 3).Value = Me.cmbAdded.Value
        .Cells(rowToUpdate, 4).Value = Me.cmbElementSelection1.Value
        .Cells(rowToUpdate, 5).Value = Me.txtNlsfb11.Value
        .Cells(rowToUpdate, 6).Value = Me.txtNlsfb21.Value
        .Cells(rowToUpdate, 7).Value = Me.cmbProductName1.Value
        .Cells(rowToUpdate, 8).Value = Me.cmbEDN1.Value
        .Cells(rowToUpdate, 9).Value = Quantity1
        .Cells(rowToUpdate, 10).Value = Me.txtUnit1.Value
        .Cells(rowToUpdate, 11).Value = MKIpUnit1
        .Cells(rowToUpdate, 12).Value = MKI1
        .Cells(rowToUpdate, 13).Value = MKIscaled1
        .Cells(rowToUpdate, 14).Value = Me.cmbScalable1.Value
        .Cells(rowToUpdate, 15).Value = convertedScalingFactor        ' Store the converted scaling factor
        .Cells(rowToUpdate, 16).Value = totalcosts1
        .Cells(rowToUpdate, 17).Value = Me.txtLifespan1.Value
        .Cells(rowToUpdate, 18).Value = Me.txtBuildinglifespan1.Value
    End With

    MsgBox "Data successfully updated!", vbInformation

End Sub

Sub SortAndInsertRows1()
    Dim ws          As Worksheet
    Dim lastRow     As Long

```

```
    ' Reference to the worksheet
    Set ws = ThisWorkbook.Sheets("DATA_SF")

    ' Determine the last row with data
    lastRow = ws.Cells(ws.Rows.Count, "A").End(xlUp).Row

    ' Sort by Column B and then by Column C
    ws.Sort.SortFields.Clear
    ws.Sort.SortFields.Add Key:=ws.Range("B2:B" & lastRow), Order:=xlAscending
    ws.Sort.SortFields.Add Key:=ws.Range("C2:C" & lastRow), Order:=xlAscending
    ws.Sort.SortFields.Add Key:=ws.Range("D2:D" & lastRow), Order:=xlAscending
    ws.Sort.SortFields.Add Key:=ws.Range("G2:G" & lastRow), Order:=xlAscending
    With ws.Sort
        .SetRange ws.Range("A1:T" & lastRow)
        .Header = xlYes
        .MatchCase = FALSE
        .Orientation = xlTopToBottom
        .SortMethod = xlPinYin
        .Apply
    End With
End Sub

Private Sub cmbElementSelection1_Change()

    'Ensure that from the cmb ElementSelection1 options can be selected and that based on the selected option the correct options in cmb ProductName and EDN are selected to be displayed
    Dim ws          As Worksheet
    Dim i           As Integer
    Dim selectedCode As String
    Dim productCode As String

    ' Clear the cmbProductName1 combobox
    Me.cmbProductName1.Clear

    ' Clear the cmbEDN1 combobox
    Me.cmbEDN1.Clear

    ' Get the selected code from cmbElementSelection1
    selectedCode = Left(Me.cmbElementSelection1.Value, 1)

    ' Set the worksheet containing the database
    Set ws = ThisWorkbook.Sheets("NMD_DATABASE")

    ' Loop through the database and add matching products to cmbProductName1 and cmbEDN1
    For i = 2 To ws.Cells(ws.Rows.Count, "B").End(xlUp).Row        ' Define that the data in the NMD_DATABASE starts from row 2
        productCode = Left(ws.Cells(i, "B").Value, 1)
        If productCode = selectedCode Then
              Me.cmbProductName1.AddItem ws.Cells(i, "D").Value         'if the requirement is set, data from column D from the NMD_DATABASE is shown in the dropdownlist cmbProductName1
            Me.cmbEDN1.AddItem ws.Cells(i, "E").Value        'if the requirement is set, data from column E from the NMD_DATABASE is shown in the dropdownlist cmbEDN1
        End If
    Next i

    ' Ensure cmbProductName1 and cmbEDN1 are dropdown lists
    Me.cmbProductName1.Style = fmStyleDropDownList
    Me.cmbEDN1.Style = fmStyleDropDownList

    ' Enable cmbProductName and cmbEDN if cmbElementSelection has a value
    If Me.cmbElementSelection1.Value <> "" Then
        Me.cmbProductName1.Enabled = TRUE
        Me.cmbEDN1.Enabled = TRUE
    Else
        Me.cmbProductName1.Enabled = FALSE
        Me.cmbEDN1.Enabled = FALSE
    End If
End Sub
```

```
585
586Private Sub cmbProductName1_Change()
587
588    'Ensure that when a Product Name is selected, it automatically selects the correct environmental declaration number in the cmbbox "cmbEDN" and loads the data stored in the
NMD_DATABASE
589    Dim ws          As Worksheet
590    Dim basews      As Worksheet
591    Dim i           As Integer
592    Dim cellValue   As Double
593
594    ' Set the worksheet containing the databases
595    Set ws = ThisWorkbook.Sheets("NMD_DATABASE")
596
597    'Set the worksheet containing the project data
598    Set basews = ThisWorkbook.Sheets("Overview")
599
600    ' Loop through the database to find the matching EDN value, MKIpUnit value, and Unit value
601    For i = 2 To ws.Cells(ws.Rows.Count, "D").End(xlUp).Row        ' Define that the data in the NMD_DATABASE starts from row 2
602        If ws.Cells(i, "D").Value = Me.cmbProductName1.Value Then
603            Me.cmbEDN1.Value = ws.Cells(i, "E").Value
604            Me.txtMKIpUnit1.Value = Format(ws.Cells(i, "I").Value, "#,##0.00")        ' Set the MKIpUnit value with comma as decimal separator
605            Me.txtUnit1.Value = ws.Cells(i, "F").Value        ' Set the Unit value for the mki
606            Me.txtNlsfb11.Value = ws.Cells(i, "B").Value        'Define the NL-SfB1 digit
607            Me.txtNlsfb21.Value = ws.Cells(i, "C").Value        'Define the NL-SfB2 digit
608            Me.txtLifespan1.Value = ws.Cells(i, "G").Value        'Define the lifespan of the product
609            Me.txtcosts1.Value = ws.Cells(i, "BE").Value        'Define the costs per unit of the material
610            Me.txtcostunit1.Value = ws.Cells(i, "F").Value        ' Set the Unit value for the costs
611
612            ' Define the lifespan of the entire building
613            cellValue = CDbl(basews.Range("C14").Value)
614            Me.txtBuildinglifespan1 = cellValue
615
616            ' Check if the product is scalable
617            If ws.Cells(i, "J").Value = "Yes" Then
618                Me.cmbScalable1.Enabled = TRUE
619                Me.txtScalingfactor1.Enabled = TRUE
620            Else
621                Me.cmbScalable1.Enabled = FALSE
622                Me.txtScalingfactor1.Enabled = FALSE
623            End If
624
625            Exit For
626        End If
627    Next i
628
629    ' Clear txtMKI and txtTotalcosts value
630    Me.txtMKI1.Value = ""
631    Me.txtTotalcosts1.Value = ""
632
633    ' Call CalculateMKI & CalculateCosts subroutines
634    CalculateMKI1
635    CalculateCosts1
636
637    ' Check if txtQuantity and cmbScalable should be enabled
638    CheckEnableControls1
639
640End Sub
641
642Private Sub cmbEDN1_Change()
643
644     'Ensure that when an Environmental declaration number is selected, it automatically selects the correct product name in the cmbbox "cmbProductName" and loads the data
stored in the NMD_DATABASE
645    Dim ws          As Worksheet
646    Dim basews      As Worksheet
647    Dim i           As Integer
648    Dim cellValue   As Double
```

```
649
650     ' Set the worksheet containing the databases
651     Set ws = ThisWorkbook.Sheets("NMD_DATABASE")
652
653     'Set the worksheet containing the project data
654     Set basews = ThisWorkbook.Sheets("Overview")
655
656     ' Loop through the database to find the matching ProductName value, MKIpUnit value, and Unit value
657     For i = 2 To ws.Cells(ws.Rows.Count, "E").End(xlUp).Row        ' Define that the data in the NMD_DATABASE starts from row 2
658         If ws.Cells(i, "E").Value = Me.cmbEDN1.Value Then
659             Me.cmbProductName1.Value = ws.Cells(i, "D").Value
660             Me.txtMKIpUnit1.Value = Format(ws.Cells(i, "I").Value, "#,##0.00")        ' Set the MKIpUnit value with comma as decimal separator
661             Me.txtUnit1.Value = ws.Cells(i, "F").Value        ' Set the Unit value
662             Me.txtNlsfb11.Value = ws.Cells(i, "B").Value        'Define the NL-SfB1 digit
663             Me.txtNlsfb21.Value = ws.Cells(i, "C").Value        'Define the NL-SfB2 digit
664             Me.txtLifespan1.Value = ws.Cells(i, "G").Value        'Define the lifespan of the product
665             Me.txtcosts1.Value = ws.Cells(i, "BE").Value        'Define the costs per unit of the material
666             Me.txtcostunit1.Value = ws.Cells(i, "F").Value        ' Set the Unit value for the costs
667
668             ' Define the lifespan of the entire building
669             cellValue = CDbl(basews.Range("C14").Value)
670             Me.txtBuildinglifespan1 = cellValue
671
672             ' Check if the product is scalable
673             If ws.Cells(i, "J").Value = "Yes" Then
674                 Me.cmbScalable1.Enabled = TRUE
675                 Me.txtScalingfactor1.Enabled = TRUE
676             Else
677                 Me.cmbScalable1.Enabled = FALSE
678                 Me.txtScalingfactor1.Enabled = FALSE
679             End If
680
681             Exit For
682         End If
683     Next i
684
685     ' Clear txtMKI and txtTotalcosts value
686     Me.txtMKI1.Value = ""
687     Me.txtTotalcosts1.Value = ""
688
689     ' Call CalculateMKI & CalculateCosts subroutines
690     CalculateMKI1
691     CalculateCosts1
692
693     ' Check if txtQuantity and cmbScalable should be enabled
694     CheckEnableControls1
695
696End Sub
697
698Private Sub FillFormFields1(productName As String)
699
700     'Ensure that the fields in the Inputform are filled with the correct data from the NMD_DATABASE
701     Dim ws          As Worksheet
702     Dim lastRow     As Long
703     Dim i           As Long
704     Dim found       As Boolean
705     Dim elementValue As String
706     Dim itemExists  As Boolean
707     Dim j           As Long
708     Dim loadedScalingFactor As String
709     Dim loadedTotalCosts1 As String
710     Dim loadedQuantity1 As String
711
712     Set ws = ThisWorkbook.Sheets("DATA_SF")
713     lastRow = ws.Cells(ws.Rows.Count, "F").End(xlUp).Row
714     found = FALSE
```

