The effect of the Estimated Service Life on the sustainability of vacancy strategies.

Sascha Jansz

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Title Research Project
The effect of the Estimated Service Life on the sustainability of vacancy strategies

Name student
Sascha Jansz

Student number
1302949

E-mail address
S.N.Jansz@student.tudelft.nl

Date
06-07-2012

Name MSc Laboratory
Real Estate Management

First Mentor
Hilde Remøy

Second mentor
Andy van den Dobbelsteen

Graduation Company and supervisor
CBRE
Ank Dorscheidt, Pauline Folkers, Bert Sandberg

1 Foreword

This Thesis is the result of my graduation research. It is written for the master of Real Estate and Housing at the faculty of Architecture of the Technical University of Delft. Within this master I have chosen for the laboratory of Real Estate Management, and I will connect to the research topics of estimated service life, sustainability and vacancy strategies such as transformation, renovation and demolition & new-build.

The chosen language of this report is the English language.

Delft, 06-07-2012

Sascha Jansz

1.1 Readers guide:

This report is divided in five parts, an Executive summary and appendices. These parts are: Introduction to the research design, Literature study, The model, The cases and Conclusions & recommendations. A list of figures, tables and abbreviations is given on page 107.

In the introduction to the research design the problem analysis and objective of this research are described. This is accompanied by the main and sub research questions and hypothesis. The literature study describes the current body of knowledge structured by a mind map based on three main topics; Real estate management, Sustainability and Estimated service life. In the final chapter of this part the application of the theory in the research is described.

The part about the model describes how the S^3 model is set-up and how it calculates the necessary values. In the part about the case the results generated by the model are discussed and compared with the expectations. For readers who are familiar with the subjects of sustainability and estimated service life it is recommended to start with this part.

Finally the conclusions answer the research question and reflect the hypothesis. Then recommendations are made for further research. In the appendices the more elaborate information that has been referred to in the report can be found.

2 Abstract

In the ‘Actieprogramma leegstaande kantoren’ the strategies of redevelopment, transformation and demolition of existing office buildings are suggested to reduce the high vacancy rate in the Dutch office market. Available research on which strategy is most sustainable did not incorporate the estimated service life of the strategies, but applied a standard expectation, which leads to an inaccurate estimation of the environmental load per year of service life. Because the strategy is chosen in the initiative phase of a project, the design is often not present for all strategies. A perfect design for the new-build structure is often assumed leading to an unequal comparison of designs.

To find the effect of the estimated service life (ESL) on the sustainability of vacancy strategies the S^3 model is developed that includes ESL and replaces the design of a strategy with ambition levels. The sustainability of three real and one averaged case is assessed and the effect of the ESL on these results is analyzed. The model does not include financial or social factors. Sustainability has been defined as ecological sustainability as calculated by Greencalc$^+$ 4.0.

A comparison is made between the linear deduction in the lifespan accounting model and an annuity deduction. To prevent negative ESL values the improved factor method by Van Nunen (2010) is adapted and a piecewise formula is used to determine the ESL. A method that standardizes the assessment of ESL factors has been developed. Score tables describe the requirements for a building to be assigned a certain score, which are later translated to factors.

The results show that the estimated service life does influence the measurement of the sustainability of vacancy strategies. Because the environmental load caused by materials is deducted over the entire service life, a higher ESL reduces the load per year for materials more than a lower ESL. This means that strategies with a higher ESL are advantaged. Excluding the remaining environmental load decreases this effect because it decreases the environmental load caused by materials.

A positive annuity deduction method will cause a higher remaining environmental load and will increase the effect of including the ESL. A negative annuity will cause a lower remaining environmental load and will decrease the effect of including the ESL.

Keywords: Sustainability, Renovation, Transformation, Demolition & new-build, Estimated service life, deducting environmental loads, S^3 model, Triple S model.

Executive summary

Introduction

The current vacancy rate in the Dutch office market of 14 % has increased the public awareness of this problem. This led to the 'Actieprogramma leegstaande kantoren', an initiative of the government and private parties, which suggests to reduce the vacancy rate by redevelopment, transformation and demolition of existing office buildings.

What strategy is most sustainable is hard to assess. Research on this topic did not incorporate the estimated service life of the strategies, but applied a standard expectation. This means that the building's qualities or shortcomings were not taken into account. The design would only be included in some of the strategies and be assumed optimal in others. The main problem therefore is the absence of Estimated Service Life (ESL) and an unequal comparison of designs in current sustainability models used to compare real estate strategies for vacant office buildings.

Research methods

The main goal of this research is to find the effect of the estimated service life on the sustainability on vacancy strategies. This is done by developing a sustainable strategy selection model (S^3 or triple S model) that includes ESL and replaces the design with ambition levels. To answer the main research question one averaged case and three real cases have been conducted. Not only the sustainability of the cases is assessed, but also the effect of the ESL on these results is analyzed. This is done by manipulating the factors and comparing the results.

The scope of this research has been limited by excluding all other decision factors, apart from sustainability. Sustainability has been defined as ecological sustainability, which means that only the environmental load caused by materials, energy and water is considered. To calculate this load Greencalc$^+$ 4.0 has been used. As Greencalc$^+$ uses a standard lifespan for all strategies the output generated by Greencalc$^+$ is used as input in the S^3 model.

State-of-the-art

To calculate remaining environmental load the lifespan accounting model by Van Den Dobbelsteen (2004) is used. A comparison is made between the linear deduction used in this model and an annuity deduction as used in the mortgage system. The effect of the method used to deduct the environmental load caused by the construction of a building is described.

To prevent negative ESL values the improved factor method by Van Nunen (2010) is adapted and a piecewise formula is used to determine the ESL. The formula uses the factors and weights but does not include the statistical distribution proposed by Van Nunen.

Because there was no precedent describing how the ESL factors should be assessed a method has been developed. This concerns the three factors that were decisive in the model. The reference has been standardized and the factors are assessed through the use of score tables. These score tables describe the requirements for a building to be assigned a certain score. These scores, which range from 1 – 10, are translated into factors inside the S^3 model. These score tables are also presented in the S^3 model as an excel questionnaire which automatically translates the building's specifications to the ESL scores.

The S^3 model

The S^3 model describes the sustainability of each strategy with the following formula

$$Env.L.^{p}/_{y}\,strategy\ x = \frac{Remaining\ Env.L. + Total\ once\ off\ load}{ESL} + Env.L.Energy^{p}/_{y} + Env.L.Water^{p}/_{y}$$

The remaining environmental load in calculated by the model by using the lifespan accounting model of Van Den Dobbelsteen (2004). The total once-off load is the environmental load caused by the construction of a strategy. This is given as an annual load by Greencalc$^+$ but is recalculated in the S^3 model as a once-off load.

Conclusions

The results show that the ESL does have an effect on the measurement of the sustainability. The Greencalc$^+$ scores of case A show transformation to sustainable dwellings as most sustainable strategy. The results of the S^3 model show that demolition & new-build of sustainable dwellings has a lower environmental load per year.

In the transformation strategy the materials load can be deducted over 125 years, in the demolition & new-build strategy it can be deducted over 201 years. This results in a lower 'load per year caused by materials' for the demolition strategy, even though the investment is much higher. Whether this will change the most sustainable strategy differs per case, but the bigger the difference between the ESL's of the strategies, the bigger this advantage for strategies with a longer ESL will be.

Another factor that influences the results is the remaining environmental load. If this is not taken into account the total load caused by materials will be lower which weakens the effect of the ESL. The chosen deduction method directly influences the remaining environmental load and therefore the effect of the ESL. A positive annuity will cause a higher remaining environmental load and will increase the effect of the ESL. A negative annuity will cause a lower remaining environmental load and will decrease the effect of the ESL.

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List of abbreviations

ESL	Estimated service life
RSL	Reference service life
S^3 model	Triple S model or sustainable strategy selection model
BREEAM	Building Research Establishment Environmental Assessment Method
BREEAM-BBG	BREEAM bestaande bouw en gebruik
LEED	Leadership in Energy and Environmental Design
EPC	Energie prestatie coëfficiënt
EPA	Energie prestatie advies
EPA-U	Energie prestatie advies utiliteitsbouw
LCA	Life cycle assessment or life cycle analysis
MIG	Milieu index Gebouw
MIB	Milieu index beheer
ISO	International organisation for standardisation
C2C	Cradle to cradle
C2G	Cradle to grave
TR SUS DW	Transformation to sustainable dwellings
D&N TR DW	Demolition & new-build to traditional dwellings

ESL Factors:

A	Factor for the quality of components
B	Factor for the design level
C	Factor for the work execution level
D	Factor for the indoor environment
E	Factor for the outdoor environment
F	Factor for usage conditions
G	Factor for the maintenance level

Part 1: Introduction to the research design

4 Introduction to the research design

In this chapter the research is introduced, including the problem analysis, relevance, and research questions. Finally the framework of the research is defined and the research methods are discussed.

4.1 Introduction

With the percentage of vacant office buildings in the Dutch real estate market rising, the number of discussions on what to do with the all these empty square meters increases too. While the 'healthy' vacancy percentage is between 5-8% of the total building stock, currently 14% of the office buildings are vacant (CBRE, 2012). This leads to the question on what to do with these buildings, a societal problem recognized by the government which lead to the 'Actieprogramma Leegstande kantoren', a program meant to reduce the high vacancy rate (M.H. Schultz van Haegen, 2011).

Some claim that reusing a building is more sustainable than demolishing it and building a new one. After all, it uses less material and produces less waste. On the other side there are those who claim that, with the new techniques we have to make A^{++} low energy consumption buildings, demolition & new-build in fact isn't just financially more attractive, but also more sustainable.

This is often a point of discussion as there is little research done on this subject. A recent publication of DHV concludes that demolition would, at least in the case of the old tax office in Utrecht, indeed be more sustainable than transformation (DHV, 2011b).

In the meeting arranged by DHV to explain their findings, which was attended by the writer of this report, several points of critique arose. The most important ones were the inclusion of the transformation design, as opposed to assumptions for the new-build strategy, and the exclusion of the estimated service life (Metz, 2011).

This thesis wants to explore effect of these factors on the measurement of sustainability of all relevant strategies for vacant office buildings, especially the effect of the estimated service life. It will do so by studying the available literature, extracting the methods that can be used to include the estimated service life and developing a model that can show this effect. This will be a model in an Excel environment that uses the results of existing sustainability models for several cases of vacant office buildings to show the effect of including the estimated service life.

The model will calculate these effects for several possible strategies for a vacant office building, after which the results can be used by stakeholders in their decision making process. The model will only represent the sustainability of the strategies and will not consider any other decision making factors, such as economic or social factors. Placing the results in the right phase of the decision making model is therefore important.

4.2 Problem analyses

The ‘Actieprogramma leegstaande kantoren’, in which the Dutch government and private real estate companies created a plan to deal with the high structural vacancy, shows that vacancy is a hot topic in the Dutch office market. This plan presents three main solutions:

1) Redevelopment, transformation and demolition of existing office buildings.
2) Measures to ensure a good functioning of the office market now and in the future.
3) Better regional spatial planning, programming and fine-tuning. (M.H. Schultz van Haegen, 2011)

Solution 2 and 3 are based on government actions, but solution 1 can be implemented by private parties. Apart from the ‘Actieprogramma leegstaande kantoren’, another important factor for private real estate parties to consider sustainability is that it adds to the perception of an office and is becoming more important when trying to find a new tenant (Vastgoedmarkt, 2011).

The strategies mentioned under 1) are all based on the idea that the oversupply must be reduced by extracting offices from the market (transformation and demolition) or upgrading offices to meet today’s standards (redevelopment and new-build). When facing this major decision in a building’s lifecycle it is hard to assess the sustainability of these strategies. The currently available models are not developed to compare strategies, though there are some researches that have used these models to make a comparison.

Current research by DHV has compared transformation to demolition & new-build, concluding that in their case, an old tax office in Utrecht, demolition & new-build would be more sustainable. The same conclusion was reached by De Groot, in the case of the Rabotoren in Groningen. These results were explained by the far lower energy consumption of the new building opposed to the transformed building (DHV, 2011a) and the fact that the space in a transformed building is less optimally used in the transformation design versus when you start from scratch (de Groot, 2011).

These researches were criticized on the used calculation method to compare the strategies and the used input. Especially the absence of the Estimated Service Life (ESL) and the input of the design (Metz, 2011). Another point of criticism was that all possible strategies at this point in a building’s life cycle should be considered and compared, including renovation and consolidation (doing nothing).

Therefore there is a need for a calculation model that can show the effect of the calculation method by taking into account the effect of the ESL and unequal comparison of designs, while including all possible strategies. This model must be simple to use and be specified on the initiative phase so it can be used by all stakeholders.

Main problem:

An absence of Estimated Service Life (ESL) and an unequal comparison of designs in current sustainability models used to compare real estate strategies for vacant office buildings.

4.3 Objective and intended end product

The objective of this research is to develop a calculation model that shows the effects of the ESL on the sustainability of relevant strategies for vacant office buildings. These strategies are: Consolidation, Renovation, Transformation and Demolition & new-build. To ensure an equal comparison the designs will be replaced with ambition levels. These ambition levels will indicate the ambition for the design, whether it will be traditional or sustainable, but does not require a finished design. This is important because the model will be used in the initiative phase when a design is often not present. This will be developed for the target group; owners, advisors and developers who may use the results as input for their decision making process. It should be possible to get results from the model within a limited time frame (preferably one day), given the availability of required data.

Ambition levels:

Traditional:
In line with the building decree 2012

Sustainable:
At least an A++ energy label or BREEAM excellent label

Goal:

To find the effect of the estimated service life on the sustainability on vacancy strategies by developing a model that includes ESL and replaces the design with ambition levels

This model will connect to existing databases and existing sustainability models. It will be based in Excel, to ensure that no specialist knowledge is required to use the model, although knowledge of an existing sustainability model may be required. The model will compare strategies on their sustainability in order to select the most sustainable one. The model will therefore be named the sustainable strategy selection model or triple S model (S^3 model).

5 Relevance and motivation

This chapter will explain the relevance of this research, as well as the personal motivation to choose this research topic. Both the scientific and societal relevance will be discussed and the personal learning objectives will be explained.

5.1 Scientific relevance and originality

In this research the aim is to develop a model that calculates sustainability of relevant strategies for a vacant office building. This has been researched before by DHV for the Belastingkantoor in Utrecht and by De Groot for the Rabotoren in Groningen, both considering the strategies of transformation and demolition & new-build (DHV, 2011a, de Groot, 2011).

They both concluded that demolition & new-build would be more sustainable in these cases than transformation. Especially the research of DHV, published in a press release, received many reactions and as a response they organized a meeting in which the methods and results of the research were discussed. During this meeting it became clear that the used methods were controversial. Especially the used unit, environmental load per square meter living area, the absence of the estimated service life and the input of only one design created resistance (Metz, 2011).

The added value of this research is to extend the existing sustainability models, such as the one used by DHV, by including important factors and analysing their effects. The main factors taken into account will be the estimated service life and replacing the design with ambition levels. By replacing the design with ambition levels the model will be usable in the initiative phase as a sustainability model specialized on vacant office buildings. It will therefore add to the existing body of knowledge on vacancy strategies as well as sustainability- and transformation tools. Existing transformation tools already measure design potential and financial feasibility, but sustainability is not yet represented.

Existing transformation tools: (Fikse, 2008)

1. Vacancy risk meter
2. Transformation potential meter
3. Possible redevelopment guide
4. ATB quick scan
5. Transformation meter for churches
6. Believe in transformation
7. Cultural and historical value meter
8. Triple-jump method
9. TOK-checklist
10. INKOS

5.2 Societal relevance

Currently 14% of all offices in the Netherlands are structurally vacant (CBRE, 2012). This is not only a problem for the owners of these offices that cannot find new tenants, but is described by minister Schultz van Haegen of infrastructure and environment in 'Actieprogramma leegstaande kantoren' as: "*A waste of space and capital and harmful to spatial and economic development*" (M.H. Schultz van Haegen, 2011).

This is confirmed by private parties in the real estate sector, but the problem remains on how to make the right decision for a specific building. Until recently only financial arguments were used to define the best solution, but increasing awareness of the public opinion about the vacancy problem and the sustainability of the build environment call for a more holistic approach.

The intended effect of this research is therefore to help solve the vacancy problem by creating a tool that will give a clear and objective sustainability score, in which all relevant factors have been taken into account. This model may be used in practice to help decision makers in solving the problem of the high vacancy rate.

5.3 Utilisation potential:

The utilisation potential of this research is high, as the end result will be a practical model that can deliver input for the decision process of stakeholders. By measuring the difference in sustainability between consolidation, renovation, transformation and demolition & new-build it will create clarity on the question what is more sustainable in the case of a vacant office building. This can be used to speed up the decision process or to create a well-founded advice.

5.4 Personal motivation:

Although I must admit I have done it myself in the bachelor phase of my study (see frame), I am still very much surprised by how easily people state that re-use is more sustainable than demolition and new-build, without any reference to a relevant research.

Figure 5.1: The Santos building in Rotterdam

In my transformation design for the Santos building in Rotterdam I used a flexible floor plan to prolong the possible service life of my design. This caused a lot of resistance from my fellow students as they were not convinced that this could add to the sustainability of the design, which was an important aspect of the program of requirements.

The many reactions to a research done by DHV, claiming that demolition & new-build was more sustainable than transformation, shows that this is a presumption that is well embedded in the mind of the building industry (DHV, 2011b).

This triggered my interest for this topic and after my initial literature study I realized that current research is not very much in depth and does not include all factors that seem important to me. I therefore decided to attend the meeting arranged by DHV to explain their research. During this meeting I felt that the methods used could still be improved. There had been no reference at all to the estimated service life (ESL) of the new or old building and the design scenarios that had been used as input were copied form an earlier financial analysis. This meant that, though they had a very big influence on the actual score, there had been no attempt to optimize the designs on sustainability issues, or even to fit in as many dwellings as possible.

After my initial literature study on the effects of the estimated service life I was sure that this would have a big influence on the sustainability of a strategy and that it should be included in the sustainability assessment. I wanted to figure out if the ESL could be included in existing sustainability models and if this could be generalized into an objective sustainability model for vacant office buildings.

5.4.1 Personal learning objectives:

During my graduation I do not only want to do a research, I also want to use this as an opportunity to complete the following personal learning objectives:

To obtain...

1. Knowledge about sustainability in general and how this term is used in the building industry.
2. Knowledge about the effect of the estimated service life on the sustainability of a building and how this can be measured.
3. Knowledge about the different models that exist in the building industry that are used to assess the sustainability of a building and their differences.

4. Experience in an internationally oriented company through a graduation-internship.
5. Experience in writing a research design and doing a research.
6. Experience in processing theories in a way that creates a practical model that can be used by others.

These personal learning objectives are based upon the experiences I already have gained in university and what I still feel I miss. For example, I have not done an internship during my study and I would therefore like to do one during my graduation, to be able to decide how I want to start my working career. I would like to do this internship in an internationally oriented company as I want to explore if I would like to go abroad after my study.

6 Research questions

In this chapter the main research question, hypothesis and sub questions are introduced and the framework for the research design is given.

6.1 Main research question

The problem statement indicates two problems, the absence of the estimated service life in sustainability models and the unequal comparison of designs.

To eliminate the unequal comparison of designs, these will be excluded from the calculation. Instead design constraints will be formulated by ambition levels. This can be a traditional ambition level, which means that the building will comply with the building decree of 2012. It can also be a sustainable ambition level, which means that the building will outperform the building decree and have at least an A^{++} energy label or BREEAM excellent certificate. By including the design in this way the effectiveness of the use of space is of no influence to the results of the model but the quality of the design is taken into account as an important factor.

After replacing the design with ambition levels the effect of the estimated service life has been formulated into a main research question:

Main research Question:

What effect does the Estimated Service Life (ESL) have on the measurement of the sustainability of possible real estate strategies for vacant office buildings?

6.2 Hypothesis

The hypothesis for this research is:

A longer estimated service life has a positive effect on the sustainability of a strategy.

If this is taken into account in a measurement model, a more precise estimation on the sustainability effects between consolidation, renovation, transformation and demolition & new-build can be made.

6.3 Sub questions

To be able to answer the main research question four sub questions have been formulated, which will be answered through the use of different research methods.

Sub questions

1. What is sustainability in the build environment and how can it be measured?
2. What is the effect of Estimated Service Life (ESL) on the sustainability of buildings?
3. How can the effect of the ESL be included in sustainability measurements?
4. What is the effect of including the ESL in the sustainability assessment of the case study?

These questions will be answered though the use of a literature study (question 1+2), Interviews and simulation (question 3) and a case study (question 4).

7 Research Design

In this chapter the research design will be discussed, this concerns the research methods, case study selection and phasing.

7.1 Research concept

The figure below shows how different research topics are combined to be able to develop the final model.

