[MASTER THESIS]

The benefits of applying the Life Cycle Costing method

For the main-actors within the Dutch Commercial Real Estate sector

2013

Commissioned by: University of Greenwich
Saxion University of Applied Sciences
SOM=

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Fulltime/Parttime: Fulltime
Date: 26 September 2013

EUROPEAN MASTER FACILITY & REAL ESTATE MANAGEMENT

[DISSERTATION MASTER REM]

LIFE CYCLE COSTING

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26 September 2013

Keywords: Life Cycle Costing, capital investment decisions, real estate, cost effectiveness, investment costs, operational costs, sustainability, ISO 15686-5, NEN 2699; 2013

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Declaration of own work

Except where stated otherwise, this report is based on the candidates own work.

“I certify that this is my own work. The work has not, in whole or part, been presented elsewhere for assessment. When material has been used from other sources it has been properly acknowledged. If this statement is untrue I acknowledge that I will have committed an assessment offence”.

Agelo, September 2013
Joost Lansink

Preface

This report is about Life Cycle Costing (LCC) in the field of real estate. In this research you'll read about the benefits of LCC for the main-actors on the Dutch commercial real estate market. This research has been conducted in the context of my master thesis on behalf of my MSc degree 'Real Estate Management' at the University of Greenwich.

This study is intended primarily for professionals in the field of real estate who dare to think creative and act innovative. This can be consultants, investors, developers but also users of real estate. In addition I'll hope that this research contributes to the science in the field of real estate.

The Life Cycle Costing method can be seen as an integral cost management tool that can be applied within several sectors, including the real estate sector. The fields of sustainability and cost management come together within the LCC method. During my study Real Estate Management, I became interested in the theme of sustainability at the course on 'Sustainable Project Management'. Nowadays, there is an increasing demand for sustainable buildings by the modern users of real estate buildings and by the society itself. Therefore, I'm fully convinced that sustainability will become increasingly important within the field of real estate. In addition, I have always been interested in the way we can achieve 'as much as possible' for a 'minimal investment' by optimizing the price-quality ratio. Cost management has been discussed in the course of 'Asset Management', because Asset Management requires cost effective strategic decisions. By the confluence of cost management and sustainability the Life Cycle Costing method attracted me. The reasons as mentioned above were the motivation for me to conduct this research about Life Cycle Costing in the Real Estate sector. Despite of the many efforts, I worked with great pleasure on this study. However, this would not have been possible without the help of others and that's why I would like to thank a few people.

First of all I would like to thank Mr. Drs. Peter Ruepert for his positive critical comments which have improved this research for sure. Secondly, I would like to thank Mr. Ir. Paul Scholten because he has given me the opportunity to graduate at SOM= and to execute my research about Life Cycle Costing there. SOM= is a company specialized in real estate- and project management with specific knowledge about Life Cycle Costing, Total Cost of Ownership and BREEAM. Graduating at this company meant a high added value for the quality of this research and for developing my own skills. That's why, in addition to Mr. Scholten, I would like to thank all my colleagues at SOM=. Thirdly, I would like to thank all the interviewees for their time and effort. Finally I would like to thank my parents and my girlfriend Ashley for their unconditional support to me.

Agelo, September 2013
Joost Lansink

Executive Summary

In the Dutch real estate sector the 'Gross Initial Yield' (Dutch; Bruto-aanvangsrendement) is an often used calculation method for appraisals. The gross initial yield is based on the gross annual rent in the first year of operation and the total initial investment. This means that the operational costs often are disregarded in the calculation models of developers and investors (Australian National Audit Office, 2001). This may have a negative effect on the reliability of the appraisal of a building, or at least this may not lead to long term cost optimization (EMSD, 2004).

Life Cycle Costing (LCC) is an integrated approach regarding to the investment- and operational costs. The greatest advantage of LCC is that it can be used to explain different options next to each other and to compare them with each other (Norman, 2007; Dell'Isola and Kirk, 2003) based on several key factors such as costs, quality, and comfort over the entire life cycle of the product (Collier, 2009; Flanagan et al., 1989). According to the NEN 2699; 2013, LCC is defined as follows;

"The Life Cycle Costs are all costs incurred for an property during the life cycle of that property, to meet its own performance requirements" (NNI, 2013)

To convince the main-actors on the Dutch commercial real estate market about the benefits of the Life Cycle Costing method, this research was needed to give an insight in the advantages of LCC. For this reason the research will answer the following main question;

What are the benefits of applying the Life Cycle Costing method for the main-actors within the Dutch commercial real estate sector? **(A+)**

This research examined the benefits of Life Cycle Costing within three projects, based on a qualitative research methodology. For this, eight interviews were conducted with users, investors and developers. Three pilot interviews were executed to validate the different questionnaires. Additionally, a document analysis is carried out in which advertising materials and a plan of requirements, have been analyzed. These two methods, together with the literature study, provides the answer to the main research question.

The analysis resulted in seven main areas in which the results are divided. Some respondents reported that LCC is a difficult method to understand. It is therefore important that the main-actors work together, have collective benefits and make decisions together. This thesis answers the main research question by the following conclusions;

- The insight into the life cycle costs of a building will help the main-actors to justify the highness of the investment costs to each other and to those who make the final decision about the design of a building. Additionally, all main-actors have an economical advantage of applying the LCC method because cost optimization is possible and profits can be shared.
- LCC leads to better thought out buildings by mapping the risks of a building with respect to the life cycle costs, like vacancy. Buildings designed based on the LCC method are highly future-proofed because they better reflect the needs of the user.

- LCC contributes to the development of more durable buildings with a certain degree of sustainability, such as BREEAM 'Excellent'. This is because LCC provides the insight into the lower operational costs of sustainable materials and installations in buildings. This will allow more users, investors and developers to realize highly sustainable buildings because the additional investment costs can be justified.

- More conscious choices regarding to the comparison of different alternatives and/or materials could be made based on the LCC methodology. Based on LCC analyses and calculations accurate estimates can be made about the life cycle costs of a building. Therefore, LCC contributes to the risk management of the main-actors by reducing risks regarding to the investment costs.

In several other countries such as the United States, Canada and Australia they are much further in applying Life Cycle Costing than in the Netherlands. This research resulted in new insights of the benefits of Life Cycle Costing on the Dutch commercial real estate market. Based on this research, it is recommended to make decisions with respect to the design of buildings, based on the Life Cycle Costing method.

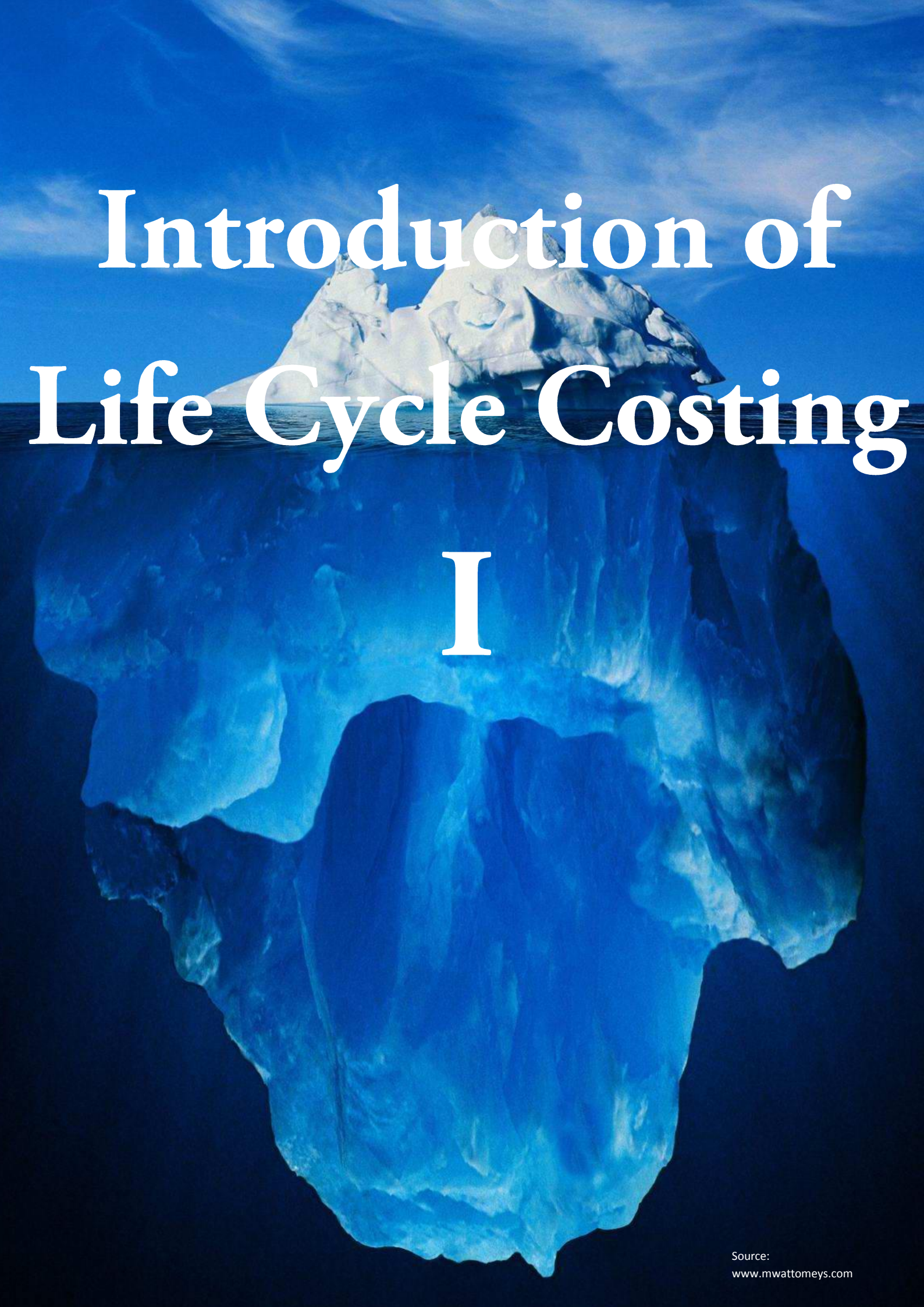
Table of Content

Table of Tables

Table of Figures

Introduction of Life Cycle Costing

I



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1. Introduction

1.1 Background of Life Cycle Costing

Life Cycle Costing (LCC) was originally designed for investment purposes in the U.S. Department of Defence (White and Ostwald, 1976). The importance of LCC for the U.S. Department of Defence was shown by the fact that the operational costs regarding to weapon systems, where 75% of the total life cycle costs. The U.S. National Science Foundation (NSF) organized, together with the U.S. Department of Defence an integral academical and industrial conference. During this conference many methods were drafted to gain an insight in the economical considerations in the design stage according to the life cycle costs of different weapon systems (Asiedu and Gu, 1998). Later the LCC method was also applied in the automobile sector (Witik, 2011) and in the engineering sector (Blanchard, 2011).

But what exactly is Life Cycle Costing? There are many terms of Life Cycle Costing, the most frequently used definitions of LCC will be explained to get a better understanding of LCC. According to Emblemsvåg (2003) Life Cycle Costing is described as; “the total costs that are incurred, or may be incurred, in all stages of the products life cycle”. Dell'Isola and Kirk (2003) clarified Life Cycle Costing as an economic assessment of an item, system or facility over its lifespan, expressed in terms of equivalent cost using baselines identical to those used for initial costs. Dhillon (1989) defines LCC as; “the sum of all costs incurred during the life time of an item, i.e. the total of investment- and operational costs”. LCC is therefore based on an integrated approach with respect to the investment- and operational costs.

However, in the Dutch real estate sector the ‘Gross Initial Yield’ (Dutch; Bruto-aanvangsrendement) is an often used calculation method for appraisals. The gross initial yield is based on the gross annual rent in the first year of operation and the total initial investment costs. Therefore, the operational costs are often disregarded in the calculation models of developers and investors (Australian National Audit Office, 2001). In addition, cost savings are also excluded in the calculations of these parties (Van Gool et al., 2007). According to Flanagan and Jewell (2005) an office building will consume more than four times its initial capital costs over a 25 year period. They consider it as strange that still far more attention is paid to the initial capital costs. In figure 1 this is illustrated by Kawauchi and Rausand (1999) by means of ‘The Iceberg Principle’.

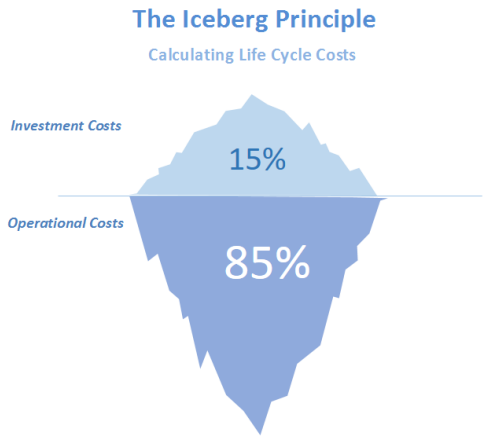


Fig. 1; The Iceberg Principle; based on figure 2 from Kawauchi and Rausand (1999)

Now the supply on the Dutch office market is greater than the demand for office buildings. The consequence is a struggle for the user of office buildings. Where there was a supply-driven market in the recent decades, this is now changing towards a demand-driven office market (DTZ, 2013). Users now are asking for office buildings with optimized life cycle costs. In the problem statement you can read the importance of the application of LCC in the Dutch field of real estate.

1.2 Problem Statement

Traditionally real estate developments be approximated based on the first three stages of the life cycle of a building. These are the initiative & definition stage, the design stage and the realization stage. The operational stage of a building is often disregarded (BBN, 2013; Mortelmans, 2005). This may have a negative effect on the reliability of the appraisal of a building, or at least this may not lead to long term cost optimization (EMSD, 2004). According to EMSD (2004) LCC allows the financial implications of future savings due to additional investments made at present for enhancing performance (e.g. energy efficiency or durability of materials) which should be assessed for decision making. To work more cost-effective we need to think on the long term to improve cost optimization, e.g. an extra investment in a more durable roof will save operational costs such as maintenance and replacement costs (van der Voordt, 2007). van der Voordt (2007) also states that it's more cost-effective to invest proactively in flexibility, durability and sustainability than wasting a lot of money to renovation costs in a later stadium. LCC is based on an integrated approach regarding to the investment- and operational costs (BBN, 2013; Rabobank and PwC, 2011)(figure 2). By applying the LCC method, cost optimization for the main-actors of commercial real estate buildings like developers, investors and users, might be realized.

The design of a building like the shape, the materials, the use of space and the installations applied do have a relation with the operational costs in a later stadium of the building's life cycle (Francissen, 2007). To optimize the life cycle costs it is important to show the relationship between design choices and the resulting life cycle costs (Schade, 2007). Life Cycle Costing can be used as a method to compare different alternatives and to select between competing alternatives based on costs in the long run (CBZ, 2006). According to CBZ (2006) the LCC method is beneficial for care organizations, so it might be beneficial for the main-actors involved on the Dutch commercial real estate market to. A problem is that not every market participant has the same interests (Moerkamp, 2013). It is known that most investors don't want to invest more than required to construct a building (Stanford University, 2005). Additionally, in the commercial real estate market always is a certain field of tension between the investor and the user of a building, often a (one or more) tenant(s) (Ten Cate, 2007). From the point of view of the investor, the investor tries to get the highest return on the asset (Geltner, et al. 2007). Rationally, a tenant wants to rent a 'green building' for the lowest price as possible.

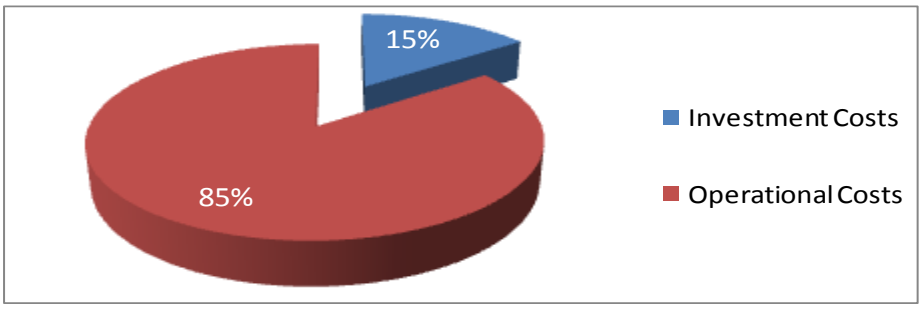


Fig. 2; Life Cycle Costs of a building, based on Kawauchi and Rausand (1999)

Performing a calculation of the life cycle costs provides a forecast of the operational costs of a building in the future, the result might be a better understanding of the life cycle costs of a building for the developer, investor and user (BBN, 2013). The unnecessary waste of money must be stopped, so long term cost optimization is needed. Besides, the Dutch real estate market needs to create 'future-proof' (Dutch; Toekomstwaarde) flexible commercial real estate buildings to meet the modern demands of the market, applying the LCC method might be the solution to meet this demand (Agentschap NL, 2011; Rabobank and PwC, 2011).This method has been used for over a decade in the United States (AIA, 2010), the same applies to Australia according to the Australian National Audit Office (2001).

To convince the main-actors on the Dutch commercial real estate market about the benefits of the Life Cycle Costing method, this research is needed to give an insight in the advantages of LCC. For this reason the research will answer the following main research question;

What are the benefits of applying the Life Cycle Costing method for the main-actors within the Dutch commercial real estate sector? **(A+)**

Based on the answers to the main research question and sub-questions of this study, the investigation will clarify the benefits of LCC for the main-actors in the Dutch commercial real estate sector, by means of a qualitative research approach which is explained in chapter 3. The objective is; showing the benefits of applying the Life Cycle Costing method in real estate developments, to convince the main-actors on the Dutch commercial real estate market for applying Life Cycle Costing.

1.3 Research Aim

Based on the problem statement in paragraph 1.2 the main purpose of this research will be;

"Showing the benefits of applying the Life Cycle Costing (LCC) method in real estate developments, to convince the main-actors on the Dutch commercial real estate market for applying LCC" **(1)**

The main purpose can be divided into multiple targets, knowing;

- Showing the main-actors on the Dutch commercial real estate market that the use of sustainable applications in buildings, have a positive effect on the cost-saving of operational costs of buildings. **(2)**

- Giving an insight in the benefits of long-term cost optimization when capital investment decisions must be made. **(3)**

Indirect;

- Encouraging the use of sustainable applications in buildings, by showing that the use of sustainable applications within buildings can save money. **(4)**

1.4 Definitions

BREEAM; a method to determine the sustainability performance of buildings (DGBC, 2013).

Dutch Commercial Real Estate Market; the office building market in the Netherlands and more specifically, new office buildings that were completed in 2011 or later. Office buildings combined with a production hall are included.

Flexible buildings; buildings that can easily be adapted to a new function or a changing demand from its user(s).

Future proofed building; a building that represents a certain economical value in the future and thereby extends the economic lifetime of a building.