```
715
716    For i = 2 To lastRow
717        If ws.Cells(i, 7).Value = productName Then
718            ' Populate the fields with the data from the selected row
719            Me.txtRowNumber1.Value = i
720
721            ' Get the value for cmbElementSelection
722            elementValue = ws.Cells(i, 4).Value
723
724            ' Check if the value exists in the combobox
725            itemExists = FALSE
726            For j = 0 To Me.cmbElementSelection1.ListCount - 1
727                If Me.cmbElementSelection1.List(j) = elementValue Then
728                    itemExists = TRUE
729                    Exit For
730                End If
731            Next j
732
733            ' Add the value to the combobox if it doesn't exist
734            If Not itemExists Then
735                Me.cmbElementSelection1.AddItem elementValue
736            End If
737
738            ' Set the value of the combobox
739            Me.cmbElementSelection1.Value = elementValue
740
741            Me.CmbSharedFacility.Value = ws.Cells(i, 2).Value
742            Me.cmbAdded.Value = ws.Cells(i, 3).Value
743            Me.txtNlsfb11.Value = ws.Cells(i, 5).Value
744            Me.txtNlsfb21.Value = ws.Cells(i, 6).Value
745            Me.cmbProductName1.Value = ws.Cells(i, 7).Value
746            Me.cmbEDN1.Value = ws.Cells(i, 8).Value
747
748            Me.txtUnit1.Value = ws.Cells(i, 10).Value
749            Me.txtMKIpUnit1.Value = ws.Cells(i, 11).Value
750            Me.txtMKI1.Value = ws.Cells(i, 12).Value
751            Me.txtMKIscaled1.Value = ws.Cells(i, 13).Value
752            Me.cmbScalable1.Value = ws.Cells(i, 14).Value
753
754            ' Load the value from cell i,15 and convert it
755            loadedQuantity1 = ws.Cells(i, 9).Value
756            loadedScalingFactor = ws.Cells(i, 15).Value
757            loadedTotalCosts1 = ws.Cells(i, 16).Value
758            ' Replace periods with commas
759            Me.txtQuantity1.Value = Replace(loadedQuantity1, ".", ",")
760            Me.txtScalingfactor1.Value = Replace(loadedScalingFactor, ".", ",")
761            Me.txtTotalcosts1.Value = Replace(loadedTotalCosts1, ".", ",")
762
763            Me.txtLifespan1.Value = ws.Cells(i, 17).Value
764            Me.txtBuildinglifespan1.Value = ws.Cells(i, 18).Value
765
766            Me.txtcosts1 = loadedTotalCosts1 / loadedQuantity1
767
768            found = TRUE
769            Exit For
770        End If
771    Next i
772
773    If Not found Then
774        MsgBox "Product Not found.", vbExclamation
775    End If
776End Sub
777
778Private Sub cmbScalable1_Change()
779
780    ' Lock or unlock txtScalingfactor1 based on the value of cmbScalable
```

```
    If Me.cmbScalable1.Value = "Yes" Then        'Ensure that when the product is scalable txtscalingfactor1 is unlocked and enabled
    Me.txtScalingfactor1.Locked = FALSE
    Me.txtScalingfactor1.Enabled = TRUE
Else
    Me.txtScalingfactor1.Locked = TRUE        'Ensure that when the product is not scalable txtscalingfactor1 keeps locked and will not be enabled
    Me.txtScalingfactor1.Enabled = FALSE
    Me.txtScalingfactor1.Value = ""        ' Clear the value if not scalable
End If
End Sub

Private Sub cmbProductNameChange1_Change()

    'Ensure that that the correct data from the selected product in the ProductNamechange1 combobox is loaded
    Dim ws          As Worksheet
    Dim lastRow     As Long
    Dim i           As Long
    Dim found       As Boolean

    Set ws = ThisWorkbook.Sheets("DATA_SF")
    lastRow = ws.Cells(ws.Rows.Count, "A").End(xlUp).Row
    found = FALSE

    For i = 2 To lastRow
        If ws.Cells(i, 7).Value = Me.cmbProductNameChange1.Value Then
            found = TRUE
            Exit For
        End If
    Next i

    If found Then
        ' Highlight the selected product in the listbox
        HighlightListBoxItem Me.cmbProductNameChange1.Value
    Else
        MsgBox "Product Not found.", vbExclamation
    End If
End Sub

Private Sub HighlightListBoxItem(productName As String)

    'Ensure that when a user select a product in the productnamechange combobox, the product is highlighted in the list
    Dim i           As Integer

    ' Loop through the items in the listbox
    For i = 0 To Me.lst_Inputdatabase1.ListCount - 1
        ' Check if the current row matches the selected product name
        If Me.lst_Inputdatabase1.List(i, 6) = productName Then        ' Column 6 is the product name
        ' Select and highlight the row
        Me.lst_Inputdatabase1.Selected(i) = TRUE
        Exit For
    End If
Next i
End Sub

Private Sub CheckEnableControls1()

    'Define the settings for disabling and locking textboxes and comboboxes
    If Me.cmbProductName1.Value <> "" Or Me.cmbEDN1.Value <> "" Then
        Me.txtQuantity1.Enabled = TRUE
        Me.txtcosts1.Locked = FALSE
        Me.txtcosts1.Enabled = TRUE

        ' Check if the product is scalable
        Dim ws      As Worksheet
        Set ws = ThisWorkbook.Sheets("NMD_DATABASE")
        Dim i       As Integer
        For i = 2 To ws.Cells(ws.Rows.Count, "D").End(xlUp).Row
```

```
            If ws.Cells(i, "D").Value = Me.cmbProductName1.Value Or ws.Cells(i, "E").Value = Me.cmbEDN1.Value Then
                If ws.Cells(i, "J").Value = "Yes" Then
                    Me.cmbScalable1.Enabled = TRUE
                    Me.txtScalingfactor1.Enabled = TRUE
                    Me.txtLength1.Enabled = TRUE
                    Me.txtWidth1.Enabled = TRUE
                    Me.txtHeight1.Enabled = TRUE
                    Me.cmbLengthUnit1.Enabled = TRUE
                    Me.cmbWidthUnit1.Enabled = TRUE
                    Me.cmbHeightUnit1.Enabled = TRUE
                Else
                    Me.cmbScalable1.Enabled = FALSE
                    Me.txtScalingfactor1.Enabled = FALSE
                    Me.cmbScalable1.Value = "No"        ' Set cmbScalable to "No" if the product is not scalable
                    Me.txtScalingfactor1.Value = ""        ' Clear the value if not scalable
                    Me.txtLength1.Enabled = FALSE
                    Me.txtWidth1.Enabled = FALSE
                    Me.txtHeight1.Enabled = FALSE
                    Me.cmbLengthUnit1.Enabled = FALSE
                    Me.cmbWidthUnit1.Enabled = FALSE
                    Me.cmbHeightUnit1.Enabled = FALSE
                    Me.txtLength1.Value = ""        ' Clear the value if not scalable
                    Me.txtWidth1.Value = ""        ' Clear the value if not scalable
                    Me.txtHeight1.Value = ""        ' Clear the value if not scalable
                    Me.cmbLengthUnit1.Value = ""        ' Clear the value if not scalable
                    Me.cmbWidthUnit1.Value = ""        ' Clear the value if not scalable
                    Me.cmbHeightUnit1.Value = ""        ' Clear the value if not scalable
                End If
                Exit For
            End If
        Next i
    Else
        Me.txtQuantity1.Enabled = FALSE
        Me.txtcosts1.Locked = TRUE
        Me.txtcosts1.Enabled = FALSE
        Me.cmbScalable1.Enabled = FALSE
        Me.txtScalingfactor1.Enabled = FALSE
        Me.cmbScalable1.Value = "No"        ' Set cmbScalable to "No" if no product is selected
        Me.txtScalingfactor1.Value = ""        ' Clear the value if no product is selected
        Me.txtLength1.Enabled = FALSE
        Me.txtWidth1.Enabled = FALSE
        Me.txtHeight1.Enabled = FALSE
        Me.cmbLengthUnit1.Enabled = FALSE
        Me.cmbWidthUnit1.Enabled = FALSE
        Me.cmbHeightUnit1.Enabled = FALSE
        Me.txtLength1.Value = ""        ' Clear the value if no product is selected
        Me.txtWidth1.Value = ""        ' Clear the value if no product is selected
        Me.txtHeight1.Value = ""        ' Clear the value if no product is selected
        Me.cmbLengthUnit1.Value = ""        ' Clear the value if no product is selected
        Me.cmbWidthUnit1.Value = ""        ' Clear the value if no product is selected
        Me.cmbHeightUnit1.Value = ""        ' Clear the value if no product is selected
    End If
End Sub