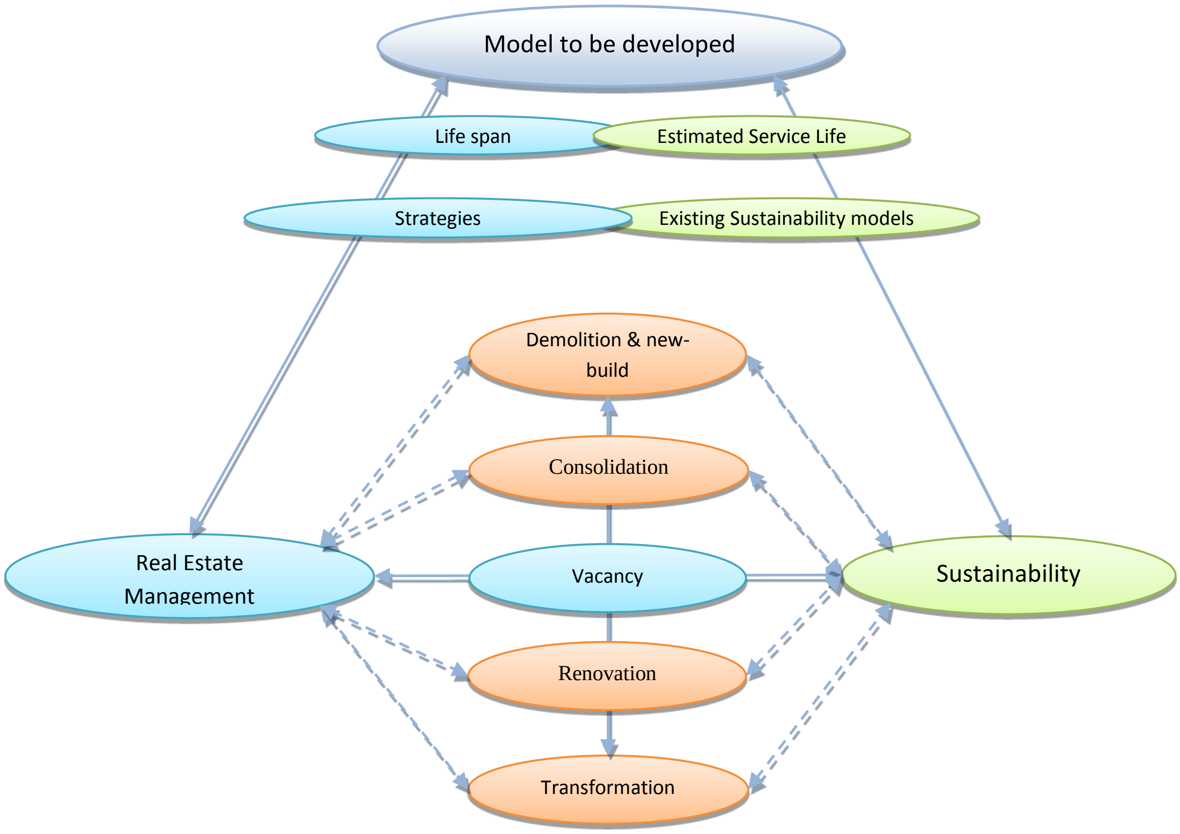


Figure 7.1: Concept diagram of the research

The research combines the topics of real estate management and sustainability by solving the vacancy problem in the most sustainable way. This can be through consolidation, renovation, transformation or demolition & new-build. The model finds the most sustainable solution by judging the real estate strategies with existing sustainability models. By linking the concepts of lifespan, originating from real estate management literature, to the concept of estimated service life, originating from sustainability literature, these models are adapted to also include the estimated service life.

7.2 Framework

To be able to conduct the research in the limited time frame this research has had to make assumptions and define the limits in order to from a well-defined research area.

The following framework has been used to define these limitations and their effect on representing reality.

Starting points:

- No financial considerations.
- No social considerations.
- The comparison of the strategies should be as objective as possible.

Constraints:

- This research considers three cases; this means that the results cannot be generalized.
- The three cases have been averaged into one main case that has been used to develop the model. This has been done to avoid extremes and to prevent the disclosure of confidential building information.

Assumptions:

- All strategies are executed on the same location, including the new-build after demolition.
- All strategies are executed by the same contractor, equalling the quality of execution.
- All strategies will have the same owner, user, project manager or any other actor.
- All strategies will have the same owner, user, project manager or any other actor as the reference building.

Boundaries:

- This research will compare multiple existing sustainability models for estimating environmental impact to select the most appropriate one to serve as the base for the S^3 model.
- This research will consider the existing literature on sustainability and estimated service life determination.

This research will not consider:

- The effect of a change in location.
- The effect of including any financial factors, such a lower or higher energy price.
- The effect of including social values.
- The correctness of the Greencalc$^+$ calculations.

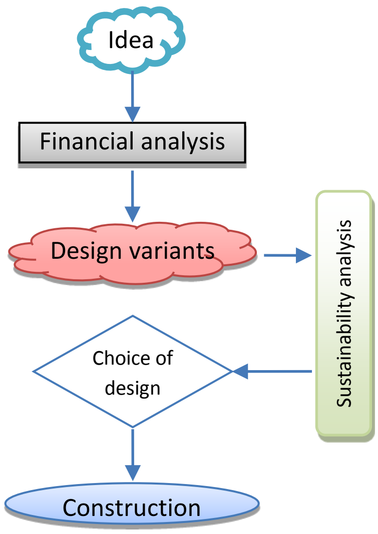


Figure 7.2: Traditional place in the decision making process

7.3 Place in the decision making process

Figure 7.2 shows the place of the newly developed sustainability model in the decision making process of the owner of a vacant office building.

The process starts with an idea, inspired by the fact that the building is vacant, which results in the will to make a plan. At this point all possible real estate strategies for vacant office buildings need to be considered. Traditionally they are compared on their financial attractiveness and the two most attractive ones are translated to a design. These designs are compared to the demands of the owner and the most attractive one is chosen and constructed. In this process, if sustainability played a role at all, this was considered after the design was made.

Currently there is much more awareness, both inside and outside the building industry and sustainability is assessed directly after or simultaneous with the financial analysis. The environmentally conscious route in which the sustainability analysis is conducted simultaneously with the financial analyses is therefore applied more often.

The results of the sustainability analysis are then used as a second argument to decide whether or not to abandon a strategy. This can make a large difference, for example if a strategy that does not create a large financial benefit turns out to be far more sustainable.

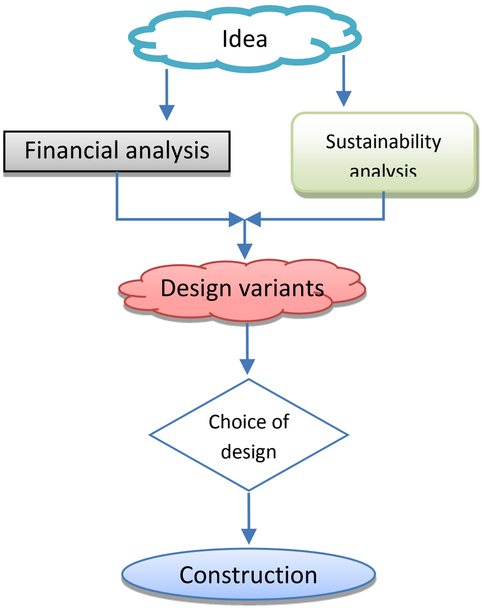


Figure 7.3: Environmentally conscious place in the decision making process

7.4 Research methods

In order to answer the sub questions the following research methods will be used. The literature study will give an overview of the current state-of-the-art on this research topic and the case study, combined with simulation, will be used to develop and test the model. Finally the model and the test results will be discussed with an expert panel.

7.4.1 Literature study

In order to get an overview of the current state-of-the-art in the considered research topics a literature study was performed. A literature study can be used for several purposes:

- To identify the research question
- To focus the topic of inquiry
- To understand the makeup of the research question
- To understand an idea's genetic roots
- To understand the current conceptual landscape. (Groat & Wang, 2002)

By conducting the literature study all these goals have been met and the end result is presented in this report. The literature study is presented in the second part of this report and concerns three main topics; Real estate management, Sustainability and Estimated service life.

7.4.2 Case study

To be able to develop and test the model three case studies have been averaged into one main case. This has been done to prevent the disclosure of confidential building information. These three cases have also been assessed separately.

Yin describes a case study as an empirical enquiry that investigates a contemporary phenomenon within its real life context especially if the boundaries between phenomenon and context are not clearly evident (Jin, 2003). This definition applies here because other researches to this topic have been done before and they have shown that the phenomenon (measuring the sustainability of real estate strategies for vacant office buildings) is very dependent on the chosen context (what factors you take into account). Using case studies to clarify this effect is therefore a valid research methodology.

"*The case study gives the story behind the result by capturing what happened to bring it about, and can be a good opportunity to highlight a project's success, or to bring attention to a particular challenge or difficulty in a project*." (P. Neale, 2006)

Neale also states that cases may be selected because they are highly effective, not effective, representative, typical or of special interest. In this research the cases will be mainly selected on the basis of availability. However, it will be tested on representativeness to be able to say if the results can be generalized. Case studies are easily over generalized (P. Neale, 2006) and therefore the literature study will be used to support the findings of the case study.

7.4.3 Case selection

To develop the model one main case will be used. This is the average of three cases that have been provided by the graduation company, CBRE. These three cases were selected upon the following criteria:

- The case concerns a vacant office building with little perspective on finding a new tenant.
- There is enough information available on the case.
- Building year lies between 1960 – 1990.
- The building is not a monument.
- The building has an energy label and this report is available.

7.4.4 Simulation

Simulation occurs if a replication of a real-world context (model) contains within it dynamic interactions that are the result of manipulated factors. A simulation research design is one that is able to collect data on these interactions for application into the real world context (Groat & Wang, 2002).

In other words, the model runs a simulation because it uses factors that can be adjusted. In the case of this research the input stays the same; the building characteristics, and the output is given for each strategy.

The model will be tested with different factors to seen the influence of one specific factor. By re-running the model over and over again with different values the flaws can be discovered and fixed.

Finally this will result in the end model that will generate the end results for the case study. These results may then be used in the real world by stakeholders who can include them in their decision making process.

7.4.5 Expert meeting

An expert panel will be formed to see if the developed model is a valid representation for the building industry. The calculation method used in the model will be discussed and the results will be reviewed.

Goal:

The goal of this meeting is to get feedback on the model form experienced experts in the buildings industry. Therefore the panel will have members from different specializations of the building industry. The model will be presented in the development stage. It will include all the important factors but not be finished yet, so that the comments of the panel can be included. This means that a balance is to be found between the level of detail necessary to deliver preliminary results and flexibility and time to reflect and incorporate the comments given by the experts.

Experts:

Preferably the panel will consist of experts from different specialisation of the building industry. They should be representative for the current knowledge of measuring sustainability in the build environment. Preferably a member of the Dutch Green Building council should be included. The Dutch Green Building counsel has a leading role in the implementation of sustainability labels in the build environment, such as BREEAM.

Secondly an expert should be present who has experience in applying sustainability labels on existing buildings in practice, to be able to assess that practicality of the proposed model. To represent the end user of the model: the decision maker, the presence of an investor or building owner would be preferable. Finally an expert on estimated service life would complete the panel and the mentors of the research should be present.

Preparation:

The meeting should be prepared by supplying documents to the experts to reduce the time needed to introduce the research. This introductory document should consider the main research question and research definitions, a clear overview of the used literature and the progress of the research so far, as well as an indication of the topics that are to be discussed. To ensure that the meeting will be as effective as possible an agenda has to be made and distributed before the meeting.

Processing the results of the meeting:

During the meeting the minutes should be made by someone who does not take part in the discussion so that all comments can be processed. After the meeting a feedback form will be distributed to the experts. This will filter out the most important comments that definitely need to be incorporate in the research.

After the meeting the model should be improved and finalized according to the comments received in the meeting, or a valid argumentation should be given why the comments are not processed. This means that the meeting will have to be arranged just after P3, to ensure that there will be time to process the comments.

Part 2: Literature study

8 Introduction to the literature study

In this part the existing body of knowledge in the research fields relevant to this thesis is presented. This has been collected through a literature study conducted with the following search words:

Sustainability in the build environment, Vacancy and sustainability, Vacancy and sustainability + build environment, Vacancy strategies, Sustainability models, BREEAM, Greencalc$^+$, GPR Gebouw, Lifetime build environment, Sustainable building and construction, Added value sustainability, Estimated service life, Service life prediction, Factor method, Lifespan accounting model, Annuity mortgage, Improved factor method, Duurzaamheid Gebouwen, Korte levensduur Gebouwen, Inleiding bouwmanagement, Bouwen met karton 20 jaar, kantoor transformatie.

8.1 Mind map literature study:

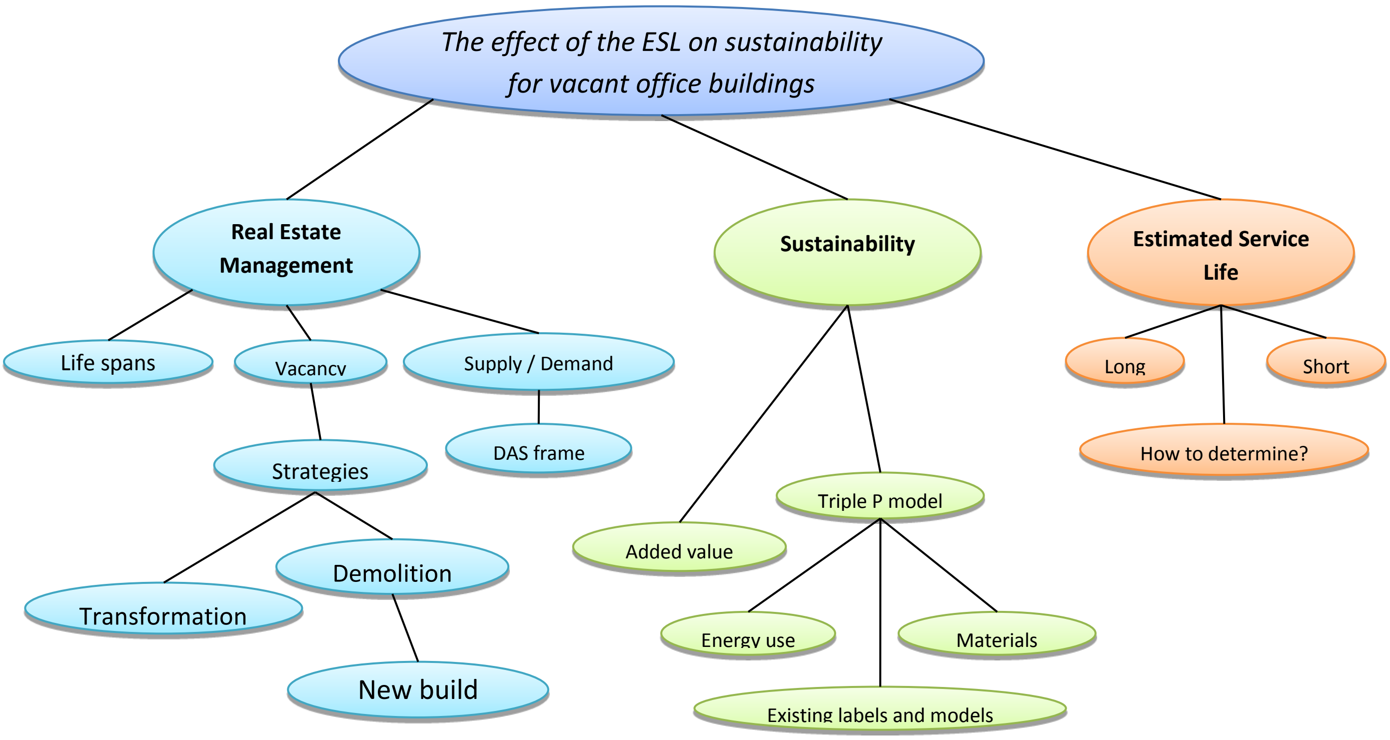


Figure 8.1: Mind map of the literature study

There are three main subjects in this literature study; real estate management, sustainability and estimated service life. Real estate management literature functions as a framing of the research in the laboratory in which it is conducted, the laboratory of real estate management. The topic of sustainability deals with defining sustainability in the built environment and gives an overview of the current conceptual framework in this field. Finally, the topic of the estimated service life (ESL) concerns the currently available methods to determine the estimated service life and its effect on sustainability.

8.2 Prior research

As mentioned in the introduction and research design previous researches have been conducted on comparing strategies for vacant office buildings. However, these mostly only compared two; transformation and demolition & new-build.

The most recent and most discussed research on this topic was done by DHV. A research that received less attention was done by De Groot. Both researches resulted in the conclusion that demolition & new-build was more sustainable than transformation in their case studies. These researches will now be evaluated to further support the statements made in the problem analyses.

8.2.1 DHV

The research of DHV considered the old tax office on the Gerbrandystraat in Utrecht, which has been vacant for several years. The owner of the building, the Rijksgebouwendienst, asked DHV to give an advice concerning this building. Would it be more sustainable to transform or demolish it? As an initial market analyses proved that there was no demand for such a big office building in the area, renovation was not considered in the research (Metz, 2011).

The research considered both the material and energy use of the building, which was presented in environmental costs per square meter living area. These environmental costs were based on a Greencalc$^+$ calculation. The conclusion was that demolition & new-build would be more sustainable as the energy use of the new building would be much lower and the space use (square meter living area) much more efficient (DHV, 2011a).

Formula used in DHV research (based on Greencalc$^+$):

$$Total\ Env.L. = Remaining\ Env.L. \ + Env.L\ Materials\ {}^{p}/_{y} + Env.L.Energy\ {}^{p}/_{y} + Env.L.Water\ {}^{p}/_{y}$$

$$\frac{Total\ Env.\ L.}{M2\ living\ area} = \textit{Environmental load per year}$$

This was published in a press release and a meeting was held to explain the conclusions. During this meeting the main discussion considered the calculation method: by using the unit 'environmental load per square meting living area' the use of space influenced the results much more than the material use or energetic quality of the building (Metz, 2011).

It also became clear that the use of space was not yet defined in the new-build strategy, as no design was made (it was assumed to be optimal as it would be designed especially for its new function). The transformation design had in no way been made to ensure effective space use, as the design made for the financial analyses (optimized on cost effectiveness) had been adopted. This therefore favoured demolition & new-build as the most optimal solution, as a non-existing design was compared to a financially based design.

Another factor that was unequally compared was lifetime. A service life estimation for the new-build was not included. Also, the lifetime of the transformation strategy was assumed to be 75 years, the standard assumed lifetime for a residential building. If the ESL assessment methodology as specified by ISO would have been used, the inclusion of this factor would have been more useful.

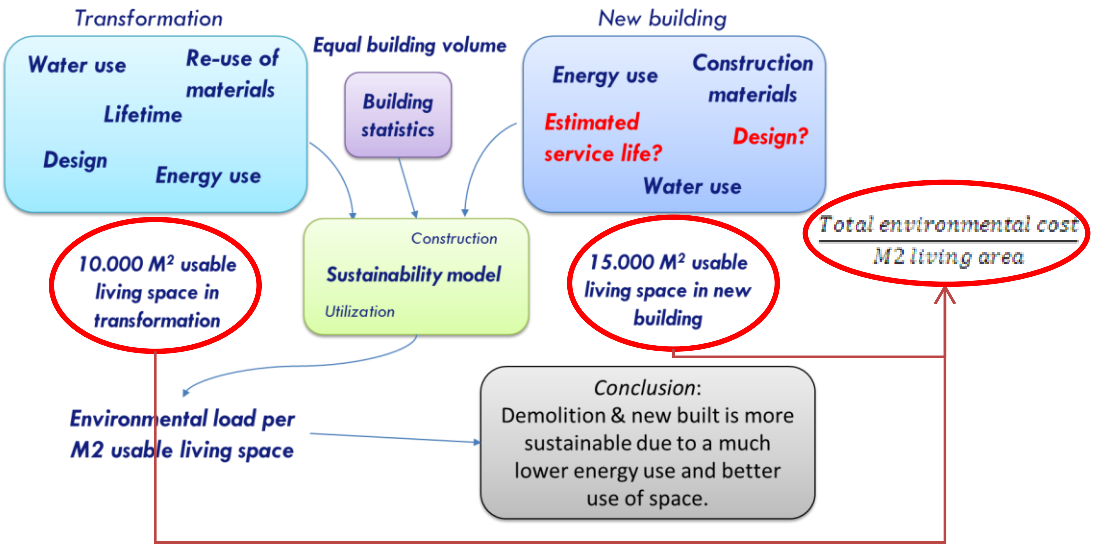


Figure 8.2: Analysis DHV research

8.2.2 De Groot

The research of De Groot was a thesis research, as is this one. These conclusions were remarkably similar as the conclusions made by DHV. Transformation only scored better in material use, but was overtaken by demolition & new-build as soon as energy use was included. This difference was simply too big to be compensated by more efficient material use. De Groot also included space use to create a normalized value. Whether or not this greatly influenced her results is unclear, as it was not possible to review the calculation method (de Groot, 2011).

9 Real estate management

In this chapter the background for this research will be explained, which is the construction industry and the built environment.

9.1 Vacancy

Currently 14% of the office supply in the Netherlands (6,6 million square meters) is vacant (CBRE, 2012). This vacancy is a problem to the owners of these offices as no income cash flow is generated, while costs are still being made. For instance, mortgages still have to be paid off and maintenance has to be done.

An office building can be vacant for several reasons. This is based on the principles of supply and demand (Van Der Voordt et all, 2004). If the supply of office buildings is much higher than the demand, not all vacant buildings will be able to attract new tenants. When new buildings are developed they add to the existing supply and can increase the oversupply if the demand stays the same.

9.2 Lifespan

The reason that a building remains vacant depends on where the building is in the buildings life's cycle and how it compares with the other available buildings on the market.

The building's life cycle as described by Blakstad (2001) starts with the initiative phases during the design and construction of the building. Then comes the phase of use and operation, a phase in which the building ages and with the passing of time, becomes less and less attractive to tenants as more new and better buildings are constructed. This stage alternates with adaptations which can be big or small and may require new programming, design or construction. Eventually the building will reach a stage where obsolesce may occur and its future usability and value will have to be assessed. At this point the decision will have to be made if the building will undergo a major adaption or be demolished (Blakstad, 2001).