Greencalc; a tool for mapping the sustainability of a building or district (Stichting Sureac, 2013).

Investment Costs; the total of investment costs as you can read in table 1.

LEED; a green building tool that addresses the entire building lifecycle recognizing best-in-class building strategies (USGBC, 2013).

Life Cycle Costing; "The Life Cycle Costs are all costs incurred for an property during the life cycle of that property, to meet its own performance requirements" (NNI, 2013)

Main-Actors; all the actors who have an direct influence on the price formation on the Dutch commercial real estate market. The main-actors are established based on the 4Q model of DiPasquale & Wheaton (1992) as you can see in figure 13.

Operational Costs; the total of operational costs as you can read in table 1 and 2.

Residual Value; the residual value or disposal costs according to code Z3B1 as described in table 2.

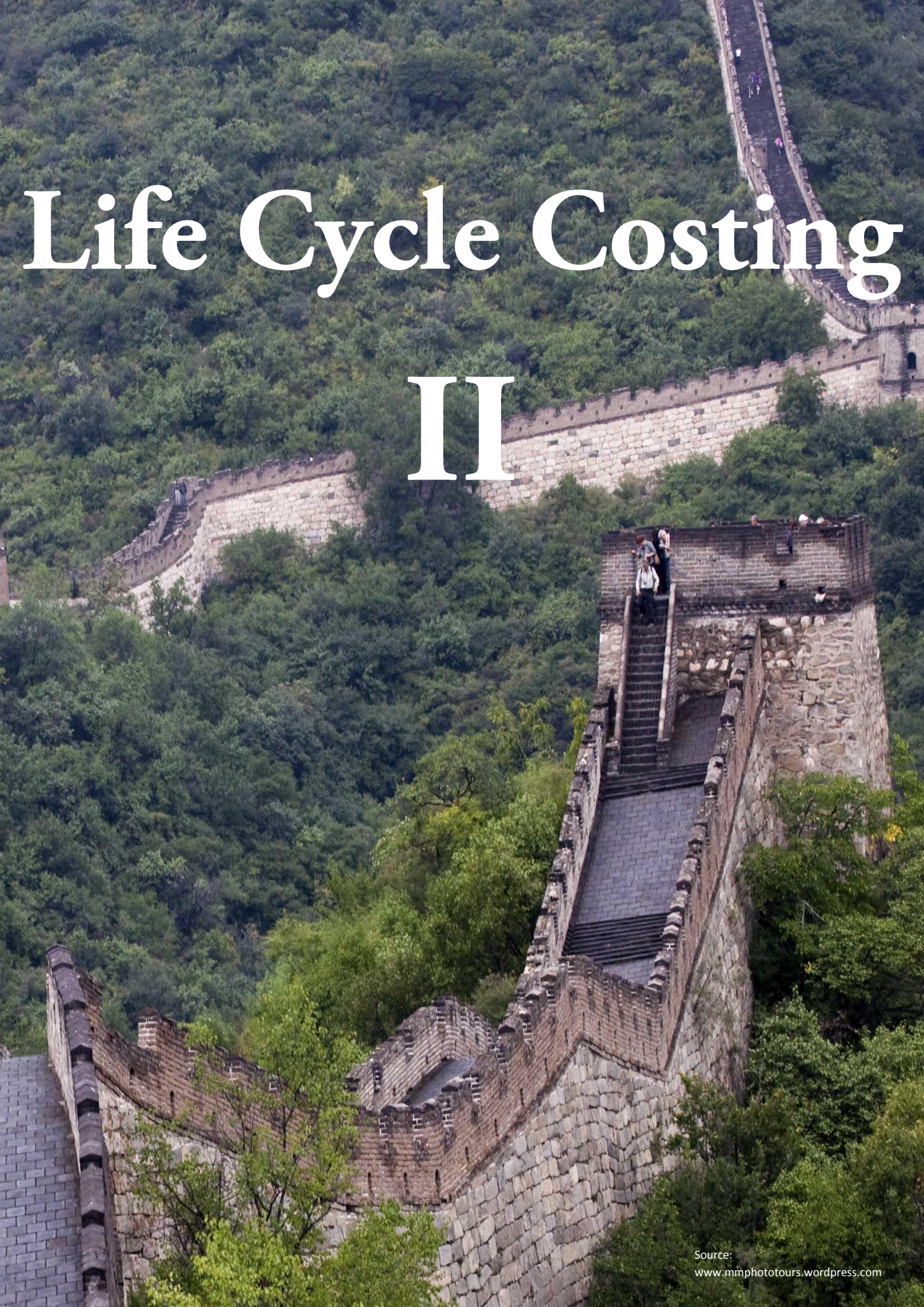
1.5 Reading Guide

Now you have read the background of the Life Cycle Costing method (paragraph 1.1), the problem statement (paragraph 1.2) and the research aim (paragraph 1.3), you will read the theory about LCC in chapter 2. The different terms in this literature study (and the rest of this research) should be interpreted in the way as described in the 'definitions' in the last paragraph (paragraph 1.4).

In chapter 2 the theory about Life Cycle Costing will be elaborated. This literature study will answer the research questions **A**, **D**, **E** and partly **B** and **C**. The Life Cycle Costing Analysis and the Life Cycle Costing Calculation will be explained in this chapter. In addition, the Dutch commercial real estate market will be further explained in chapter 2. Chapter 3 is intended to show how the study was conducted which will give the reader a better understanding of this research. Besides, it gives critical fellow researchers the opportunity to check the repeatability of the research. Chapter 3 is the stepping stone for chapter 4 where the results of the study are shown. The results are based on the literature study (chapter 2) and the analyzed data which has been obtained by the interviews and the documentation analysis (as described in chapter 3).

The results in chapter 4 are the basis for the conclusions and recommendations in chapter 5. In chapter 5 you can also read the discussion where the conclusions are being discussed critically. In addition, the research opportunities for further research are also described in chapter 5. Finally, the annexes are attached at the end of this report.

Life Cycle Costing II



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2. Life Cycle Costing

In this chapter the theory about Life Cycle Costing will be explored to answer the sub questions **A** to **E** (partly) as you can see in the research model in chapter 3 'Methodology'. This literature study serves as input for the interviews and the documentation analysis as you can see in the theoretical framework, which is described in chapter 3. The sequence of the theory in this literature study will be explained as much as possible in the same order as in the theoretical framework is shown. Therefore, is started with an explanation of the definition of Life Cycle Costing in paragraph 2.1.

2.1 Definition of Life Cycle Costing

Life Cycle Costing (LCC) is defined in the International Organization for Standardization standard, Buildings and Constructed Assets, Service-life Planning, Part 5: Life-cycle Costing (ISO 15686-5) as an "economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value. The projected costs are those needed to achieve defined levels of performance, including reliability, safety and availability" (ISO, 2008). Life Cycle Costing is part of Whole Life Costing (figure 3), which is a more extended method of LCC. As you may have read in paragraph 1.3 the research aim is to show the benefits of applying the LCC method in real estate developments, to convince the main-actors on the Dutch commercial real estate market for applying LCC.

According to ISO (2008) typical LCC analyses are conducted based on:

- ✓ Construction costs and all associated costs such as delivery, installation, commissioning and insurance;
- ✓ Operational costs, including utility costs such as energy and water use;
- ✓ Maintenance costs, including all costs of replacement, maintenance, repair and adaptation of the constructed asset;
- ✓ End-of-life costs such as removal, recycling or refurbishment and decommissioning (figure 3).

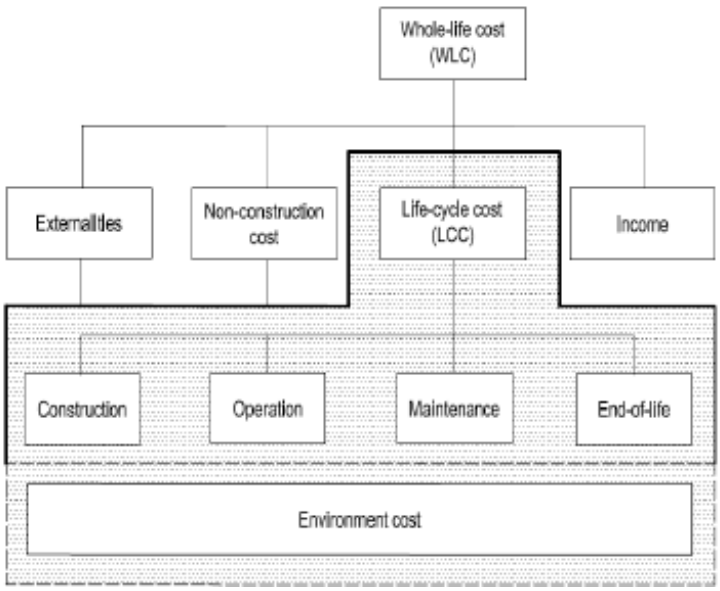


Fig. 3; Life Cycle Costing as a part of Whole Life Costing (ISO, 2008)

The NEN 2699; 2013 is the Dutch version of the ISO 15686-5 and thus this standard is based on the ISO 15686-5 which is as mentioned before, established by the International Standardization Organization (NNI, 2013). The NEN 2699; 2013 is prepared by the Dutch Nationalization Institute (NNI) and provides standards according to the investment costs , operational costs and (Whole) Life Cycle Costs (W)LCC (NNI,2013). The former NEN 2631, NEN 2632 and NEN 2634 are combined in an new up to date NEN 2699; 2013 published by the NNI on the first of January 2013 (NNI, 2013). In table 1 you will read the investment- and operational costs in more detail.

NEN 2699; 2013 Investment Costs and Operational Costs as part of Life Cycle Costing	
Investment Costs	**Operational Costs**
Site (A)	Housing (X1A)
Construction (B)	Taxes (X1B)
Interior (C)	Insurance (X1C)
Additional Costs (D)	Maintenance (X1D)
Unforeseen (E)	Mutations and Disposal (X1E)
Taxes (F)	Energy, water etc. (X1F)
Financing (G)	Management (X1G)
	Interest (X1H)
	Cleaning (X2C)

Table 1; Investment Costs and Operational Costs according to the NEN 2699; 2013 (NNI, 2013)

Note; the markings (between brackets) refer to the coding of the different tables in appendix 2 "NEN 2699;2013. A more detailed explanation of the different costs, is given there (in Dutch).

All variables in table 1, indicated with the coding A to F, X1A to X1H and X2C are part of the investment- or operational costs. The investment- and operational costs together, cover the largest part of the Life Cycle Costs. However, there are also revenues. The revenues as shown in table 2 complete the investment- and operational costs as Life Cycle Costs (NNI, 2013).

NEN 2699; 2013 Revenues as part of Life Cycle Costing	
Coding	**Revenues**
Z3A1	Rent
Z3A4	Subsidies
Z3B1	Residual Value or Disposal Costs

Table 2; Revenues of Life Cycle Costing according to the NEN 2699; 2013 (NNI, 2013)

All the elements as shown in the tables 1 and 2 will have an influence on the costs (or revenues) within the LCC method and thus within the Life Cycle Cost Analysis (LCCA) and the Life Cycle Cost Calculation (LCCC).These costs and revenues are further elaborated in appendix 2. Although the NEN 2699; 2013 is based on the ISO 15686-5, it is useful to know that there is a minor difference between these two standards. Within the NEN 2699; 2013 the site costs are included while this is excluded in the ISO 15686-5. ISO (2008) defines Life Cycle Costing as;

"An economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value. The projected costs are those needed to achieve defined levels of performance, including reliability, safety and availability" (ISO, 2008)

The Netherlands Standardization Institute endorses the definition about Life Cycle Costing of the ISO (NNI, 2013). They define Life Cycle Costing as follows;

"The Life Cycle Costs are all costs incurred for an property during the life cycle of that property, to meet its own performance requirements" (NNI, 2013)

Within this research the definition of Life Cycle Costing by the NNI (2013) is determinative.

2.2 Pros and cons of the Life Cycle Costing method

The last paragraph defines Life Cycle Costing as "an economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value". "The projected costs are those needed to achieve defined levels of performance, including reliability, safety and availability" (ISO, 2008). Therefore, the Life Cycle Costing method can be used to compare various options by identifying and assessing economical impacts over the total life span of all options compared (Norman, 2007; Dell'Isola and Kirk, 2003). This is important because, as discussed in the background of this research, the investment costs often are emphasized while the operational costs during the life cycle of a building are much higher (Flanagan and Jewell, 2005). Anyway, the LCC methodology offers new opportunities when making capital investment decisions (Francissen, 2007).

As mentioned, LCC is a method to estimate all costs (and revenues) as shown in table 1 and 2, which are all costs in the total life cycle of an item regarding to producing, using and disposing an item. These costs are not necessarily for one (main) actor. LCC is primarily intended for the (main) actor(s) who have to make decisions about the design or purchase of an item (Boone and Meeusen, 2002).

According to Dell'Isola and Kirk (1995) the main motivation to use LCC is to increase the possibility of cost reductions when making decisions in the design stage regarding to the operational costs, even if this leads to additional investment costs. For example, decisions about the design of a building like the shape, the materials, the use of space and the installations applied do have a relation with the operational costs such as the cleaning costs and maintenance costs in a later stadium of the building's life cycle (Francissen, 2007). A basic assumption is that it is possible to affect the future

costs of an item on beforehand, by improving the item (Kumar et al., 2004). In this research this means the researcher assumes that it's possible to affect the future costs of commercial real estate buildings on before the construction stage, by improving these commercial real estate building through applying the LCC method. To clarify the main objective as mentioned by Dell'Isola and Kirk (1995) the most important pros of LCC are mentioned below;

- ✓ Planning and budgeting on the long term and therefore improving risk management (figure 4) ;
- ✓ Improve the decision making process by means of a more systematic and a more measurable analysis;
- ✓ Comparing competitive alternatives and selecting between competing alternatives (CBZ, 2006).

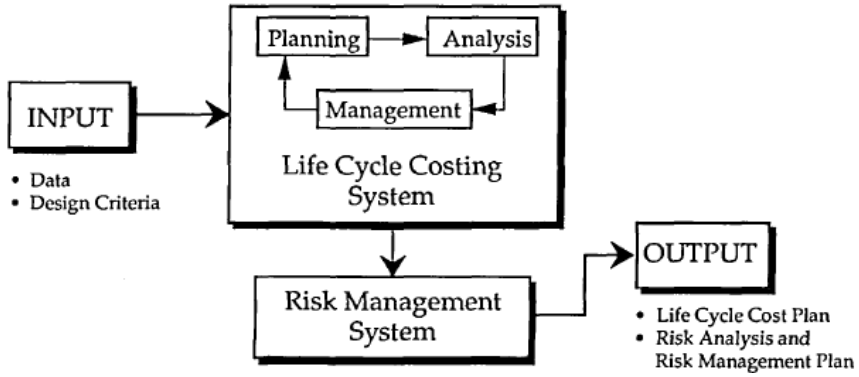


Fig. 4; Life Cycle Costing and Risk Management (Norman, 2007)

Life Cycle Costing provides a structured approach to identify the costs over the total life cycle of buildings as a method to improve the decision making regarding to capital investments (CBZ, 2006). In the considerations that must be made are the one-off investment costs just only a part of the total information needed, the recurring operational costs are the other part (Francissen, 2007). According to the Australian National Audit Office (2001) LCC assists in assessing future costs and can therefore also provide useful input to risk analyses. Management decisions about the design of a building have an influence on the investment costs of that building (Francissen, 2007; Dell'Isola and Kirk, 1995). The investment costs of an building affect the operational costs and thus the Life Cycle Costs of a building as you see in figure 5. The investment costs are denoted by 'A'. The operating costs are denoted by 'B'. Finally, the Life Cycle Costs are denoted by 'C'. When the investment costs are very low (curve 'A'), the operational costs are very high (curve 'B'). On the other hand, very high investment costs will lead to very low operational costs. Where curve 'C' is at a minimum, the total Life Cycle Costs of a building are optimized (figure 5).

Often there is no complete understanding of the consequences which investment decisions have on the costs of owning those assets (Highton, 2012). In many cases real estate appraisals in the Netherlands are solely based on the investment costs (Geltner et al., 2007; Van Gool et al., 2007). However, Figure 5 shows a simple representation of how LCC can lead to cost savings. Which is according to Norman (2007) and Dell'Isola and Kirk (1995) the main motivation to apply the LCC method.

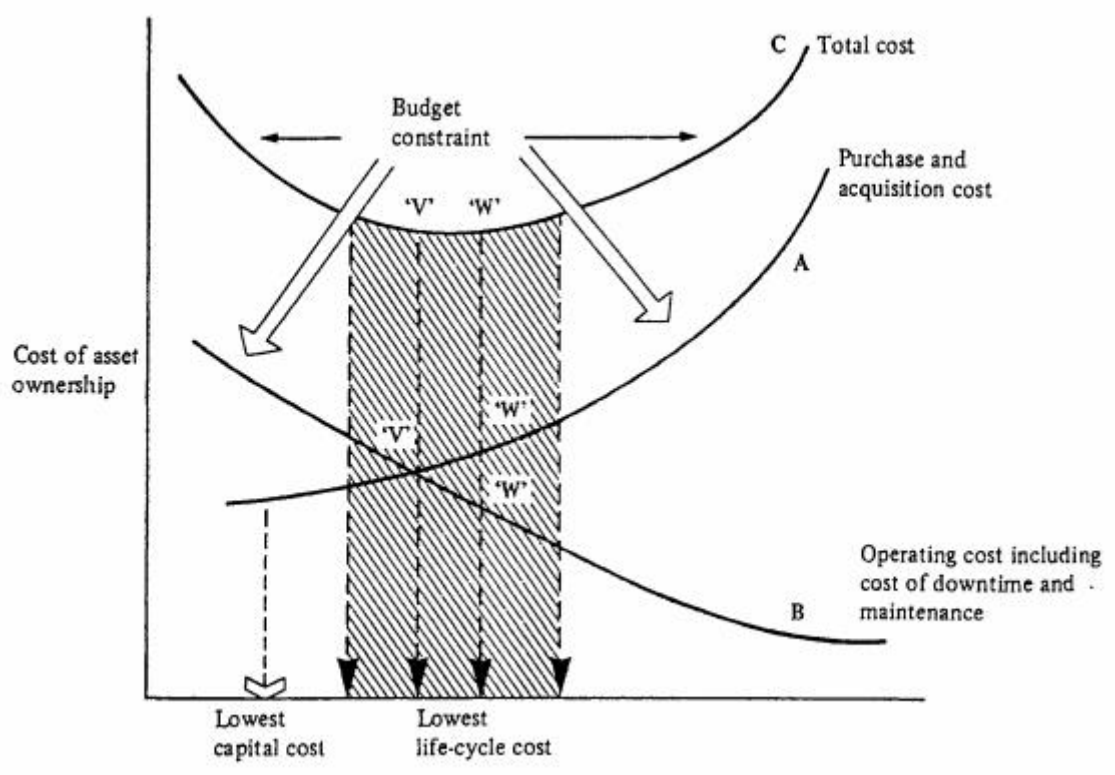


Fig. 5; Cost trade-offs in Asset Ownership (Woodward, 1997)

The last advantage of LCC is the possibility to monitor the costs incurred throughout the life cycle of a product (Lindholm and Suomala, 2007; Asiedu and Gu, 1998; Woodward, 1997; Ashworth, 1996). For example, in figure 6 you see this monitoring of (life cycle) costs regarding to different types of roofs. In figure 6 you also see that the alternative with the lowest investment costs is not the alternative with the lowest Life Cycle Costs.