Private Sub CalculateMKI1()

    'Calculation to calculate the MKI1 and MKIscaled1
    Dim MKIpUnit    As Double
    Dim Quantity    As Double
    Dim ProductLifespan As Double
    Dim BuildingLifespan As Double
    Dim MKI         As Double
    Dim NoReplacements As Double

    ' Check if txtMKIpUnit1 or txtQuantity1 is empty
    If Me.txtMKIpUnit1.Value = "" Or Me.txtQuantity1.Value = "" Then
```

```
        ' Clear MKI and MKIscaled fields if either input is empty
        Me.txtMKI1.Value = ""
        Me.txtMKIscaled1.Value = ""
        Exit Sub
    End If

    ' Retrieve values from text boxes
    MKIpUnit = Me.txtMKIpUnit1.Value
    Quantity = Me.txtQuantity1.Value
    ProductLifespan = Me.txtLifespan1.Value
    BuildingLifespan = Me.txtBuildinglifespan1.Value

    ' Calculate the number of product replacements during the lifespan of the building
    NoReplacements = BuildingLifespan / ProductLifespan

    ' Ensure NoReplacements is at least 1
    If NoReplacements < 1 Then
        NoReplacements = 1
    End If

    ' Calculate MKI
    MKI = MKIpUnit * Quantity * NoReplacements

    ' Set MKI value
    Me.txtMKI1.Value = MKI

    ' Calculate MKIscaled if applicable
    If Me.cmbScalable1.Value = "Yes" And Me.txtScalingfactor1.Value <> "" Then
        Me.txtMKIscaled1.Value = MKI * CDbl(Me.txtScalingfactor1.Value)
    Else
        Me.txtMKIscaled1.Value = ""
    End If

End Sub

Private Sub CalculateCosts1()

    'Calculation to calculate the construction costs
    Dim Costsunit   As Double
    Dim Quantity    As Double
    Dim totalcosts  As Double

    ' Check if txtcosts1 or txtQuantity1 is empty
    If Me.txtcosts1.Value = "" Or Me.txtQuantity1.Value = "" Then
        ' Clear Totalcosts field if either input is empty
        Me.txtTotalcosts1.Value = ""
        Exit Sub
    End If

    ' Retrieve values from text boxes
    Costsunit = Me.txtcosts1.Value
    Quantity = Me.txtQuantity1.Value

    ' Calculate total costs
    totalcosts = Costsunit * Quantity

    ' Set Totalcosts value as currency
    Me.txtTotalcosts1.Value = totalcosts

End Sub

Private Sub txtQuantity1_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)

    'Ensure that the data entered in txtQuantity1 is numeric and has maximal 4 decimal places
    If Me.Visible = FALSE Then Exit Sub        ' Check if the form is being closed

```

```
    ' Check if txtQuantity contains a valid number
    If IsNumeric(Me.txtQuantity1.Value) And Me.txtQuantity1.Value <> "" Then
    Else
        MsgBox "Please enter a number With up To 4 decimal places.", vbExclamation
        Cancel = TRUE
        Exit Sub
    End If

    ' Clear txtMKI1 and txtTotalcosts1 value
    Me.txtMKI1.Value = ""
    Me.txtTotalcosts1.Value = ""

    ' Call CalculateMKI1 & CalculateCosts1 subroutines
    CalculateMKI1
    CalculateCosts1
End Sub

Private Sub txtcosts1_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)

    'Ensure that the data entered in txtcosts is a financial value
    Dim userInput   As String
     Dim regex       As Object
     Set regex = CreateObject("VBScript.RegExp")

     userInput = txtcosts1.Text

     ' Check if the form is being closed
     If Me.Visible = FALSE Then Exit Sub

     ' Regular expression pattern for currency with 2 decimal places
     regex.Pattern = "^\d+(\,\d{2})?$"
     regex.IgnoreCase = TRUE
     regex.Global = TRUE

     If Not regex.Test(userInput) Then
         MsgBox "Please enter a valid financial value With 2 decimal places (e.g., 123,45).", vbExclamation
         Cancel = TRUE
     End If

     ' Clear txtMKI1 and txtTotalcosts1 value
     Me.txtMKI1.Value = ""
     Me.txtTotalcosts1.Value = ""

     ' Call CalculateMKI1 & CalculateCosts1 subroutines
     CalculateMKI1
     CalculateCosts1
End Sub

Private Sub txtScalingfactor_AfterUpdate()
     ' Ensure the data in txtScalingfactor is a number with up to 4 decimals
     If Me.Visible = FALSE Then Exit Sub        ' Check if the form is being closed

     Dim Scalingfactor As Double
     Dim inputValue  As String
     inputValue = Me.txtScalingfactor.Value

     ' Replace comma with dot if necessary
     inputValue = Replace(inputValue, ",", ".")

     ' Check if the input value is numeric after replacing the comma
     If IsNumeric(inputValue) Then
         ' Valid input, proceed with further actions
     Else
         MsgBox "Please enter a valid scaling factor With up To 4 decimal places.", vbExclamation
         Me.txtScalingfactor.Value = ""
     End If
```

```
1045
1046    ' Clear txtMKI value
1047    Me.txtMKI.Value = ""
1048
1049    ' Call CalculateMKI subroutine
1050    CalculateMKI
1051End Sub
1052Private Sub txtLength1_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)
1053
1054    'Ensure that the data entere in txtlength is entered in the correct way
1055    Static isHandlingErrorLength As Boolean
1056    If isHandlingErrorLength Then Exit Sub
1057
1058    ' Check if the form is being unloaded
1059    If Me.Visible = FALSE Then Exit Sub
1060
1061    Dim Length      As String
1062    Dim regex       As Object
1063    Set regex = CreateObject("VBScript.RegExp")
1064
1065    ' Get the value from the textbox
1066    Length = Me.txtLength1.Value
1067
1068    ' Define the regular expression pattern for a number with up to 4 decimal places
1069    With regex
1070        .Pattern = "^\d+(\.\d{1,4})?$"
1071        .IgnoreCase = TRUE
1072        .Global = FALSE
1073    End With
1074
1075    ' Check if the textbox is not empty and does not match the pattern
1076    If Length <> "" And Not regex.Test(Length) Then
1077        isHandlingErrorLength = TRUE
1078        MsgBox "Please enter a number With up To 4 decimal places.", vbExclamation
1079        Cancel = TRUE
1080        isHandlingErrorLength = FALSE
1081    End If
1082End Sub
1083
1084Private Sub txtWidth1_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)
1085
1086    'Ensure that the data entere in txtwidth is entered in the correct way
1087    Static isHandlingErrorWidth As Boolean
1088    If isHandlingErrorWidth Then Exit Sub
1089
1090    ' Check if the form is being unloaded
1091    If Me.Visible = FALSE Then Exit Sub
1092
1093    Dim Width       As String
1094    Dim regex       As Object
1095    Set regex = CreateObject("VBScript.RegExp")
1096
1097    ' Get the value from the textbox
1098    Width = Me.txtWidth1.Value
1099
1100    ' Define the regular expression pattern for a number with up to 4 decimal places
1101    With regex
1102        .Pattern = "^\d+(\.\d{1,4})?$"
1103        .IgnoreCase = TRUE
1104        .Global = FALSE
1105    End With
1106
1107    ' Check if the textbox is not empty and does not match the pattern
1108    If Width <> "" And Not regex.Test(Width) Then
1109        isHandlingErrorWidth = TRUE
1110        MsgBox "Please enter a number With up To 4 decimal places.", vbExclamation
```

```
        Cancel = TRUE
        isHandlingErrorWidth = FALSE
    End If

End Sub

Private Sub txtHeight1_BeforeUpdate(ByVal Cancel As MSForms.ReturnBoolean)

    'Ensure that the data entere in txtWidth is entered in the correct way
    Static isHandlingErrorHeight As Boolean
    If isHandlingErrorHeight Then Exit Sub

    ' Check if the form is being unloaded
    If Me.Visible = FALSE Then Exit Sub

    Dim Height      As String
    Dim regex       As Object
    Set regex = CreateObject("VBScript.RegExp")

    ' Get the value from the textbox
    Height = Me.txtHeight1.Value

    ' Define the regular expression pattern for a number with up to 4 decimal places
    With regex
        .Pattern = "^\d+(\.\d{1,4})?$"
        .IgnoreCase = TRUE
        .Global = FALSE
    End With

    ' Check if the textbox is not empty and does not match the pattern
    If Height <> "" And Not regex.Test(Height) Then
        isHandlingErrorHeight = TRUE
        MsgBox "Please enter a number With up To 4 decimal places.", vbExclamation
        Cancel = TRUE
        isHandlingErrorHeight = FALSE
    End If

End Sub

'Stored in module 3

Sub Reset_SharedFacility()

    Dim ws          As Worksheet
    Dim lastRow     As Long
    Dim i           As Long