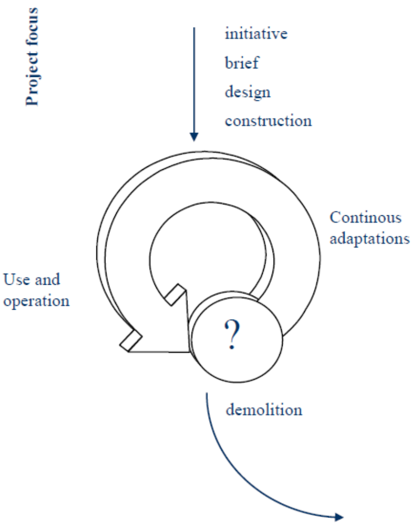


Figure 9.1: A buildings lifecycle by Blakstad (2001)

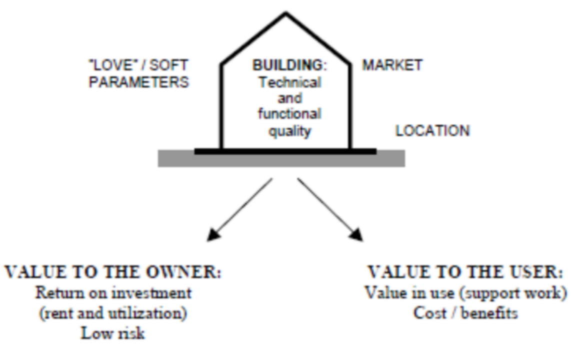


Figure 9.2: Important decision values by Blakstad (2001)

Which decision will be wisest is hard to measure as there are many different factors and values that need to be taken into account. These can be separated in soft and hard values. Soft values are very hard to measure, they consider the 'Love' that is felt for a building and the will of stakeholders to keep it. Hard values, like market and location, are much easier to assess and can be divided in to value to the owner and value to the user (Figure 9.2). The final factor is the technical and functional quality of the building, as this affects both the user value and the owner value, due to its profound influence on the financial feasibility. This can be measured or indicated by three types of lifespan:

1) Technical lifespan
2) Functional lifespan
3) Economic lifespan (Van Der Voordt et all, 2004)

When a building is closer to the end of one of these life spans than a competing building it is less likely to attract a new tenant and more likely to remain vacant, thus adding to the vacancy problem. The different types of lifespan are explained below, as they are represented in chapter 3.5 of Inleiding Vastgoedmanagement (Vijverberg, 2004).

9.2.1 Technical lifespan:

The technical lifespan is the length of time during which the real estate object can meet the necessary technical and building physical demands that are needed to be able to use the building and protect the safety and health of the users. The technical lifespan can be prolonged by applying maintenance to the building. This can be something like repairing a leak in the roof, but does not include measures that improve the initial technical quality of the building.

9.2.2 Functional lifespan:

The functional lifespan is the period of time during which a real estate object complies with the functional demands of the user. This lifespan is ended when the building limits the user. This is linked to the type of use that is located in the building and dependant on the specific user of the building. When the end of the functional lifespan is reached there are several options. An investment can be made to improve the building, after which it is again able to support the same use as before. Or the choice can be made to house a different function in the building.

9.2.3 Economic lifespan:

The economic lifespan is the period of time during which the real estate object generates more income than costs. This is the period in which the present value of all future income is higher than the present value of all future costs. The income a property can generate depends on the price, quality and competition in the market; the costs depend on what is needed to maintain the building. The economic lifespan ends when an owner can no longer see a possibility to generate more income than costs. The global or regional economy can have a very profound effect on the economic lifespan of a building and shorten or lengthen it drastically.

These three types of lifespan have an influence on each other. For example, if the functional lifespan has ended, this usually implies that the economic lifespan also ends. If the functional lifespan ends, it is not possible to find a tenant for the building which means the building can no longer generate income to cover the costs. The ending of the functional lifespan may be caused by the ending of the technical lifespan; however it is often the case that a building is still in a technically good condition when the end of the functional lifespan is reached.

9.2.4 Environmental lifespan

A forth lifespan is added by Van Den Dobbelsteen (2004), the environmental lifespan. This is:

"The time-span after which demolition and reconstruction becomes environmentally more favourable than renovation and re-use. This lifespan is therefore similar to the economic lifespan, yet with the environmental load instead of actual costs as a decisive criterion." (Van Den Dobbelsteen, 2004)

This fourth type of lifespan is separate of the other three as it is not directly visible to either the owner or user and therefore can easily be forgotten. Calculating whether the environmental lifespan has ended takes time and will therefore only be done if it has an added value to the owner or user.

Lifespan and vacancy

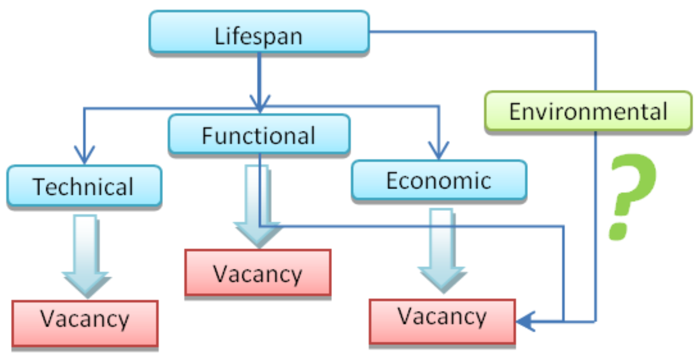


Figure 9.3: Lifespan and vacancy

For a building to become or remain vacant, only one lifespan (technical, functional or economic) has to end. Therefore the term lifespan has been used in this report as a more general indication that considers any of these three life spans. Whether or not the end of the environmental lifespan will also lead to vacancy is uncertain, as this is not clearly visible from the building itself. However, with the increasing public attention and preference for sustainable buildings this may also be the case in the future.

9.3 Strategies

If a building no longer complies with the demands of the user or owner there are several strategies to choose from:

Strategy after ending of functional lifespan	Level of intervention	Change of: *Materialisation*	*Spatial layout*	*Building volume*	*Function*
Function extension	Modification	X			
	Renovation/remodelling	X	X		
	Expansion	X	X	X	
Function change	Transformation (Conversion)	X	X	X	X
Function ending	Demolishment	X	X	X	X
Sale	*The new owner will have to make the same trade off as the original owner*				

Table 9.1: Strategies (Den Heijer & De Jonge, 2004)

The last strategy is to consolidate, to do nothing and leave the building as it is. This is often referred to as a benchmark to compare the different strategies.

Below is a model showing which factors influence the decision on which strategy to take (Den Heijer & De Jonge, 2004).

		Internal value	
		Strategic	*Not strategic*
External value	*Easy to sell*	Sell or keep income-cost trade off	Sell
	Not easy to sell	Keep	Demolish or Transform (redevelop)

Table 9.2: Strategy decision model (Den Heijer & De Jonge, 2004)

Applied on generic vacant office

Since there is an oversupply in the market, buildings that are vacant will have significant disadvantages compared to the building that do find new tenants. It may therefore be assumed that they will not be easy to sell. Whether or not the building is strategic to the owner is harder to judge, but since a building that does not generate income will cause losses to the owner, it may be assumed not strategic. This means the strategies of demolition and transformation (redevelopment) are to be considered. Table 9.1 shows that renovation can be included as a 'light weight' solution, as it has a lower level of intervention. Whether or not this will be useful depends on the problem; the economic, functional or technical lifespan. After demolition the lot can again be used to develop a new building. This can be considered as the strategy: Demolition & new-build.

9.4 DAS frame

As described before transformation is seen as a part of the solution to the vacancy problem as it will rebalance the equilibrium between supply and demand. This can be explained by using the DAS frame displayed in the figure below.

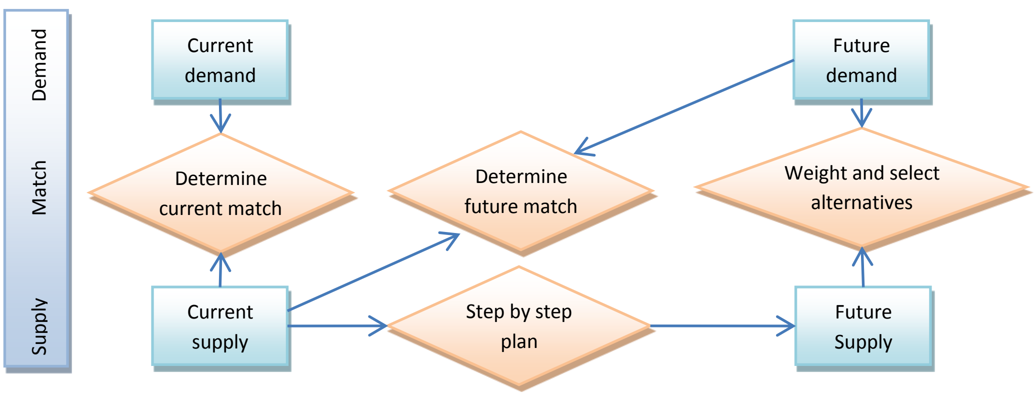


Figure 9.3: The DAS frame (De Jonge et all, 2009)

The current high structural vacancy is caused by a mismatch between the current demand and current supply. The current demand in the office market is much lower than expected, creating an oversupply of office space. This is caused by trends such as 'the new way of working', which demands less space per employee, and by the financial crises causing companies to decrease their working force. Next to that there is a mismatch between demand and supply in the type of office that is on the market. More and more companies want to have a state-of-the-art sustainable office, while many of the available offices do not comply with this high standard.

To rebalance the office market the DAS frame states that the future match must be determined between the current supply and the future demand. It is generally believed that sustainability will only grow in importance in the office market, and that the current over supply will not be filled up again completely even if the economy improves (Jones Lang LaSalle, 2010). The future match will therefore be a smaller office market containing more sustainable office buildings.

To reach this future supply a step by step plan has to be made. This plan will be different for each building owner as it depends on the building portfolio. The 'actieplan leegstaande kantoren' states that the step-by-step plan to the future supply should be to make the market smaller by reducing the amount of square meters of office space.

Making the office market smaller can be done in two ways, by demolishing unused buildings, or by transforming them into another function. The building then leaves the office market and enters the market attached to its new function, for example the housing market.

9.5 Vacancy risk meter

To be able to assess whether or not a vacant office building is likely to remain vacant the vacancy risk meter has been developed by Geraedts and Van Der Voordt (2007). This is a checklist based assessment method with three stages; veto criteria, gradual criteria & vacancy risk assessment

9.5.1 Veto criteria

There are three veto criteria including the location and building level.

Location

- Is the building in a municipal priority zone for dwellings?
- Is the capacity of parking space ≤ 1 parking space / 200 M^2 GFA?

Building

- Is there a concentration of buildings with a low rent level (≤ 90, - €/m^2 GFA) in the neighbourhood?

If the answer to any of these questions is 'Yes' the veto criterion is not met and a further assessment of the building is not deemed useful until the issue is resolved. If the answer to all questions is 'No' the gradual criteria can be assessed.

9.5.2 Gradual criteria

The gradual criteria are also divided in a location and building level. On the location level there are 23 criteria, on the building level there are 37. To give an indication the first criteria are displayed below, the complete list of criteria can be found in the appendix.

Location

- City ≤ 50.000 inhabitants?
- Located in a specific city area?
- Concentration of buildings with a low rent level?
- Mono-functional location?
- Distance to the highway ≥ 5 km?
- …

Building

- Building year between 1960 – 1980?
- Outdated exterior?
- No identity compared to other buildings?
- Simple finish exterior?
- Entrance not recognisable?
- …

If these criteria are not met this is a disadvantage for the building, but some criteria may be considered more important than others. Therefore a weight can be added from 1-3; being not very important to very important. The default weight between location- and building criteria is Location: 5 and Building: 3.

9.5.3 Vacancy risk assessment

After assessing all criteria the results are summarized in a vacancy risk class.

Score	Class
Location+ Building = 0 - 136	1 = Very suitable for preservation as office
Location+ Building = 137 - 272	2 = Suitable for preservation as office
Location+ Building = 273 - 408	3 = Limited suitability for preservation as office
Location+ Building = 409 - 544	4 = Hardly suitable for preservation as office
Location+ Building = 545 - 678	5 = Not suitable for preservation as office

Table 9.3: Vacancy risk class (Geraerds & Van Der Voordt, 2007a)

This class can be used to compare the vacancy risk of the building with that of other buildings and can be used to support the decision making process.

Interpretation of the vacancy class

One thing that stands out in the assessment criteria of the vacancy risk meter is that the market analysis is limited to a study on surrounding buildings with a low rent level. This is indeed an indicator of the local real estate market, but does not suffice to give a complete overview. Especially since the financial crisis started in 2008 (after the publication of the vacancy risk meter) the market analysis has become much more important in assessing the vacancy risk. The vacancy rate has risen from 10% in 2007 to 14% in 2011 (Renooy, 2008, CBRE, 2012) which calls for a more elaborate market research when assessing the vacancy risk. This can be done by applying a heavier weight to the criteria that are not met (assess them as "very important") or by shifting the vacancy risk classes. In this research all criteria that were not met have been weighted as "very important" (e.g. weighted 3 on the scale of 1-3). This can be seen in the appendix.

9.6 Transformation potential meter

The transformation potential meter is also developed by Geraedts and Van Der Voordt (2007) and is very similar to the vacancy risk meter. It includes veto criteria, gradual criteria and the final assessment of the transformation class.

9.6.1 Veto criteria

There are 8 veto criteria concerning market, location, building and organisation.

Market

- Is there a demand for dwellings by local target groups?

Location

- The land-use plan does not allow a function change to dwellings
- Health or nuisance risks

Building

- Floor to ceiling height ≤ 2.60 m.

Organisation

- Absence of an enthusiastic initiator
- Internal criteria initiator on accessibility
- Internal criteria initiator exterior of the building
- No willingness to sell from the building owner

If any of these veto criteria are not met further assessment of the building is not useful until these problems are resolved. Only if an initiator still needs to be found a further assessment is useful because this can indicate how much time and effort should be spend on this and can be used as an argument to convince an initiator.

9.6.2 Gradual criteria

The gradual criteria are divided in a location and building level. The first five criteria of these levels will be shown here, the other criteria can be found in the appendix.

Location

- Located in an industrial area or office park
- Bad views compared to other buildings
- Daily grocery store ≥ 1 km
- Neighbourhood meeting places ≥ 500 m
- Distance to parking spaces ≥ 250 m

Building

- Recently constructed (less than 3 years ago)
- (Partly) vacant
- No possibility to fit in dwellings (design)
- Depth more than 10 m
- Grid ≥ 5.40 m

The transformation potential meter does not weight criteria on location or building level separately but only applies a standard weight of location: 5 and building: 3.

9.6.3 Assessment of the transformation potential

After assessing all gradual criteria the transformation class is determined.

Score	Class
Location+ Building = 0 – 40	1 = Very suitable for transformation
Location+ Building = 41 – 80	2 = Suitable for transformation
Location+ Building = 81 – 120	3 = Limited suitability for transformation
Location+ Building = 121 – 160	4 = Hardly suitable for transformation
Location+ Building = 161 – 199	5 = Not suitable for transformation

Table 9.4: Transformation potential class (Geraerds & Van Der Voordt, 2007b)

9.7 Conclusion

In this research the term lifespan will be used as a general term indicating that either one of the possible life spans; technical, economic or functional, has come to an end. This choice has been made because it does not matter which lifespan has come to an end for an office building to become vacant.

In the case of a vacant office building the risk of structural vacancy (remaining vacant for 3 consequent years or more (Muller, 2009)) has to be assessed to be able to determine the possible strategies for the building. Then the transformation potential is assessed to see if the building can be reused in another function. (In the scope of this research only a residential function is applied.)

After these assessments the possible strategies for the building correspond with the levels of intervention explained in table 9.1. The final table of possible strategies, assuming that the vacancy risk is low and transformation potential is high, is:

Possible strategies	Description
Consolidation	Do nothing
Renovation	Replacing installations and interior
Extensive renovation	Stripping down to the structure and redesigning as office
Traditional transformation	Stripping down to the structure and redesigning as apartment building
Sustainable transformation	Stripping down to the structure and redesigning as apartment building with the ambition to get an A^{++} energy label or BREEAM Excellent certification
Traditional demolition & new-build Office	Demolishment and new-build of an office that complies to all specifications in the building decree
Traditional demolition & new-build residential	Demolishment and new-build of an apartment building that complies to all specifications in the building decree
Sustainable demolition & new-build Office	Demolishment and new-build of an office with the ambition to get an A^{++} energy label or BREEAM Excellent certification
Sustainable demolition & new-build residential	Demolishment and new-build of an apartment building with the ambition to get an A^{++} energy label or BREEAM Excellent certification

Table 9.5: Possible strategies for vacant office buildings

These are the strategies used in this research and in the model. In the case of renovation a distinction between a traditional and sustainable renovation could have been made, but since a renovation is seen as a function extension with a low intervention level this has not been included.

Excluded strategies

In the table above not all possible strategies are represented as an infinite number of strategies are possible. The strategies represented here are a good representation of the options available in the initiative phase. They represent both office and residential functions, which are the two options which are mentioned most often. The list would be more complete if a sustainable renovation strategy and sustainable extensive renovation strategy had been included, as well as transformation to hotels or other functions. However, this has not been included in the scope of this research

10 Sustainability:

In this chapter the term sustainability will be explained, from its origins to its implication in the built environment. It will discuss the existing possibilities to measure sustainability and the existing models that are available.

10.1 What is sustainability?

To be able to use the term 'sustainability' in this report the concept of sustainability will first have to be defined. In order to do this the history and current use of the term will be discussed.

10.1.1 History

The concept of sustainability originates from the industrial revolution in the late 18th and early 19th century. During this time large factories were built with no concern to toxic or normal waste disposal, which eventually resulted in laws and regulations to prevent life-threatening situations (William McDonough, 2007).

This increased environmental awareness inspired two perspectives:

1. Malthus: Population growth and human actions deplete the worlds resources which will cause huge food shortages (Malthus, 1798).
2. Romantic writers: The beauty of nature as origin of the thought that humanity is to blame for destruction of nature which resulted in the first environmental protection societies.

In the 1960's the romantic views on the protection of nature started to melt with scientific reasons by starting the discussion on the influence of chemicals like DDT which eventually resulted in the prohibition and regulation of industrial chemicals.

Later, in 1972 the club of Rome published the report 'The limits to growth'. This enforced the philosophy of Malthus, predicting that if the natural resources continued to decrease in the same pace due to destructive industrial activities and the increasing population, the limits of the earth would be reached within 100 years (D. Meadows, 1972).

All of this finally concluded to the currently most cited definition of sustainable development in the Brundtland report of 1987 (Brundtland, 1987):

> "***Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs***."

10.1.2 The triple P model

To be able to define sustainability in a less abstract way the 'triple bottom line' was introduced by John Elkington in his book, Cannibals with forks. This was later named the triple P model, based on the three bottom lines; People, Planet and Profit (Elkington, 1997).

In this division, People stands for the social part of sustainability, Planet represents the physical part and Profit the economic part.

In real estate the economic part, Profit, is well represented. Only seldom something is done which has not been calculated through very well and has been assessed on risk and profit. This will therefore not be further discussed.

Figure 10.1: Triple P model (Anon, 2011)

The People factor is more difficult to define, but is well put by Kua & Lee (2002) in their sustainability model for buildings as Social and Cultural sustainability (see figure 10.2). This concerns the protection of health and comfort and the preservation of social and cultural values. These aspects of a building are defined by its design, which is mostly done by an architect.

The final factor, Planet, concerns the natural resources and ecosystems on our planet. Depletion of natural resources should be prevented by carefully choosing what and how many materials to use. To protect the existing ecosystems not only the mining of materials needs to be considered, also the disposal and possible recycling of waste is important.

10.1.3 Sustainability in the built environment

The model below shows how the triple-P model can be applied on the build environment.

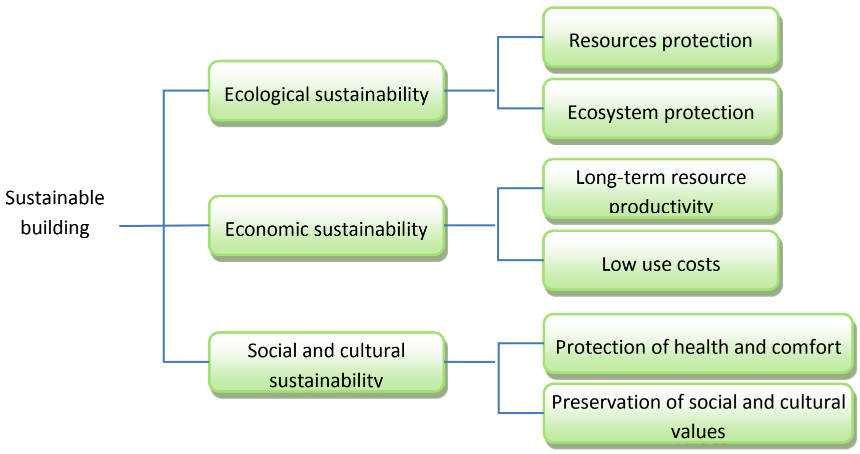


Figure 10.2: Types of sustainability (H.W. Kua & S.E. Lee, 2002)

Perception of sustainability

When a new development with a minimalistic approach on sustainability is started, the first concern of the developer is the economic sustainability. This is not viewed as a sustainability issue, but as a necessity to be able to construct the building: if the costs cannot be covered by the profits the building cannot be build.

Next up is the social and cultural sustainability which is also not seen as a sustainability issue. This is because the minimal demands of this aspect are covered by the building decree and other regulations. If these regulations are not met it will not be possible to get a building permit and the project will be cancelled.

The final type, ecological sustainability, does not have a direct influence on the project and is therefore often forgotten. However, because of the increasing perception of ecological sustainability as a type of branding, sustainability models are being used more often to promote a building.

10.2 Definition of sustainability in this report

In this report the term sustainability will be used in the following context:

*When sustainability is mentioned this concerns the **ecological sustainability** of a building according to Brundtland. This means it concerns the **materials, energy and water use of a building**. It does not concern the social and economic aspects mentioned in this chapter.*

Why these other factors have been excluded is explained in the framework of the research. This is mainly because the model will be used in the initiative phase, after or simultaneous with the financial feasibility analyses but before the design phase. This means that the economic sustainability has already been addressed and the design, the social sustainability, will be addressed later.

10.3 How to measure sustainability:

As stated before the objective of this research is to compare the sustainability of vacancy strategies. To be able to do this a method is needed that can measure sustainability. A lot of models have already been developed for this purpose, also for application in the building industry. In this chapter these models will be compared and one will be selected to serve as a basis for the model to be developed.

10.3.1 Cradle 2 Cradle

The concept of sustainability is continuously updated, inspired by the increasing publicity and branding possibilities. One perception is the cradle 2 cradle concept introduced by William McDonough en Michael Braungart in 2002. This concept aims to take sustainability to the next level by introducing a Waste = Food mentality. Not only the production of an item should be sustainable, also the disposal of the item must be considered during the design phase. By making products that can be disassembled the different resources can be reused without having to 'downcycle' them (see frame).