On the other hand, performing a Life Cycle Cost Analysis and a Life Cycle Cost Calculation isn't convenient and therefore not always feasible to execute by all stakeholders (Francissen, 2007). That's why in paragraph 2.3 'Life Cycle Costs Analysis' a description is given about the steps to be taken to conduct a successful LCCA and LCCC. Another disadvantage of LCC is that unreliable data, or a lack of reliable data, may lead to unreliable results (Emblemsvåg, 2003). Thirdly, the LCCA and LCCC must be executed in an early stadium of the design stage in order to achieve the desired effect (Dhillon, 2011).The disadvantage of this is that not always all actors already are involved in the beginning of real estate developments (KvK, 2013). You will read more about these cons in the next paragraphs.

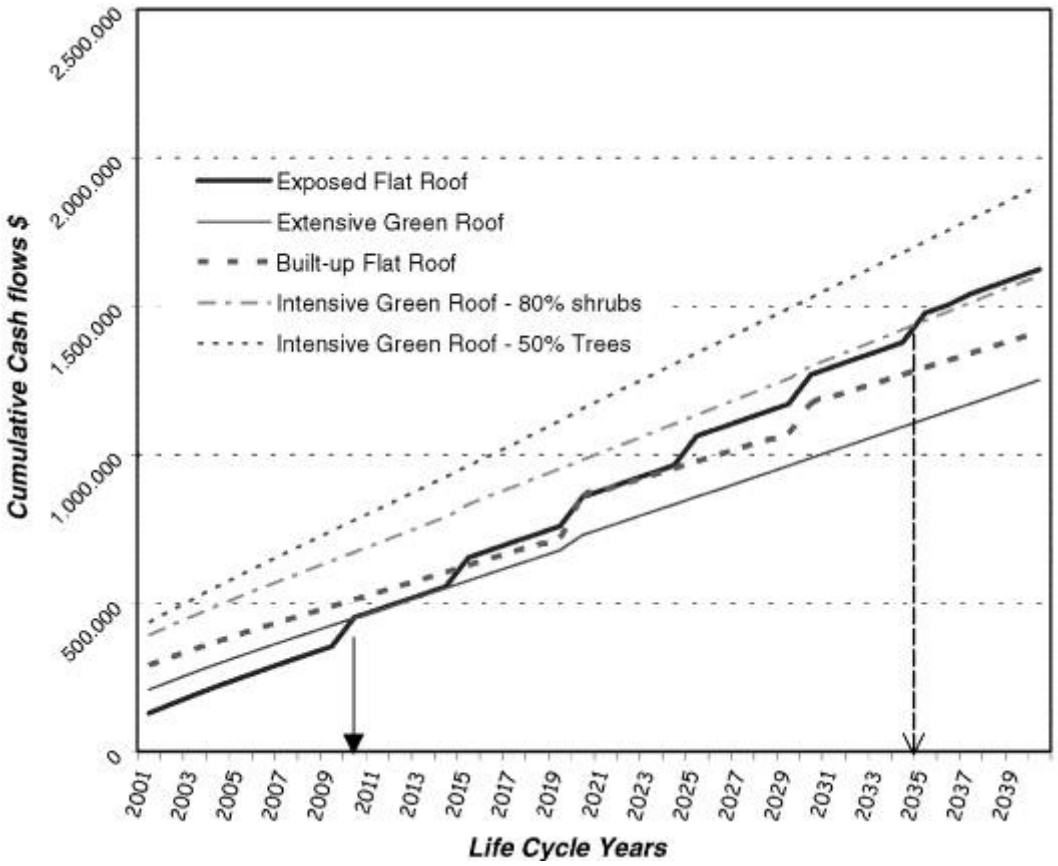


Fig. 6; Monitoring of life cycle costs of different types of roofs (Wong, 2003)

2.3 Life Cycle Costs Analysis

Life Cycle Costs Analysis (LCCA) is an economic assessment of an item over its lifespan, expressed in terms of equivalent costs, using baselines identical to those used for the initial costs. A LCCA is used to compare various options by identifying and assessing economic impacts over the life of each option (Ten Cate, 2007; Gluch and Baumann, 2004; Dell'Isola and Kirk, 2003). According to Sacks et al. (2010), Hunter and Kelly (2009) and Flanagan and Jewell (2005) an LCCA is an exercise to evaluate various solutions in order to establish the most optimal solution. An example of a Life Cycle Costs Analysis is given in figure 7. Bloomfield et al. (2006) indicated that a LCCA includes the evaluation of the costs incurred by an asset over its useful life and compare these costs to other options in order to find the least cost solution. According to Stavenuiter (2002) it is also related to the development of more sustainable products. This means there are two types of Life Cycle (Costs) Analyses, on one hand the Life Cycle Assessment (LCA) and on the other hand the Life Cycle Costs Analysis (LCCA). An LCA is a method of measuring and evaluating the environmental impacts associated with a product, system or activity. By describing and assessing the energy and materials used and released to the environment over the life cycle (West, 2011). In this research LCC is about the LCCA method and not about the LCA methodology.

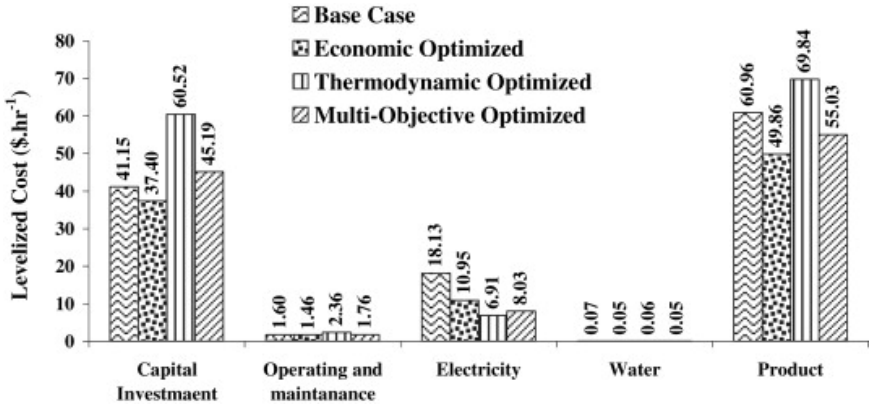


Fig. 7; Bar graph of a LCCA (Sayyadi and Nejatolahi, 2011)

The main steps to be taken in a LCC process are developed by Dell'Isola and Kirk (1995) and Flanagan et al. (1989). These steps are about; defining alternative strategies to be evaluated, identifying relevant economic criteria, obtaining and grouping significant costs and performing a risk assessment. The roadmap for applying LCC below, is drafted by Francissen (2007);

[1] Finding purpose and scope; is the analysis needed to support an investment decision or is it about optimize a design?

[2] Investigation of the options; Life Cycle Costing is always about comparing different options (figure 7). However, it is essential to establish the possible options first (Zoeteman, 2004; Dell'Isola and Kirk, 1995).

[3] Establishing general assumptions and variables; specific assumptions per option and which methods will be used to get insight in the operational costs.

[4] Estimating the costs and timing of every option; within this step the actual Life Cycle Costs and the timing of these costs will be established.

[5] Valuation of components; calculate the Net Present Value (NPV), the Internal Rate of Return (IRR) and/or the Payback Period (PP) for every option.

[6] Identifying risks; performing a sensitivity analysis and determining how to cope with uncertainties. Use is made of a so-called 'Monte Carlo' simulation (Emblemsvåg, 2003).

[7] Identifying other effects; mapping factors that cannot to be expressed in terms of money like quality and comfort. However, quality and comfort data are highly subjective and less objective comparing to cost data (Flanagan et al., 1989), therefore Life Cycle Costs estimation is based more on performance and cost data of a building (Bakis et al., 2003). Within this research the priority is cost data.

[8] Recommendations; drawing up a balanced advice based on the LCC method (step 1 to 7) and choosing the most optimal solution(s).

The purpose of a LCCA regarding to the construction of commercial real estate buildings is to obtain a set of options with the lowest costs over its entire life cycle (Ten Cate, 2007), or as Kemps (2012) explains as; 'systematically determining the costs attributable to each of one or more options over a specified period of time'. In addition, the objective can be an optimal balance between costs and other effects like quality and comfort (Francissen, 2007). The use of reliable data as input for the LCCA (step 3) is a critical success factor in this research. According to Norman (2007) LCC can be seen as a process with two stages, the first stage is assessing the options on their qualitative (comfort included) aspects. The second stage is about calculating the Life Cycle Costs of the options that are chosen from the first stage. Besides a LCCA generates hard decision making data, provided that the parameters are correctly fulfilled, it also can help to convince investors to lend money for the project at hand (Kemps, 2012).

In addition to the estimation of future costs it should be complemented with adequate monitoring, as mentioned before, during the life cycle of an item (Lindholm and Suomala, 2007; Asiedu and Gu, 1998; Woodward, 1997; Ashworth, 1996).

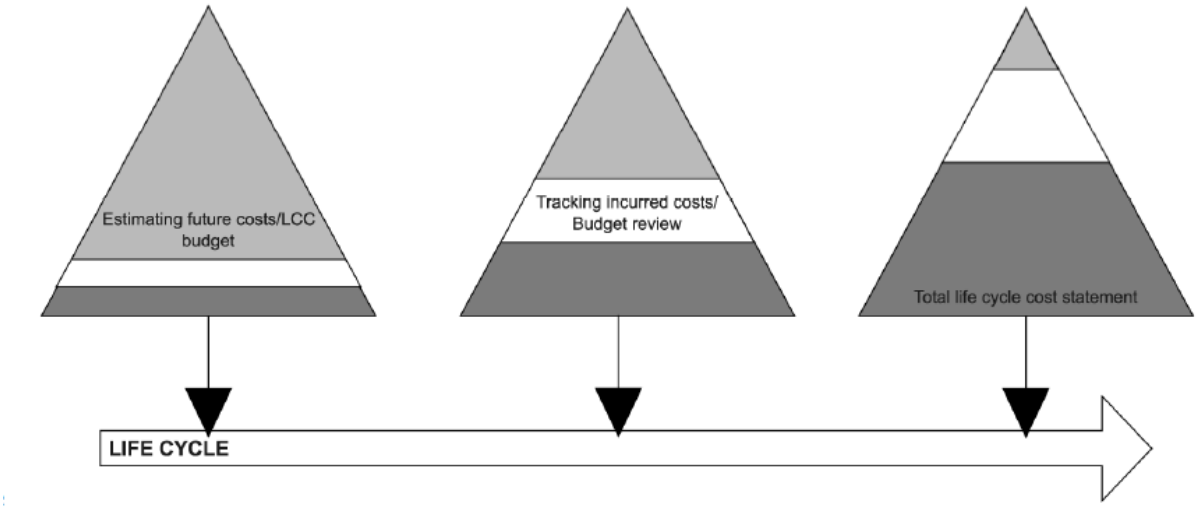


Fig. 8; Monitoring during a product's life cycle (Lindholm and Suomala, 2004)

According to Lindholm and Suomala (2004) the emphasis of LCC shifts essentially from cost estimation to cost monitoring (figure 8). In the beginning of the LCC process, LCC is mainly about the estimation of future costs. However, as time passes it becomes more difficult to influence the Life Cycle Costs of a building because of the progress of the project (figure 8). This is the reason that the emphasis of LCC shifts to cost monitoring.

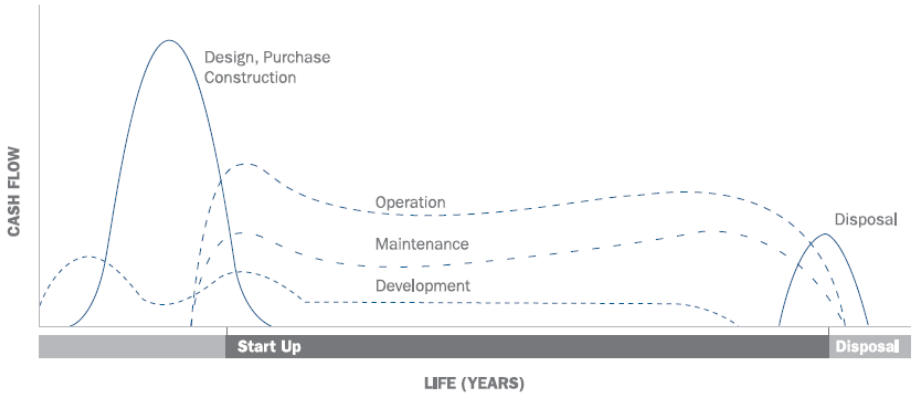


Fig. 9; Life Cycle stages of buildings (Australian National Audit Office, 2001)

The life cycle of a building consists of several stages as you can see in figure 9. In broad terms, the following stages can be distinguished, knowing; the designing stage, the operating stage where maintenance will be part of and the disposal of buildings (Gwang-Hee et al., 2012). In figure 10 you can see that it's important to conduct the LCCA as soon as possible in projects e.g. the development of commercial real estate buildings.

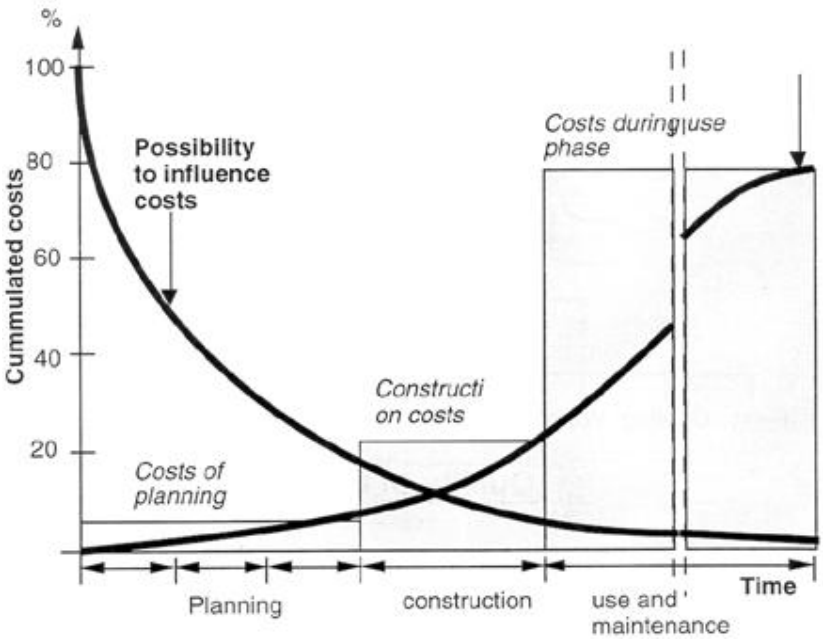


Fig. 10; Life Cycle Model including the different stages of the life cycle of a building (Dhillon, 2011)

On the basis of the foregoing, it can be stated that it's essential to apply the LCCA in the right way, which in this research means the eight steps from Francissen (2007). He states that that performing a LCCA and LCCC isn't convenient and therefore not always feasible to execute by all actors. Additionally, based on the life cycle model (figure 10) it's crucial to apply the LCC method, thus the LCCA as early as possible in the process (Dhillon, 2011; Kawauchi and Rausand, 1999).These are critical success factors.

2.4 Life Cycle Costs Calculation

The Life Cycle Costs Calculation (LCCC) is part of the Life Cycle Costs Analysis. With the formula below, based on the formulas of Gardner (2013), Ballesty and Orlovic (2004), the Australian National Audit Office (2001) and Coorens (2001) the life cycle costs of an asset can be calculated. In this research the formula to calculate the Life Cycle Costs, is adapted to the description in the NEN 2699; 2013 regarding to the investment costs, operational costs and disposal costs. Revenues are not included in the LCCC because these are no Life Cycle Costs. Instead of disposal costs, it's also possible that the building on the end of its life represents a certain economical value, this is called the residual value.

LCC = (Investment Costs* + Operational Costs) – Disposal Costs / Residual Value

LCC = ((S + C + I + A + U + T + F)* + (H + Ta +In + M + MD + EW + Ma + Int + Cl)) – DC / RV

Costs

Investment costs*

S =	Site	U =	Unforeseen
C =	Construction	T =	Taxes
I =	Interior	F =	Financing
A =	Additional		

Operational costs

H =	Housing	EW =	Energy and Water
Ta =	Taxes	Ma =	Management
In =	Insurance	Int =	Interest
M =	Maintenance	Cl =	Cleaning
MD =	Mutations and Disposal		

Disposal Costs

DC / RV = Disposal Costs / Residual Value

** If incurred at base date (year 0), they not need to be discounted*

All costs and revenues need to be discounted to the present value. In the next paragraph you read how to discount future cash flows to their present value and how to discount present cash flows to their future value.

2.4.1 Discount Rates

According to Collier (2009) one of the most important elements of strategy implementation is capital investment decision making. Capital investment means spending money now in the hope of getting it back later through future cash flows. In this respect the consideration of possible alternatives is essential. LCC is a strategy to make the capital investment process more transparent based on the comparison of various alternatives regarding to aspects such as costs, quality and comfort.

To compare future costs on basis of the current value, a discount- and a escalation rate should be used. These factors have to be used because today's euro's will not necessarily have the same value tomorrow. Future costs, such as operational costs, have to be discounted to their present values before they can be compared with such items as investment costs (Kemps, 2012).

In the literature, much has been written about discount rates and related methods for determining them. However, there is no universally accepted method or resulting rate (Kemps, 2012). There are different methods to evaluate investments, such as; accounting rate of return, payback period and discounting cash flow method. It is common for the owner to select the discount rate. The rate usually includes the basic cost of borrowing money plus an increment that reflects the risk associated with the investment (Dell'Isola and Kirk, 2003).

As mentioned before, there is not an universally accepted method to make future costs comparable to today's costs. However, according to Francissen (2007) there are some obvious methods to make the Life Cycle Costs of different alternatives comparable, knowing;

- ✓ Net Present Value (NPV)
- ✓ Discounted Payback Period (DPP)
- ✓ Internal Rate of Return (IRR)

Since there are more DCF methods, the most frequently used DCF method which is the NPV (Ross et al., 2008; Nábrádi and Szôllôsi, 2007; Helfert, 2001), will be explained below. The Net Present Value (NPV) method discounts future cash flows to their present value and compares the present value of future cash flows to the initial investment (Collier, 2009). The formulas used are from Geltner et al (2007).