    Set ws = ThisWorkbook.Sheets("DATA_SF")
    lastRow = ws.Cells(ws.Rows.Count, 1).End(xlUp).Row

    With Sharedfacility

        'reset the input data
        .CmbSharedFacility.Clear
        .cmbAdded.Clear
        .cmbElementSelection1.Clear
        .cmbProductName1.Clear
        .cmbEDN1.Clear
        .txtQuantity1.Value = ""
        .txtUnit1.Value = ""
        .txtMKIpUnit1.Value = ""
        .txtMKI1.Value = ""
        .cmbScalable1.Clear
        .txtScalingfactor1.Value = ""
        .txtMKIscaled1.Value = ""
        .txtLength1.Value = ""
```

```
1177        .cmbLengthUnit1.Clear
1178        .txtWidth1.Value = ""
1179        .cmbWidthUnit1.Clear
1180        .txtHeight1.Value = ""
1181        .cmbHeightUnit1.Clear
1182        .txtcosts1.Value = ""
1183        .txtcostunit1.Value = ""
1184        .txtTotalcosts1.Value = ""
1185        .txtRowNumber1.Value = ""
1186        .cmbProductNameChange1.Clear
1187
1188        'Add items to the different combo boxes
1189        ' Add items to the combobox "CmbSharedFacility"
1190        .CmbSharedFacility.AddItem "Garden/terrace"
1191        .CmbSharedFacility.AddItem "Kitchen"
1192        .CmbSharedFacility.AddItem "Living room"
1193        .CmbSharedFacility.AddItem "Bike parking"
1194        .CmbSharedFacility.AddItem "Laundry room"
1195        .CmbSharedFacility.AddItem "Workspace"
1196        .CmbSharedFacility.Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
1197
1198        ' Add items to the combobox "cmbAdded"
1199        .cmbAdded.AddItem "Added"
1200        .cmbAdded.AddItem "Removed"
1201        .cmbAdded.Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
1202
1203        ' Add items to the combobox "cmbElementSelection1"
1204        .cmbElementSelection1.AddItem "1. Ground, Substructure"
1205        .cmbElementSelection1.AddItem "2. Primary elements, Carcass"
1206        .cmbElementSelection1.AddItem "3. Secondary elements"
1207        .cmbElementSelection1.AddItem "4. Finishes"
1208        .cmbElementSelection1.AddItem "5. Services mainly piped And ducted"
1209        .cmbElementSelection1.AddItem "6. Services mainly electrical"
1210        .cmbElementSelection1.AddItem "7. Fittings"
1211        .cmbElementSelection1.AddItem "9. Terrain"
1212        .cmbElementSelection1.Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
1213
1214        ' Add items to the combobox "cmbScalable1"
1215        .cmbScalable1.AddItem "Yes"
1216        .cmbScalable1.AddItem "No"
1217        .cmbScalable1.Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
1218        .cmbScalable1.Value = "No"        'Set default value to "No"
1219
1220        ' Add items to the combobox "cmbLengthUnit1"
1221        .cmbLengthUnit1.AddItem "mm"
1222        .cmbLengthUnit1.AddItem "cm"
1223        .cmbLengthUnit1.AddItem "dm"
1224        .cmbLengthUnit1.AddItem "m"
1225        .cmbLengthUnit1.Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
1226
1227        ' Add items to the combobox "cmbWidthUnit1"
1228        .cmbWidthUnit1.AddItem "mm"
1229        .cmbWidthUnit1.AddItem "cm"
1230        .cmbWidthUnit1.AddItem "dm"
1231        .cmbWidthUnit1.AddItem "m"
1232        .cmbWidthUnit1.Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
1233
1234        ' Add items to the combobox "cmbHeightUnit1"
1235        .cmbHeightUnit1.AddItem "mm"
1236        .cmbHeightUnit1.AddItem "cm"
1237        .cmbHeightUnit1.AddItem "dm"
1238        .cmbHeightUnit1.AddItem "m"
1239        .cmbHeightUnit1.Style = fmStyleDropDownList        'Ensure that only predefined options can be selected
1240
1241        'Define the number of columns of the database and state that the database has headers
1242        .lst_Inputdatabase1.ColumnCount = 19
```

```
        .lst_Inputdatabase1.ColumnHeads = TRUE

        If lastRow > 1 Then
            .lst_Inputdatabase1.RowSource = "DATA_SF!A2:T" & lastRow
        Else
            .lst_Inputdatabase1.RowSource = "DATA_SF!A1:T1"
        End If

    End With

End Sub

Sub Submit_Sharedfacility()

    'Submit the form
    Dim sh          As Worksheet
    Dim iRow        As Long
    Dim MKI1        As Double
    Dim MKIscaled1  As Double
    Dim totalcosts1 As Double
    Dim Quantity1   As Double
    Dim convertedScalingFactor1 As Double
    Dim MKIpUnit1   As Double

    Set sh = ThisWorkbook.Sheets("DATA_SF")

    If Sharedfacility.txtRowNumber1.Value = "" Then
        iRow = Application.WorksheetFunction.CountA(sh.Range("A:A")) + 1
    Else
        iRow = Sharedfacility.txtRowNumber1.Value
    End If

    ' Convert MKI and MKIscaled to numbers
    Quantity1 = Val(Replace(Sharedfacility.txtQuantity1.Value, ",", "."))
    MKIpUnit1 = Val(Replace(Sharedfacility.txtMKIpUnit1.Value, ",", "."))
    MKI1 = Val(Replace(Sharedfacility.txtMKI1.Value, ",", "."))
    MKIscaled1 = Val(Replace(Sharedfacility.txtMKIscaled1.Value, ",", "."))
    totalcosts1 = Val(Replace(Sharedfacility.txtTotalcosts1.Value, ",", "."))
    convertedScalingFactor1 = Val(Replace(Sharedfacility.txtScalingfactor1.Value, ",", "."))

    ' Define the column(s) of the database in which the information needs to be stored
    With sh
        .Cells(iRow, 1) = iRow - 1
        .Cells(iRow, 2) = Sharedfacility.CmbSharedFacility.Value
        .Cells(iRow, 3) = Sharedfacility.cmbAdded.Value
        .Cells(iRow, 4) = Sharedfacility.cmbElementSelection1.Value
        .Cells(iRow, 5) = Sharedfacility.txtNlsfb11.Value
        .Cells(iRow, 6) = Sharedfacility.txtNlsfb21.Value
        .Cells(iRow, 7) = Sharedfacility.cmbProductName1.Value
        .Cells(iRow, 8) = Sharedfacility.cmbEDN1.Value
        .Cells(iRow, 9) = Quantity1
        .Cells(iRow, 10) = Sharedfacility.txtUnit1.Value
        .Cells(iRow, 11) = MKIpUnit1        ' Store MKIpUnit as a number
        .Cells(iRow, 12) = MKI1         ' Store MKI as a number
        .Cells(iRow, 13) = MKIscaled1        ' Store MKIscaled as a number
        .Cells(iRow, 14) = Sharedfacility.cmbScalable1.Value

        .Cells(iRow, 15) = convertedScalingFactor1        ' Store the converted scaling factor
        .Cells(iRow, 16) = totalcosts1        ' Store Totalcosts as a number

        .Cells(iRow, 17) = Sharedfacility.txtLifespan1.Value
        .Cells(iRow, 18) = Sharedfacility.txtBuildinglifespan1.Value
        .Cells(iRow, 19) = Application.UserName        'add user name
        .Cells(iRow, 20) = [Text(Now(), "DD-MM-YYYY HH:MM:SS")]        'add date and time of adjustment
    End With

```