Downcycling: the reused materials are of less quality than the original materials.

Example: the paint used on cars cannot be removed before recycling the used metals. They are therefore melted together with the paint, reducing the quality of the reused metal. (William McDonough, 2007)

By following this principle our waste can be transformed in to high quality resources, closing the cycle and greatly reduces the amount of resources that have to be extracted from the earth.

10.3.2 LCA

LCA stands for Life Cycle Analysis and is the most used type of sustainability measurement. LCA is a cradle to grave approach, and therefore less rigorous than the cradle to cradle approach. This means that an assessment is made in every stage of every component of a product, from cradle – the extraction of resources – to grave – the waste disposal and optional recycling. This method has been specified by European law in ISO 14040. Eventually the environmental load of all stages and components is added up. The LCA shows where the highest environmental loads are generated and what the total load will be. This information can be used to improve the product or process.

10.3.3 Cradle to grave or cradle to cradle?

For this research a choice has to be made on the scope of the model; will it adapt the cradle to grave or the cradle to cradle approach?

As stated before the main difference between these two methods is the reuse of recourses once the initial product becomes obsolete. As the cradle to grave method is now standardized by ISO and the cradle to cradle approach is not, combined with the fact that it is very hard to predict the possibilities of reuse after the expected lifespan of 50 years, the cradle to grave approach is used in this research.

There are many models available in the building industry that help to make an LCA for a building. These models will now be discussed and finally one of them will be chosen to serve as a basis for the S^3.

10.4 Existing sustainability labels and models

There are currently two types of sustainability models in use in the building industry; checklist based and calculation based models. The difference between these two types is that calculation based models use databases to calculate the environmental load of a building, whereas checklist based models use questions and answers which are awarded points. The environmental load of a building can be calculated in several ways, for example using environmental costs or a CO2 footprint. Both types of models are based on the LCA approach.

A list of the most commonly used sustainability models is shown below.

Checklist based	LCA based	Other
BREEAM-NL (New-build)	Greencalc+	Energie prestatie coëfficiënt (EPC)
BREEAM-NL BBG (In use)	GPR Gebouw	Energy label (EPA)
LEED	Eco-Quantum	
LEED Existing Buildings		

Table 10.1: Overview of available sustainability models (Techniplan Adviseurs, 2010)

As this research will focus on the Netherlands, the models that are not often used here are not discussed. This means that LEED and Eco-quantum will not be further addressed. LEED is comparable to BREAAM but is mostly used in the United States. Eco-quantum used to be common in the Dutch market but is not used anymore.

10.4.1 BREEAM

BREEAM is a checklist based sustainability model that is available in two versions; BREEAM-NL, specialized on new building projects, and BREEAM-NL BBG, specialized on existing buildings. In order to get a BREEAM-NL certification a BREEAM assessor has to be hired to assess the building or building project. A temporary assessment can be made in the design phase, but the definite BREEAM assessment is done after completion of the building (DGBC, 2012a). The assessment is made in 9 categories with their own weight:

1. Management 12%
2. Health 15%
3. Energy 19%
4. Transport 8%
5. Water 6%
6. Materials 12.5%
7. Waste 7.5%
8. Land use & Ecology 10%
9. Pollution 10%

These categories are again divided in credits. For each credit points are awarded and these add up to the final score of the building. Example: (DGBC, 2011)

MAN 1 Performance Assurance

Goal: Stimulation of correct performance assurance of installations so that an optimal functioning in usage conditions is assured.

Credit: A maximum of 3 points can be awarded:

1	Where the presented evidence shows that enough time, people and resources are made available for the start-up of installations previous to the completion of the building , so that an efficient functioning of the installations is assured.
1	Where the presented evidence shows that, in addition to the above, the start-up of installations is carried out in agreement with current practice guidelines and that seasonal start-ups will be used in the first year after completion.
1	Where the presented evidence shows that the commissioning manager has been appointed previous to the definite design.

10.4.2 BREEAM BBG (In Use)

BREEAM-NL BBG (Bestaande Bouw en Gebruik) is especially designed for existing buildings and is also checklist based. It can be used to assess existing buildings or small adjustments to existing buildings. As soon as the thermal shell of a building is adjusted it is often better to use BREEAM-NL for new-build. In BREEAM BBG the maintenance and use of the building is very important of the actual score.

The assessment is again divided in the same 9 categories, but is also divided in three components; Asset, Management (Beheer) and Use (Gebruik). These are again divided into credits.

	Management	Gezondheid	Energie	Transport	Water	Materialen	Afval	Landgebruik & Ecologie	Vervuiling
Asset	0 %	21 %	25 %	9 %	8 %	12 %	3 %	8 %	14 %
Beheer	15 %	15 %	31.5 %	0 %	5.5 %	7.5 %	0 %	12.5 %	13 %
Gebruik	12 %	15 %	19.5 %	18.5 %	3.5 %	4.5 %	11.5 %	5 %	10.5 %

Figure 10.3: BREEAM weighting (DGBC, 2012b)

Example: (DGBC, 2012b)

01MAN001B

***Topic**: Education facility manager*

***Goal**: improving efficient building use through appropriate training.*

***Question**: Are the facility managers of the building educated in the use of the building and available facilities?*

***Points**: for this question a maximum of 4 point may be allowed.*

- *Unknown [0 points]*
- *No [0 points]*
- *Yes, just the facility manager [2 points]*
- *Yes, the facility manager and the management of the facility management organisation (internal and external) [3 points]*
- *Yes, the above and all other users of the available facilities in the building [4 points]*

10.4.3 Greencalc+

Greencalc+ is LCA calculation based and focuses on material, water and energy use, the Planet side of sustainability. The results of Greencalc+ can be used as input in BREEAM in the materials category. These three aspects are combined in a final score, the environmental-index (milieu-index). There are three environmental-indices calculated; MIG (building specific ‘Milieu index Gebouw’) MIB (business operations, ‘Milieu index beheer’) and the own-index. The MIG is building specific and can be compared with other assessed buildings. The MIB includes the use of the building and is therefore influenced by the behaviour of the users. The Own-index is used if no standard reference 1990 is available, in this case the score cannot be compared with other assessed buildings (Sureac, 2010).

In order to calculate the MIG Greencalc+ uses the national environmental database. This is a standardized environmental database that will be used in all Dutch versions of sustainability tools. This has been standardized to ensure uniformity in sustainability calculations and advises and is used since 1-1-2012 (Stichting Bouwkwaliteit, 2012).

In order to be able to compare all effects of a building everything is recalculated into an environmental cost. This process is called monetizing.

The ‘prevention costs to sustainability’ consider the costs of the preventive measures that would have to be taken in order to reduce the current pollution to a sustainable level. These have been calculated on the basis of technical and societal measurements. These monetized costs are ***virtual costs.*** This means that they do not represent a real financial investment. They are the costs that are (or should be) made by society, for example replanting trees, but that are not integrated in the production cycle and that are not included in current prices (NIBE, 2002). By using monetisation all effects can be added up and compared with other buildings.

Greencalc+ can be used on different detail levels, global or detailed. The global level is used in the design phase of a project by using one of the standard material packages. If a more detailed level is required all materials can be entered in the program based on the contract documents. The energy use of the building can also be adjusted using a correction to match the actual use.

Maintenance included

The national environmental database, used by Greencalc+ and GPR Gebouw, also includes the maintenance needed to keep a building in good condition. For example: in the environmental load for the used window frames, extra layers of paint have been included to ensure that the window frames can be used during the complete lifespan of the building. Also the shorter lifespan of installations, which need not be replaced approximately every 15 years, is included in the calculated environmental load. Recycling is taken into account, although this is calculated on an average level (Bijleveld, 2012).

10.4.4 GPR Gebouw

Another calculation based LCA model is GPR Gebouw. This model was originally designed for the municipality of Tilburg but was so successful that it has been adopted by many other municipalities. It is mainly used for dwellings, but can also be applied on other types of buildings such as offices. It is divided in 5 categories: (WE adviseurs, 2012)

1. Energy
2. Environment
3. Health
4. User value
5. Future value

Each of these criteria is awarded a score on the scale 1-10, which is compared with a reference building. It also gives an indication of the energy label (see paragraph 10.4.5) and CO2 emission. Last, GPR Gebouw gives the shadow costs of the building which have been monetized in the same way as in Greencalc+. These costs are presented as shadow costs for the entire building.

These scores are calculated using the national environmental database, the same database as used in Greencalc+. In GPR Gebouw only one level of detail can be used.

Note

This analysis of GPR Gebouw may not be complete as the program did not seem to work well. GPR Gebouw is a web based program and therefore operates in a web based environment. Unfortunately this often was very slow and some components of the program could not be loaded.

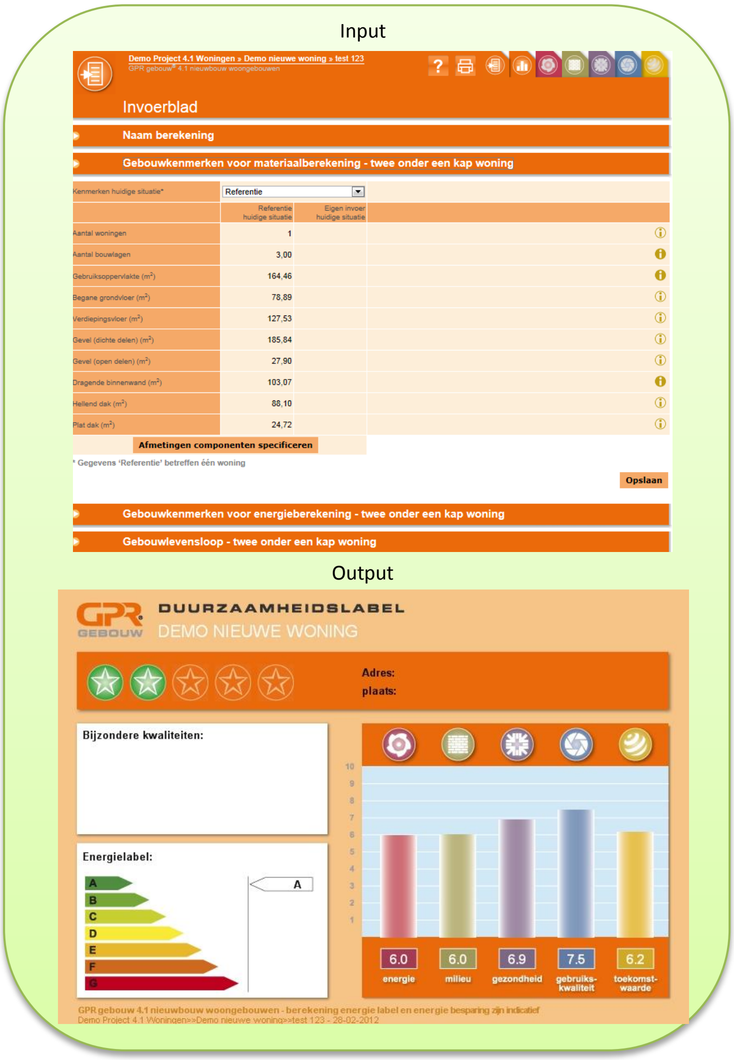


Figure 10.4: Input and Output GPR

10.4.5 EPC and energy label

EPC stands for Energie Prestatie Coëfficiënt (energy performance coefficient). The EPC was introduced by the Dutch government in 1995 as an instrument to reduce the CO2 emissions. The lower the EPC, the more energy efficient a building is. In the course of time the minimal EPC requirement stated by the government has been sharpened to a current requirement of 0,6 for dwellings (Rijksoverheid, 2012a).

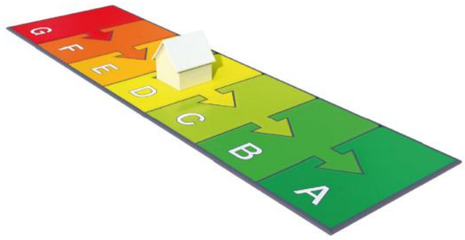


Figure 10.5: Energy labels

The energy label for buildings has been obligated by the government since 01-01-2008; it has to be present at the sale of a building. An energy label can be made by a certified assessor and ranges from A++ to G. In the label suggestions are given on how the building could be improved to get a higher energy label (Rijksoverheid, 2012b).

Both the EPC and the Energy label are based on energy use alone. They are therefore often used within BREEAM, Greencalc^{+} or GPR Gebouw.

10.5 Conclusions

When sustainability is mentioned in this research only the ecological sustainability, the planet side of the triple-P model, is meant. This includes material, energy and water use, but no other factors such a health or profit.

Because LCA is an ISO specified calculation method that uses the cradle to grave approach and the life spans of buildings are generally too long to be certain about the recycle possibilities, this is chosen over the Cradle to Cradle approach. This means the research considers a cradle to grave approach in which only the average reuse of materials is included (which is generally low).

BREEAM is one of the most used sustainability labels in the Dutch office market but has its disadvantages. It is a checklist based model that includes many different factors. Not all of these factors can be known in the initiative phase and the use of LCA models is required to be awarded points in the BREEAM components considering materials. BREEAM also has two different checklists for new-to-construct-buildings and existing buildings. This makes the model unfit for this research in which many different strategies, both existing and new-build, have to be compared.

As the EPC and energy label do not have a materials component they cannot give a complete picture of the environmental load. GPR Gebouw has the disadvantage that it only gives a total shadow price which cannot be specified.

Greencalc^{+} is therefore the program that will be used to serve as a basis for the S^3 model, as this program can provide the most detailed calculations for materials, energy and water. It can be used with ambition levels, for which not every detail has yet to be known. This makes it fit for use in the initiative phase. All strategies can be assessed though the same model and the results can be used to include the ESL.

11 Remaining environmental load and estimated service life

In this chapter the calculation of the remaining environmental load is discussed, including the used deduction method. Next, the Estimated Service Life (ESL) is researched and the current state-of-the-art on this subject is given.

11.1 The lifespan accounting model

When considering the effect of lifetime on the sustainability of buildings, one important problem arises; it is uncertain how long a building will last. When the design for an office is made, usually the assumed lifespan is 50 years (Van Den Dobbelsteen, 2004).

Van Den Dobbelsteen explains how to calculate how much of a buildings environmental load is still “left” after a certain period of time by using the lifespan accounting model, which is similar to the mortgage system in housing. When the building is constructed or refurbished a certain environmental load is created, which can be calculated by using the LCA method. This load is then paid off over the years the building exists.

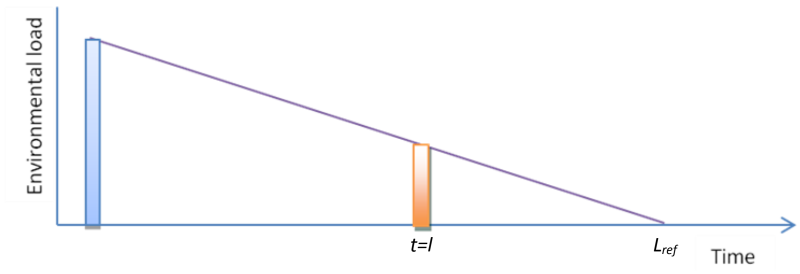


Figure 11.1: The remaining environmental debt at the year t=L before the reference lifespan L_{ref} (Van Den Dobbelsteen, 2004)

The energy use of the building is added as an annual load. When a decision is to be made between renovation, transformation or demolition & new-build these strategies can be compared by using this model. The energy load of the new building is expected to be smaller than the load of the reused building, due to maximum energy efficiency (A^{++} buildings). For these graphs a reference lifespan is assumed.

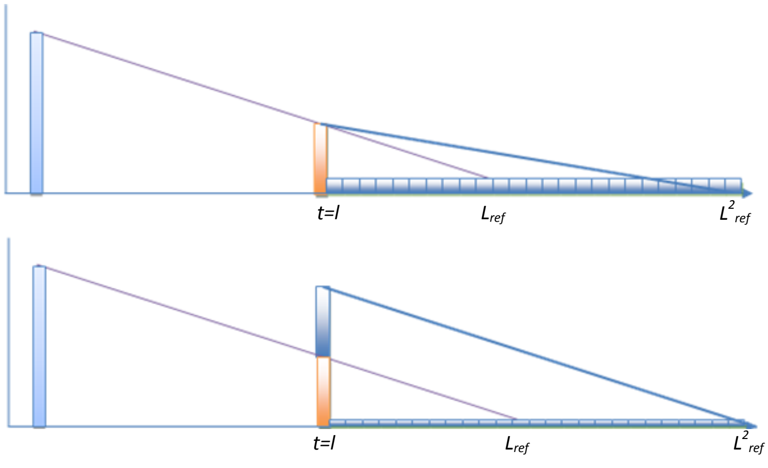


Figure 11.2: Graphic comparison of re-use versus demolition and new building (Van Den Dobbelsteen, 2004)

The new building can only be more sustainable than the adapted building if the annual load is smaller, as the initial load caused by construction will be higher. After the initial load is paid off, the higher energy consumption of an adapted building will make it less sustainable than a new building.

Another way of representing this is by making a graph that shows the added up environmental load, instead of the paid off load. This is shown in the figure below.

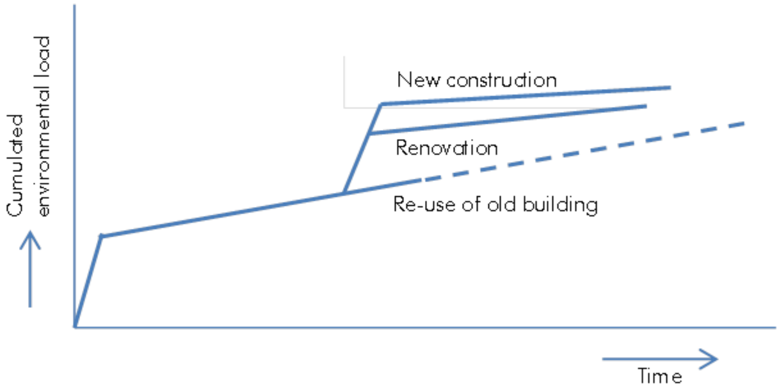


Figure 11.3: Cumulated environmental load of three alternatives, set against time (Van Den Dobbelsteen, 2004)

At some point in time the line of re-use of the building will cross with the line of renovation or new construction. This is due to the higher annual load caused by the use of the building. From this point in time on, renovation or new construction would be more favourable.

Long or short life spans:

To reduce the 'environmental load per year' caused by materials two things can be done:

1) *Assume a longer reference lifespan*
2) *Reduce the once-off environmental load*

These two options are both used in the building industry. When a building is transformed, the lifespan is prolonged. In this case an added environmental load, that represents the transformation, must also be taken into account. The second option is the basis for short lifespan buildings, buildings that are designed to last only 20 years instead of 75.

Figure 11.4: Westborough primary school (Designboom, 2012)

An example of a short lifespan building is Westborough Primary School (Cottrell + Vermeulen Architecture). This is a permanent structure made of cardboard, designed to last 20 years. 90% of the construction materials were recycled, keeping the environmental load of the building very low. (RIBA, 2011) When using this type of buildings there is also less maintenance as the usual maintenance lifecycle is 20 years (Anon, 2003). However, it is still to be seen if after the 20 year period the building will be replaced, or if this may take longer.

11.2 Annuity model

A subject that is not addressed by Van Den Dobbelsteen is why the pay-back method should be linear. In financial mortgages there are many ways to repay the initial loan, such as the annuity mortgage. The difference between a financial mortgage and an environmental mortgage is that there is no interest on environmental mortgages, or at least not one we can see.

In the annuity mortgage a constant amount is paid to the bank. However, this is not divided continuously though time between the interest and the repayment. At first most of that amount is spent on paying the interest which is high, because the loan is still high. A small amount is used as repayment. Gradually this repayment causes the loan to reduce, which also reduces the interest. This means that more money can be used as repayment, as less is needed for interest. Eventually practically all money is used as repayment and the complete loan is repaid.

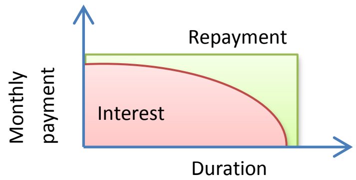


Figure 11.5: Annuity mortgage

It is questionable whether or not this is a better way of writing off the remaining environmental load, but it cannot just be assumed that this should be done linearly. Therefore a comparison will now be made to see the effect of the deduction method.

11.2.1 Components or complete building

The problem when writing off the environmental load of a building is the fact that a building is not one unity, but a composition of many components. These components all have their own ESL. The structure of a building will last the longest, sometime more the 150 years. However, the installations in a building need to be updated and replaced much more often, typically assumed every 15 years.

This means that the accumulated environmental load is not just decreasing, but also increasing at times when maintenance has to be done or new installations have to be placed.

However, in the national environmental database [this] effect is already taken into account. The database includes the extra environmental loads needed to keep the building in good condition, for example replacement of the installations and new paint every so many years. This is all calculated within the once-off load.

The argument that the environmental load should decrease fast in the beginning because some elements already reach the end of their lifespan is therefore not valid (negative annuity).

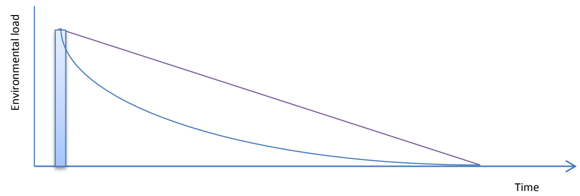


Figure 11.6: Negative annuity

Another argument is that the environmental load of a building can only be repaid slowly, causing the remaining environmental load to stay high for a long period of time, because nature needs a lot of time to recover from the extraction of resources (positive annuity).

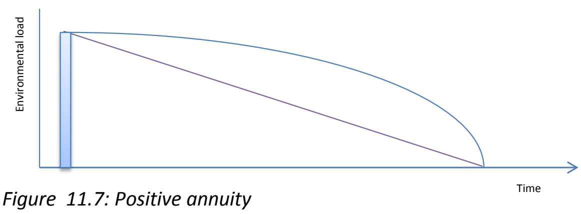


Figure 11.7: Positive annuity

This argument is hard to prove or disprove as there is currently not enough research done on this topic. For example; the impact of extraction of resources is currently based on their rarity. Stone like materials are not considered rare as there is a great supply of these materials all over the world. The effect of the extraction on the environment is calculated in prevention costs, as explained before. This means that the time needed for the environment to recover is not taken into account.