For discounting a future sum to the present value;

$$PV = \frac{FV}{(1+r)^N}$$

NPV = (Present Value of Future Cash Flows – Investment Costs) + Residual Value

For discounting a present sum forward to its future equivalent;

$$FV = (1+r)^N PV$$

NPV = (Future Value of Present Cash Flows + Investment Costs) - Residual Value

FV = Future Value (in euro's)
PV = Present Value (in euro's)
r = Discount Rate (in percentages)
N = Number of Periods (in years)

The NPV of an investment is the difference between the sum of the discounted cash flows as a result of an investment and the amount of the investment itself. Through this, all costs and revenues are discounted to one amount. If the investment costs, according to 'NEN 2699; 2013' are incurred at the base date, they not need to be discounted. On the other hand the operational costs and residual value need to be discounted. Buildings normally have an extremely long lifespan, mostly 30 years or longer. There should not be annexed too much importance to cash flows for over more than 30 years in the future as shown in figure 11 (Eijgenraam et al., 2000).

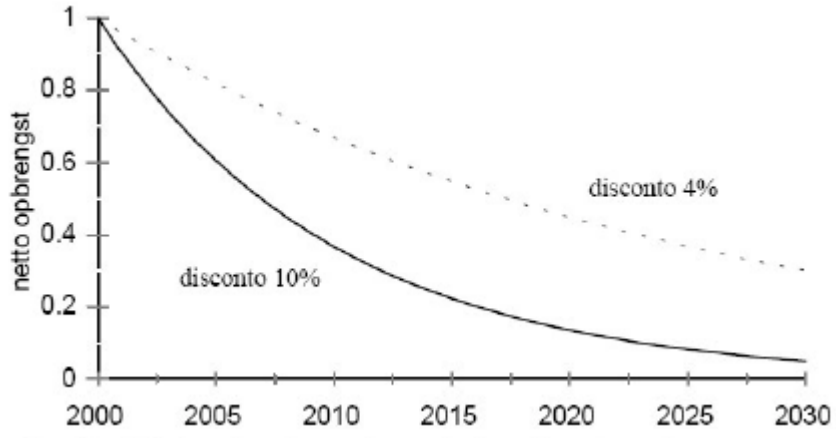


Fig. 11; Discount rate and the weight of future cash flows (Eijgenraam et al., 2000)

Regarding to real estate different types of life cycles can be distinguished. The functional life cycle is the period in which the building can be used for its original purpose. The economical life cycle is dependent on the functional life cycle. When a building is not longer attractive for potential users, the economical life cycle has ended (Francissen, 2007; De Jong and De Roon, 2005).

The residual value of the building, when a new investor would like to invest in that specific building, is often calculated based on the investment value. This is a value that an investor assigns itself to that specific building. The method involves the calculation of the present value of estimated future cash flows with a certain return required. The required return serves as a discount rate. The formula used is based on Van Gool et al (2007);

$$IV = [CF_1 / (1 + RR)^1 + [CF_2 / (1 + RR)^2 + ... + [CF_n / (1 + RR)^n$$

IV = Investment Value (in euro's)
CF_n = Cash flow in period 'n' (in years)
RR = Return required (in percentages)

2.4.2 Risks and Uncertainties

Investment costs can usually be determined accurately. Other cash flows will have to be estimated, these estimates are nearly always subject to some degree of uncertainty (Nábrádi and Szôllôsi, 2007; Brealey et al., 2006; Helfert, 2001). This must be expressed consistently within the LCCA and LCCC. The data input for these two instruments is uncertain which will cause unpredictability (Kemps, 2012). Emblemsvåg (2003) defines uncertainty as a part of unpredictability. He states that the problem implies the lack of information about specific parameters regarding the data input. A sensitivity analysis (SA) is often useful to make due to uncertainties that may exist about the future (Nábrádi and Szôllôsi, 2007). An SA can be conducted to identify (high) cost distributors. According to Norman (2007) the purpose of this type of analysis is to clarify how sensitive Life Cycle Costing is for changing assumptions in the calculation of a selected option. The advantage is that it becomes possible to visualize the effects of different scenario's (Kemps, 2012) (Kroese et al., 2008).

There are different methods developed to conduct a sensitivity analysis. With regard to the LCCA the Monte Carlo simulation is often used. The Monte Carlo simulation is a mathematical algorithm that allows for each of the uncertain elements in the LCCA to be observed probabilistically (Hamilton and Brink, 2012). The model is set up in an Microsoft Excel spreadsheet utilizing Palisade's @Risk software. The principle is that the estimates will be calculated based on a large number of times (e.g. 10,000 times) as you see in the example in figure 12. In each calculation the estimate is re-passed with randomly drawn amounts, prices and events within the specified boundaries. The result of a Monte Carlo simulation can be displayed in a histogram, which will give a well-founded understanding of the expected value, the bandwidth, and the probability of exceeding or downward violation of a certain amount (CROW, 2010; Kroese et al., 2008). Since LCC takes a long time into consideration it's essentially to perform a sensitivity analysis to establish the impact of changing economical circumstances on the life cycle costs (Coorens, 2001). it must be noticed that the LCC method will reduce risks as much as possible, but risks are not excluded Emblemsvåg (2003).

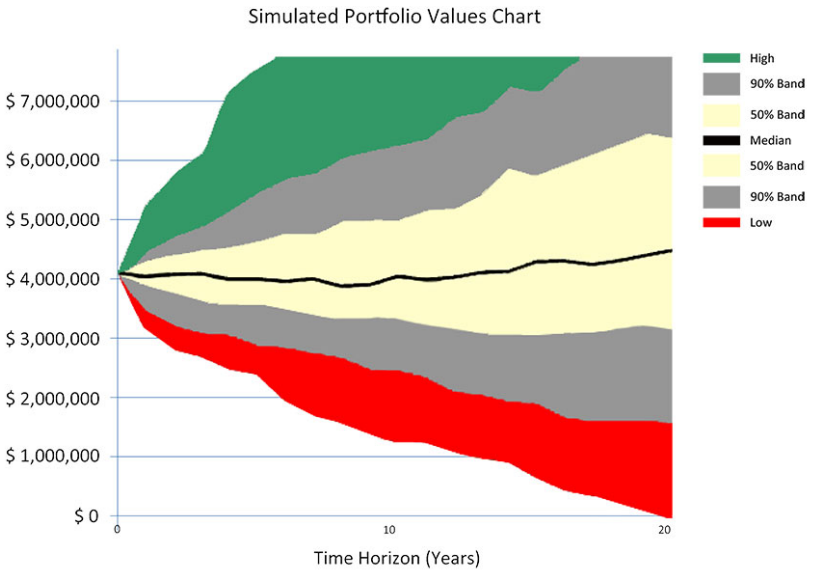


Fig. 12; Example of Monte Carlo simulation of a portfolio values chart (Paliside, 2013)

2.5 Functioning of the Dutch Real Estate Market

In this paragraph the Dutch real estate system will be clarified by means of the four quadrants model of DiPasquale & Wheaton (1992). Based on this model the reason to select some actors as main-actors in this research will be explained in paragraph 2.5.1.

2.5.1. Dutch Real Estate System

For a fundamental understanding of the Dutch real estate market there are several models. However, the four quadrant (4Q) model developed by DiPasquale and Wheaton (1992) can be seen as the most intuitive approach of Dutch real estate system (Van Gool et al., 2007). For this reason the 4Q model, which is an economical model from the point of view of the investor, is used in this research to explain the system on the Dutch real estate market.

The model of DiPasquale & Wheaton (1992) in figure 13 consists of four quadrants with four distinct relationships interrelated to each other. These are known as the rental price (I), value of investments (II), building production (III) and the stock (IV). This means that the dynamics of the market are connected to the financial developments. To estimate the value of this 4Q model all quadrants will be discussed separately.

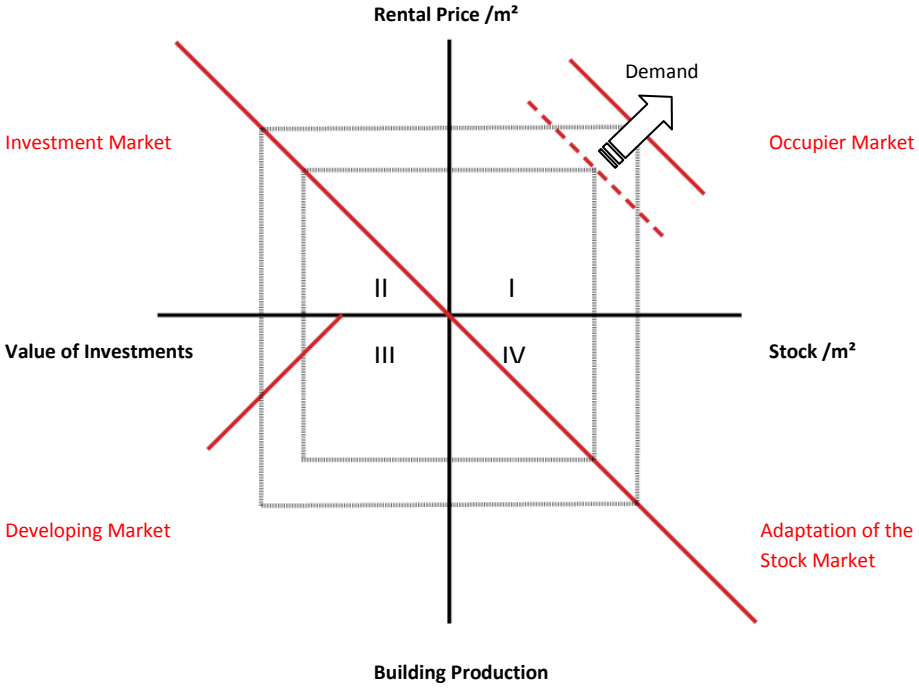


Fig. 13; Four Quadrant Model, based on DiPasquale and Wheaton (1992)

In the first quadrant the central question is about the demand for real estate. The downward course of the line indicates a lower demand for real estate when the rental prices are increasing. Both in prosperity and adversity the demand for real estate will decrease equably as the rental price per square meter will rise.

The second quadrant illustrates the relationship between the rental price real estate and the value of the property. The straight line implies an proportional increase or decrease of the interrelated

factors 'rental price' and 'value of investments'. The line also implies the quotient of the rental price and the value of investments which is also called the gross initial yield.

Quadrant III indicates the building production pertaining to the value of investments. As the value of investments will increase, the building production will increase as well, proportionally in relation to the value of investments. The line in the graphic doesn't start in its origins because a minimum value of investment must be reached before the construction costs can be compensated. The building production is the input for the last quadrant.

In the last quadrant (IV) the building production is connected to the total stock (measured in square meters) which is a consequence of the construction and demolition of properties. The greater the production (or construction), the greater the total stock of real estate in square meters. This clarifies the sloping line from the graphics origin (Geltner et al., 2007; Van Gool et al., 2007).

As you have read, the 4Q model is about the financial developments on the real estate market. The main-actors (in paragraph 2.5.2.) are established based on the 4Q model of DiPasquale & Wheaton (1992). This because these actors all have an direct influence on the prices of real estate on the Dutch commercial real estate market.

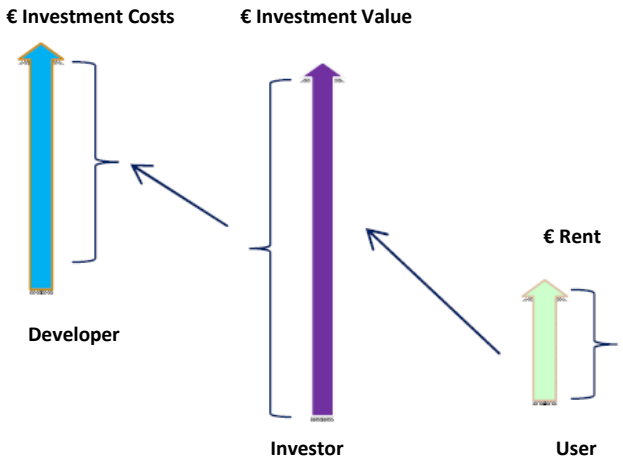


Fig. 14; Price formation on the Dutch Real Estate Market (Zuidema and Van Elp, 2010)

In addition to the 4Q model the price formation model (figure 14) will help to get an better understanding of the different cash flows between the actors on the Dutch commercial real estate market. Central in this pricing system is the value of the office for the user. The rent that a user is willing to pay represents a cash flow, valuated to an investment value by the investor. The investment value serves to, in case of new developed real estate, to get a rate of return that at least covers the investment costs (Zuidema and Van Elp, 2010).

The investment value is a derivative of the rental price. The investment costs are paid from the investment value and the development and site costs paid. The investment value is equal to the amount of the initial investment (Zuidema and Van Elp, 2010).

2.5.2. The main-actors on the Dutch Real Estate Market

The Developer

According to Drenth (2006) a developer often is the initiator and stimulator when developing real estate projects with a certain risk factor. A developer is engaged in adding to the stock and real estate with the (re)development, renovation and reallocation parts of the stock. In addition, professional developers are interested in the development of real estate, trade in and even the operation of the property. A developer has a unique combination of expertise to properly deal with complex real estate situations (Van der Meijden, 2006). The added value of a developer is according to Van Gool et al (2007) a number of elements:

- ✓ The presence of market knowledge, market sentiment and creativity to develop real estate;
- ✓ Planning, legal, financial and engineering expertise;
- ✓ Building a network of relationships;
- ✓ Specific experience related to the development of real estate, real estate concepts and the ability to deal with specific situations.
- ✓ Developing value, ensure the value is created.

The Investor

Investors can be distinguished in developing- and non-developing investors. In times of a favourable economic situation, investors have an tendency to develop their real estate for their own portfolio to get a better grip on new real estate developments (PBL and ASRE, 2013). A non-developing investor should fulfil his profitability requirements based on the desired return of the investor, which can be calculated by the DCF method (paragraph 2.4.1). An investor invests in real estate in exchange for future revenues. Their purpose is to maximize the rate of return (Van Gool et al., 2007). When a investor is interested in a real estate object to invest, his expectations, needs and demands from that asset are different from those of the user. He does not have to invest in any particular piece of real estate, he can pick and choose (Dewulf and Blanken, 2009).

The User

Users are those persons or enterprises which make use of real estate (Laning, 2002). Users always make a conscious decision to start renting a property or to buy it. The advantage of buying a real estate property is securing of business management for a certain time. In addition it's easier for the user to adapt the real estate object to their own needs. On the other hand renting means a higher degree of flexibility for the user (Drenth, 2006). Within the projects in this research the users are renting property from the investor. The rent a user is willing to pay represents a cash flow which will be appraised by an investor to an investment value (Zuidema and Van Elp, 2010). The reason to select projects with users who rent from the investor, is because the purpose of this research is mapping the added value of LCC for all the main-actors on the Dutch commercial real estate market. One of those stakeholders is the investor, therefore the users in the projects of this research are automatically renting.

2.6 Conclusions out of the Literature

In this paragraph the conclusions out of the literature study are described. These conclusions answer the sub questions **A**, **D**, **E** and partly **B** and **C** as you can see in the research model (paragraph 3.6). Firstly, the definition of Life Cycle Costing (LCC) will be explained. Thereafter the pros and cons of Life Cycle Costing will be described followed by a description of the critical success factors of Life Cycle Costing. Then, the effect of the Life Cycle Cost Analysis (LCCA) and Life Cycle Cost Calculation (LCCC) as part of the Life Cycle Costing method will be explained along with a description of which costs will affect the LCCA and LCCC. Finally the main-actors on the Dutch commercial real estate market will be discussed.

The definition of Life Cycle Costing is;

"The Life Cycle Costs are all costs incurred for an property during the life cycle of that property, to meet its own performance requirements" (NNI, 2013)

The pros and cons of LCC below, are listed in table 3. The first pro of Life Cycle Costing is that it can be used to explain different options next to each other and to compare them with each other (Norman, 2007; Dell'Isola and Kirk, 2003) based on several key factors such as costs, quality, and comfort over the entire life cycle of the product (Collier, 2009; Flanagan et al., 1989) **(1)**.

Secondly, the LCC method will help to get a accurate estimation of the Life Cycle Costs, which will have a positive effect on the risk management of a company (Norman, 2007; CBZ, 2006). It prevents the main-actors on the Dutch commercial real estate market for unpleasant surprises after a building is constructed. By making a valid estimation of the operational costs using the discounting cash flow (DCF) method and making use of a Monte Carlo Analysis (MCA), the main-actors on the Dutch commercial real estate market have a more reliable insight of the life cycle costs of a building **(2)**. Because various options will be compared, it also improves the decision making process by means of a more measurable and systematic process (Francissen, 2007; CBZ, 2006) **(3)**. LCC also provides the opportunity to the main-actors on the Dutch commercial real estate market to monitor the expenses incurred throughout the life cycle of a real estate building (Lindholm and Suomala, 2007; Asiedu and Gu, 1998; Woodward, 1997; Ashworth, 1996) **(4)**. Finally, the main motivation to apply the LCC method is to increase the possibility of reducing the life cycle costs of buildings (Dell'Isola and Kirk, 1995)**(5)**.

Alongside the pros of LCC, the LCC method also knows some cons. Performing a LCCA and LCCC isn't convenient and therefore not always feasible to execute by all stakeholders (Francissen, 2007) **(6)**. Like the data for the input of the analysis, a lack of reliable data and/or assumptions may lead to unreliable results (Emblemsvåg, 2003). In addition, it must be noticed that the LCC method will reduce risks as much as possible, but risks are not excluded (Emblemsvåg, 2003) **(7)**. Lastly, it is hard to conduct the LCCA and LCCC in an early stage in real estate developments because not always all actors already are involved in the beginning of real estate developments (KvK, 2013) **(8)**. However, the LCCA and LCCC must be executed in an early stadium of the design stage in order to achieve the desired effect (Dhillon, 2011).The above has answered sub question **A**.

Pros and Cons of Life Cycle Costing for the main-actors	
Pros	**Cons**
1. Simplifies the comparison of alternatives **(1)**	1. Hard to conduct a LCCA and LCCC **(6)**
2. Improved risk management **(2)**	2. Unreliable data may lead to unreliable results **(7)**
3. Stimulates an objective decision making process **(3)**	3. Hard to conduct the LCCA and LCCC in an early stage **(8)**
4. Improves cost monitoring **(4)**	
5. Long term cost optimization **(5)**	

Table 3; Overview of the Pros and Cons of Life Cycle Costing

It can be stated that it's essential to execute the LCCA in the right way, which means using the eight steps from Francissen (2007) **(I)**. Additionally, based on the life cycle model (figure 10) it's crucial to apply the LCC method and thus the LCCA as early as possible in the process (Dhillon, 2011; Kawauchi and Rausand, 1999) **(II)**. The third critical success factor is using reliable data (Emblemsvåg, 2003) **(III)**. To compare future costs on basis of the current value, a discount- and a escalation rate should be used. Because today's euro's will not necessarily have the same value tomorrow. Future costs have to be discounted to their present values before they can be compared with each other (Kemps, 2012). The NPV method is most frequently used for this purpose (Ross et al., 2008; Nábrádi and Szôllôsi, 2007; Helfert, 2001) **(IV)**. Finally, since LCC takes a long time into consideration it's essentially to perform a sensitivity analysis to establish the impact of changing economical circumstances on the Life Cycle Costs (Coorens, 2001) **(V)**. These critical success factors (table 4), are the answer to sub question **B**.