```
1309End Sub
1310
1311Sub Show_Sharedfacility()
1312
1313    'show the form
1314    Sharedfacility.Show
1315End Sub
```

Appendix 12

Decision support tool description guide

Table of contents

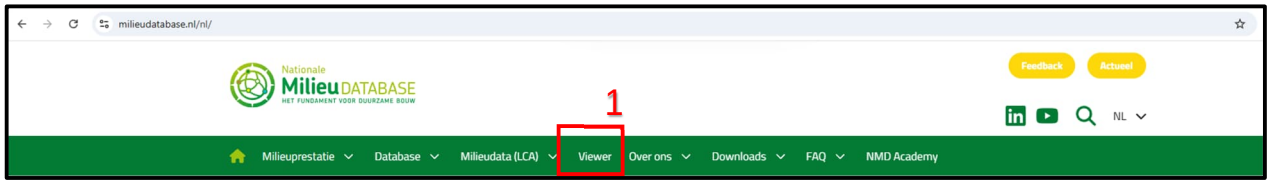
Introduction

This description guide provides a quick-start guide to using the developed decision support tool.

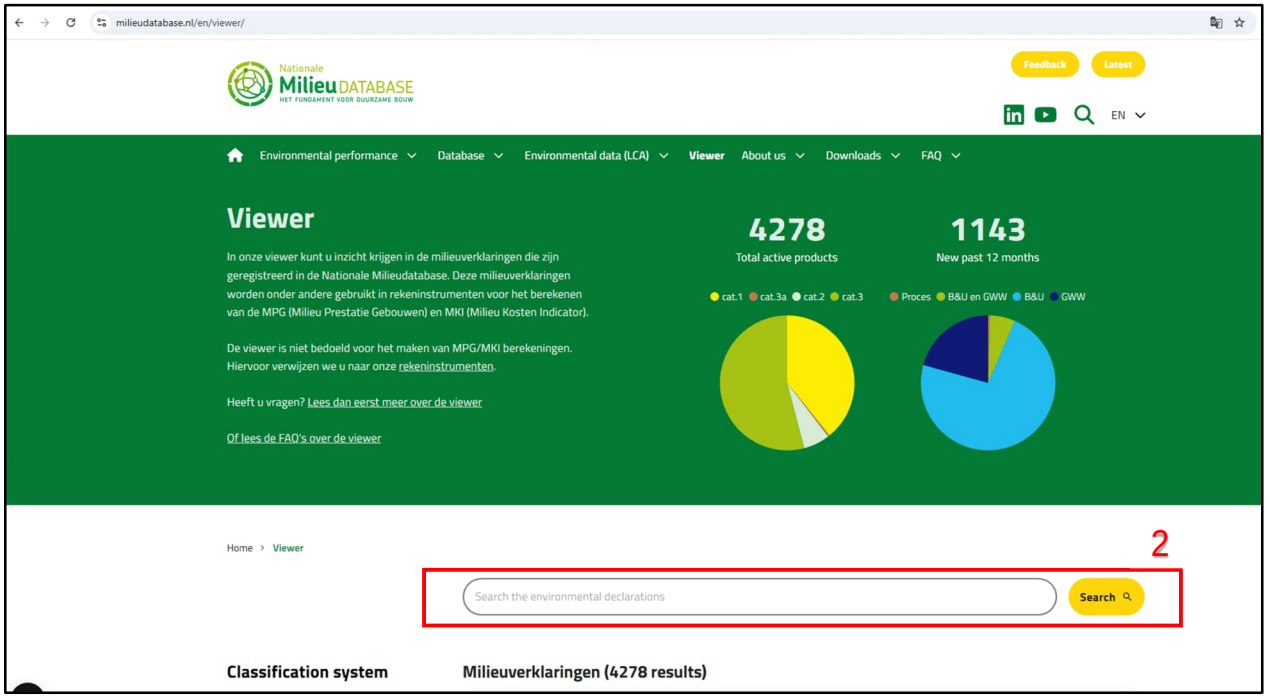
1. Storing Environmental product declarations (EPDs)

Data from the NMD database managed by Stichting NMD cannot be assessed directly (Stichting Nationale Milieudatabase, n.d.-a). Therefore, the Environmental Product Declarations (EPDs) that are required for the project you are calculating needs to be stored in the local NMD_DATABASE of the tool.
The following steps provide a step by step instructions on how to assess the EPD data via the NMD viewer on the website of Stichting NMD and how to store this data in the local NMD_DATABASE.

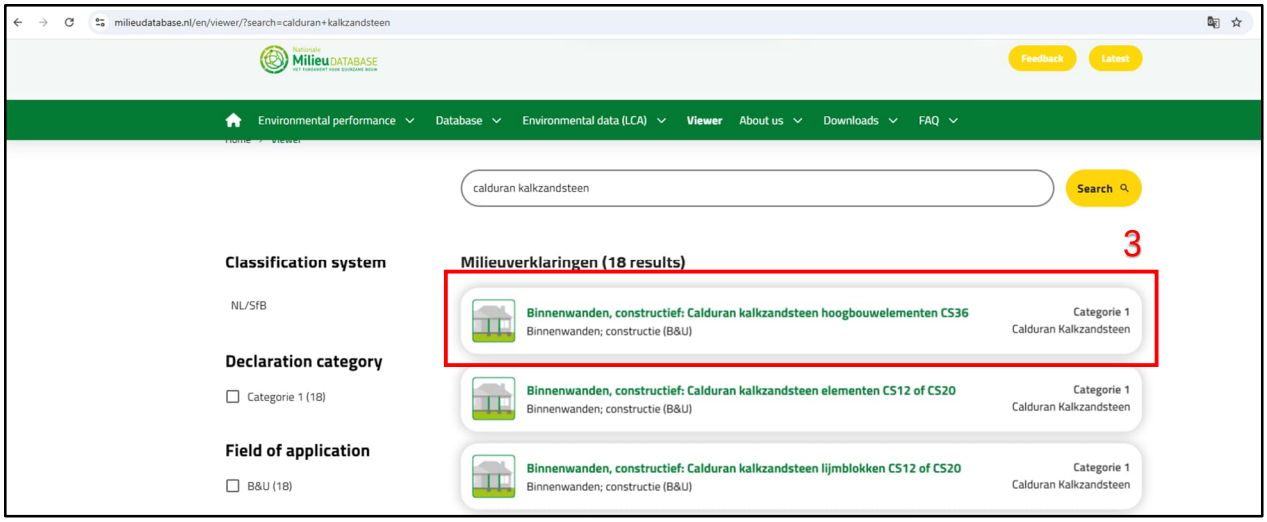
1. Go to the website of Nationale Milieudatabase and go to the NMD Viewer (1), as visible below, or use the following link: https://milieudatabase.nl/nl/viewer/



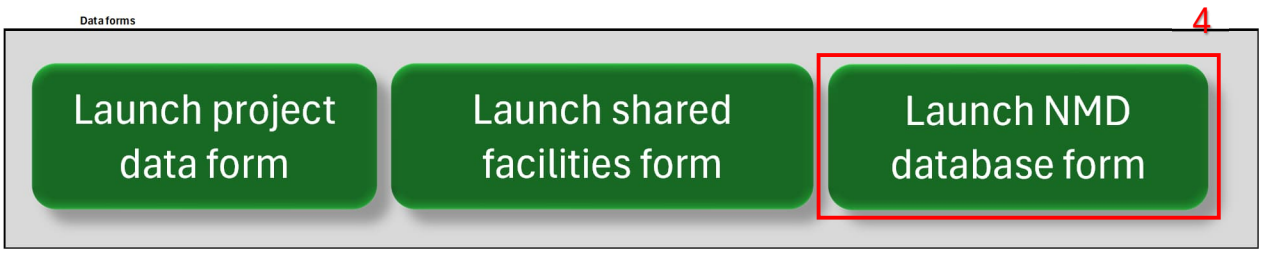
2. Use the search function (2) to find the EPD that you want to add based on its Environmental Declaration Number (EDN) or product name.



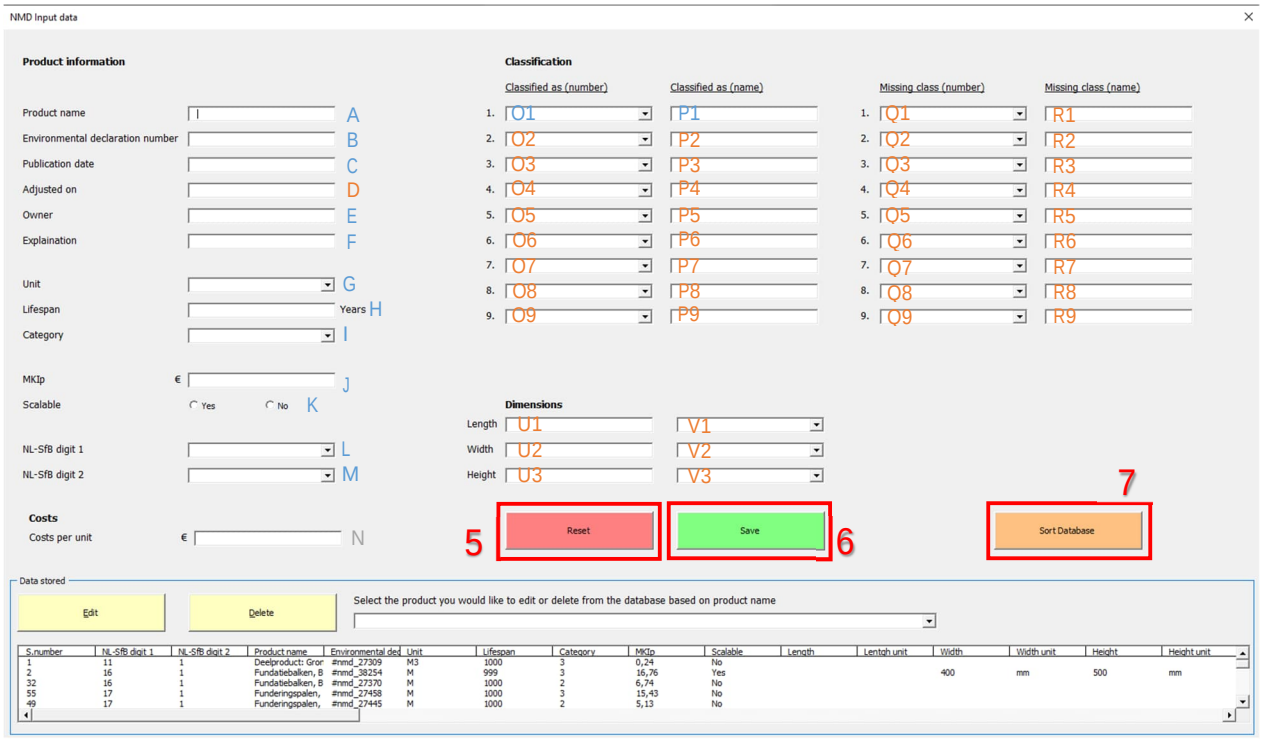
3. A number of EPDs are shown, select the applicable one (3)



4. The EPD data stored in the selected EPD will become visible, this data can be used to fill the NMD database form (4) in the decision support tool.



5. The data can be entered or copied into the NMD database form. Below the corresponding data is indicated using a letter, so for example “A” is the Product name indicating that it should be selected from the “Product name” of the EPD needs to be stored in the “Product name” textbox of the NMD database form.
   A = Required data
   A = Optional data
   A = Data needs to be entered by user, but is not required


NMD Input data
Product information
Product name
Environmental declaration number
Publication date
Adjusted on
Owner
Explaination
Unit
Lifespan
Years
Category
MKIp
€
Scalable
Yes
No
NL-SfB digit 1
NL-SfB digit 2
Costs
Costs per unit
€
A
B
C
D
E
F
G
H
I
J
K
L
M
N
Classification
Classified as (number)
Classified as (name)
Missing class (number)
Missing class (name)
1. O1 P1 Q1 R1
2. O2 P2 Q2 R2
3. O3 P3 Q3 R3
4. O4 P4 Q4 R4
5. O5 P5 Q5 R5
6. O6 P6 Q6 R6
7. O7 P7 Q7 R7
8. O8 P8 Q8 R8
9. O9 P9 Q9 R9
Dimensions
Length U1 V1
Width U2 V2
Height U3 V3
5
Reset
Save
6
7
Sort Database
Data stored
Edit
Delete
Select the product you would like to edit or delete from the database based on product name
S.number NL-SfB digit 1 NL-SfB digit 2 Product name Environmental dec Unit Lifespan Category MKIp Scalable Length Length unit Width Width unit Height Height unit
1 11 1 Deelproduct: Gror #nmd_27309 M3 1000 3 0,24 No
2 16 1 Fundatiebalken, B #nmd_38254 M 999 3 16,76 Yes 400 mm 500 mm
32 16 1 Fundatiebalken, B #nmd_27370 M 1000 2 6,74 No
55 17 1 Funderingspalen, #nmd_27458 M 1000 3 15,43 No
49 17 1 Funderingspalen, #nmd_27445 M 1000 2 5,13 No

Categorie 1 Environmental declaration

Binnenwanden, constructief: Calduran kalkzandsteen hoogbouwelementen CS36