To reach a conclusion on this topic the question was also presented to an expert panel constituted by several professionals on sustainability in the build environment. As there is not enough research present to prove the argument that an annuity can or cannot be used, more research is needed on this topic. However, for now it may be best to assume a linear decrease (Jansz, 2012).

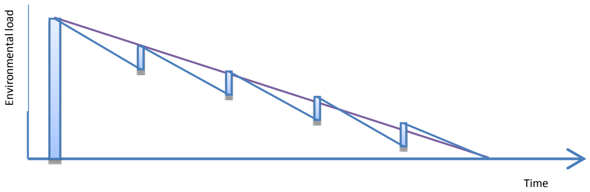


Figure 11.8: Wave like pattern

It is most likely that the decrease will be linear because all maintenance and replacement loads have already been included in the once off environmental load. The most accurate decrease is expected to be a wave like motion as components are written off. This wave will approach a linear decrease and since there is not enough research yet, and it is not the goal of this thesis to provide this, a linear decrease will be assumed. By assuming a linear decrease this research will also be more comparable with previous researches, as these all used a linear decrease.

11.3 Calculating the Estimated Service Life (ESL)

To be able to make a more accurate estimation of the reference lifespan of a building another factor is introduced, the estimated service life (ESL). This factor is influenced by several aspects: future value, use value, experience value and ecological value. As can be seen in the figure these values are not separate and greatly influence each other. For example, future value is made by all other three values, but is even more than the sum of them.

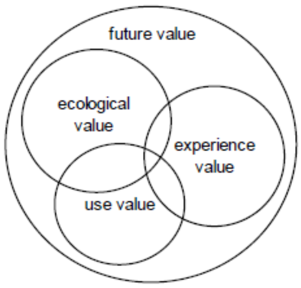


Figure 11.9: ESL factors (Van Den Dobbelsteen, 2004)

There are several methods to calculate the ESL; the one specified by ISO is the factor method. Next to this a probabilistic method is used in cases where a tailor made solution is required. The drawback of these two methods is that the factor method is fairly simple while the probabilistic method is very complicated. A third method is therefore the engineering design method in which a hybrid between the two can be created (Moser & Edvardsen, 2002).

11.3.1 The factor method

ISO 15686, ISO, 2000 (in Van Den Dobbelsteen, 2004) describes the following formula to calculate the ESL of building components:

$$ESL = RSL \times A \times B \times C \times D \times E \times F \times G$$

With:
A = factor for the quality of components
B = factor for the design level
C = factor for the work execution level
D = factor for the indoor environment
E = factor for the outdoor environment
F = factor for usage conditions
G = factor for the maintenance level

Van Den Dobbelsteen argues that to be able to calculate the ESL for a complete building the following variables should be considered:

Basic qualities	*Technical quality, functionality, health quality*
Flexibility	*Including multi-functionality*
Ecological quality	*Ecological quality of resources used, energy and water consumption performance, spatial performance, ecological educational quality*
Architectural quality	*Spatial quality, aesthetic quality, social-cultural-historical quality*
Neighbourhood quality	*Functional diversity, architectural diversity*

However, some of these factors can be excluded for the following reasons:

- For new buildings the basic qualities are not distinctive, as they may be assumed equal in all cases.
- Ecological quality needs to be excluded from the list because most of the qualities applying to it are already subject to the estimated service life factor (ESL factor).
- The features of neighbourhood quality do not judge the building in itself, but the situation in which it is put, i.e. the city planner.

Next to this architectural values are hard to measure, although they do have a profound influence on the estimated service life.

"A conclusion may therefore be that for the ESL factor only aspects of flexibility seem useful, and possibly and preferably architectural qualities as well." (Van Den Dobbelsteen, 2004)

11.3.2 The improved factor method

As mentioned before it is possible to adjust the ESL method to fit the situation. This is called an engineering design method.

The improved factor method is such a method and was designed by Haico Van Nunen (2010) to be able to make an estimation fit for the IFD-today project of the Eindhoven University of Technology. This IFD-Today project considered a building system that was highly flexible and Van Nunen wanted to know if this added to its sustainability.

He found three issues in the factor method that he wanted to improve:

1) There are more reasons for obsolesce possible then represented
2) The ESL has a fixed value but in practice variations occur
3) It can be questioned whether all factors are of equal weight (Van Nunen, 2010)

His first improvement was to add two more factors:

- Trends
  Used to adjust the reference service life according to the choices people make, based on how a product looks or a space is used.
- Related Components
  Used to take replacements into account that are not an effect of technical deterioration, but because other material connected to the considered one are being replaced.

Also a statistical probability was added to the factors. Because of this the outcome was no longer a fixed value but a statistical distribution. Last, a weighing was introduced to all factors. This weight is based on a questionnaire with 143 respondents.

Factor	Description	Weight	Factor	Description	Weight
A	Quality of components	1.89	F	In-use conditions	0.95
B	Design level	1.62	G	Maintenance level	1.06
C	Work execution level	1.14	T	Trends	1.19
D	Indoor environment	0.51	R	Related components	0.85
E	Outdoor environment	0.79			

Table 11.1: Weight of ESL factors(Van Nunen, 2010)

By including the extra factors and adding a weight to the factors the method fine-tunes the estimation of the service life.

11.3.3 The probabilistic method

The third method to estimate the service life is the probabilistic method. This method uses statistical calculation based upon the actual condition of the building. This means that very specific information is needed, not just the use of materials but also all past experiences in the building etc. This makes the method very unfit for this research, as the model will be applied in the initiative phase. It is also too complicated to be used by all stakeholders. Therefore this method will not be further discussed (Moser & Edvardsen, 2002).

11.4 The effects of the ESL

Van Den Dobbelsteen (2004) calculated the effects lifespan would have on the case of the office building for the Road & Water Engineering (RWE) Department in Delft. To show this effect the results for a 'normal' sustainability calculation, one that includes lifespan and one that includes the ESL factor are displayed below (calculated by using the factor method). The different options are:

- Demolition and building a traditional new office approved by NEN standards
- Demolition and building a state of the art new sustainable office
- Extensive renovation; the supporting structure (60% of the building) is stripped and new facades etc. (40%) are made.
- Renovation of building services. Only 10% of the building is renovated.

To prove the effect of the estimated service life Van Den Dobbelsteen first calculated which strategy would be most sustainable if the ESL was not taken into account. Then he added the age of the building at the moment of intervention. Finally he calculated the sustainability of the strategies if both the age and the estimated service life were taken into account.

Solution	Normal	Include age	Include age & ESL
RWE building original	1.04	1.13	1.01
Demolition & new building, traditional	1.07	1.07	1.17
Demolition & new building, sustainable	1.60	1.80	2.01
Extensive renovation	1.23	2.15	2.03
Renovation of building services	1.07	1.59	1.49

Table 11.2: Effect of including the ESL (Van Den Dobbelsteen, 2004)

The table shows that including the building's age and ESL does affect the results. Extensive renovation rises in sustainability and surpasses the sustainable demolition & new building strategy. A note to be made about the calculations is that re-use of the demolished building components was not taken into account.

These calculations, based on Greencalc+, show that it is possible for an extensive renovation to be more sustainable than demolition and new build. The question is whether this is comparable to transformation. Because the assumption is that the complete supporting structure is stripped and reused in the extensive renovation strategy, this may be so. The same happens during transformation, only the supporting structure is reused and filled up with new building components to make it fit for a new function (Van Den Dobbelsteen, 2004).

Comparing different life spans

Figure 11.10: Different life spans (Van Den

In the following graph the relation between the environmental loads of materials, energy and water in case of different life spans is made visual.
Building materials make up just over 50% of the total load if the building has a lifespan of 15 years. When the lifespan is around 20 years both materials and energy consumption are important and if the lifespan is more than 25 years the energy use becomes dominant in the environmental load (Van Den Dobbelsteen, 2004).

As the assumed reference lifespan for an office building is 50 years, energy use will produce the biggest environmental load during the building's life cycle. The focus on energy efficient buildings is therefore legit. Most vacant buildings are now approximately 20 to 30 years old. In this case the materials component holds a much larger percentage of the buildings total load and therefore the remaining environmental load of the building cannot be ignored.

11.5 Conclusions

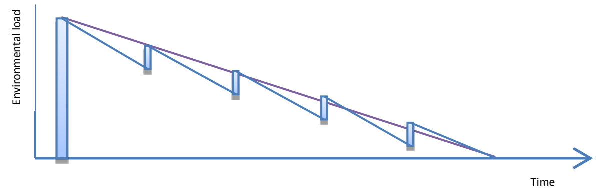


Figure 11.8: Wave like pattern

In the lifespan accounting model a linear decrease of the remaining environmental load can be assumed, because the database already includes maintenance factors. Therefore the shorter lifespan of, for example, installations does not affect the total repayment.
There has not been enough research done to be able to include the effect of extracting natural resources in this decrease. The expectation of the expert panel is that the actual decrease will follow a wave-like pattern, which will approach a linear decrease (Jansz, 2012) .

To determine the ESL the improved factor method by Van Nunen (2010) is most fit, although the statistical distribution will not be used. As all factors used to determine the ESL are estimates, the results should not be interpreted as predictions, but as estimations that may be used to compare possible strategies. This means that using the statistical distribution is not necessary.

The calculation by Van Den Dobbelsteen (2004) shows that including the estimated service life can have a profound effect on the sustainability of a strategy. In his example the inclusion of the ESL brought the strategies of extensive renovation and demolition & new-build of a sustainable building to nearly the same level of sustainability, slightly favouring extensive renovation.

12 From theory to practice

In this chapter the methods discussed in the literature study are applied in the research. A comparison and choice is made between the described sustainability models. The ESL formula is adapted to fit this research.

12.1 Comparison and choice of sustainability models

In this report a choice for one of the in chapter 10 discussed sustainability models will be made on the basis of the following criteria:

1. It has to be applicable on both new-build and existing buildings, as it needs to compare all ***strategies***; consolidation, renovation, transformation and demolition & new-build.
2. It has to be able to include the ***remaining environmental load*** of the existing building.
3. It must be possible to adjust or add on to the program so that it will include the ***Estimated Service Life*** (ESL).
4. It must be possible to use to program with easily acquired ***input***; the program must be usable for all relevant stakeholders in the decision process.

12.1.1 Strategies

The model that will serve as a basis for the S^3 model must be applicable for all vacancy strategies; consolidation, renovation, transformation and demolition & new-build. The scores of these strategies have to be comparable and the input of all strategies must be equal. As mentioned in the research design this means that the design is replaced by ambition levels to ensure that the model can be used in the initiative phase.

This is an advantage for Greencalc$^+$ and GPR Gebouw as these use only information that is known in the initiative phase (or at least the ambition level is known). It is a disadvantage for BREEAM as this uses two different checklists for new and existing buildings and the scores are not comparable. The EPC and Energy label can be used for all scenarios but their scores do not include the materials component.

12.1.2 Remaining environmental load

To be able to calculate the complete environmental load of a strategy the remaining environmental load of the vacant building must also be calculated (see chapter 11). This is a problem for BREEAM as it has no means of calculating the materials component. The questions that concern this subject need input from an LCA calculation based program to be awarded any points. Also EPC and Energy label cannot comply with these criteria as they do not have a materials component. GPR Gebouw has a disadvantage because it only shows the shadow price for all elements together and therefore the materials cannot be assessed separately.

This leaves only Greencalc$^+$ as possible model. Greencalc$^+$ does not calculate the remaining environmental load, but the results can be used as input for this calculation.

12.1.3 Estimated Service Life

One of the problems described in the research design was the absence of the ESL in the current approach to sustainability. It is therefore not surprising that none of the sustainability models have an option to include the ESL. It is however possible to adapt BREEAM, Greencalc$^+$ and GPR Gebouw to include this. For EPC and the Energy label this is not possible as they do not include the service life in any way, whereas the other models use a reference lifetime of 50 years for offices and 75 years for dwellings.

12.1.4 Input

In all models building specific information needs to be known to be able to use the model. However, the level of detail and amount of information is different. In BREEAM a lot of detailed information is needed, as it concerns more issues than GPR Gebouw and Greencalc$^+$. This means it is less usable in the initiative phase when this amount (and detail) of information is not yet known. For EPC and Energy label the amount of information needed is less, as it only concerns energy use. GPR Gebouw requires the least amount of input as it has a global detail level. This makes it easier to use in the initiative phase but also less accurate (Agentschap-NL, 2010).

Greencalc$^+$ has two detail levels, a global level with a choice between 4 ambition levels and the possibility to assign the exact materials as specified in the contract documents. This makes it usable in the initiative phase and more accurate than GPR Gebouw, as it has the choice between 4 ambition levels.

12.1.5 Choice

In the table below the criteria described above are applied on the discussed models.

	1. Strategies	2. Remaining Environmental load	3. ESL	4. Input
BREEAM	- -	- -	++	- -
Greencalc+	++	++	++	++
GPR Gebouw	++	-	++	+
EPC	+	- -	- -	- -
Energy label	+	- -	- -	- -

Table 12.1: Comparison sustainability models

Based on these arguments Greencalc$^+$ will be used as basis for the S^3 model. This is the only model that can be used for all strategies, which can be modified to give the remaining environmental load, includes the service life and does not need too much input to be used in the initiative phase. All the other models could not be used to calculate the environmental load and are therefore not fit to serve as the basis for the S^3 model.

12.2 Applying the ESL formula

In order to use the ESL in the S^3 model the formula to estimate the service life has to be adapted. As mentioned before the statistical distribution introduced by Van Nunen (2010) will not be used. This simplifies the model and the outcome. The weighing of the factors will be used in the model and therefore has to be incorporated in the formula. This formula is given by Van Nunen (2010).

A = The original factor

a = The weight

A_w= Factor A after the weighting

$$ESL = RSL * A_w * B_w * C_w * D_w * E_w * F_w * G_w * T_w * R_w$$

$$A_w = \left(\left((A-1)*a\right)+1\right)$$

$$B_w = \left(\left((B-1)*b\right)+1\right)$$

...

A) Quality of components
B) Design level
C) Work execution level
D) Indoor environment
E) Outdoor environment
F) In-use conditions
G) Maintenance levels
T) Trends
R) Related components

Not all of these components are relevant in this research, as future strategies will be compared. In the framework of the research it has been decided to keep all circumstances in all strategies as equal as possible. This is not a representation of reality, but a simplification. The results of the model should therefore be interpreted as such.

Because all strategies are assumed as similar as possible, factors like work execution level (C) will be left out of the equation. For all strategies the same contractor is assumed, as well as the same project manager, the same client and the same objections of residents. Therefore the eventual work execution level is also assumed the same.

As all strategies will be constructed on the same location the outdoor environment (E) will be equal. Assuming the same user and the same owner means assuming the same in-use conditions (F) and maintenance levels (G). For related components (R) an equal factor can also be assumed for all strategies, as this factor is influence by the owner and facility manager, which are also assumed the same. In the framework of this research the decision was made to replace the design (B) with ambition levels. This will therefore not be included in the assessment of ESL factors. This means that the factors B, C, E, F, G & R will all be assumed equal. As described in the framework of this research they will also be assumed equal to the reference building. Effectively this means that all these factors will be 1 in the equation and will therefore not influence the ESL. The factors that will influence the ESL are A, D & T.

Leaving out factors

By leaving out factors from the ESL formula there is one disadvantage. Consolidation, the strategy in which the current situation is not adapted, will not be determined correctly. This is the only strategy in which these factors will differ, as no intervention is made. However, this only concerns the in-use conditions (as there is no user in a vacant building) and the maintenance levels, as no intervention means that only the absolutely necessary maintenance will be done. The consolidation strategy is meant to serve as a comparison and will probably result in a low ESL since the building is vacant. The decision has been made to simplify the model to this extent, even though the estimation for consolidation will be off. Simplification of the model will make it easier to use for all stakeholders and will also reduce the error range of the model.

12.3 Weighing the factors

In order to weight the factors properly a mathematical trick is required. This is necessary because simply multiplying all factors as represented in the formula above does not work. This is because multiplying factors is independent of this factors place in the equation. For example:

$$2 * 5 * 10 = 10 * 2 * 5 = 100$$

In order to avoid this, the following formula is used by Van Nunen:

$$ESL = RSL * A_w * B_w * C_w * D_w * E_w * F_w * G_w * T_w * R_w$$

With:

$$A_w = \left(\left((1 - A) * a\right) + 1\right)$$

A = factor a = Weight

This formula has the following effect:

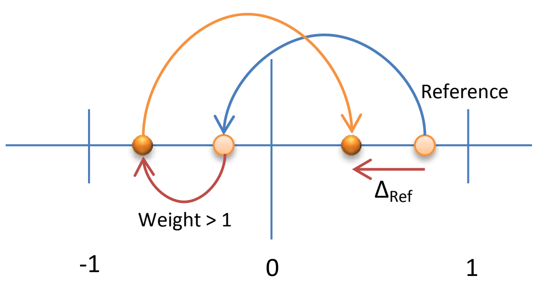


Figure 12.1: Extra distance created when a factor is lower than 1 e.g. Worse than the reference building

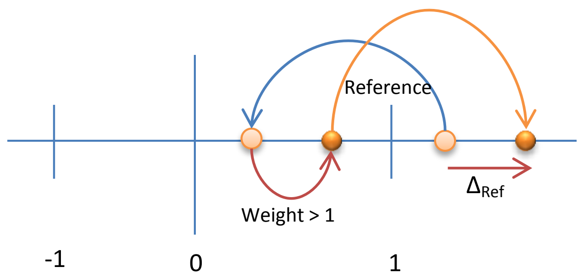


Figure 12.2: Extra distance created when a factor is higher than 1 e.g. Better than the reference building

As can be seen in the figures above the formula causes the factors to enlarge their distance from the reference, since the weighing factor is larger than 1. If the weighing factor is 1, nothing happens as

$$5 * 1 = 5 \quad Or \quad 25 * 1 = 25$$

If the weighing factor is smaller than 1, this will cause the distance to the reference to become smaller, e.g. the factor has a lesser influence on the differentiation of the ESL from the RSL.

12.4 Negative values?

Unfortunately the method described above can also generate negative values.

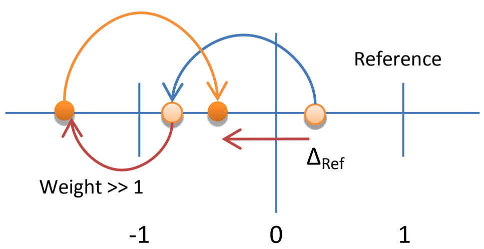


Figure 12.3: Negative values caused by a low score and high weighing

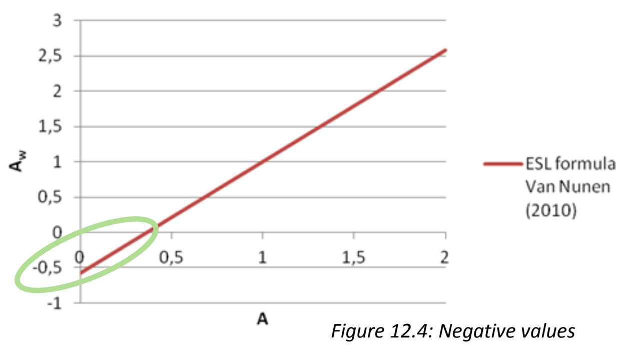


Figure 12.4: Negative values

One option to solve this problem is to transform the weighing factors never to be higher than 1. In that case the multiplication with the weighing factor can never result in a score lower than -1. A weighted score below -1 will remain negative since the used formula uses a -1 and +1 system.

$$0.4 - 1 = -0.6 \;\; THEN \; -0.6 * 1.89 = -1.134 \; AND - 1.134 + 1 = -0.134$$

$$\mathrm{ESL} = 50 * -0.134 \; = \; -6.7$$

Theoretically the ESL of an existing building can never be lower than 0, since that is the moment at which an intervention has to be made in order to prolong the buildings lifetime.

By rescaling the weighing factors to be lower than 1 it is no longer possible to end up with a negative ESL. If the ratio between the weighing factors remains the same, the weighing stays intact.

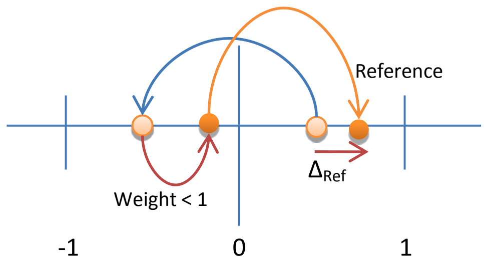


Figure 12.5: With a weight lower than 1 a negative value is no longer possible

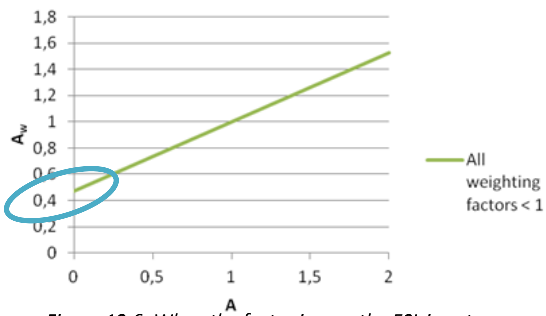


Figure 12.6: When the factor is zero the ESL is not zero

However, if we simulate this effect in a graph another problem becomes clear. If the factor is 0 (on the x-axis), the weighted factor (on the y-axis) is not 0. In fact, it will never be lower than 0.47.

Another problem is that the ESL also flattens out; all ESL's will be closer to the reference service life compared to the original weighing factors, even if they are better than the reference. This is shown in figure 12.7.