Critical Success Factors for applying the LCC method
Critical success factors
1. Take the eight steps described by Francissen (2007) **(I)**
2. Conduct the LCCA and LCCC early in the process **(II)**
3. Make use of reliable data **(III)**
4. Discount future costs to their present value **(IV)**
5. Perform a sensitivity analysis **(V)**

Table 4; Overview of the critical success factors of Life Cycle Costing

The LCCA is a way to choose the best option out of several alternatives for commercial real estate buildings in terms of money (Dhillon, 2011). By showing information about different alternatives and techniques for a building regarding to the Life Cycle Costs in terms of money, it is possible that decision makers can make the most optimal decision. (Ten Cate, 2007; Gluch and Baumann, 2004). Bloomfield et al. (2006) indicated that an LCCA includes the evaluation of the costs incurred by an

asset over its useful life and compare these costs to other options in order to find the least cost solution. The assumptions, as input for the LCCC will be calculated based on a large number of times (e.g. 10,000 times) in a Monte Carlo Analysis (MCA). The result of a MCA (performed by Palisade's @Risk software) can be displayed in a histogram, which will give a well-founded understanding of the expected value, the bandwidth, and the probability of exceeding or downward violation of a certain amount (CROW, 2010) (Kroese et al., 2008). The above has answered sub question **C**.

To calculate the Life Cycle Costs of commercial real estate buildings, the following formula can be used;

LCC = (Investment Costs* + Exploitation Costs) – Disposal Costs

This formula is based on the formulas of the Gardner (2013), Ballesty and Orlovic (2004), the Australian National Audit Office (2001) and Coorens (2001). The investment- and operational costs that influence the life cycle costs of an commercial real estate building are inherited from the NNI (2013) as you see in table 5.

NEN 2699; 2013 Investment Costs and Operational Costs regarding to Real Estate	
Investment Costs	**Operational Costs**
Site (A)	Housing (X1A)
Construction (B)	Taxes (X1B)
Interior (C)	Insurance (X1C)
Additional Costs (D)	Maintenance (X1D)
Unforeseen (E)	Mutations and Disposal (X1E)
Taxes (F)	Energy, water etc. (X1F)
Financing (G)	Management (X1G)
	Interest (X1H)
	Cleaning (X2C)

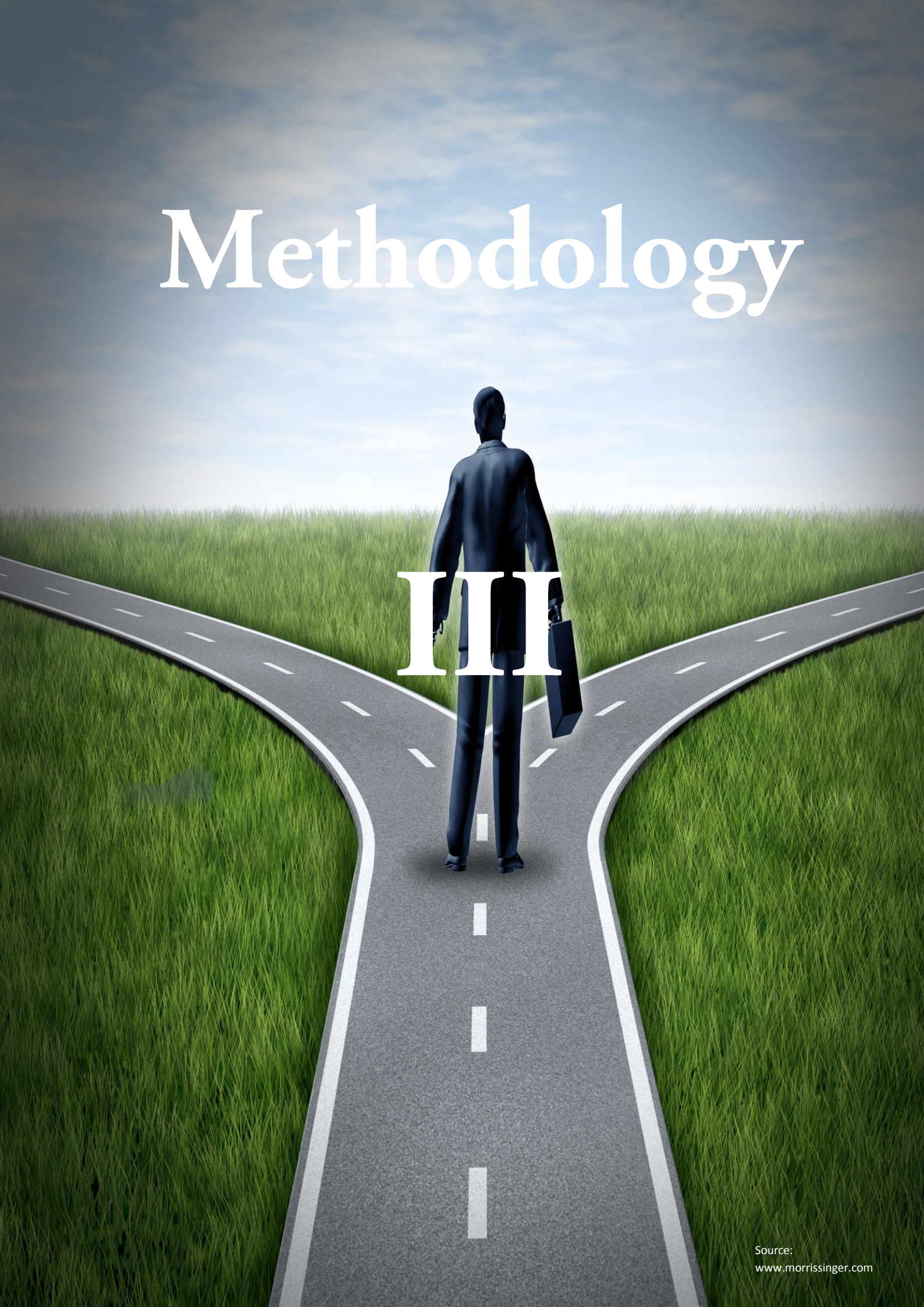
Table 5; Investment Costs and Operational Costs according to the NEN 2699; 2013 (NNI, 2013)

Note; the markings (between brackets) refer to the coding of the different tables in appendix 2 "NEN 2699;2013. A more detailed explanation of the different costs, is given there (in Dutch).

All the factors as shown in table 5 will have an influence on the costs in the LCC method. Additionally, the disposal costs (or residual value) will complete the investment- and operational costs as you have read in the formula above. The above has lead to the answering of sub question **D**. The main-actors on the Dutch commercial real estate market are developers, investors and users because these actors all have an direct influence on the prices of real estate on the Dutch commercial real estate market (DiPasquale and Wheaton, 1992). This is the answer to sub question **E**. In the next chapter of this study the research methodology is described. That will give you an better understanding of the link between the literature study and the practical study.

Methodology

III



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3. Methodology

In this chapter the several research methods to answer the main research question are described. In paragraph 3.1 you read the context of this research. This is followed by the main research question and the sub-questions in paragraph 3.2 and 3.3. In paragraph 3.4 the reason for conducting qualitative research is explained. After that, an global overview of the research is given by means of the research framework, followed by a more detailed insight in the research through the research model, this is described in the sections 3.5 and 3.6. In paragraph 3.7 the methods and techniques used are explained. Finally in paragraph 3.8 is explained in which manner the data has been analyzed.

3.1 Context Research

As discussed in the introduction the operational costs are often disregarded in the calculation models of developers and investors (Australian National Audit Office, 2001). For example, the gross initial yield is based on the gross annual rent in the first year of operation and the total initial investment only. Operational costs are excluded. This may have a negative effect on the reliability of the appraisal of a building, or at least this may not lead to long term cost optimization (EMSD, 2004). To avoid this, it's important for the main-actors within the Dutch real estate market to apply the Life Cycle Costing method. However, the benefits of LCC are insufficiently known to developers, investors and users of commercial real estate in the Netherlands. In this study is chosen to interview the main-actors of commercial real estate within several projects. In this way, the potential benefits of LCC are being viewed from multiple angles.

This research examines the benefits of Life Cycle Costing within three projects. These projects are chosen because it are all newly built office buildings completed in 2010 or later, all with an sustainability label (LEED, BREEAM or Greencalc). At SOM= it was known that the LCC method was been applied within all three the projects The projects are;

1. TNT Green Office in Hoofddorp, the Netherlands (LEED score: Platinum)
2. UPC building in Leeuwarden, the Netherlands (BREEAM score: Excellent)
3. Rabobank Zuiderval in Enschede, the Netherlands (Greencalc score: B)

In appendix 1 you read more background information about these three projects. The research focuses on relationships between the 'success of a particular project' and 'the contribution to that success through the application of the LCC methodology'. A number of benefits can arise here e.g. savings in life cycle costs of commercial real estate, possibilities for more objective decision making, more sustainable constructed office buildings with higher future-proofing and an higher flexibility. The potential relationships can contribute to draw up a list of benefits when applying the LCC method. Therefore, this study will give an better insight in the benefits of Life Cycle Costing. By the qualitative character of this study, this research can be characterized as a qualitative research. Further explanation about qualitative research is described in paragraph 3.4 'Qualitative Research'. The next paragraph describes the main research question.

3.2 Main Research Question

The main research question is:

What are the benefits of applying the Life Cycle Costing method for the main-actors within the Dutch commercial real estate sector? **(A+)**

The next paragraph describes the corresponding sub-questions.

3.3 Research Questions

The main research question will be answered through the following sub-questions;

A. What is Life Cycle Costing and what are the pros and cons of this method? **(A)**

B. What are the critical success factors for applying the Life Cycle Costing method in Dutch real estate developments? **(B)**

C. What is the effect of the Life Cycle Costing Analysis and the Life Cycle Costing Calculation on the result of a project, as part of the Life Cycle Costing method? **(C)**

D. Which costs affect the LCCA and the LCCC for the main-actors within the Dutch commercial real estate market? **(D)**

E. Who are the main-actors within the Dutch real estate market that are involved in the decision making process about commercial real estate developments? **(E)**

F. To what extent are the main-actors of commercial real estate developments in the Netherlands, involved in the decision making process? **(F)**

G. What are the benefits of applying the Life Cycle Costing method? **(G)**

In the next paragraph (3.4) is described how the sub questions **A** to **G** will be answered via the empirical-analytical qualitative research stream.

3.4 Qualitative Research

Qualitative research is conducted within many different disciplines, like in the fields of ethnography, medical science and theology (Baarda et al., 2013). There are various scientific streams to distinguish, like the empirical-analytical stream. According to Baarda et al. (2013), the empirical-analytical qualitative research stream is mainly about determining facts. This explains why this research is conducted from the empirical-analytical qualitative research perspective, because this research is about determining factual benefits of the Life Cycle Costing method for the main-actors within the Dutch commercial real estate market.

Qualitative research is often used when in-depth information is desired. Information is being gathered about motives, thoughts, behaviour and emotions. Qualitative research is not intended to generalize the findings of a whole target-group, but to get an accurate view of the opinions or mindset of the target-group (Yin, 2003). Because in this research in-depth information is more beneficial than quantitative data, qualitative research is most appropriate to answer the main research question.

Qualitative research is a form of interpreting empirical research in which data is collected, analyzed and reported in a systematic and verifiable manner. It is essential that the various stages of a research such as drafting a problem definition, drawing the research questions, determining the study design, the data collection, the data analysis and the data reporting can overlap each other and not need to be strictly separated as in quantitative research is very common. As a result, the various steps in the research can be taken multiple times. This repetitive or iterative nature is the strength of qualitative research (Plochg and Van Zwieten, 2007).

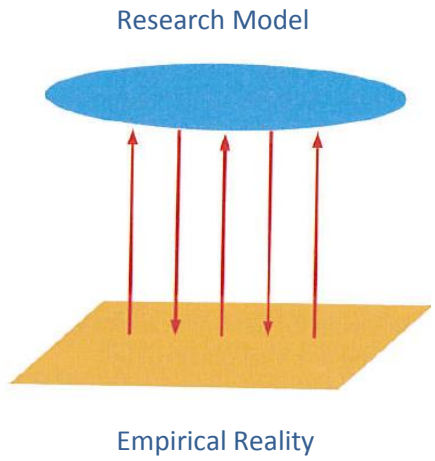


Fig. 15; Iterative Process (Baarda et al., 2013)

In figure 15 this iterative process is schematically shown. Iterative means that the process between observing, collecting data and reflecting will be constantly repeated. Preferably until no new information is obtained (Baarda et al., 2013). For this reason there are various research methods used to obtain as much as possible information to get an reliable reflection. In this study the following research methods are used, knowing; literature study, interviews and documentation analysis. The implementation of these methods is further described in paragraph 3.7.

First of all, in the next paragraphs (3.5 and 3.6) respectively, the research framework and the research model are shown. This, in the first instance to provide you a clear overall view of this study.

3.5 Research Framework

In this paragraph the research framework (figure 16) is discussed. The research framework is meant to give you an first answer to the question of how the research was conducted.

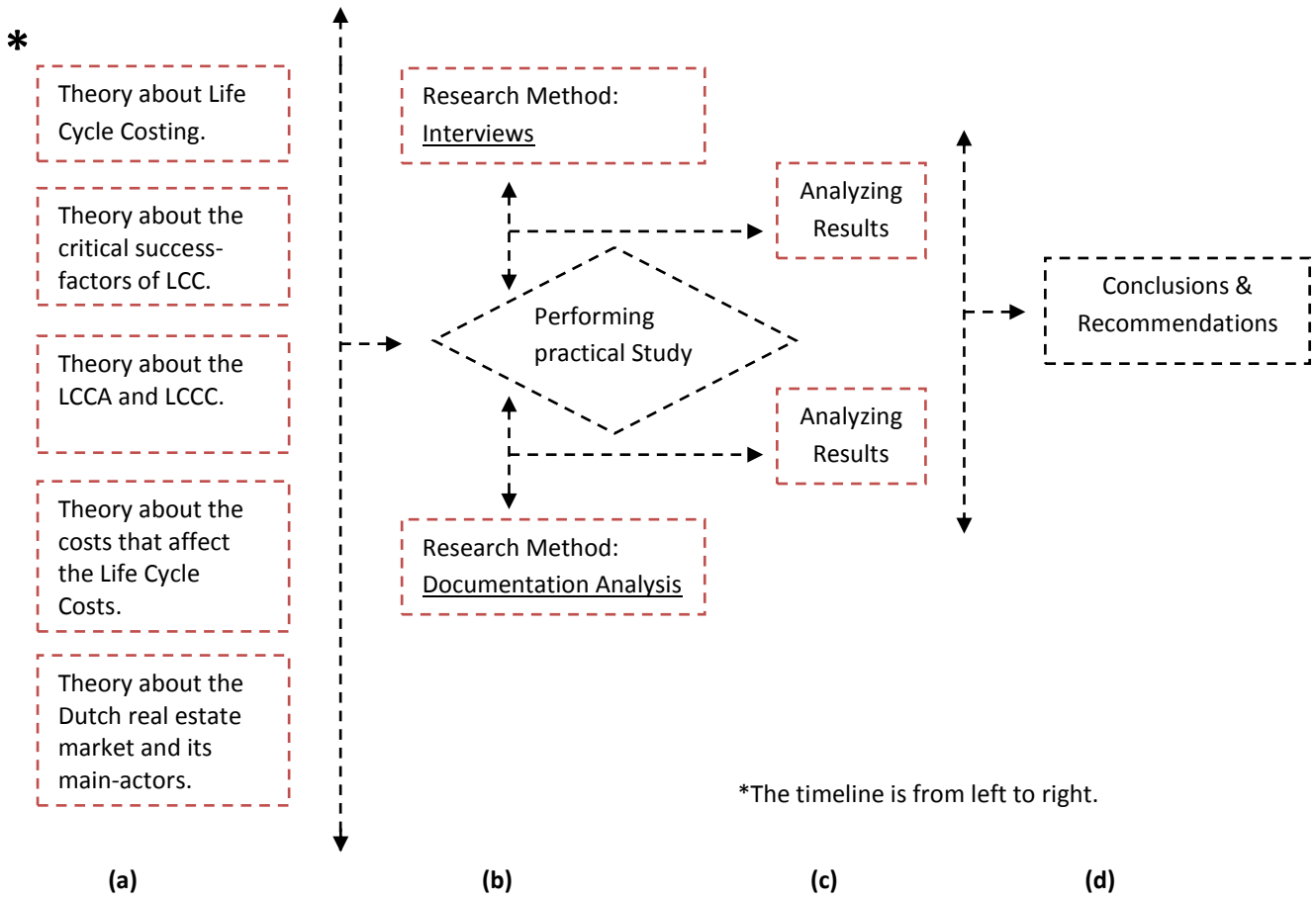


Fig. 16; Conceptual Framework, based on Verschuren and Doorewaard (2011)

Explanation 'Research Framework'

On the basis of studying relevant literature in the area of Life Cycle Costing (sub question A), the critical success factors of LCC in the commercial real estate sector (sub question B), theory about the effect of the LCCA and the LCCC on the result of a project (sub question C), theory about the costs that affect the Life Cycle Costs of a commercial real estate building and finally the theory about the Dutch real estate market and its main-actors, the practical study is performed **(a)**. Within the practical study the data collection methods 'Interviews' and 'Documentation Analysis' are used **(b)**. All the data from interviews and documentation analysis is being analyzed according to the qualitative analysis as described in paragraph 3.8 **(c)**. Based on the results of the analysis, conclusions and recommendations are given **(d)**.

In paragraph 3.6 the research model is discussed. This model will give you an more detailed insight of how the different data collection methods are used to answer all the sub questions.

3.6 Research Model

Below in figure 17 you see the research model of this study. This research model is meant to give you an schematic overview of how the different research methods are used to answer all the sub questions.