This verified environmental declaration #nmd_92793 for the construction product Binnenwanden, constructief: Calduran kalkzandsteen hoogbouwelementen CS36 was published on *4/27/2023* in the Dutch Environmental Database (NMD). This declaration was prepared on behalf of *Calduran Kalkzandsteen*

The environmental cost amounts to **€3.39** at a lifespan of **999 years**. For Category 1 data, the NMD only discloses the aggregated environmental cost, calculated according to the Environmental Performance Assessment Method for Construction Works. Category 1 data is proprietary data from manufacturers and suppliers. The data has been verified by an independent, qualified third party in accordance with the NMD Verification Protocol.

Product name	Binnenwanden, constructief: Calduran kalkzandsteen hoogbouwelementen CS36 A
Environmental Declaration Number	#nmd_92793 B
Publication date	4/27/2023 C
Owner	Calduran Kalkzandsteen E
Explanation	De Calduran kalkzandsteen hoogbouwelementen hebben een referentiedikte van 175 mm (B) en een druksterkteklasse CS36. Afwijkende diktes en diverse combinaties van afmetingen voor deze blokken zijn beschikbaar (538-648*997mm (H*L), raadpleeg hiervoor de technische specificaties op de website van Calduran. De hoogbouwelementen zijn onder andere geschikt voor dragende binnenspouwbladen en binnenwanden, die naderhand afgewerkt kunnen worden. Ze worden verwerkt met een dunne laag lijmmortel. Het product is inclusief de lijmmortel van de lijmblokken, exclusief afwerking (stucwerk) en eventuele bevestigingsmiddelen. F Show less

Unit	m² G
Lifespan	999 year H
Category	Categorie 1 I

Environmental profile	MKI A1	MKI A2	Scalable
CAL-HRelementen	€3.39	€6.33	Yes J
Total: K	**€3.39**	**€6.33**	

Classification

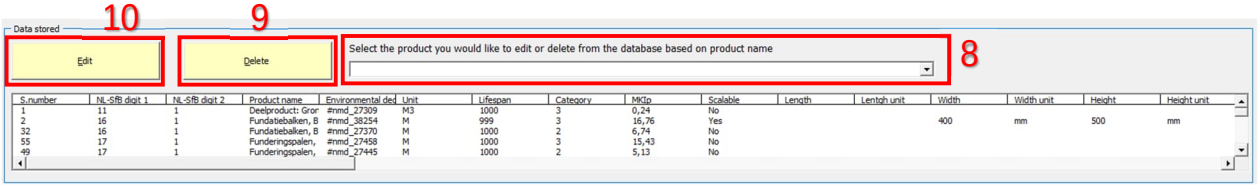
This product is classified as Binnenwanden; constructie (22.2).

L O1
✓ 22.2 – nr01 Constructieve binnenwanden P1
M

This environmental declaration does not cover the entire element. The following mandatory components are missing.

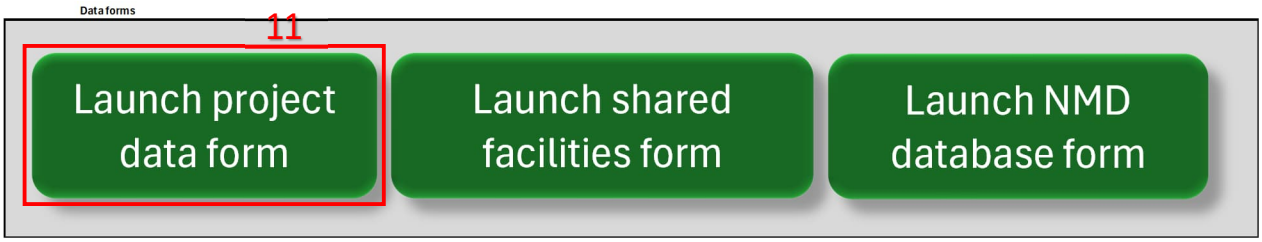
Q1
✗ 22.2 – nr02 Randaansluitingsvoorzieningen R1
Q2
✗ 22.2 – nr03 Elementen die een onderdeel met de wand vormen zoals isolaties en afwerkingen R2
Q3
✗ 22.2 – nr06 Dilatatievoegconstructies R3
Q4
✗ 22.2 – nr07 Verankeringen R4
Q5
✗ 22.2 – nr08 Bevestigingsmiddelen R5

6. After entering all the data you can use the Save button (5) to save the data to the database or use the Reset button (6) to clear the input form. The Sort database (7) can be used to sort the data stored in the NMD_DATABASE.
7. Stored data can be selected to edit or delete based on the product name (8), by pressing the Delete button (9) the data can be deleted from the database and by pressing the Edit button (10) data stored in the data.

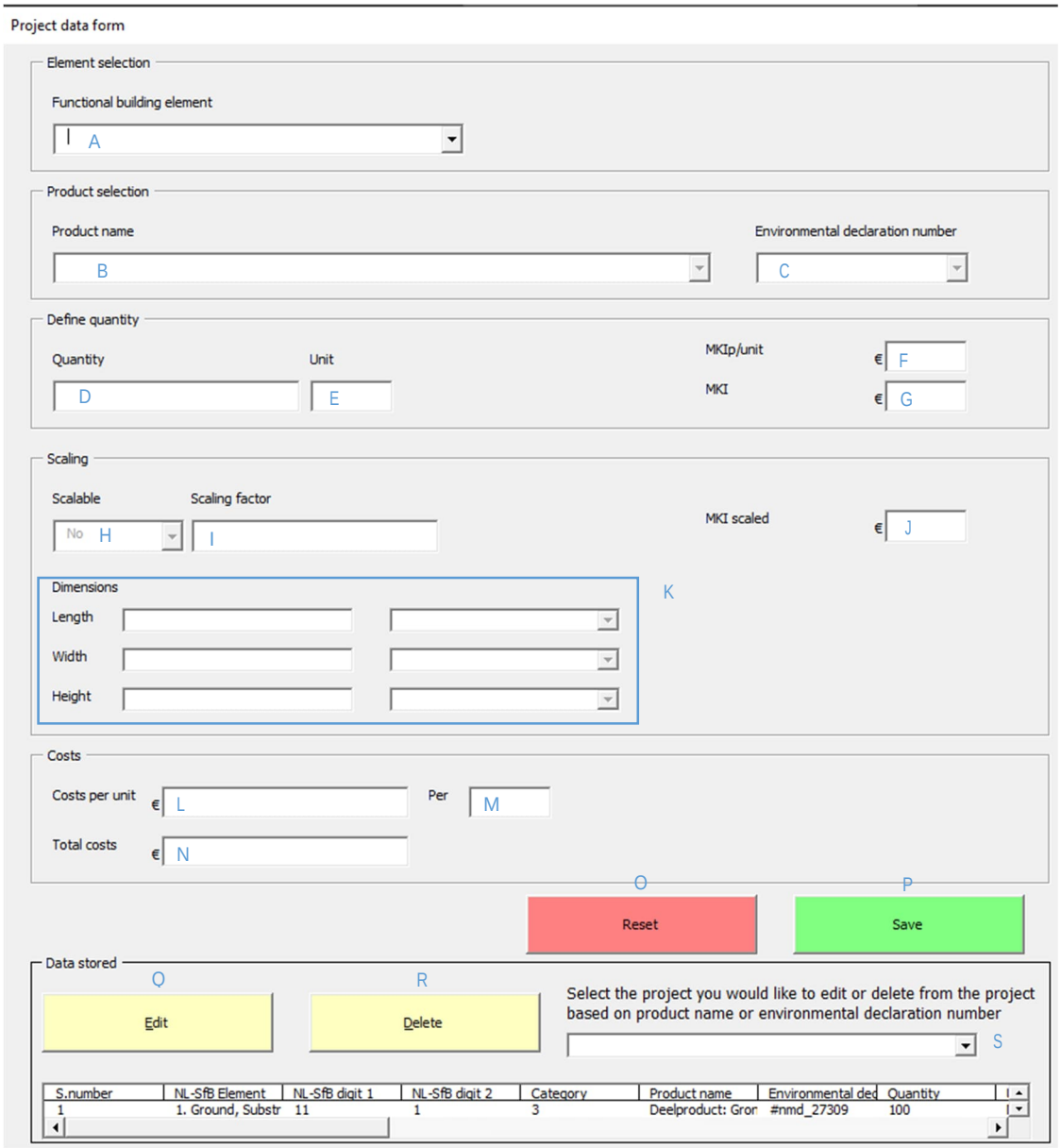


2. Assigning product data to the base design

1. To assign EPD data stored in the NMD_DATABASE to the base design of the project the Launch project data (11) form needs to be used. This ensures that the data is stored in the Extra_data_SF database.



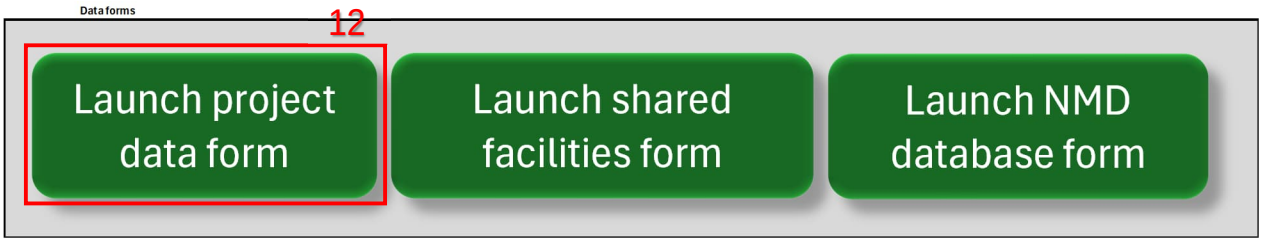
2. The Functional building element box (A) need to be used to select the functional building element to which the product you would like to assessed