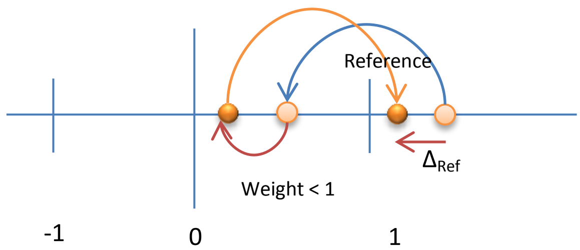


Figure 12.7: When the weight is always lower than one, everything will move closer to the reference

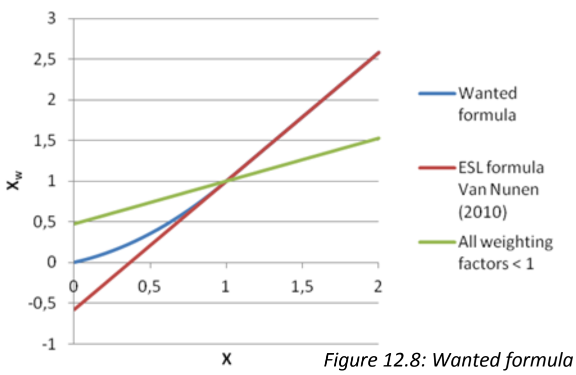


Figure 12.8: Wanted formula

A minimum weighted factor of 0.47 is not correct, as the perfect formula would go through [0, 0], if the factor is 0 the weighted factor should be 0. To find a formula that describes this without influencing the values above 1 is very difficult and therefore a piecewise formula will be used. This formula will consider the formula given by Van Nunen for values above 1 and consider a new formula for values below 1. This formula has been documented by Olthof & Jansz (2012) as an adaption to the improved factor method of Van Nunen. The derivation of this formula can be found in the appendix.

New formula (Olthof & Jansz, 2012): (See appendix)

$$ESL = RSL * A_w * B_w * C_w * D_w * E_w * F_w * G_w * T_w * R_w$$

With:

$$A_w = \left\{ \begin{matrix} 1 + (A - 1)a_0 & for\ A > 1 \\ a_1 A^2 + a_2 A & for\ A \in [0..1] \end{matrix} \right\}$$

Where $a_1 = a_0 - 1$
$a_2 = 2 - a_0$

and similar for B, C etc.

Van Nunen:

$$A' = \left(\left((1 - A) * a \right) + 1 \right)$$

Can also be described as:

$$A' = 1 + (A - 1)a_0$$

It is shown by Olthof & Jansz (2012) that for $a_0 \in [0 \ldots 2]$ no values exist for A which give a negative value for A_w. Since all of the weighing factors given by Van Nunen lie in this domain, this function can be used without further warning for negative estimated service life.

The resulting relationship between A and A_w as well as the relationship between D and D_w is shown below.

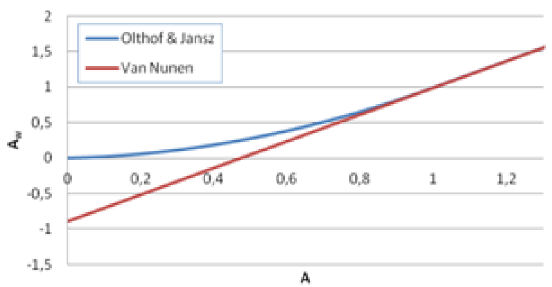


Figure 12.9: Comparison IESL methods weight = 1.89 (Olthof & Jansz. 2012)

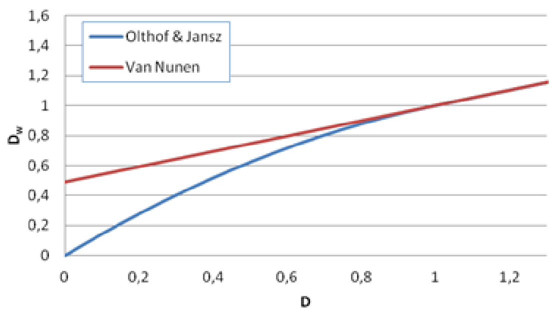


Figure 12.10: Comparison IESL weight = 0.51 (Olthof & Jansz, 2012)

The final formula used in this report is then:

$$ESL = A_w D_w T_w$$

With:

$$A_w = \left\{ \begin{matrix} 1 + (A - 1)a_0 & for\ A > 1 \\ a_1 A^2 + a_2 A & for\ A \in [0..1] \end{matrix} \right\}$$

where $a_1 = a_0 - 1$
$a_2 = 2 - a_0$

and similar for D_w & T_w

Changing the weights

When weighing the factors it is important to know the effect of these weights on the actual results. Therefore a small sensitivity analysis will be performed on the weighing factors.

The table shows a fictive case in which the used weighing factors were interchanged. When the factors are small the difference seems little, from 0.4 to 2 years. However this is 5 times as much.

Name	Weight	Factor	ESL
A	1,89	0,8	
T	1,19	0,5	2
D	0,53	0,1	
A	0,53	0,8	
T	1,19	0,5	0,4
D	1,89	0,1	

Table 12.2: Changing weights, low factors

Name	Weight	Factor	ESL
A	0,53	1,1	
T	1,19	0,8	16
D	1,89	0,6	
A	1,89	1,1	
T	1,19	0,8	33
D	0,53	0,6	

Table 12.3: Changing weights, medium factors

If one of the factors is higher than 1 the effect of the weighing becomes clearer. When changing the highest and lowest weight the ESL rises from 16 to 33 years, twice as much.

As soon as the factors are all higher than 1, then absolute values change even more. When a higher factor has a higher weight the ESL increases. When a lower factor has a higher weight the ESL decreases.

Name	Weight	Factor	ESL
A	1,89	1,1	
T	1,19	1	75
D	0,53	1,5	
A	0,53	1,1	
T	1,89	1	84
D	1,19	1,5	
A	1,19	1,1	
T	0,53	1	109
D	1,89	1,5	

Table 12.3: Changing weights, high factors

Because the factor 'quality of components' has a much higher weight than the other two factors it would not be surprising to see that this factor has a decisive role in the determination of the ESL. Whether or not this is the case is described in chapter 15. This means that the weighing of the factors is very important for the final results in the model, as the ESL is used to write off the environmental load. It has a direct effect on the sustainability of a strategy.

The weighting used in this research has been defined by Van Nunen (2010) through an expert enquiry and an expert panel. Therefore this is a representation of the general opinion in the building industry, but no research has been done yet on the effects these weights or how precise these represent reality. However, since the quality of components, and especially the quality of the structure of a building, is decisive in the decision to reuse a building or not, the weighting factors have been adopted from the research done by Van Nunen.

12.5 Determination of ESL factors

In order to be able to assign a value to an ESL factor the range and reference must be defined.

The reference that will be used is an existing office building which has been recently build. This has been done in a traditional way, complying with the building decree, but with no special regard to sustainability.

Impression:

Figure 12.11: Impression reference building

In order to compare the assessed building to the reference building, the building decree will be used as a benchmark. This is because the building decree represents the minimal demands a building must comply with. The reference building is a recently build office, complying with the building decree. As the building decree is in constant movement, being updated with stricter requirements approximately every 10 years, there may be differences between the reference building and existing buildings. Existing buildings may comply with the building decree in the year they were build, but not to the stricter demands of the current degree. Next to that, there may also be buildings that perform better than required by the building decree, for example high quality sustainable buildings.

To be able to assess all buildings equally, even though there may be large differences, a scale from 1 – 10 will be used. On this scale the reference building is placed at a score 6, since the building decree represents the minimum demands of a building. For a highly sustainable building a score of 7 or 8 may be assigned, if it performs significantly better than the reference building. A score 9 can only be assigned if there are distinguishing features, for example when the building is a monument, that assure a longer lifespan. A score 10 can only be assigned in retrospect since it is not possible to predict what the quality of a building needs to be to outperform the reference building to this extent.

12.6 Score tables

To ensure that all buildings are assessed in the same way the following score tables will be used. These tables indicate the requirements for the building in order to make a certain score and are represented per ESL factor.

12.6.1 Quality of components

The first factor concerns the quality of components. In this research only the structure and the facade will be assessed, as these are the two main elements that will be reused in the strategies. Both are tested to the building decree of their own year and the current building decree. This can be done through a quick scan and an accurate method.

The quick scan can be applied by using checklists such as provided by BRIS (BRIS, 2011). These checklists test the building to all building decree specifications by using existing data. In the accurate method new data has to be acquired in order to make sure that the used information is not outdated.

Assessment method	Description
Quick scan	Assessment though checklist for buildings in use; for example: BRIS Toezicht. Assessment based on drawings and site visit by project manager. (BRIS, 2011)
Accurate	Site examination including measurements and performance test for foundation, structure and facade such as determination of Rc-values. Assessment made with specialist equipment.

Table 12.4: Assessment methods quality of components

After the assessment the conclusion has to be made if the building does or does not comply with the current building decree (2012) or the building decree of its own building year. If the building does comply on most points but not on others an assessment needs to be made whether or not these flaws can be (easily) adjusted. The final score of the building is represented in the table below.

Component	*Up-to-date with:*	0	1 - 2	3	4 -5	6: Reference building	7 - 8	9	10
Structure (Incl. foundation)	*Current building decree*	No	No	No	Adaptable	Yes	Significantly better	There are distinguishing features (e.g. listed as a monument) that assure a longer lifetime	This score can only be assigned in retrospect
	Building decree of the building year	No	Adaptable	Yes	Yes	Yes	Yes		
Facade	*Current building decree*	No	No	No	Adaptable	Yes	Significantly better	There are distinguishing features (e.g. listed as a monument) that assure a longer lifetime	This score can only be assigned in retrospect
	Building decree of the building year	No	Adaptable	Yes	Yes	Yes	Yes		

Table 12.5: Score table quality of components

In this table the scores 1 – 2, 4 – 5 and 7 – 8 have not been defined in detail to allow some flexibility to the user. For example: if the building's structure is lacking in order to comply with the current building decree it falls between the specified 4 – 5. The user may then assign a 4 if a lot needs to be done, but a 5 if the adaptations are less radical.

12.6.2 Trends

In order to assess the current market a different benchmark has to be used. This is more difficult as there is no clear definition of a "Normal" market, such as the building decree for physical specifications. Therefore the building will be compared to the other buildings in the market. This can be done in two ways, through a quick scan and an accurate method.

Assessment method	Description
Accurate	Thorough scan of the building based on extensive market research, preferably by an experienced broker. Comparison on a national and regional level, income, costs, perception, municipal issues, etc.
Quick scan	Market research through scanning available supply of offices on basic qualities such as location, rent level, energy label, etc. Vacancy rate can be found in quarterly publications from large real estate brokers.

Table 12.6: Assessment methods trends

Both these methods are based on a comparison with the current or "normal" market and are therefore based on knowledge of these markets. This means that a real estate broker (or advisor) will be the most reliable source. The current vacancy rate is administrated by large real estate brokers and updated approximately every 3 months.

The translation of the market analyses to the actual score is shown in the table below.

<table>
<tr><th>Trends</th><th>0</th><th>2</th><th>4</th><th>6: Reference to 'normal' market</th><th>8</th><th>9</th><th>10</th></tr>
<tr><td>Vacancy percentage</td><td>20% or higher</td><td>20 – 15 %</td><td>15 – 11 %</td><td>8 -5 %</td><td>5% or lower</td><td rowspan="2">There are distinguishing features that assure a continuous unchallenged position in the office market with a very low vacancy percentage</td><td rowspan="2">This score can only be assigned in retrospect</td></tr>
<tr><td>Market position</td><td>95% of offices is better</td><td>70% of offices is better</td><td>45% of offices is better</td><td>20% of offices is better</td><td>10% of offices is better</td></tr>
</table>

Table 12.7: Score table trends

12.6.3 Indoor quality

The last factor is the current indoor quality of the building, which can be assessed by comparison with the building decree. This can be done by measuring the actual performance of the building's installations but this does not show the complete picture.

A building complying to the building decree should satisfy 80 – 90% of its users through regulations on indoor temperature, humidity and ventilation rate (Van Agtmaal, 2012). However, current research shows that only in 11% of the researched cases this score of 80% satisfaction was reached. This considered an enquiry with 34,000 respondents from 215 buildings (complying to the building decree) in the US, Canada and Finland (Huizenga, 2006).

In order to also measure this component a post-occupancy evaluation should be done. However, as this research considers vacant buildings this may prove difficult. Therefore the quick scan relies on information provided by the previous user. If a post occupancy measurement has been done these results can be used to assess the building.

Assessment method	Description
Accurate	If possible: conduct a Post-occupancy evaluation (building is still in use). If the building is vacant, perform extensive measurements whit al installations up and running. Use the same score for enquiry as for measurements if no enquiry can be done.
Quick scan	Ask the previous owner or building manager for results of an earlier enquiry. If these are not present ask for an overview of received complaints. Include the state and age of the used installations. Use the same score for measurements as for enquiry if no measurement is done.

Table 12.8: Assessment methods indoor climate

To make this more accurate a combination needs to be made with actual measurements. If either one of these methods cannot be performed, for example because there is no information from the old user or the installations in the building have been switched off, the score that was achieved through the other assessment method has to be used.

Indoor quality	*Up-to-date with:*	0	1 - 2	3	4 -5	6: Reference building	7 - 8	9	10
Enquiry (old) user	*% of users that complain about indoor quality*	90%	73%	55%	37%	20%	10% or less	There are distinguishing features (e.g. use of energy producing installations) that assure a longer lifetime	This score can only be assigned in retrospect
Measurements	*Current building decree*	No	No	No	Adaptable	Yes	Significantly better		
	Building decree of the building year	No	Adaptable	Yes	Yes	Yes	Yes		

Table 12.9: Score table indoor climate

In the score tables each factor is constructed out of two sub-factors. For example, trends combines market position and the current vacancy rate. To calculate the total factor for tends the model averages the sub-factors.

$$T = Market\ position * 0.5 + Vacancy\ rate * 0.5$$

$$D = Enquiry * 0.5 + Measurements * 0.5$$

In quality of components the structure has a bigger influence on the combined factor, because this is the main component of a building and it cannot be replaced. The facade therefore has a lesser influence as replacement is possible. If a building has a load baring facade, the facade is part of the structure and has to be assessed in the sub-factor structure. After consulting with the expert panel a ratio of 65% for structure and 35% for facade is assumed (Jansz, 2012).

$$A = Structure * 0.65 + Facade * 0.35$$

Assessment methods

The actual energy use of the building is not used as an assessment method, because this is dependent on more factors then just building or indoor quality. The user can have a great influence on the energy use, especially if many electronic devices are needed. Therefore only the specifications of the installations and the energetic quality of the facade, like the RC-value, are used. Another note is that the local market may be very different from the national market. In this case the user of the model can fill in the model twice, once with national values and once with regional values in order to compare the results.

12.7 ESL factors of the strategies

Inside the model the ESL factors of the strategies are pre-set. In the table below only the adaptations to the scores of the existing building are shown.

Possible strategies			A		T		D	
			Structure	Facade	Market position	Vacancy rate	Enquiry	Measurements
Consolidation		*Office*						
Renovation		*Office*			+1		St	St
Extensive renovation		*Office*		St	+2		St	St
Transformation	Traditional	*Residential*		St	St	x	St	St
Transformation	Sustainable	*Residential*		G	G	x	G	G
Demolition & new-build	Traditional	*Office*	St	St	St		St	St
Demolition & new-build	Traditional	*Residential*	St	St	St	x	St	St
Demolition & new-build	Sustainable	*Office*	G	G	G		G	G
Demolition & new-build	Sustainable	*Residential*	G	G	G	x	G	G

Table 12.10: ESL factors of the strategies

In the renovation scenario the installations will be replaced, improving the buildings market position by 1 point and raising the indoor climate to the standard score 6 (=equal to the reference building). In the extensive renovation strategy the facade is also replaced, causing the facade quality to reach a standard score and improving the buildings market position even more.

In the transformation strategies the facade is also replaced. In the traditional strategy it is replaced with a facade complying with the building decree. In the sustainable strategy it is replaced with a sustainable facade that performs better for the indoor climate and has a better quality of components. In all residential strategies the vacancy rate for the office market is no longer included in the ESL, as this has no effect on the residential market. The market position is still included as this is also important in the residential market, and is set at the standard score 6 for traditional strategies and a ‘Good’ score 8 for sustainable strategies.

12.8 From score to factor

In order to use the ESL formula the scores assigned in the previous paragraph are translated to factors. This is done automatically in the model. A factor can be between 0 and 2, in which 1 means that the factor is equal to the reference.

The reference building is a new-build building complying to the building decree, for which the reference lifespan is 50 years. A factor lower than 1 therefore results in a lower estimated service life and a factor higher than 1 results in a longer estimated service life.

The translation from score (1 – 10) to factor (0 – 2) is done on a linear scale. As can be seen in the figure a factor higher than 1.67 (corresponding with a 10) is not possible. This is because it is hard to make a building that is so much better than the current building decree that it will last that much longer. Also, this would result in a very long ESL which would be to insecure.

ESL, score --> factor	
10	1,67
9	1,50
8	1,33
7	1,17
6	1,00
5	0,83
4	0,67
3	0,50
2	0,33
1	0,17
0	0,00

Table 12.11: From score to factor

Impression from score to factor

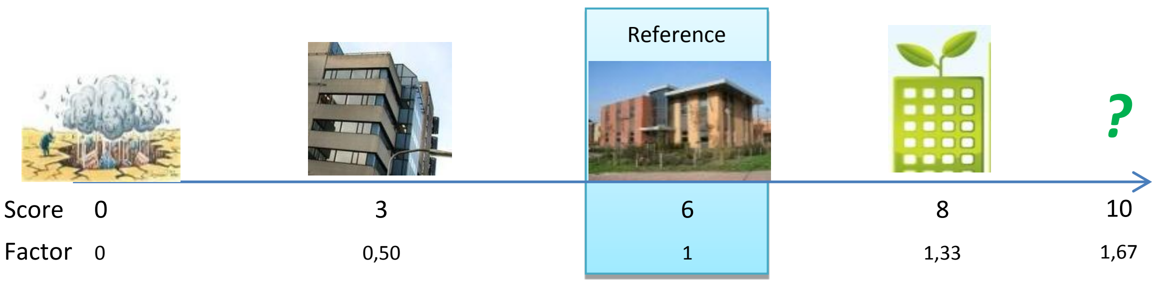


Figure 12.12: Impression from score to factor

12.9 Expert panel

To test and validate the choices in the model, an expert panel was held on the 7th of May 2012 in Rotterdam. Here the deduction methods, ESL determination and inner working of the model were explained in order to receive comments on the used method. The main questions during this meeting were:

- What deduction method should be used (linear, positive annuity or negative annuity)
- Is the translation from building specifications to ESL factors, through the use of score tables, correct?

It is important to note that some aspects of this research were changed due to the comments made in the expert meeting. To see the progress of the research at the time of the Expert meeting the documents provided to the experts can be viewed. These are represented in the appendix.

12.9.1 The experts:

The panel consists of experts from different specialisations in the real estate industry. By combining these specialisations in the panel it can look at the research from many different perspectives and give a sound input to the research.

Name	Company	Specialisation
Hilde Remøy	TU Delft	Vacancy and transformation
Bert Sandberg	CBRE	Sustainability in the built environment
Hans Korbee	AgentschapNL	Sustainability and vacancy strategies
Edwin van Eeckhoven	C2N	BREEAM in the built environment
Dong Cao	DGBC	Sustainability and the built environment
Joost van Linder	Rijksgebouwendienst	Vacancy and the built environment

Table 12.12: Members of the expert panel

12.9.2 Documents at the meeting

Two documents were provided: the agenda and a small introduction to the research. During the meeting a PowerPoint presentation was given. Since the expert meeting was meant to give input in the process of developing and improving the model, the input of the experts has been processed in the research after the expert meeting. To get an impression of the progress in the research at the time of the meeting the documents provided to the experts are presented in the appendix.

12.9.3 Summary of the meeting

During the meeting the developed model was explained by giving a fast overview of the research methods used (described in part 1, the literature study) and the calculation rules used by the model (described in part 3, the model). The goal of the meeting was to check the assumptions of the model and see if any changes needed to be made to the used calculation rules.

Deduction method

At the time of the expert meting no decision had yet been made on which deduction method to use. The options were:

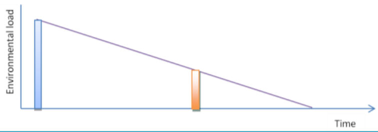
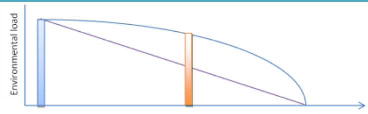
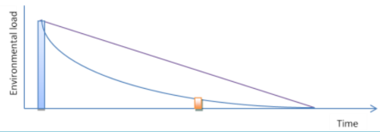
Deduction method	Description	Figure
Linear deduction	This is the standard assumption in current ESL research	
Positive annuity	This assumes that the environmental load reduces very slowly at first, the biggest part of the load is paid back at the end of the ESL	
Negative annuity	This assumes that the environmental load reduces very fast in the beginning, but is paid off very slowly at the end of the ESL	

Table 12.13: Deduction methods; the orange bar shows the remain environmental load at t=x

Question:

What is the best deduction method for an environmental load, as opposed to a financial load? Should this be linear as has been assumed in literature so far, or should a comparison with an annuity model, like in financial mortgages, be used?

Conclusion of the expert panel:

In order to find the best deduction method for the remaining environmental load, this load should be divided among the separate components of the building (like: structure, facade, installations, etc.) These components should all be deducted according to the method most fit for that component.