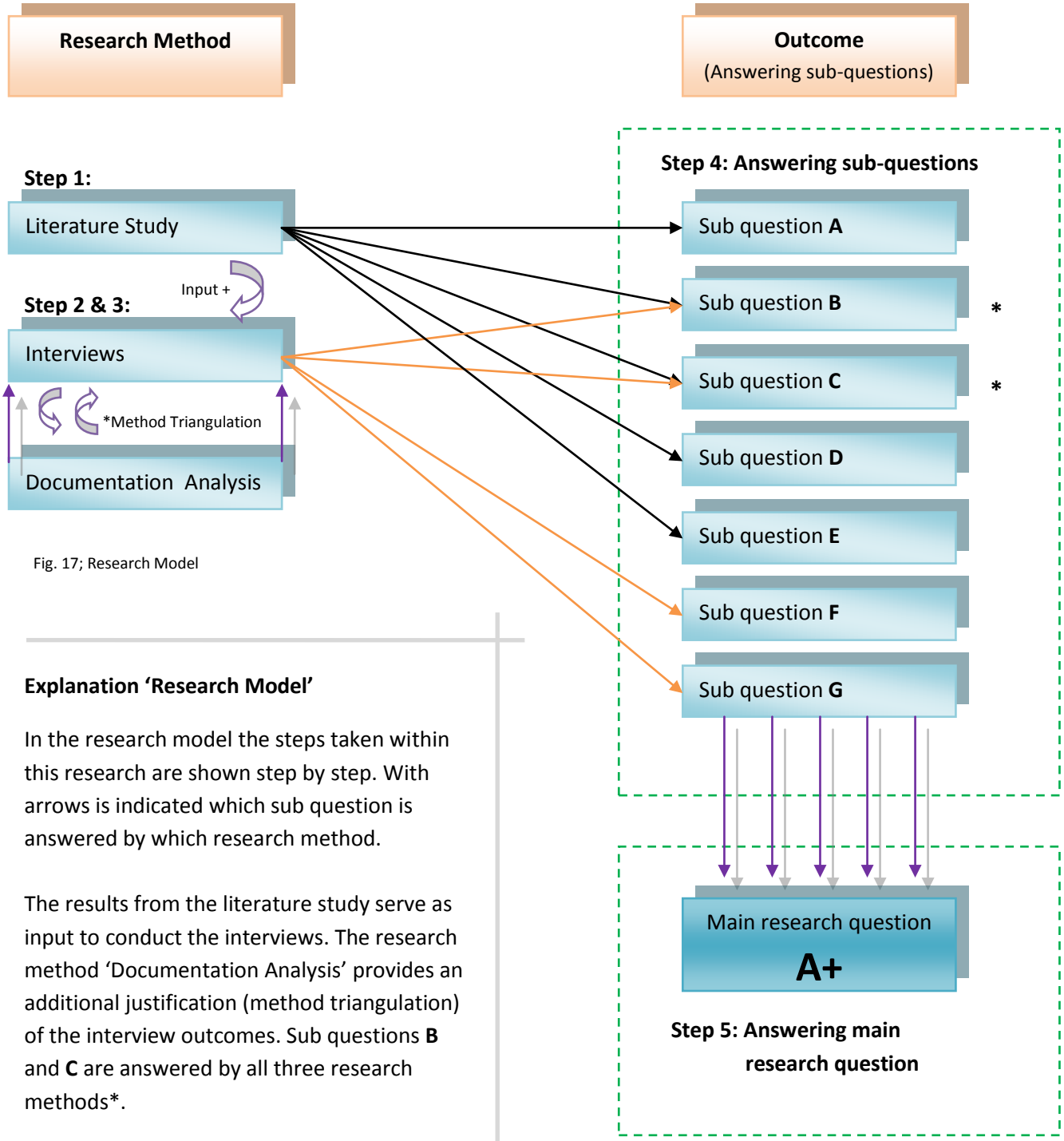


Fig. 17; Research Model

Explanation 'Research Model'

In the research model the steps taken within this research are shown step by step. With arrows is indicated which sub question is answered by which research method.

The results from the literature study serve as input to conduct the interviews. The research method 'Documentation Analysis' provides an additional justification (method triangulation) of the interview outcomes. Sub questions **B** and **C** are answered by all three research methods*.

The sub questions **A** to **G** answer the main research question **A+**.

3.7 Methods and Techniques

In this paragraph the applied research methods (as you have seen in step 1 and 2&3 in the research model) and techniques are explained.

3.7.1 Literature Study

The literature study has started with focussing on LCC models and required data for a LCC analysis. The start key words were have been searched on, were Life Cycle Costing (LCC) and Life Cycle Costs. The field of LCC is wide and to be able to keep focus on the real estate sector all words have been combined with real estate, commercial real estate, building, office or property. This has narrowed the view. While reading the first literature it became clear that often terms like whole life cost and whole life costing were being used in the literature, as well as whole life appraisal (WLA), Total Cost of Engineering (TCE) and Total Cost of Ownership (TCO/TOC). These words have been added to the list of key words were have been searched on. The main sources for the literature research were databases, such as Environmental Sciences, Emerald, Science Direct, Scirus, Elsevier and Google Scholar. The search for articles was complemented with systematic search via the online library of the University of Greenwich.

The literature study was meant to form a theoretical framework that serves as basis for the practical study, thus the interviews and the documentation analysis.

3.7.2 Interviews

For the interviews in this study semi-structured questionnaires have been used (appendix 3). Besides the topics, also the most important questions were established and listed in the questionnaires before the interviews. For this semi-structured interview approach was chosen because this offered both guidance and flexibility during the interviews. By the high level of flexibility it was possible to ask questions to the interviewees in a different order. On the other hand, by the guidance of not only topics but also interview questions the researcher had more control during the interviews (although the researcher knew what he could expect, there were still unexpected things that could occur). The high level of flexibility was also the main reason for choosing face-to-face interviews. After all, when someone didn't understand a interview question it was possible to ask the same question in a different more clarified way. Trough this, it was still possible to acquire the desired answers.

Through the literature study already a lot of knowledge about Life Cycle Costing was obtained, but not the complete knowledge about LCC. This was the second reason for choosing the semi-structured interview approach. To be able to obtain the full knowledge about the benefits of LCC it was necessary that the interviewees had the opportunity to share (all) their knowledge with the interviewer.

During the literature study it also became clear that LCC has many similarities with sustainability. The choice of individual interviews has been made because interview questions about sustainability can lead to socially desirable answers. In that case the answers obtained can be trustful but not valid (Baarda et al., 2013). In groups, people may be more inclined to give socially desirable answers. To get a trustful insight in the benefits of LCC for the main-actors on the Dutch commercial real estate market the choice has been made to interview multiple actors involved in the same project (triangulation of sources). Therefore, it was possible to confront statements of actor 'A' with statements of other actor 'B' and/or 'C'.

By recording the interviews through using recording equipment it was possible to play and listen these recordings as often as desired. The recordings of the interviews have been transcribed by 'Transcriptie Online' in Rotterdam (the Netherlands). Parts of the recordings were compared with the transcripts by the researcher to ensure the reliability of the interview data. The transcripts be analyzed as described in paragraph 3.8. It allows the readers of this study to check the data and the analysis. The trustfulness of the questionnaires used in the interviews is tested via pilot interviews. As you see below, three pilot interviews are conducted;

1. The questionnaire for developers is tested in an pilot interview with:
   Mrs. O. van Kampen, Consultant and Sales Officer at S&G Asset Management

2. The questionnaire for investors is tested in an pilot interview with:
   Mr. G. van Oosterom, Construction Costs Consultant at BBN

3. The questionnaire for users is tested in an pilot interview with:
   Mr. P. Scholten, Owner at SOM=

By executing test interviews, the researcher tried to achieve a greater validity of this study. In addition the researcher studied the practical guide from Baarda et al. (2012) to learn interrogating. Finally, the interviews were all conducted within a period of seven weeks in order to avoid confounding elements due to excessive time differences between the interviews. The most important disadvantages of qualitative interviews according to Yin (2009) and Yin (1994), knowing; invalid questions drafted by the researcher, bad interrogation by the interviewer and social desirable answering by the interviewees, now are tackled.

In addition to the three pilot interviews, eight interviews were conducted. Three interviews with users, two interviews with developers, two interviews with investors and one interview with a developing investor as you can see in appendix 4. In total eight interviews were taken. It was not possible to execute more interviews within the limited time. However, the researcher tried by means of the triangulation of sources (more interviewees of one project) and methods (documentation analysis) to provide the reader reliable results about the benefits of LCC. The main-actors (developers, investors and users) are established based on the four quadrant model (paragraph 2.2).

3.7.3 Documentation Analysis

As mentioned in the last subparagraph the researcher tried by means of triangulation of methods to provide the reader reliable results about the benefits of LCC. For this reason an documentation analysis has been executed. The documents analyzed, are interpersonal public documents with the focus on communication between several actors. Examples of these interpersonal public documents used, are; information and advertising documents, plan requirements or other business documents. These documents are attached in the digital version on USB stick.

Note: The research design of this study appears to be a case study. However, this study is less in-depth than a case study. The researcher preferred to interview more main-actors instead of investigating one or two cases.

3.8 Qualitative Analysis

In this paragraph the qualitative analysis is explained. In this research the process of analysis from Baarda et al. (2013) is used to analyse all data (figure 18). This qualitative analytical process is about three main steps, known as; observing, analyzing and reflecting. In the observation part of this research the data to be analyzed is collected through the literature study, the interviews and the documentation analysis. The second step is analyzing the data. The data analysis is conducted according to the 'open coding', 'axial coding' and 'selective coding' technique as described in Verschuren and Doorewaard (2011). The third and last step is reflecting the contribution of the outcomes of the analysis to the research questions.

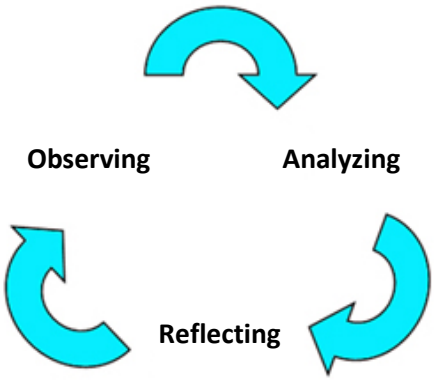


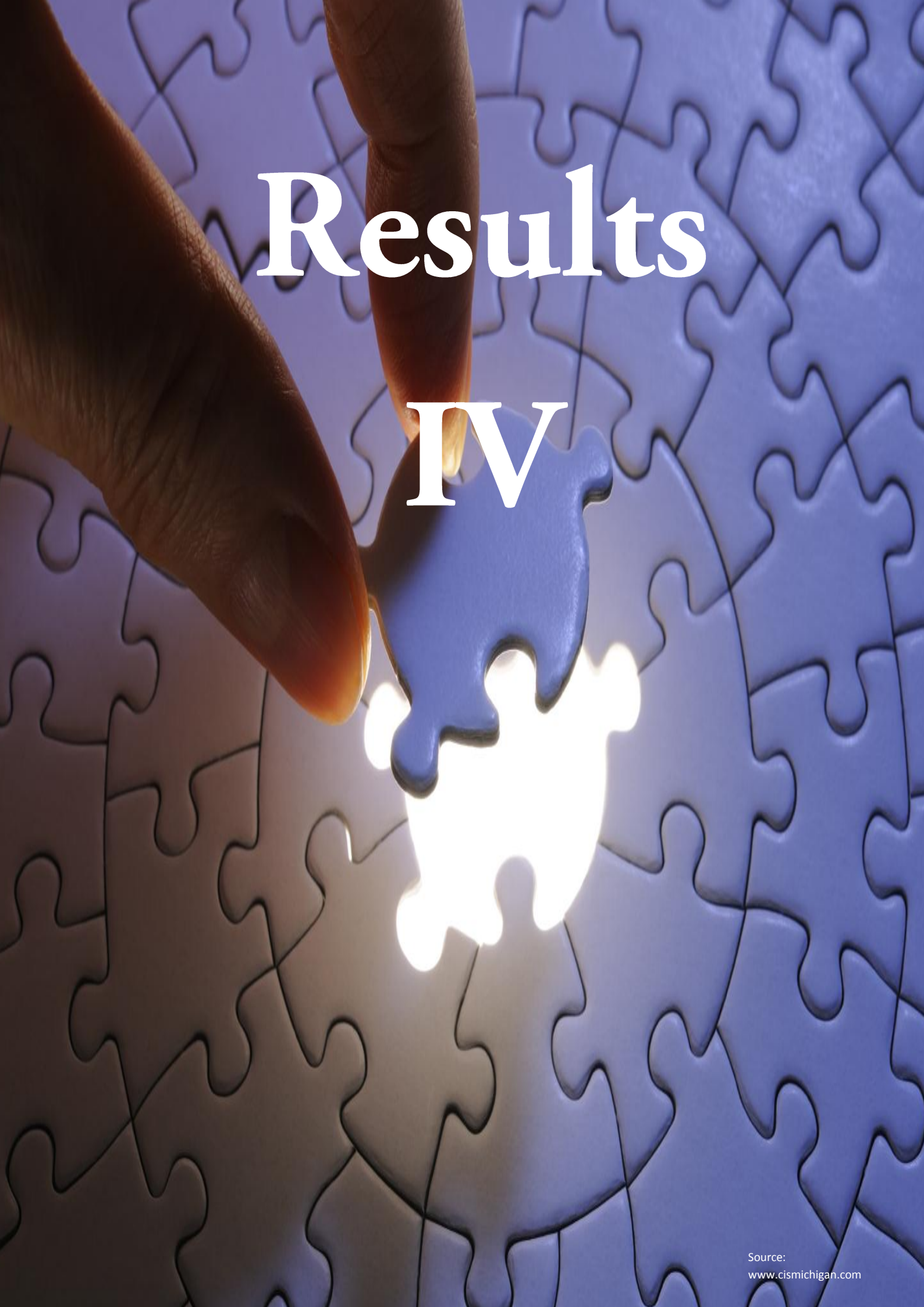
Fig. 18; Process of Analysis, based on Baarda et al. (2013)

The encoding requires a further explanation. As mentioned, the data is encoded according to the 'open coding', 'axial coding' and 'selective coding' technique as described in Verschuren and Doorewaard (2011). By open coding the field of research is explored. Open coding is the analytical process through which concepts are identified and their properties and dimensions are discovered in data (Corbin and Strauss, 2008). In this study small pieces of data were provided with an label and have been categorized. The analysis according to the open coding systematic is attached in appendix 5.

The second part of the analysis is axial coding. Axial coding is the process of relating categories to their subcategories, termed "axial" because coding occurs around the axis of a category, linking categories at the level of properties and dimensions (Corbin and Strauss, 2008). In this stage categories have been systematically connected to each other to form the theory. The third and last analyzing step performed is selective coding. In this selective coding part the theory is integrated and refined. The many phenomena are reduced to core categories. These core categories are clarified by the reasoning behind the coherence of these phenomena as described in Verschuren and Doorewaard (2011). The core categories (from now on called 'Themes') are shown in chapter 4.

Results

IV



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4. Results

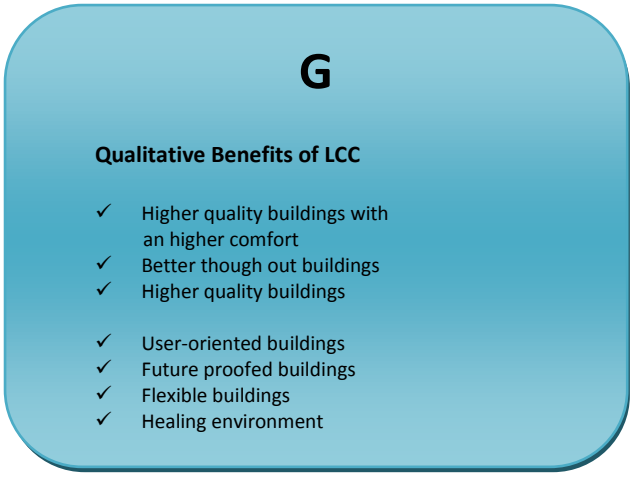
In this chapter the results of this master thesis are shown. The results of this chapter are obtained via interviews and a documentation analysis as you can see in the research model in paragraph 3.6.

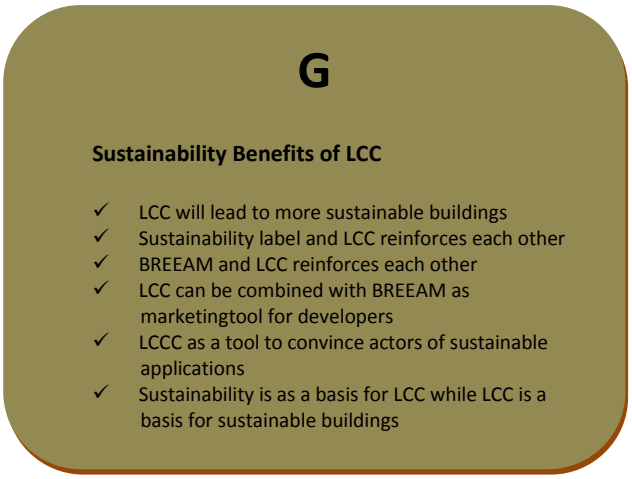
4.1 Themes

The results in this chapter are described by theme. The themes in this paragraph are the result of the open, axial and selective coding process as described in paragraph 3.8. Through this system the results of the 'Interviews' and the 'Documentation Analysis' are analyzed. The results are linked to the associated sub questions. It must be noted that some results which should answer sub question **C** are linked to the several benefits of LCC. This is because the LCCA and LCCC are both beneficial and therefore, sometimes are linked to sub question **G**.

You could have read in chapter three, the manner in which the validity and reliability of the results in this chapter are checked. Sub question **D** about which costs affect the LCCA and LCCC will be not discussed in this chapter, the results of this sub question are shown in paragraph 2.6 'Conclusions out of the Literature'. The same applies for sub question **E**.

Hereafter, the seven themes which are established via the Axial and Selective coding system, are shown. These themes are created by the combination of the different codes which have emerged from the Open coding system.





G

Economical Benefits of LCC

- ✓ Cost optimization
- ✓ Sustainable applications will lead to cost savings
- ✓ Cost savings for the user
- ✓ Higher rent for the investor

- ✓ More profit for the developer
- ✓ Better thought out buildings with higher revenues / savings
- ✓ Insight into costs between the main-actors
- ✓ Future proofed buildings with higher economical values

- ✓ Cost savings for the investor
- ✓ LCC creates economical value
- ✓ Higher quality buildings with higher revenues
- ✓ Increased labour productivity

- ✓ LCC gives better insight in the market value of buildings
- ✓ Investment costs can be easily recovered by high productive employees

- ✓ Comparison of different alternatives *
- ✓ Comparison of different materials *

B

Preconditions for applying LCC successfully

- ✓ Transparent list of requirements
- ✓ Plan of requirements as a basis for LCC
- ✓ Teamwork

- ✓ Sustainable ambitions as a starting point
- ✓ Reliable data
- ✓ Transparent process

- ✓ Collective benefits for the main-actors
- ✓ Collective benefits by cooperation of at least 2 actors
- ✓ Manageable scope

- ✓ DBFMO contracts as a basis for LCC
- ✓ Contract as a basis for LCC
- ✓ Actors with an equal level of knowledge about real estate

- ✓ Make decisions together
- ✓ No time horizon but quality as a starting point

- ✓ Time horizon to justify the investment costs
- ✓ Cost spread over several periods

C

Process-related Benefits of LCC

- ✓ Reduction of risks
- ✓ More conscious choice based on a LCCA and LCCC
- ✓ Important decision making method
- ✓ LCC will lead to a longer contract with the user
- ✓ LCCA and/or LCCC can be simple

F

User-oriented Market

- ✓ Changing market
- ✓ User takes final decisions
- ✓ Investor takes decisions (investor is the same party as the user)
- ✓ All actors involved in the design stage

G

Disadvantages of LCC

- ✓ LCC is a difficult method to understand
- ✓ Unfair distribution of savings

The results based on the seven themes above will be clarified in the following paragraphs of chapter four. The results out of the literature study in chapter two will be linked to the results obtained by the practical research.