3. The Product Name box (B) or Environmental declaration number (C) can be used to select the EPD you would like to assign to the base design. After selecting a product the boxes E, F and .. are automatically filled with data stored in the NMD_DATABASE
4. In the Quantity Box (D) you can enter the quantity of the product that is used in the base design using a "." as delimeter. After entering the quantity, the MKI (G) is automatically calculated
5. If a product can be scalable, the scalable combox (H) is unlocked. This allows you to define if you would like to apply a scaled version of the product. If selected "Yes", then you should enter the Scaling Factor (I). After entering the scaling value the MKI scaled (J) is automatically calculated. How to determine the scaling factor is described in the chapter 4. Scaling Factor of this guide.



6. If you wish you can provide the dimensions of the scaled product (K), however this is not necessary.
7. The costs per unit of the product can be adjusted (when stored in the NMD_DATABASE) or defined in the Costs per unit box (L). After adjusting or adding the construction costs per unit the total costs (N) are calculated automatically.
8. After entering all the data you can use the Save button (P) to save the data to the database or use the Reset button (O) to clear the input form.
9. Stored data can be selected to edit or delete based on the product name (S), by pressing the Delete button (S) the data can be deleted from the database and by pressing the Edit button (Q) data stored in the data.

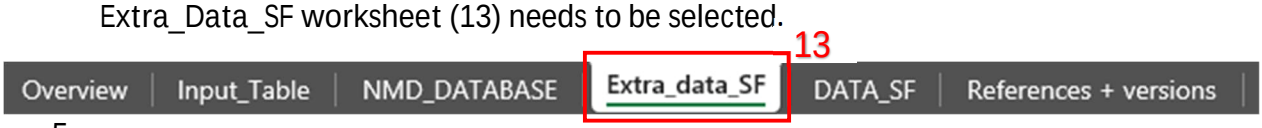
3. Assigning product data to a shared facility

1. To assign EPD data stored in the NMD_DATABASE to a shared facility the Launch shared facilities form (12) needs to be used. This ensures that the data is stored in the DATA_SF database.



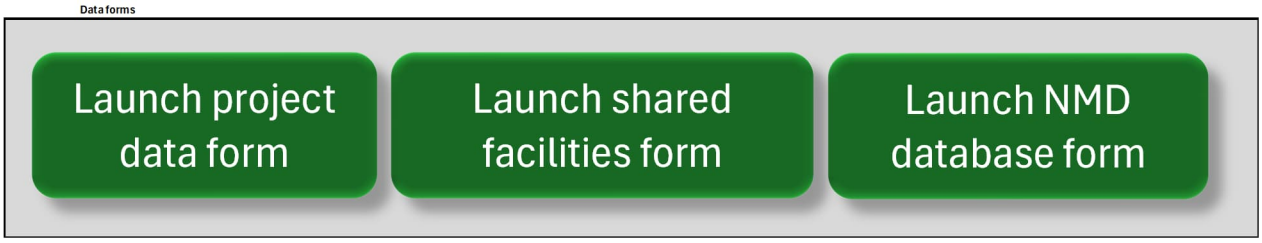
2. The shared facility to which the product needs to be assigned needs to be selected using the Shared facility combobox (X)
3. It needs to be defined if the product needs to be added or removed from the base design, therefore the Added or Removed combobox (Y) can be used

4. Beside assigning the EPD data to the shared facilities, the impact of the shared facility on the GFA of the building needs to be determined, therefore the Extra_Data_SF worksheet (13) needs to be selected.



5.

6. design of the project the Launch project data (11) form needs to be used.

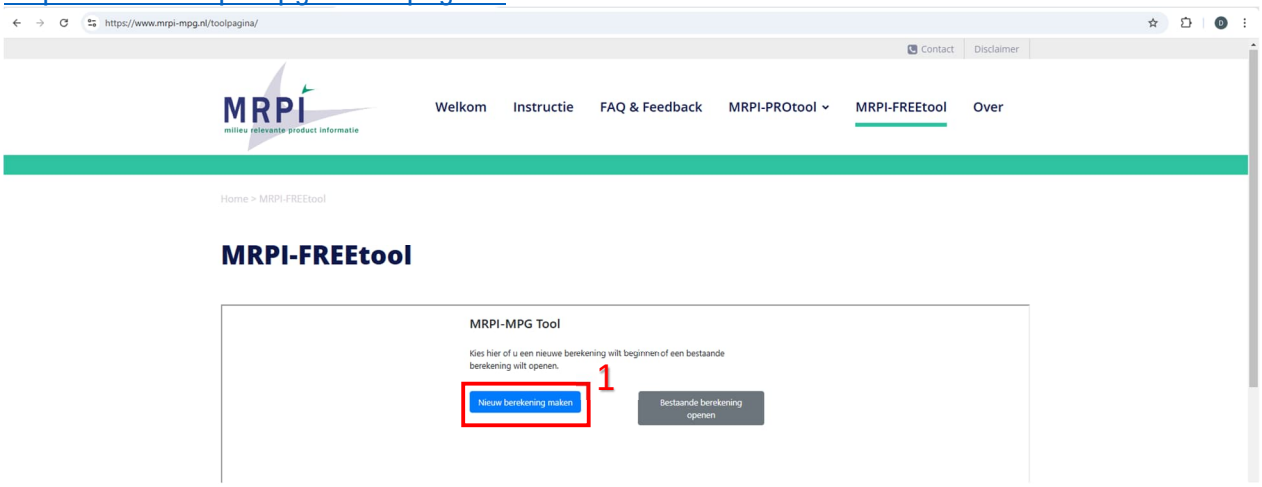


7. The Functional building element box (A) need to be used to select the functional building element to which the product you would like to assessed
8. The Product Name box (B) or Environmental declaration number (C) can be used to select the EPD you would like to assign to the base design. After selecting a product the boxes E, F, H and M are automatically filled with data stored in the NMD_DATABASE

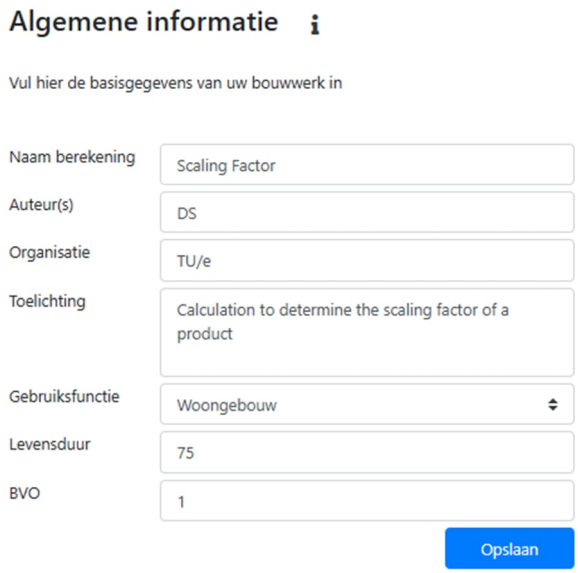
9. In the Quantity Box (D) you can enter the quantity of the product that is used in the base design using a "." as delimeter. After entering the quantity, the MKI (G) is automatically calculated
10. If a product can be scalable, the scalable combox (H) is unlocked. This allows you to define if you would like to apply a scaled version of the product. If selected "Yes", then you should enter the Scaling Factor (I). After entering the scaling value the MKI scaled (J) is automatically calculated. How to determine the scaling factor is described in the chapter 4. Scaling Factor of this guide.