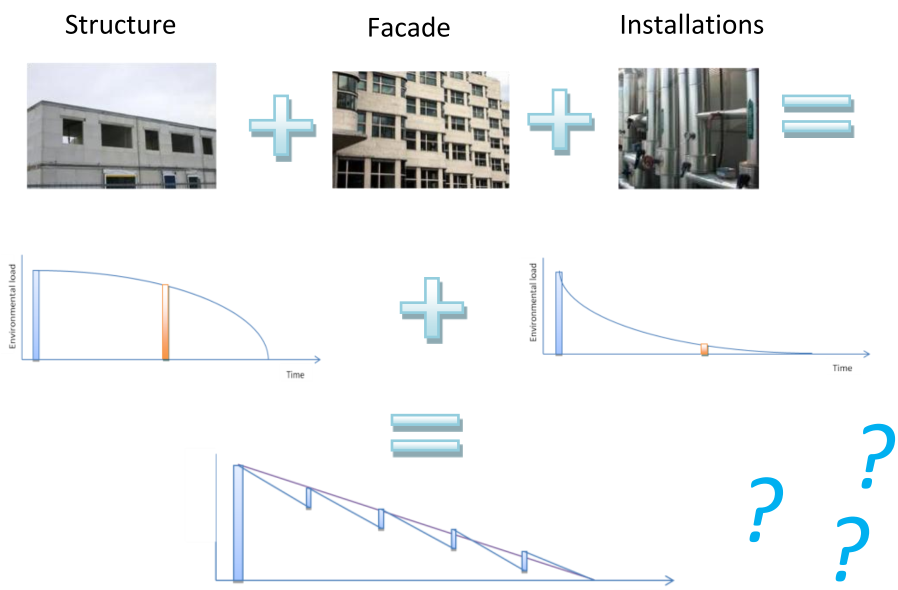


Figure 12.13: Approaching a wave like pattern

For the structure of a building this would probably approach a positive annuity, the structure can be re-used for a long time until a certain point is reached, after which the decline goes fast. The installations need to be preplaced approximately every 15 years and the facade will need a lot of maintenance to keep it in good condition. When all these loads and deduction methods are added up, the expectation is that this will create a wave-like motion which approaches a linear decline for the complete building. To be sure of this effect a research should be done following the described method, but that would be to extensive for the research conducted now. Since Greencalc^{+} includes the extra loads caused by maintenance and replacements this is already included in the total load on a global level and therefore a linear deduction may be assumed (Jansz, 2012).

Incorporation in the research:

Based on the conclusion of the expert panel a linear deduction has been assumed, though more research needs to be done on this topic. To give an overview of the effects of choosing another deduction method both a positive and a negative deduction method have been incorporated in the model.

ESL factors

The next topic of discussion was the use of score tables to define the ESL factors of existing buildings. Because there is no research on how to assess an existing building in order to determine the ESL, a method had to be developed. Initially the score tables had assumed the reference building at a score 8 in the score tables. A score 10 was assigned to new-build sustainable buildings.

Question:

Is the use of score tables to assess existing buildings and the chosen reference building correct and sufficient to determine the ESL of an existing building?

Conclusion of the expert panel:

The use of score tables to determine the ESL results in a clear overview of what score should be awarded. The use of the building decree is a good and objective standard, but may be too technical. The building decree does not consider user potential, aesthetics, location or flexibility although these are important to determine the estimated service life of a building.

However, the choice to place the reference building at score 8 may give the wrong impression. Strictly following the building decree requires only the minimal demands for a building, which may therefore be interpreted as a 6. If only the technical quality of a building is assessed the reference may refer to an 8, since the building decree is very up-to-date on technical requirements.

The score tables could be improved by adding other assessment factors, like location, flexibility and user potential, to balance out the emphasis on technical factors. A further improvement would be to investigate the different demands for offices and dwellings, and their effect on the ESL. If these additions fit in the scope of this research remains to be seen.

Finally it is correct to assume that the structure has a bigger influence on the factor ‘quality of components’ than the facade, because if the structure is not in a good condition re-using the building is not a good option. The division of 65% for structure and 35% for facade is correct, although maybe even a 70 or 75% for structure cloud be assumed.

Incorporation in the research:

Based on the conclusions of the expert panel the score for the reference building has been changed from a score 8 to a score 6. This has been done because a score 8 may give the impression that the building is above standard, as a scale from 0 -10 is used. A score 6 is therefore a better representation of the achievements of the building, since the building decree only represents the minimal demands of a building.

To prevent a very large gap between the score 6 assigned to the reference building and the score that should be assigned to a sustainable building, the score for a sustainable building has been changed to a score 8. A score 9 can only be assigned if there is sufficient evidence that a building has a very high chance of a long service life, for example when it is listed as a monument. A score 10 can only be rewarded in retrospect since this leads to such a high ESL that the insecurity of the estimation would be too high. A reference for a score 10 could be the canal houses in Amsterdam. This is also explained in chapter 12.6.

12.10 Conclusions

Because the assumptions in the strategies are as equal as possible, same contractor, same location, same owner, a number of factors can be left out of the equation. To prevent negative ESL values the following piecewise formula will be used.

$$ESL = A_w D_w T_w$$

With:

$$A_w = \begin{cases} 1 + (A - 1)a_0 & for\ A > 1 \\ a_1 A^2 + a_2 A & for\ A \in [0..1] \end{cases}$$

Where $a_1 = a_0 - 1$, $a_2 = 2 - a_0$

and similar for D_w & T_w

The used weights have a great influence on the results and additional research on whether or not these weights represent reality is needed. Because such research is not available now the weights by Van Nunen (2010) have been used.

How the ESL factors should be determined is also not clearly described in literature and therefore the building decree 2012 will be used as a benchmark. Score tables on how to assess the building are provided in this chapter, which are translated into an ESL factor inside the model.

Part 3: The model

13 Introduction to the model

In this part of the report the development of the model will be discussed with special attention to the framework used to develop the model. This framework has its limitations and it is therefore important the results are interpreted as comparison material, not as real figures and predictions.

As mentioned before the goal of this research is to develop a model that can compare the sustainability of possible strategies when dealing with a vacant office building:

1. Consolidation
2. Renovation
3. Transformation
4. Demolition & new-build

All these strategies may be executed in two ways:

1. Traditionally, complying with the rules and regulations in the building decree.
2. Sustainable, incorporating all possible state-of-the-art technology to create a building with an A++ label or BREEAM excellent certificate.

13.1 Framework of the model

The framework of the model, as explained before, is based the following limitations:

- Excluding ***all other real-life factors*** but sustainability of materials, energy and water.
- Excluding the design
- Including the ESL

This means that the model shows a simplification of reality and all results given by the model should only be used to compare the different strategies.

13.1.1 Excluding all other real-life factor but sustainability of materials, energy and water

This research has been conducted as a simplification of a real life situation. In real-life, the financial considerations would always be taken into account, as would the social values like the acceptance and appreciation of the existing building. This is also shown in figure 7.2. To be able to conduct the research in the given timeframe the decision has been made to leave out all of these factors. The results of the model should therefore always be placed in the bigger picture of the building.

13.1.2 Excluding the design

To prevent a bias in the results the (architectural) design will not be included. It is unrealistic to expect a design or floor plan of the new-build scenario in the initiative phase (Metz, 2011). As this is the phase in which the model will be used the design cannot be required as input. To ensure an equal comparison the design or floor plan of all other strategies is therefore also excluded.

Instead the model uses *ambition levels* to define the essential difference between the strategies that affect their sustainability. (See chapter 4.2.)

For example: Is it the ambition to create a state of the art sustainable building (A^{++}) or a traditional new-build office that complies with the NEN regulations?

By including the ambition level the influence of the design is acknowledged, but does not create a bias in the input or results.

13.1.3 Including the ESL

One of the conclusions of Van Den Dobbelsteen was that the estimated service life of a transformation or new-build strategy is often not included, creating an advantage for new-build strategies. By including this in the model it can be completed and give a better representation (Van Den Dobbelsteen, 2004).

13.2 How the model works

In the figure below the concept of the model is displayed, showing what input is needed and what output is generated.

13.2.1 Input

The input required from the user are the building statistics, general information and an assessment of the ESL factors according to the specifications described in chapter 11.9. These may all be found in the EPA-U, the report made when the energy label of a building is determined, which is obligatory when a building is sold. This information is entered into Greencalc+ and used to fill in the checklist based vacancy risk and transformation potential meter (Geraerds & Van Der Voordt, 2007a, Geraerds & Van Der Voordt, 2007b). Next, the defined strategies are entered into Greencalc+ as ambition levels. These are defined in chapter 9.7

This output is then used as input for the excel model.

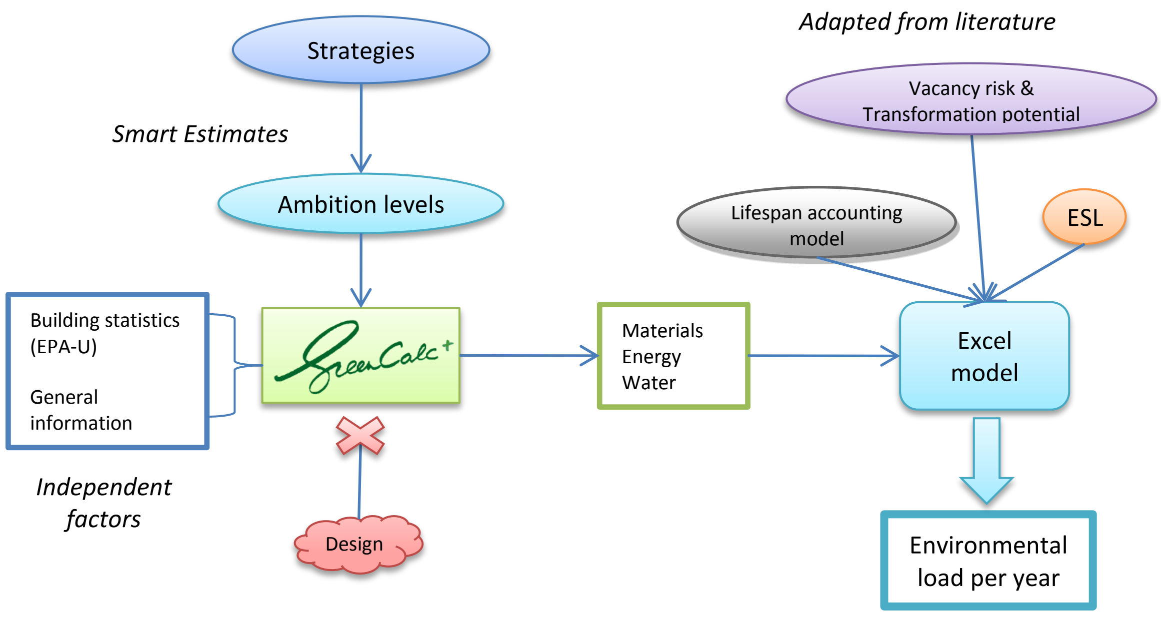


Figure 13.1: How the model works

13.2.2 Inside the excel model

Inside the excel model there are two pre-set factors: the lifespan accounting model and the ESL formula.

The results from the Greencalc^{+} analysis of the existing building are used in the model to calculate the remaining environmental load. Next the ESL factors are used to determine the service life that may be expected.

Because Greencalc gives an environmental load per year based on the fixed reference service life of 50 years, an extra calculation step is required for the once off load caused by materials.

$$Total\ once\ off\ load = Env.L.Materials * RSL\ Greencalc = Env.L.Materials * 50$$

The environmental loads per year for energy and water can be used directly, as these are truly annual loads and not once-off loads. The formula describing the model is:

$$Env.L.{}^{p}/_{y}\ strategy\ x = \frac{Remaining\ Env.L. + Total\ once\ off\ load\ + Env.L.Energy\,{}^{p}/_{y} * ESL + Env.L.Water\,{}^{p}/_{y} * ESL}{ESL}$$

This can be simplified to:

$$Env.L.{}^{p}/_{y}\ strategy\ x = \frac{Remaining\ Env.L. + Total\ once\ off\ load}{ESL} + Env.L.Energy\,{}^{p}/_{y} + Env.L.Water\,{}^{p}/_{y}$$

13.2.3 Output

The final output given by the model is the environmental load per year, based on the estimated service life for a specific strategy. In this load per year the ESL, the remaining load and the load caused by construction and use of the buildings are all included. The strategy with the lowest environmental load per year is the most sustainable strategy for the assessed case.

14 The steps of the model

This chapter will explain the different steps that are integrated in the model. It also considers the effects of the methods used on the results given by the model. In this chapter the main case will be used to explain the several steps.

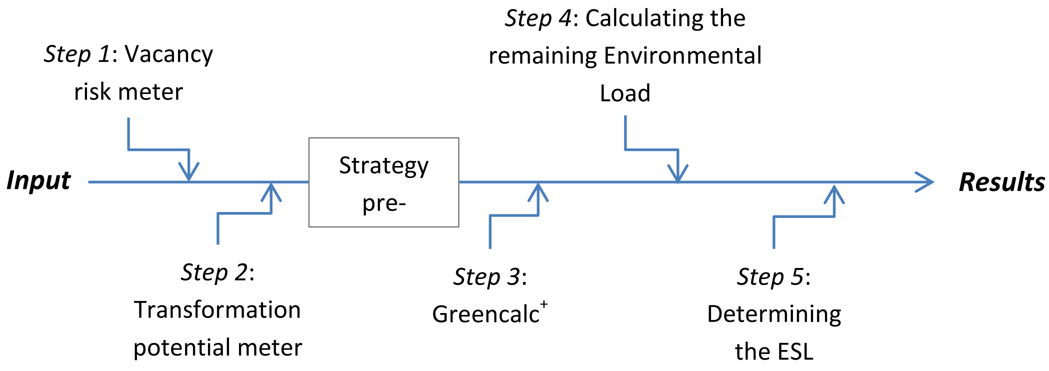


Figure 13.2: Steps in the model

14.1 Step 1: Vacancy risk

The first step is meant to analyse whether or not the building is at risk of remaining or becoming a (structurally) vacant office building, the target group for this model. The definition of a structurally vacant office building is a building that has been vacant for 3 consequent years or longer. (Muller, 2009)

To measure the vacancy risk a meter was developed by Geraerds & van der Voordt (2007a) which exists of three steps: veto criteria, gradual criteria and determining the vacancy risk. The vacancy risk meter is explained in chapter 9.5 and results in a vacancy risk class. This can be between 1 and 5, with class 1 representing a very low risk of vacancy as an office building and class 5 represents a very high risk.

14.2 Step 2: Transformation potential

The next step is to assess the transformation potential of the building; would it even be possible to transform the office to a residential function? To measure this the transformation potential meter is applied (Geraerds & Van Der Voordt, 2007b). The build-up is the same as the vacancy risk meter, there are veto criteria and gradual criteria that are combined into a transformation potential score. This is also explained in chapter 9.6.

These scores are translated into a transformation class from 1 – 5. Class 1 means that the building is very suitable for transformation to a residential function, class 5 means that the building is not at all suitable.

14.3 Strategy pre-selection

After the vacancy risk and transformation potential have been assessed a pre-selection can be made on which strategies can be applied. For example: if the vacancy risk proves high, renovation or new-build of an office is not very interesting. Also if the transformation potential is very low, this can be excluded from the model. To get a complete picture of the situation it is recommended to apply all strategies to the model, as has been done in this research. The pre-selection of strategies saves time because fewer strategies have to be entered in Greencalc$^+$. However, when the user is experienced with the program not much extra time is required to fill in all strategies.

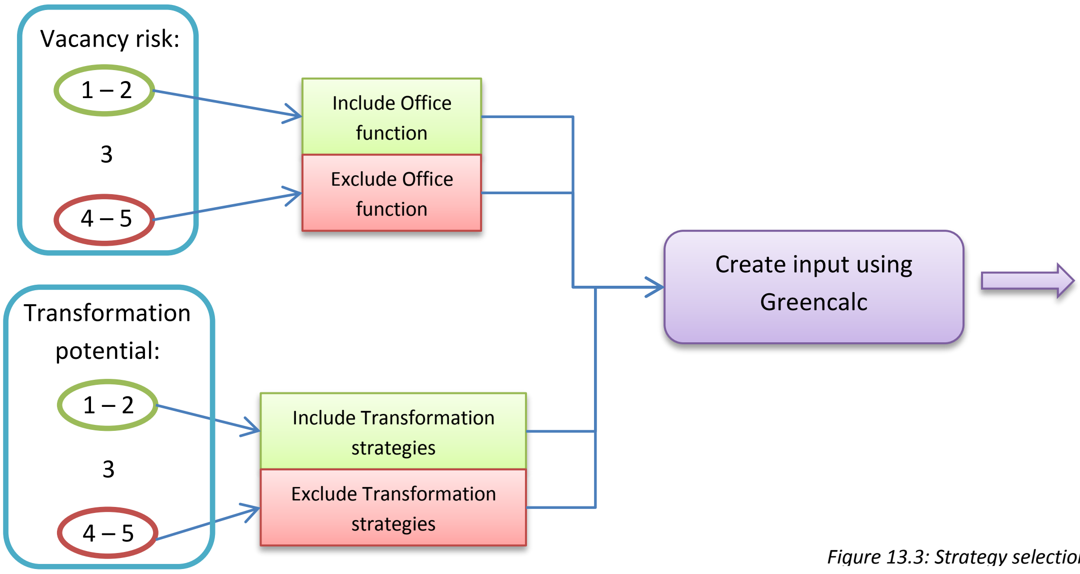


Figure 13.3: Strategy selection

As can be seen in the figure a vacancy risk class or transofrmation potential calss 3 is a case of doubt. Here the user of the model can choose wether or no to incorporate the strategy into the model.

14.4 Step 3: Creating input through Greencalc+

To be able to calculate the difference in sustainability between the strategies the model will need a building specific input. This input should consider the materials used in the building during construction and the energy use during the user phase of the building.

In the chapter 10 the available sustainability models have been discussed and assessed on their suitability to serve as basis for the S^3 model. Only Greencalc$^+$ was found to be suitable as it generates a monetized output. This monetized output can be used as input in the excel model and can be used to calculate the remaining environmental load through the lifespan accounting model of Van Den Dobbelsteen (2004).

In Greencalc$^+$ two detail levels are available in the materials input. The global level is based on a reference material index indicating the ambition level of the building. There are four indexes available that correspond to the following ambition levels: (Bijleveld, 2012)

- 120-135 For older existing buildings
- 130 – 150 For existing buildings optimized on sustainable material use
- 145 – 170 For state of the art A++ sustainable buildings to be designed

The other option is to select all the genuinely used materials form the database by hand, a very time consuming process. This can be done by using the contract documents of the building. As this is to detailed and time consuming for the initiative phase, this will not be required to use the model.

The extra material needed to implement or construct a strategy is also calculated by using Greencalc$^+$. This can be done by only inserting the extra materials needed for the strategy and the new installations. For example:

For the strategy of renovation only the interior and installations of the building are updated. This concerns the divisional walls (of separate offices) but not the actual structure of the building. Therefore only the interior materials have to be entered in Greencalc$^+$. The easiest way to do this it by copying the original building and deleting all materials that will not be altered. (E.g. the roof and structure.) Then all the materials that will be replaced have to be changed into their new counterparts. If all partition walls will be replaced from drywall to wood, and be put in different positions, the material is changed to wood and the new M^2 total of inner walls is inserted (Bijleveld, 2012). This can be done for all strategies, showing the extra once-off load created by the adaptations made or the new construction.

Effect of deleting materials

By deleting the materials that are not necessary to realise a strategy the energy calculation made by Greencalc⁺ changes too. It is therefore important that two files are made, one with the complete buildings, including all present materials, to calculate the energy use. And one with only the added materials to calculate the extra load caused by the new materials.

14.5 Step 4: Calculating the remaining environmental load

As described in the literature review the environmental load of an existing building may be calculated by using the lifespan accounting model by Van Den Dobbelsteen. This has been explained in detail in chapter 11. The graph below shows the remaining environmental load over time, created by the once-off construction load.

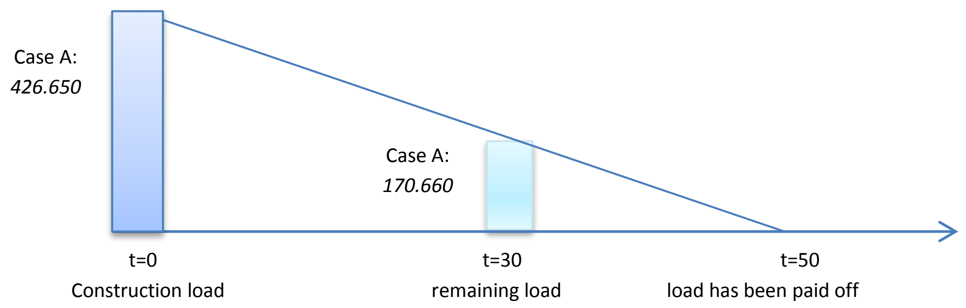


Figure 13.4: Lifespan accounting model

This graph makes visible that the environmental load reduces over time, at t=30 less than half of the load is left. A disadvantage of this graph is however that it does not directly show the repayment per year. This repayment defines the gradient of the graph.

Surface below the graph

The surface below the graph has no further value and the graph does not show the repayment per year. The total once-off load is already given at t=0; the graph can only be used to find the remaining load at a certain point of time.

The repayment per year can be calculated by dividing the once-off load with the reference lifespan. The remaining load of the original building is calculated by using the reference lifespan as assumed on the moment of construction (the building year). As the discussion about service life and the effect of service life has only recently been addressed this is usually fixed on 50 years for offices and 75 years for dwellings (Sureac, 2010, WE adviseurs, 2012).

Figure 13.5: Once off load to annual load

To calculate the total load caused by the building the environmental load caused by the energy and water use needs to be included. In this way the once off load can be added up with the energy load and the best case scenario can be selected in the basis of lowest pay-off per year.

$$Env.L.^{p}/_{y}\ strategy\ x =$$
$$\frac{Remaining\ Env.L. + Total\ once\ off\ load}{ESL} + Env.L.Energy^{p}/_{y} + Env.L.Water^{p}/_{y}$$

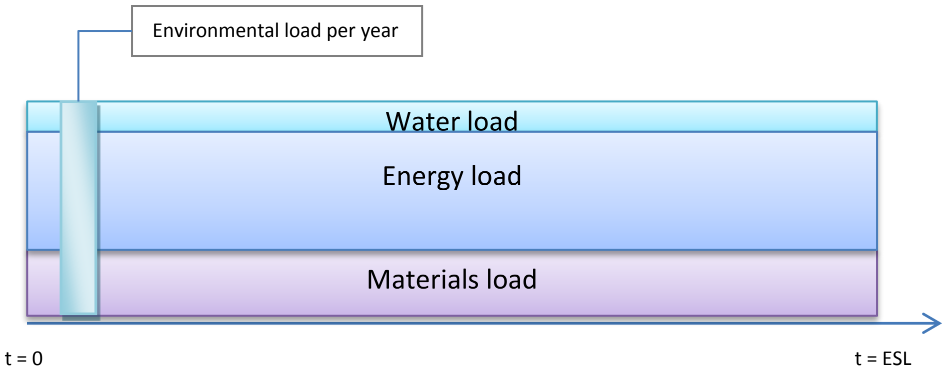


Figure 13.6: Total annual load

14.6 Determining the ESL

The next step of the model is to make an estimation for the service life of the building as has been discussed in chapter 12. In order to do this the ESL scores which are part of the input of the model are used. The assessment of these scores is done by the user according to the specifications in chapter 12.