4.2 Economical benefits of Life Cycle Costing

The first theme where the results of this research are linked to, are the economical benefits of Life Cycle Costing. The LCC methodology provides insight into the total life cycle costs of buildings, to the main-actors on the Dutch commercial real estate market. This insight into the life cycle costs of a building will help the main-actors to justify the highness of the investment costs to each other and to those who make the final decision about the design of a building. The main-actors can make more conscious choices based on the outcomes of the LCCA and LCCC when applying the LCC method successfully. You will read more about this in paragraph 4.5. Additionally, the investment costs can be explained to the management board of the developing and/or investing company, after all they take decisions. Complementary, the highness of the annual rent can be argued to the user by the outcomes of the LCCA and LCCC.

"This means a rental increase of € 9,- but because they will save at least € 12,- on operational costs, they have at least € 3,- net benefit"

- Bert Krikke -

The quote above shows that, when applying the Life Cycle Costing method successfully, it will lead to cost savings for the user. In this example, at least € 3,- per square meter per year. So despite the fact the user pays a higher rental price per square meter per year, it will lead to cost savings because of the savings on energy, maintenance and cleaning costs. The publication of Agentschap NL about UPC confirms that despite the higher rent for UPC, the life cycle costs of the UPC building are lower. On the other hand it's also beneficial for the investor since his rent will increase with € 9,- per square meter per year. This increase of the annual rent represents a certain economical value for the investor at a possible sale of the building. The extra rental income for the investor pays back the extra investment in energy saving measures (sustainable applications). It should be mentioned that the developer and investor were one party because of their joint venture in the development of the UPC building, the benefits of such a cooperation of two actors is described in paragraph 4.8.

The publication of Agentschap NL about the TNT Green Office shows a similar construction. TNT, the tenant of the building, pays a higher rent to the investor but saves energy costs in return. For the user the LCC systematic is economical beneficial because of the possibility to optimize the energy costs, maintenance costs and cleaning costs based on the LCCA and LCCC. Additional investments or an increase of the rental price can be earned back through lower energy costs, maintenance costs and/or cleaning costs. If the energy costs, maintenance costs and/or cleaning costs (partly) are for the investor because this has been agreed by a DB(F)MO contract, the investor is also intrinsically motivated to optimize the total life cycle costs of a building. In that case the investor optimizes the net initial yield to achieve the highest possible net return. Mr. Verbaan stated that Rabo Eigen Steen chooses for facades consisting as little as possible timber because it increases maintenance costs tremendously. More about DB(F)MO contracts can be read in paragraph 4.8.

"We will use timber as little as possible in our facades, because it increases our costs tremendously"
- Otto Verbaan –

Additional investments regarding to the investment costs of a building are possible because cost savings will be made during the operational stage of that particular building. This is underlined by the fifth pro in the literature study (table 3). In the TNT Centre Book is confirmed that the savings on the total costs of ownership of the TNT Green Office in percentages, are 10%. This means 10% savings on the life cycle costs of a building. The additional investments, which are according to almost all respondents often in the application of sustainable installations, because these sustainable installations will lead to cost savings during the operational stage. Secondly, developers, investors and users (depending on how the arrangements have been made around the rent) are willing to invest additionally in the flexibility of a building to reduce risks regarding any vacancy of (a part of) the building. By means of this flexibility a future-proofed building is created and this future-proof building represents a certain economical value in the future.

A few respondents noted that the investment costs and rental costs of a building are totally irrelevant. Increased investments in the quality and comfort of a building may lead to fewer sick leaves and an increased labour productivity among employees. In the design stage of the UPC building both aspects are explicitly taken into account. In the designs of the Rabobank building and the TNT Green Office the main-actors have tried to establish the impact of additional investments on an increased labour productivity of the workforce. In the TNT Centre Book, TNT expects an increase of labour productivity of 1.5%. According to Mrs. De Jonge and Mr. Verhoeven both, by creating a healthy indoor environment. Although, this definitely is an element to take into account, all respondents agree that it's impossible to show the financial benefits of additional investments in the quality and comfort of a building. Therefore, it is not discussed further in this research because this cannot be sufficiently substantiated. This soft side of possible financial benefits because of Life Cycle Costing, requires further research.

"We have said; that building should just be fine, if we achieve just 1% less sick leave, you will not even talk about the rent anymore"
- Henk Buitink -

Mr. Schut explains that top engineers would not choose for Liberty Global (UPC) if they are not housed in a high quality building with a high comfort. Because Liberty Global wants to attract the best engineers in the Netherlands they feel themselves compelled to invest in housing. He states that it's more important to attract the best engineers, than to save on housing costs, but not at any price. The LCC method offers a solution in terms of showing the financial costs and benefits of choices made regarding to different alternatives and/or materials in the design stage of a building. If these costs contribute to the (financial) success of a company, additional investments are defendable. In

response to the quality of a building, when designing and constructing a high quality building with a certain degree of flexibility in terms of the layout of the building, again a future-proofed building is created. As mentioned before, a future-proof building represents a certain economical value in the future. When a building after 30 years does not have to be demolished but only re-adjusted to future standards, this will save the investor a lot of money in the future. If the economical benefits of Life Cycle Costing already can be achieved via a higher rental price like in case of the UPC building in Leeuwarden and the TNT Green Office in Hoofddorp , the previous advantage of LCC is a welcome bonus for the investor.

For the developer the LCC systematic can be used as a marketing tool towards tenants. In paragraph 4.7 you can read that users fulfil an increasingly important role within the Dutch commercial real estate market. Developers can trump competitors by conducting a LCCA and LCCC because they can offer their future tenants a better financial perspective. It is easier to convince tenants about a particular building based on a Life Cycle Cost Calculation (as long as a certain quality and comfort of the building is ensured). This means that LCC represents a certain market value for the developer.

Via the LCC method choices can be made regarding to the life cycle costs of different alternatives and materials. The influence of the investment costs on the operational costs of a building can be monitored. This is in consistent with the fourth pro out of the literature study (table 3). Materials and/or alternatives with the lowest life cycle costs can be selected via LCC, like the example of Mr. Verbaan about using wood in facades, as mentioned before. For 'Rabo Eigen Steen' this is very interesting because besides they keep the building in their investment portfolio, the Rabobank is also the user. By checking different alternatives it is certainly possible that (one of) the main-actors figure out that the life cycle costs of TL-lightening are lower than LED-lights as Mr. Verhoeven says. In the literature study this is called the simplification of the comparison of alternatives and the stimulation of an objective decision making process (table 3).

Finally the LCC method can be used to compare the costs of several alternatives to reach a certain level of sustainability. For example, to get insight in the highness of the minimum investment to achieve the 'BREEAM Excellent' certificate.

4.3 Qualitative benefits of Life Cycle Costing

Through Life Cycle Costing the offices in the three investigated projects are much better thought out. In chapter 4.2 you could read that a flexible building is more future-proof. For example, both, the actors from the TNT Green Office and the UPC building have cleverly handled by making the staircases flexible. In the TNT Green Office separate staircases were incorporated into the design of the building, so the upper floors are separately accessible, which means that the building could be made multitenant. In the TNT Centre Book is confirmed that the building can be made multitenant. Mr. Krikke explains the necessary basis for new buildings, to create future-proofed buildings as follows;

> *"There are bad buildings on a bad place, those buildings must be demolished directly. There also are bad buildings on a good spot, those buildings should be redeveloped if possible. Thirdly there are good quality buildings on a bad place, all you can do is hoping for a tenant. Finally there are good quality buildings on a good spot. Actually we only want this last category. The point is, there are far too many bad buildings on the wrong place".*

This is also been the starting point for the development of the TNT Green Office. It is situated in Hoofddorp near the international airport 'Schiphol' and near Amsterdam, this is one of the best places in the Netherlands and it's very unlikely that this is not an attractive place anymore over 30 years. Amsterdam will not run away and 'Schiphol' will not be moved quickly as well. Therefore, it was also possible for TNT and OVG/Triodos (later on, the consortium 'Join') to a long-term contract to engage with each other as you can read in the publication of Agentschap NL about TNT. In the plan requirements of Rabobank in combination with Rabo Eigen Steen, the desired flexibility is explicitly defined;

- The highest possible flexibility in relation to extensibility and redeployment of the building;
- Alternative uses (of parts) of the building;
- Multifunctional design.

The building needs to be adaptable, so it remains a useful building in the future. This indicates the relation between the flexibility of a building and the future-proofing of a building. Mr. Buitink expressed this as follows;

"The future-proofing of current buildings, is secured in buildings with a story behind of it, with energy efficient features, that are cleverly designed and situated on the right spot"

- Henk Buitink -

LCC leads to better thought out buildings because elements as location and quality and comfort have an impact on the economical value of a building. As mentioned before, these buildings have a higher quality and therefore, these buildings ensure a certain degree of durability. Here, arises a big relationship with the usability of a building, a building can be durable, but not user-oriented. Through the LCC methodology user-oriented buildings will be created because elements as location, quality and comfort are assessed in the LCCA. Hereby, it is important to focus on the wishes of the user as Mr. Kamphuis explains. Other respondents share this opinion. LCC will lead to high quality comfortable buildings which meet the needs of users. To achieve this, all parties should be involved in the design stage of a building as you will read in the paragraphs 4.7 and 4.8.

Multiple respondents indicated that sustainable applications in buildings also will lead to a higher quality and comfort. In the LCCC materials and/or alternatives will be compared based on costs, however, in the LCCA materials and/or alternatives can be compared based on quality and sustainable aspects. This is shown by the three tables in the 'Greencalc Document' of the Rabobank. By the comparison of these options, for example based on the energy performance of the different materials and/or alternatives, buildings will achieve a higher quality. Besides, they also considered to which extent an alternative contributes to a certain sustainability score.

"You're totally insane if you nowadays design a building that isn't sustainable, then you're a terrible person.... especially, since it will lead to cost savings"

- Jos Schut -

According to Mr. Verhoeven, this high quality is achieved by checking everything. Investigate if there are still better alternatives than the present ones. Finding manufacturers who are willing to think, to create a high quality building. Additionally, in the publication of Agentschap NL about TNT can be read that this high quality is also achieved by focussing on the wishes of the user. The TNT Centre Book underlines the high quality of the new TNT Green Office, employees now have modern and efficient workplaces, TNT's reputation has been improved and therefore employees have a better binding with the enterprise and there are organizational profits because of the design of the building. In addition, through this high quality of the TNT Green Office, the operational costs of the building are lower. As mentioned in paragraph 4.2 the cost savings on the total life cycle costs of the building amounts 10%.

Also in the development of the Rabobank in Enschede extra quality and comfort is achieved by applying the LCC methodology. Based on the LCCA conscious choices are made like the use of plastic materials (Dutch; Kunststof Materialen) instead of natural materials. Although these plastic materials are maybe not as sustainable as natural materials, the durability is longer. The integrated approach regarding to the investment costs and operational costs of these materials are decisive to choose for the materials with the highest quality. This contributes to a long-term high quality of their building. In

paragraph 4.2 you could have read that the Rabobank and Rabo Eigen Steen save on maintenance costs because they use as little as possible wood in the facades of their buildings. This indicates that despite the higher quality of materials, savings can be made on the life cycle costs of a building.

Another example is the initially planned thermal storage in the Rabobank building. By the composition of the soil it was almost impossible to realize a thermal storage. At least, this would lead to insurmountable high investment costs. Because a part of the available investment budget was left over, is decided to invest in a raised floor for computers as Mrs. De Jonge explains. The LCCC helped in this case to get insight in the financial (un)feasibility of the thermal storage, while, on the other hand via the LCCA still a good alternative was found to add additional quality to the building.

Mr. Schut indicates that in case of the UPC building in Leeuwarden is chosen for a human approach. According to him all humans are the same, we are all cheerful when the sun shines, so we know what human beings like. Now it just should be implemented within buildings. Through the LCCA alternatives and/or materials may initially be examined on the life cycle costs, it's also possible to make decisions based on quality and comfort. Life Cycle Costing shows that it's sometimes wise to invest more upfront, in order to achieve the economical benefits of this, at a later stage e.g. because of a increased labour productivity. However, according to Mr. Schut it does not necessarily increases the investment costs, it's just about taking the right decisions. The LCC method contributes to make the right decisions because developers, investors and users are able to make more conscious choices based on Life Cycle Costing (as you will read in paragraph 4.5). The LCC method also contributes to the use of higher qualitative and more comfortable buildings by showing the financial advantages reflected in the lower life cycle costs of sustainable materials and installations.

The qualitative benefits of Life Cycle Costing by the development of commercial real estate are a new insight regarding to the question why the LCC method should be applied. These qualitative benefits are not founded by the literature study. However, the statements of the respondents in combination with the documentation analysis provides a sufficient basis to state that the LCC methodology will lead to buildings with an higher quality- and comfort.

4.4 Sustainability benefits of Life Cycle Costing

"Our target was to create a BREEAM 'Excellent' building and in addition we have negotiated about the Life Cycle Costs to make certain investments possible"

- Henk Buitink -

The quote above illustrates the relationship between BREEAM (and other sustainability labels) and Life Cycle Costing. Both, reinforce each other. In case of the UPC building in Leeuwarden, the main-actors had sustainable ambitions. It all started with the user who asked for a user-oriented building. In the last paragraph you could have read about this human approach which is applied during the development of the UPC building. According to all respondents involved in the project of UPC, there have been made clear choices between the main-actors in terms of quality and comfort of the building, for the user. The relation between quality and sustainability is related as follows in the publication of Agentschap NL about the UPC;

> *"In the new sustainable UPC office in Leeuwarden they created quality workplaces that not only serve the employees but also serve their environment. They show that economical growth and sustainable development not need to exclude each other"*

Additional investments were made to make the UPC building as sustainable as possible. Therefore, you'll save on the operational costs of a building. According to Mr. Schut sustainable buildings aren't more expensive. LCC provides this insight into the lower operational costs of sustainable buildings, the quote of Mr. Krikke in section 4.2 shows this as well.

In the development of the Rabobank Zuiderval in Enschede you see similarities with the UPC project. According to Mrs. De Jonge, could measures be taken regarding to the design of the building, resulting in lower operational costs of the building. Although in this case the Rabobank and Rabo Eigen Steen had sustainable ambitions, they didn't want to realize these sustainable ambitions at any price. Mr. Wieland from AM Real Estate says that they wanted to achieve a certain sustainability label as costs-efficient as possible. The quality of the building here was not forgotten as Mr. Wieland states. The HR+++ glazing and the PV solar collectors are just two examples of high quality sustainable applications. Both are compared, based on costs, with other materials and alternatives as you can see in the first two tables in the 'Greencalc document Rabobank' from the documentation analysis. Also the quotes from this document suggest a clear relation between the application of sustainable solutions and LCC. LCC serves to get insight in the costs of the different sustainable applications, and to communicate these costs against the board of directors as Mrs. De Jonge states. Both users, Mr. Schut and Mrs. De Jonge indicated that it is important for them to apply sustainable applications that recoup themselves. This payback period can be calculated via the LCCC as you could read in paragraph 2.4 of the literature study. Additional investments are therefore easier to explain between developers, investors and users and to their boards of directors.

The most convincing evidence may be found in the TNT Centre Book out of the documentation analysis. The TNT Green Office is certificated with LEED platinum, has over 1000 Greencalc points and an A+++ energy label. On the other hand the total life cycle costs of the building are decreased with 10%. However, additional investments where needed. LCC contributes to the sustainability of this building by showing the reduced operational costs and by showing that the savings on the operational costs were higher than the additional investment costs. Here we have not even mentioned the 1.5% expected increase of labour productivity due to a healthy indoor climate as stated in the TNT Centre Book. According to Mr. Verhoeven several payback periods have been used in their LCCC to show the economical advantages of, for example, solar collectors.

4.5 Process-related benefits of Life Cycle Costing

Life Cycle Costing has various process-related benefits. Starting with the reduction of risks for the main-actors involved in the three different projects. Based on LCC analyses and calculations accurate estimates can be made about the life cycle costs of a building. According to Mr. Verhoeven, Mr. Kamphuis and Mr. Schut LCC contributes to their risk management by reducing risks regarding to the investment costs. Additionally, in the publication of Agentschap NL about TNT this is underlined by the statement that they estimated the energy costs based on a simulation within the LCCA to reduce the risks about the functioning of their specific energy concept. It ensures the functioning of the specific energy concept and the associated savings on the operational costs. Therefore, LCC has not only contributed to the use of sustainable installations but also to justify the investment costs of these sustainable installations. The reducing of risks by applying the LCC method is also an outcome of the literature study (the second pro in table 3). A more reliable insight for the main-actors in the total life cycle costs of a building and the comparison of different alternatives and materials are in the literature study considered as risk-reducing aspects.

Another process-related advantage of LCC is the more conscious choices that could be made based on the LCC methodology. According to almost all respondents LCC helps to make more conscious choices about the design of a building. To Mrs. De Jonge this was the reason not using any carpeting in the stairwells of the Rabobank building in Enschede.

“In the stairwells I didn’t want carpeting or something else, just concrete stairs... so it’s easy to clean them”

- Maaike de Jonge -

Another example came from Mr. Buitink. He explains that the construction height of each floor of the UPC building has been lowered with fifteen centimetres. This, because the LCCC showed a huge energy consumption in order to heat the whole building. The new design has led to cost savings regarding to the energy costs. According to Mr. Wieland it’s also an advantage of LCC to know in an early stadium of the project the costs and the payback period of different alternatives. These

statements show the important role that LCC can fulfil when decisions about the design of a building must be made. Mr. Buitink confirms this by saying that the LCC method was indeed an important decision making method in case of the UPC building. Mr. Kamphuis adds;

"Through Life Cycle Costing is calculated what it costs now and what it brings us in the future".

In case of the Rabobank building, the different tables in the 'Greencalc document Rabobank' show us the importance of Life Cycle Costing regarding to decisions about the design of the building.

"It gives you the opportunity to choose consciously, these are the investments and these are the related benefits"

- Bert Krikke -

A few respondents reported that Life Cycle Costing will lead to longer contracts between users and investors and developers. However, further research should identify if this is true because it's just mentioned a few times in the interviews. Therefore, this result will not be included in the chapter 'Conclusions' of this study.