4. Determining the scaling factor

The scaling factor of a product can be determined by using the MPRI-FREEtool on the website of Stichting MRPI (n.d.), which can be assessed through the following link: https://www.mrpi-mpg.nl/toolpagina/

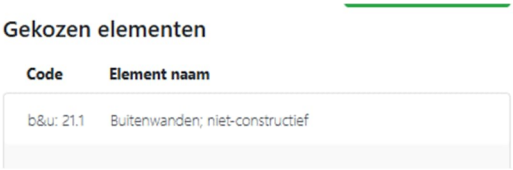


1. The first step is to create a new calculation (1)
2. Fill in the name, author, organization, and a possible explanation of the calculation and define the function of the building, which is residential (woongebouw), and set the BVO to 1, as shown in the figure below. After doing this press save.

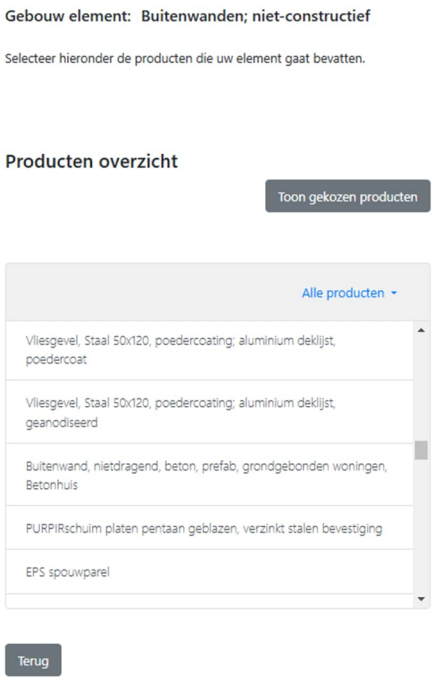


3. Select the Group and building element to which the product belongs of which you would like to determine the scaling factor, as shown in the figure below and press “Voeg element toe”, which adds the elementen

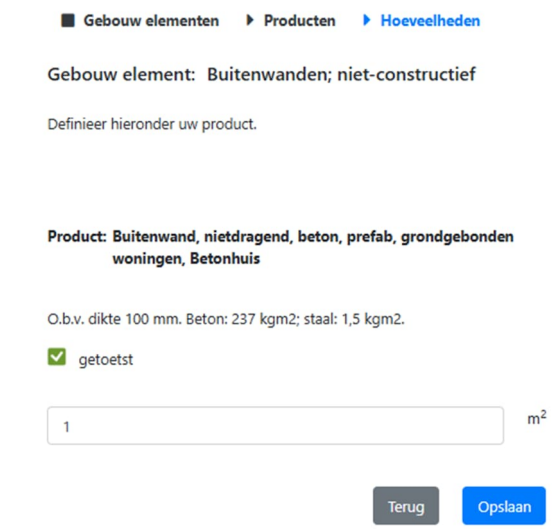
4. Press on the added element, as shown in the figure below.



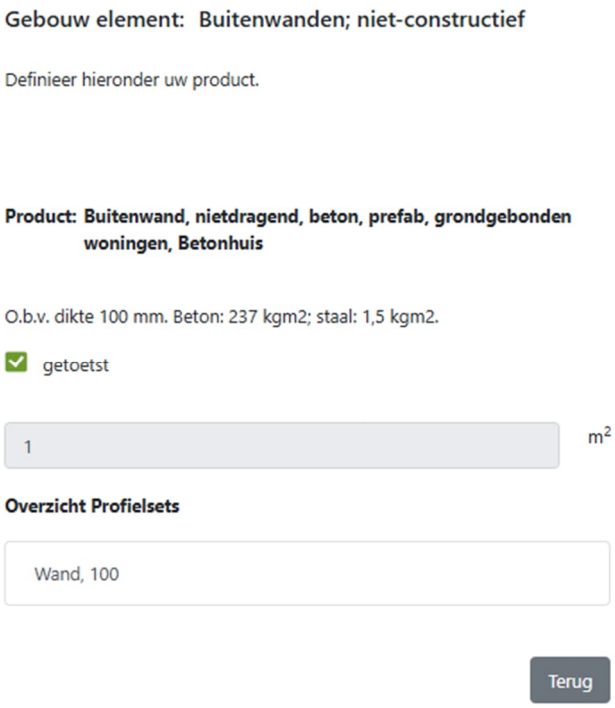
5. Select the product from the list for which you would like to determine the scaling factor in this case “Buitenwand, nietdragend, beton, prefab, grondgebonden woningen, Betonhuis” and click on it.



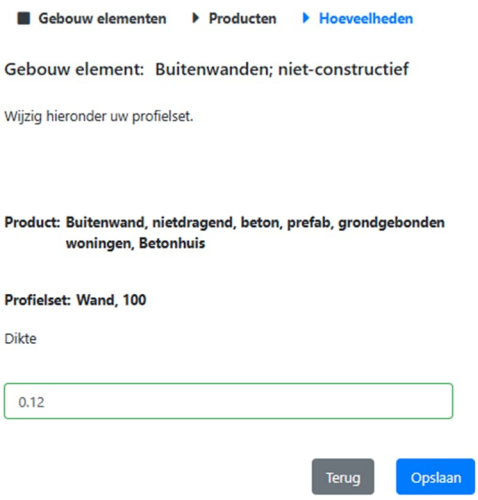
6. Set the quantity to 1 m2 and save by pressing “Opslaan”, as shown in the figure below.



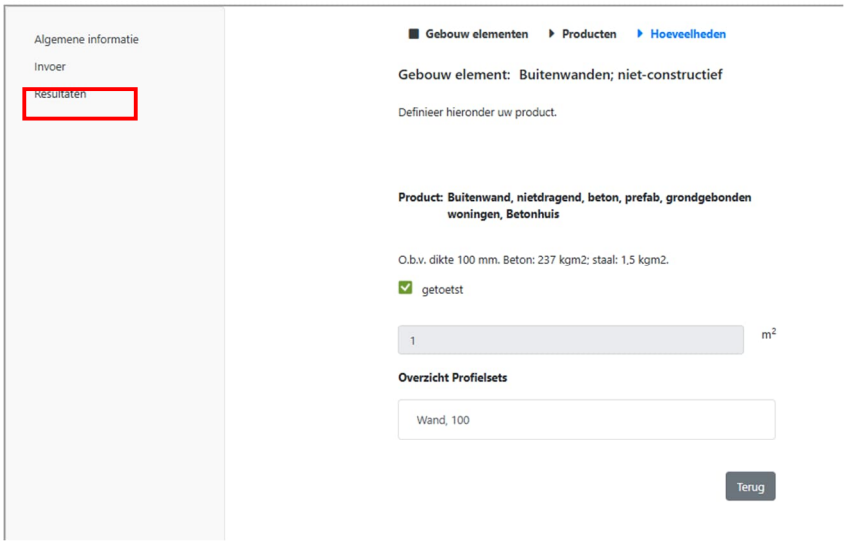
7. The reference thicknes of the wall equals 100mm, press “Wand, 100”. To adjust the reference thickness, as shown in the figure below



8. Adjust the thickness from 0.1 meter to 0.12 meter and press “”Opslaan””, as shown below.



9. The product is now adjusted, go to “Resultaten” by clicking on it, as shown below.



10. This shows the MPG of the product per m2 GFA per year. As shown below

11. To go from MPg of the product to the MKI of the product within the construction you need to apply the following formula

$$MKI_{p,icw} = MPG * lifespan\ of\ the\ building * GFA$$

12. In this example this results in the following equation and outcome

$$MKI_{p,icw} = €0.058 * 75 * 1 = 4.35$$

$MKI_{p,icwo} = MKI\ of\ product\ p\ as\ calculated\ in\ the\ context\ of\ the\ construction\ work$

13. Next the original MKI value of the product within the construction needs to be addressed, by applying the following formulas

$$V_p = \frac{L_{cw}}{L_p} - 1$$

$V_p \geq 0, else\ V_p = 0$
$L_{cw} = lifespan\ of\ the\ building$
$L_p = lifespan\ of\ the\ product\ p$

$$MKI_{p,icw,o} = MKI_{p,l} * (1 + V_p)$$

$MKI_{p,icwo} = MKI\ of\ product\ p\ original\ as\ calculated\ in\ the\ context\ of\ the\ construction\ work$
$MKI_{p,l} = MKI\ per\ unit\ of\ a\ product\ of\ product\ p$
$V_p = number\ of\ replacements\ of\ the\ product\ during\ the\ lifespan\ of\ the\ construction\ work$

$$V_p = \frac{75}{100} - 1 = 0$$
$$MKI_{p,icw,o} = 4.38 * (1 + 0) = 4.38$$

14. To determine the scaling factor you should divide the scaled MKI by the original MKI, as shown below

$$Scaling\ factor = \frac{4.35}{4.38} = 1.0069$$

References

Stichting Nationale Milieudatabase. (n.d.-a). *Viewer*. NMD. https://milieudatabase.nl/en/viewer/

Stichting MRPI. (n.d.). MRPI-FREEtool - MRPI-MPG tool - De milieuprestatie voor gebouwen berekening. https://www.mrpi-mpg.nl/toolpagina/