4.6 Disadvantages of Life Cycle Costing

Although Life Cycle Costing has many benefits, the LCC method also knows some disadvantages. In the literature study (chapter 2) you may have read that it isn't convenient to perform a LCCA and LCCC and therefore is not always feasible to execute by all stakeholders. Among other to the data for the input of the analysis, a lack of reliable data and/or assumptions may lead to unreliable results. In addition, it must be noticed that the LCC method will reduce risks as much as possible, but risks are not excluded. Lastly, it is hard to conduct the LCCA and LCCC in an early stage in real estate developments because not always all actors already are involved in the beginning of real estate developments. However, the LCCA and LCCC must be executed in an early stadium of the design stage in order to achieve the desired effect. The cons out of the literature study are summarized in table 6.

Cons of Life Cycle Costing – Out of the Literature Study
1. Hard to conduct a LCCA and LCCC.
2. Unreliable data may lead to unreliable results.
3. Hard to conduct a LCCA and LCCC in an early stage.

Table 6; Overview of the cons of LCC out of the literature study

During the interviews three respondents mentioned some disadvantages of Life Cycle Costing. The disadvantages of LCC which have been mentioned partly correspond with the cons out of the literature study. Two respondents indicated that the LCC methodology is too difficult to understand for users. However, it are not the users themselves who complain about the complexity of the Life Cycle Costing systematic.

"For a user Life Cycle Costing is much more difficult, it's not his daily business"
- Maurice Wieland -

One respondent reported that the cost savings are not always for the actor(s) who invests additionally in a commercial real estate building. It is, therefore, a condition that the main-actors have collective benefits by applying the LCC method. This is also described in paragraph 4.8. Besides, in the economical benefits of LCC (paragraph 4.2) you can read that it's truly possible to achieve collective economic benefits from LCC.

4.7 User-oriented Market

The pros and cons of Life Cycle Costing are clarified in the last five paragraphs. This paragraph is about the results related to sub question **F**. This sub question is the connection between the sub questions **E** , **G** and **A+**, so between whom the main-actors on the Dutch commercial real estate market are and what the benefits of the LCC method are for the main-actors. Therefore, it's necessary to know to what extent the main-actors are involved in the decision making process. The results will be discussed in this section.

During the interviews is revealed that the Dutch commercial real estate market is changing right now. The user has become more important in the decision making process. In the next paragraph you will read that this is a precondition for applying LCC successfully. According to Mr. Buitink there are too many risks to develop buildings without a tenant. Mr. Verbaan indicated that he expects that future buildings only will be developed if a user is involved in the design process. According to Mr. Schut you will build a low quality building if you design and construct buildings without specifications from the user. Mr. Wieland underlines this by saying that the user and investor should be involved when a developer designs a building.

Another fact that indicates the growing importance of the user, is that in all three projects the user took the decisions. According to Mr. Krikke, TNT took the final decisions in the development of the TNT Green Office in Hoofddorp. Additionally, Mr. Buitink reported that UPC took the final decisions in the development of the UPC building in Leeuwarden. This is underlined by the statements of Mr. Schut. Finally, Mrs. De Jonge, Mr. Wieland and Mr. Verbaan all stated that Rabo Eigen Steen took the final decisions in the development of the Rabobank Zuiderval in Enschede. However, Rabo Eigen Steen is part of the Rabobank, which is the user of the building.

"In multiple considerations the investor and definitely the user should be involved"
- Maurice Wieland -

In the interviews with Mrs. De Jonge, Mr. Buitink, Mr. Schut, Mr. Verhoeven and Mr. Wieland is revealed that all the main-actors were involved in the design stage of the project. The involvement of all main-actors in the design stage of the three investigated projects within this research is the answer to sub question **F**.

4.8 Preconditions for applying Life Cycle Costing successfully

The many benefits of Life Cycle Costing have already been elaborated in this chapter. However, to apply the LCC method successfully there are numerous preconditions that must be met. Because the aim of this research principally is to show the benefits of the LCC method and is not about showing the preconditions to apply the LCC method successfully, the preconditions are briefly described. The results have helped to get an additional insight in the preconditions for applying LCC successfully and therefore, must be seen as new added information to the critical success factors out of the literature (table 4). Both, the critical success factors out of the literature study and the preconditions for applying LCC successfully answer research question **B**.

The first critical success factor out of the literature study is that the eight steps according to Francissen (2007) should be taken. This roadmap ensures that you don't forget any steps. Via a list of requirements the different possibilities as mentioned in the second step from Francissen (2007), will be checked as well. In the three investigated projects within this research, for all projects a transparent list with requirements was been made by the user (in agreement with the other parties). This is confirmed by six of the eight respondents. In addition, six of the eight respondents reported that this transparent list of requirements served as a basis for applying LCC. All users confirmed that they had sustainable ambitions regarding to the development of their new housing. In the 'PVE Rabobank', the 'Greencalc Document Rabobank', the 'Publication Agentschap NL about TNT and in the 'TNT Centre Book' this is confirmed. From this, it can be deduced that all actors were involved in the design stage of the process. In paragraph 4.7 we have seen that there is a shift within the Dutch commercial real estate market. The user becomes more important in the process, without them the building has no right to exist. The requirement that all main-actors should be involved in the design stage of a building is illustrated by the quote of Mr. Verhoeven below.

"The ambition could only be realized if all parties are involved from the start, having their own responsibilities and keeping their own responsibilities"

- Paul Verhoeven -

In addition to the quote of Mr. Verhoeven, multiple respondents indicated that teamwork is an essential part for success. Mr. Krikke illustrated this by saying that he called almost every evening with the director real estate of TNT to make a success of the project. There should, however, be mentioned that the main-actors all need a certain level of knowledge about real estate.

To succeed the LCC method within a project a (DB(F)MO) contract should be made based on the list of requirements. In the development of the TNT Green Office and the UPC Building DB(F)MO contracts are used according to Mr. Buitink, Mr. Kamphuis, Mr. Krikke and Mr. Verhoeven. The statements of Mr. Krikke and Mr. Verhoeven are underlined through the documents 'Publication Agentschap NL about TNT and 'TNT Centre Book' from the documentation analysis.

According to Mrs. De Jonge the Rabobank has a rental agreement with Rabo Eigen Steen, again, actually this is one party. Although, Rabo Eigen Steen has several DBFMO contracts with manufacturers of particular materials as Mr. Verbaan explains.

In the (DBFMO) contracts of all three projects a time horizon is included to justify the investment costs. Although the quality of a building should be the most important aspect, the investment costs must be justifiable. The time horizon is therefore an important element of the LCCC to justify these investment costs. This is underlined with the fourth critical success factor in table 4. Future costs should be discounted to their present value (or discounting a present sum forward to its future equivalent). The main-actors should know the duration of the tenancy agreement to calculate the payback period of different alternatives and/or materials. The costs of these alternatives and/or materials may be spread over several periods, although this is not a requirement, it might help to justify the higher investment costs.

To successfully apply the LCC method, there must be collective benefits for the main-actors. For example in case of the UPC building. The user saves on his life cycle costs by the energy savings and the investor receives a higher rent and boasts a better building. The developer and investor were one party, here you can see the collective benefits by the cooperation of at least two actors. Collective benefits can be found easier. The quote of Mr. Krikke underlines these statements.

"When the moment is there for you as a developer to say, I will keep the building... you will automatically think in Life Cycle Costs because you're also responsible for the investment as an investor"

- Bert Krikke -

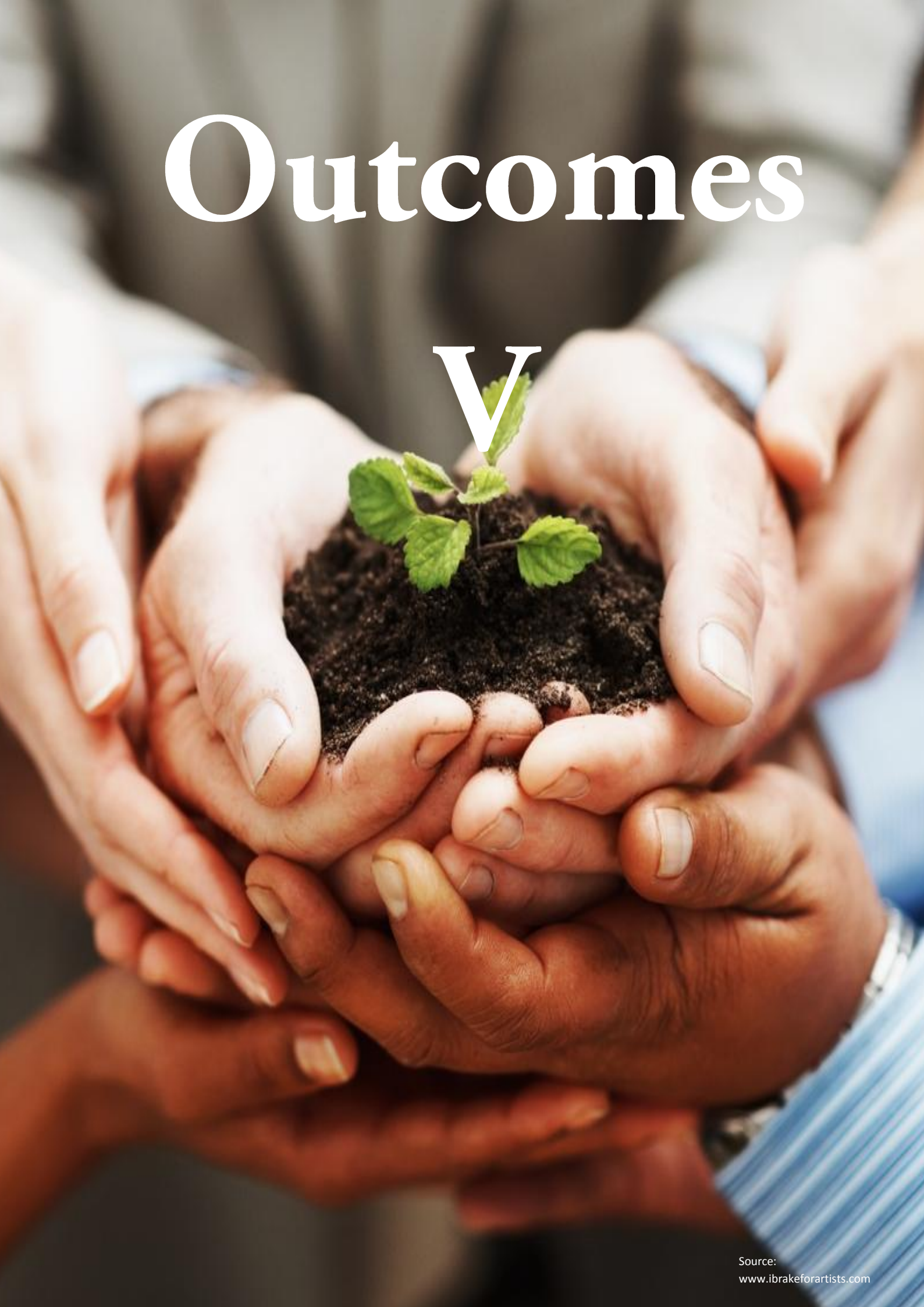
A transparent process wherein decisions are made together is in consistent with this. According to multiple respondents it's required to make decisions together in a transparent process to succeed. In the publication of Agentschap NL about UPC can be read that the UPC building is developed in a close collaboration between JOIN and UPC. Also within the other two projects, several respondents indicated the importance of this precondition for succeeding.

Finally, according to Mr. Kamphuis, Mr. Krikke, Mr. Verbaan and Mr. Verhoeven it's important to have reliable data for the LCCC. This was also one of the critical success factors for applying the LCC method successfully, in the literature study.

With these preconditions for applying the LCC method successfully, this chapter 'Results' has ended. In the next chapter you will read the outcomes of this master thesis.

Outcomes

V



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5. Outcomes

In this chapter the outcomes of this research about the benefits of Life Cycle Costing (LCC) are shown. In paragraph 5.1 'Conclusions' the main research question will be answered based on the results in chapter 4. In paragraph 5.2 these conclusions will be discussed and in paragraph 5.3 recommendations and advice for further research is given.

5.1 Conclusions

In this paragraph the main research question of this study will be answered. The main research question of this study is;

What are the benefits of applying the Life Cycle Costing method for the main-actors within the Dutch commercial real estate sector? **(A+)**

Based on the results in chapter 4 this main research question can be answered. In broad terms, there are advantages with respect to the economical benefits, qualitative benefits, sustainability benefits and process related benefits. In addition, there are also some disadvantages. Because a shift occurs towards a more user-oriented market, finally, some preconditions are given regarding for successfully applying Life Cycle Costing (LCC). The advantages which are described below can only be achieved when the preconditions will be fulfilled, so this is the baseline situation.

Economical Benefits

When applying LCC this will be economical beneficial for all main-actors. The investor (optionally in combination with the developer) will invest up front more to realize a future-proofed building, with a higher future value. This money will be returned via a higher rental price paid by the user. The investor now has a building with a higher incoming cash flow each year. This increase of the annual rent represents a certain economical value for the investor at a possible sale of the building. On the other hand, although the user pays a higher rent, he will save more on his operational costs like maintenance, cleaning- and energy costs. Profits can be shared between the main-actors. Developers can trump competitors by conducting a LCCA and LCCC because they can offer their future tenants a better financial perspective. It is easier to convince tenants about a particular building based on a Life Cycle Cost Calculation. The savings can be calculated in advance through the Life Cycle Costing Calculation (LCCC). This LCCC is part of the Life Cycle Cost Analysis (LCCA) in which different materials and alternatives will be compared based on the life cycle costs, quality and comfort and sustainability. The insight into the life cycle costs of a building will help the main-actors to justify the highness of the investment costs to each other and to those who make the final decision about the design of a building. Additionally, cost optimization of the life cycle costs of a building is possible.

Besides the LCC method can be used to compare the costs of several alternatives to reach a certain level of sustainability. For example, to get insight in the highness of the minimum investment to achieve the 'BREEAM Excellent' certificate. This will allow more users, investors and developers to realize highly sustainable buildings because the additional investment costs can be defended.

Finally, although it's almost impossible to show the financial benefits of additional investments in the quality and comfort of a building with respect to achieve fewer sick leaves, this definitely is an element to take into account.

Qualitative Benefits

LCC leads to better thought out buildings by mapping the risks of a building with respect to the life cycle costs, like vacancy. Through LCC, buildings are designed with a higher degree of flexibility because the LCC method gives insight in the high costs of vacancy and the negative influence of these high costs on the life cycle costs of a building. Therefore, additional investment costs upfront can be justified easily. Buildings developed based on the LCC methodology have a higher quality and comfort for their users because the buildings are more user-oriented. Currently, the Dutch commercial real estate market is shifting towards a user-oriented market. Without a user it's too risky to develop and/or redevelop buildings. Materials and alternatives can, in addition to the costs, also be compared based on quality and comfort by the user its requirements. Besides, it's also possible to consider to which extent an alternative contributes to a certain sustainability score. Therefore, buildings designed based on the LCC method are highly future-proofed because they better reflect the needs of the user.

Sustainability Benefits

The LCC method and a sustainability label such as BREEAM reinforces each other. This is because LCC provides the insight into the lower operational costs of sustainable materials and installations in buildings. As mentioned before in the qualitative benefits and economical benefits, LCC justifies the higher investment costs by showing the lower life cycle costs of sustainable buildings. In addition, in this research is revealed that sustainable buildings are highly future-proofed. In the economical benefits, you could already read that future-proofed buildings have an higher economical value. This means an indirect higher economical value of sustainable buildings comparing to not-sustainable buildings. Hereby, LCC contributes to the development of more durable buildings with a certain degree of sustainability, such as BREEAM 'Excellent'. HR+++ glazing and PV solar collectors are just two examples of high quality sustainable applications, that require an higher investment but which can be justified based on the lower life-cycle costs because of cost savings with respect to energy savings.

Process-related Benefits

Based on LCC analyses and calculations accurate estimates can be made about the life cycle costs of a building. LCC contributes to the risk management of the main-actors by reducing risks regarding to

the investment costs. A more reliable insight for the main-actors in the total life cycle costs of a building and the comparison of different alternatives and materials are considered as risk-reducing aspects. More conscious choices regarding to the comparison of different alternatives and/or materials could be made based on the LCC methodology.

Disadvantages of Life Cycle Costing can be avoided by meeting the preconditions as mentioned in the results (paragraph 4.8). These preconditions and the disadvantages of LCC will be not elaborated further in the conclusions because it doesn't contribute to answer the main research question.

Answering the main research question

By applying the Life Cycle Costing methodology better decisions will be made by the main-actors on the Dutch commercial real estate market, when taking decisions about the design of the building and the associated investment costs. Life Cycle Costing results in more conscious choices with respect to the design of buildings. These improved decisions lead to better buildings with economical, qualitative and sustainability benefits. Now the main research question of this study is answered. In the next paragraph, the conclusions based on this research will be discussed.

5.2 Discussion

In several other countries such as the United States, Canada and Australia the real estate markets are much further in applying Life Cycle Costing than in the Netherlands. This research resulted in new insights of the benefits of Life Cycle Costing on the Dutch commercial real estate market. For the main-actors on the Dutch commercial real estate market this research contributes to show them the economical, qualitative, sustainability and process-related benefits of Life Cycle Costing. Indirect, this research may contribute to a more sustainable real estate market in the Netherlands. Therefore, it may have a contribution to the sustainability goals that the Dutch government wants to achieve in 2020.

The outcomes of this research are partly in consistent with findings of researchers in foreign countries. There are more results known about the economical and qualitative benefits of Life Cycle Costing. On the other hand, as far as the researcher knows, it was unknown that Life Cycle Costing also contributes to the development of more durable buildings with a certain degree of sustainability, such as BREEAM 'Excellent'.

The findings of this research are founded by interviews and the documentation analysis. The triangulation of these two research methods in addition to the literature study ensure reliable and valid findings. To optimize this research, it could be better to investigate more projects and/or to interview more actors involved in the current projects. Although the findings in this research are valid, the reliability could be increased if more projects should be investigated.

5.3 Recommendations & Further Research

Based on this research, it is recommended to make decisions with respect to the design of buildings, based on the Life Cycle Costing method. As mentioned in the conclusions, besides the process-related benefits such as more conscious choices that can be made based on the LCC method, it has also a lot of economical, qualitative and sustainability benefits for the main-actors on the Dutch commercial real estate market.

Further research toward the benefits LCC could confirm the economical, qualitative, sustainability and process-related advantages as described in this research. In addition, more research would be needed to determine if Life Cycle Costing will lead to longer contracts between the main-actors as mentioned in paragraph 4.5 of the results, in this study this is not included in the conclusions because these few results were not reliable enough.

Lastly, further research is needed to discover the influence of the application of LCC in the (re)development of buildings on the enhancement of the labour productivity of employees. This would stimulate and justify additional investments regarding to the development of qualitative and sustainable buildings even further.

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