The used formula is:

$$ESL = A_w D_w T_w$$

With:

$$A_w = \begin{cases} 1 + (A-1)a_0 & for\ A > 1 \\ a_1 A^2 + a_2 A & for\ A \in [0..1] \end{cases}$$

Where $a_1 = a_0 - 1$, $a_2 = 2 - a_0$

and similar for D_w & T_w

Example fictive case

- *Good structure and facade that can be adapted to fit the building decree 2012 (score: 5)*
- *In a lower segment of a market with a 14% vacancy rate (score: 4)*
- *Indoor climate does not fit the building decree of its building year but can be adapted (score: 2)*

Possible strategies			ESL	RSL
Consolidation		*Office*	10	*50*
Renovation		*Office*	26	*50*
Extensive renovation		*Office*	35	*50*
Transformation	Traditional	*Residential*	60	*75*
Transformation	Sustainable	*Residential*	125	*75*
Demolition & new-build	Traditional	*Office*	40	*50*
Demolition & new-build	Traditional	*Residential*	75	*75*
Demolition & new-build	Sustainable	*Office*	96	*50*
Demolition & new-build	Sustainable	*Residential*	201	*75*

Table 14.1: ESL versus RSL

These values for the ESL are not real numbers as they are based on many assumptions as discussed in chapter 11. They are therefore only to be used as comparison material for the different strategies. It is however interesting to note that the current market situation has a profound effect on the ESL of a traditional new-build office building; the ESL is only 40 whereas the RSL is 50. Because all factors but trend are assumed equal to the reference scores is the only factor causing this difference.

Part 4: The case

15 Case study

<u>In order to test the model three cases have been assessed and calculated through in Greencalc+. Due to confidentiality these cases will not be disclosed, but the average score of these cases will be presented as Case A. Case A will be treated as is it were a real-life building in condition comparable to those of the three real cases.</u>

In this chapter the main case used to develop the model will be discussed, as well as the results generated by the model for this case and the three individual cases. The following steps were taking to perform the case study

1. Case description
2. Score with an existing model
3. Test with the S^3 model
4. Theory check
5. Explain the differences
6. Adapt the S^3 model

15.1 Case description

The first step of the planning is to gather the information necessary to assess the case. The information that is needed will concern: (DGBC, 2012b)

- Building statistics
- Energy label and Energy index
- Used materials
  (percentage of glass in the facade, U-value glazing, RC-value, etc.)
- Information building management
  (environmental policy, maintenance planning etc.)
- Information installations
  (Ventilation, Heating, Lighting etc.)
- Energy use
  (Gas, Electricity, oil etc.)
- Location
  (Public transport, commuter traffic, parking spaces etc.)
- Water usage
  (toilettes, Showers, use of rainwater, etc.)
- Waste processing
- "EPA maatwerkadvies"

Case A is an office building close to a secondary train station of one of the 4 largest cities in the Netherlands (Amsterdam, Rotterdam, Den Haag, and Utrecht). It has a concrete structure, masonry facade & a flat roof. It was built in 1982 and has now been vacant for 1 year. It has a low energy label, label F, but after a renovation this could be improved to label D.

Specifications	
Building year	1982
GFA	5960 M^2
Energy label	F
Used materials	Concrete structure, masonry facade

Table 15.1: Specifications case A

15.2 Score with an existing model

To assess the sustainability of the building as it is now it will be assessed with Greencalc+, without applying it to the S^3 model.

15.2.1 Greencalc+

As explained before the program Greencalc+ uses building specifications such as the used materials and installations to calculate the environmental load that is generated by the building. This load is expressed in environmental costs, so that all separate loads calculated can be added up to a total score. (NIBE, 2002)

In order to calculate the Greencalc+ score of case A all three original cases have been entered in Greencalc+ and their score has been averaged.

	Materials	Energy	Water	Total per year	MIG
Case A	8.533	30.883	684	40.100	156

Table 15.2: Greencalc+ case A

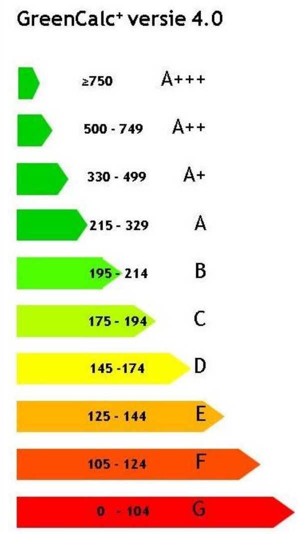


Figure 15.1: MIG label index (Sureac, 2010)

Greencalc+ uses a reference lifespan of 50 years, which makes the total environmental load per year 40.100. This includes materials, energy and water. In Greencalc+ the MIG is also calculated, this can be compared with the MIG of other buildings, regardless of the dimensions of the building. As can be seen in figure 15.1 the building current has a Greencalc+ D label.

15.3 Test with the S³ model

How the model works has been explained in chapter 13 and these steps will now be applied to case A. First the vacancy risk and transformation potential will be assessed, and the strategies will be selected. After generating the input with Greencalc+ and entering the results into the S^3 model the remaining environmental load is calculated inside the S^3 model. In the background of the model the ESL values for the different strategies are determined and finally the model gives the results.

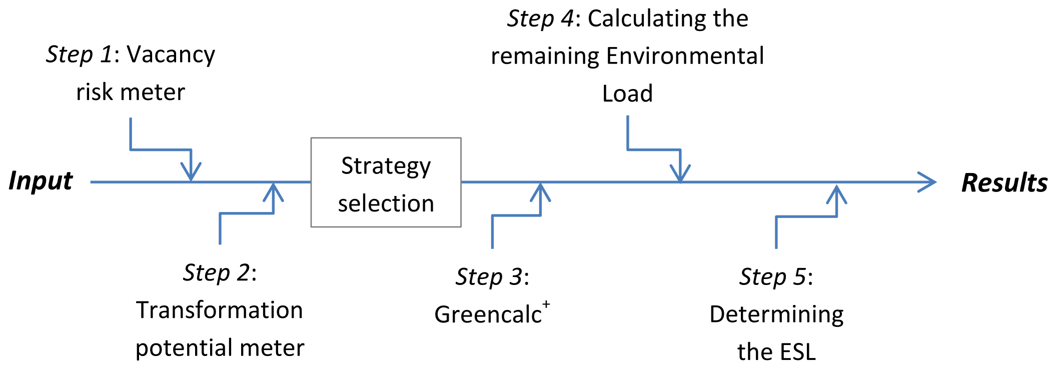


Figure 15.2: Steps in the model

15.3.1 Step 1: Vacancy risk meter

The veto criteria of the vacancy risk meter were:

Location

- Is the building in a municipal priority zone for dwellings?
- Is the capacity of parking space ≤ 1 parking space / 200 M^2 GFA?

Building

- Is there a concentration of buildings with a low rent level (≤ 90, - €/m^2 GFA) in the neighbourhood?

Case A does not lie in a municipality priority zone for dwellings, but in an area in which both a residential and office function are possible. The capacity of parking space is sufficient and there is no concentration of low rent levels. Therefore case A passes all veto criteria.

The gradual criteria are displayed in the appendix and resulted in a score of 292 points. The vacancy risk class of case A is therefore class 3. This means that there is a clear risk for the building to remain vacant.

15.3.2 Step 2: Transformation potential

The veto criteria of the transformation potential meter were:

Market

- Is there a demand for dwellings by local target groups?

Location

- The land-use plan does not allow a function change to dwellings
- Health or nuisance risks

Building

- Floor to ceiling height ≤ 2.60 m.

Organisation

- Absence of an enthusiastic initiator
- Internal criteria initiator on accessibility
- Internal criteria initiator exterior of the building
- No willingness to sell from the building owner

In case A there is a local demand for dwellings and the land-use plan does allow this function change. There are no health or nuisance risks and the floor to ceiling height is sufficient. The only veto criterion that is not met is the initiator. For case A no initiator has been found yet, but the assessment of the transformation potential can be used to find an initiator.

The gradual criteria are displayed in the appendix and resulted in a score of 33 points. The transformation class of the building is therefore class 1. This means that the building has a lot of potential to be transformed to an apartment building.

15.3.3 Step 3: strategy pre-selection

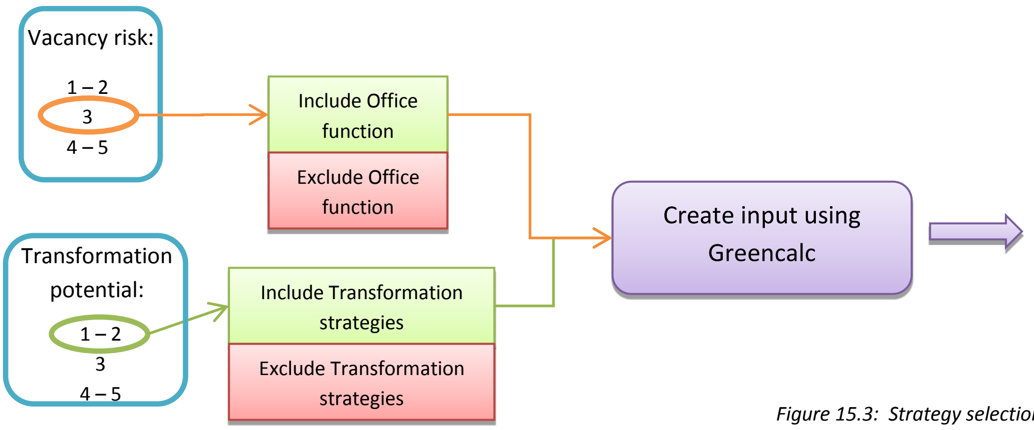


Figure 15.3: Strategy selection

Because the vacancy risk is class 3, there is a clear risk for the building to remain vacant. In a normal market this would be a case of doubt but especially in the current office market this means that the office strategies should be excluded. However, in order to give the complete picture the office strategies will be included in the calculations. When comparing the results only the strategies below will be considered.

Selected strategies	Description
Consolidation	Do nothing
Traditional transformation	Stripping down to the structure and redesigning as apartment building
Sustainable transformation	Stripping down to the structure and redesigning as apartment building with the ambition to get an A^{++} energy label or BREEAM Excellent certification
Traditional demolition & new-build residential	Demolishment and new-build of an apartment building that complies to all specifications in the building decree
Sustainable demolition & new-build residential	Demolishment and new-build of an apartment building with the ambition to get an A^{++} energy label or BREEAM Excellent certification

Table 15.1: Pre- selected strategies

15.3.4 Step 3: Greencalc^{+}

To create the necessary input for the model, all strategies have to be entered in Greencalc^{+} as described in chapter 14.4.

Strategy			Materials	Energy	Water	Total	MIG
Original building		Office	8.533	30.883	683	40.100	156
Renovation		Office	1.477	27.700	683	29.860	169
Extensive renovation		Office	5.333	23.100	580	29.013	191
Transformation	Traditional	Residential	4.733	19.833	3.800	28.367	122
Transformation	Sustainable	Residential	4.567	19.500	2.160	***26.227***	133
Demolition & New-build	Traditional	Office	8.167	24.100	630	32.897	186
Demolition & New-build	Sustainable	Residential	5.567	19.833	4.000	29.400	108
Demolition & New-build	Traditional	Office	6.633	21.767	***460***	28.860	***214***
Demolition & New-build	Sustainable	Residential	4.900	***19.300***	2.087	26.287	135

Table 15.2: Greencalc^{+} results case A

Transformation to sustainable dwellings has the lowest 'environmental load per year' with the standard reference lifetime used by Greencalc^{+}. However, the difference with demolition & new-build of sustainable dwellings is very small. The renovation strategy has the lowest materials load because this strategy has the lowest intervention level. There are only a few new materials added to the buildings in this strategy (only new installations and a new interior). New-build sustainable dwellings have the lowest energy use and new-build sustainable offices the lowest water use. When comparing the energy and water use of the strategies it must be taken into account that an office building generally uses more energy, whereas a residential building uses more water.

The MIG rises as a building is more sustainable, but there is a scale difference between office functions and residential functions. Office strategies score higher on the MIG than residential strategies. The MIG has not been used in this research and will not be further discussed.

15.3.5 Step 4: Calculating the remaining environmental load

The remaining environmental load of the original building is calculated, but is not directly shown to the user of the model. To illustrate the difference between the different ways of repaying the once-off environmental load of the original building all three methods are represented here, as discussed in chapter 11.

Total load materials	Building age	Remaining environmental load		
		Linear	*Positive annuity*	*Negative annuity*
426.650	30	170.660	342.414	28.818

Table 15.3: Remaining environmental load case A

In chapter 11 the choice was made to use a linear decrease of the remaining environmental load. The table above shows that this choice may influence the outcome of the model, as the differences between the three deduction methods are large. Therefore all three methods will be shown in the results of the model, though the linear deduction method will be used in the conclusions.

15.3.6 Step 5: Determining the ESL

In order to determine the ESL the ESL scores have to be entered into the model based on the score-tables presented in chapter 12. Case A has a structure that is up-to-date with the building decree of its own buildings year as it has been reasonably well maintained. It is not up-to-date with the current building decree but this can be adapted. Results in a score 5 for structural quality. The facade can unfortunately not be adapted to comply with the current building decree and therefore scores a 3.

The market position of case A is not very good, 70% of the offices in the area are better. It therefore scores a 2. The vacancy rate is currently 14% (CBRE, 2012) which scores a 4. The indoor climate in the building is hard to assess as it is already vacant. Because of the used installations in the building and information given by the building manager a score 2 is assumed here for the enquiry and a score 3 for measurement. This results in the following ESL:

Possible strategies			ESL	RSL
Consolidation		*Office*	5	*50*
Renovation		*Office*	14	*50*
Extensive renovation		*Office*	25	*50*
Transformation	Traditional	*Residential*	60	*75*
Transformation	Sustainable	*Residential*	125	*75*
Demolition & new-build	Traditional	*Office*	40	*50*
Demolition & new-build	Traditional	*Residential*	75	*75*
Demolition & new-build	Sustainable	*Office*	96	*50*
Demolition & new-build	Sustainable	*Residential*	201	*75*

Table 15.4: ESL case A

Very high ESL for sustainable new-build dwellings

Figure 15.4: Canal houses (Gemeente Amsterdam, 2002)

The ESL for new-build sustainable dwellings appears to be very high, 201 years. This is however based on the ambition level that it will be a building that incorporates all the latest techniques and is ahead of its time. Great examples of buildings that seem to never reach the end of their lifespan are the canal houses in Amsterdam. They have been used as houses, office storage space or many other functions and are still very popular. These also show that predicting this quality is very hard, at the time of construction there was no assurance that the building would last this long.

15.3.7 Results

The results show something remarkable: instead of transformation which was the most sustainable strategy according to the Greencalc+ calculation, demolition & new-build of sustainable dwellings is the most sustainable solution. The difference between the two is still small, but larger than expected when looking at the Greencalc results. (See table 15.2)

There is a difference between a linear deduction and the use of an annuity, but they do not result in a different strategy. In this case the used deduction method therefore does not influence the end result.

Results	Linear	Positive annuity	Negative annuity
Case A	Demolition & new-build of sustainable dwellings		

Table 15.5: No difference between the deduction methods

The results are displayed in the table below and show that, though the differences are small, demolition and new-build of sustainable dwellings is more sustainable than transformation to sustainable dwellings.

However, if a sustainable ambition level is too high (it may be too expensive) transformation to traditional dwellings is the most sustainable option. This means that establishing the ambition level in the initiative phase of the project is essential to be able to compare the sustainability of transformation as opposed to demolition and new-build.

Results					
		Do nothing			
	Linear		**62.944**		**per year**
	Positive annuity		94.524		***per year***
	Negative annuity		36.865		***per year***
Renovation			***Demolition & new build traditional Office***		
Linear	**46.222**	**per year**	**Linear**	**39.081**	**per year**
Positive annuity	58.753	*per year*	*Positive annuity*	43.338	*per year*
Negative annuity	35.874	*per year*	*Negative annuity*	35.565	*per year*
Extensive renovation			***Demolition & new build traditional dwellings***		
Linear	**41.064**	**per year**	**Linear**	**32.741**	**per year**
Positive annuity	47.892	*per year*	*Positive annuity*	35.032	*per year*
Negative annuity	35.426	*per year*	*Negative annuity*	30.850	*per year*
Transformation TR dwellings			***Demolition & new build sustainable office***		
Linear	**32.332**	**per year**	**Linear**	**26.909**	**per year**
Positive annuity	35.174	*per year*	Positive annuity	28.700	per year
Negative annuity	29.984	*per year*	Negative annuity	25.430	per year
Transformation SUS dwellings			***Demolition & new build sustainable dwellings***		
Linear	**24.521**	**per year**	**Linear**	**24.066**	**per year**
Positive annuity	25.893	*per year*	Positive annuity	24.921	per year
Negative annuity	23.388	*per year*	Negative annuity	23.360	per year

Table 15.6: Results case A

What if?

Because the vacancy risk class of the case was a class3 the strategy pre-selection excluded office functions. As the transformation potential was a class 1, transformation strategies could be included. Because demolition & new-build was one of the pre-selected strategies it is not only the most sustainable strategy but also a realistic strategy, based on the sustainability analysis. Because the framework of the research does not included any financial or social considerations these would have to be assessed before the strategy is implemented.

The model has been developed according to the framework described in chapter 7. This means that the results are only valid under these assumptions.

A comment that can be made is that investments made in the past, such as the remaining environmental load, cannot be changed and should therefore not be a part of considerations for the future. The chosen deduction method is debatable as there is not enough research done on this subject to draw a conclusion. The effect of these assumptions in described in chapter 15.7.

15.4 Explanation of differences

To be able to explain the difference between sustainable transformation having the lowest Greencalc⁺ scores and demolition & new-build having the lowest environmental loads in the S^3 model, a closer look on the model is needed.

$$Env.L.^{p}/_{y}\ strategy\ x = \frac{Remaining\ Env.L. + Total\ once\ off\ load}{ESL} + Env.L.Energy^{p}/_{y} + Env.L.Water^{p}/_{y}$$

Above the formula used in the model is shown, as explained in paragraph 13.2. In this formula the energy and water use per year are directly given by Greencalc⁺, but this is not the case for the environmental load caused by the materials. Because Greencalc⁺ uses a fixed 50 year reference lifespan for offices, it shows the load per year over a period of 50 years. As this is not a predetermined factor in the S^3 model, but dependent on the ESL, the Greencalc⁺ output has to be recalculated to show the total once off load.

$$Total\ once\ off\ load = Env.L.Materials\ ^{p}/_{y} * RSL\ Greencalc = Env.L.Materials\ ^{p}/_{y} * 50$$

The formula shows that the ESL has a direct effect on the remaining environmental load and the total once-off load needed to realize a strategy. The Greencalc⁺ score for energy and water use is not affected by the ESL and can be used directly to calculate the environmental load per year of the new strategy.

When comparing the different strategies the remaining environmental load will be the same, as this is only dependent on the deduction method (linear or annuity). The Greencalc⁺ scores alone (see table 15.2) resulted in transformation being more sustainable than demolition & new-build, so the only factor could have tipped the scale is the ESL.

Possible strategies			ESL	RSL
Transformation	Sustainable	*Residential*	125	*75*
Demolition & new-build	Sustainable	*Residential*	201	*75*

Table 15.7: ESL transformation and demolition & new-build of sustainable dwellings

The ESL of the strategies differed a lot, transformation had an ESL of 125 years, Demolition & new-build had an ESL of 201 years. This means that the environmental load caused by materials can be deducted over a much longer time period and therefore the environmental load per year will be much lower.

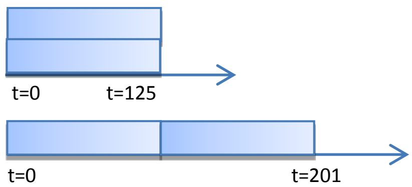


Figure 15.5: Effect of a longer ESL

The bigger the difference between the estimated service lives of de different strategies, the bigger this advantage for strategies with a longer ESL will be. This also explains why the office strategies have a much higher environmental load per year; their reference service life is 50 years, whereas the reference service life for dwellings is 75 years.

15.5 Theory check

Earlier in this report several researches have been discussed that compared different strategies for vacant office buildings. The two main researches were the one by DHV (2011) and by Van Den Dobbelsteen (2004).

The conclusions of the DHV research was that demolition & new-build would be more sustainable than transformation, because of the lower energy use (DHV, 2011a). The research done by Van Den Dobbelsteen (2004) expected that the inclusion of the ESL would be an advantage for re-use strategies, as was in the case of the Road & Water Engineering (RWE) Department in Delft.

15.5.1 DHV

The result that demolition & new-build is the most sustainable solution in the assessed case seems to match with the results in the DHV research. However, the used calculation method is very different. The DHV research is more comparable to the stand alone Greencalc$^+$ results of this research. DHV also used Greencalc$^+$ to calculate the effect of the strategies but did not include the ESL.

When looking at the Greencalc$^+$ results in paragraph 15.3.4, transformation to sustainable dwellings has the lowest environmental load. This is due to the fact that it has a lower intervention level than demolition & new-build. Fewer materials are needed to implement this strategy and this compensates for the slightly higher energy and water use. When comparing on this scale level the researches are therefore contradictory.

Both researches have adapted the basic Greencalc$^+$ scores; DHV by dividing it over the number of usable square meters living space, this research by including the ESL. These both resulted in demolition & new-build as most sustainable solution but for different reasons.

15.5.2 Van Den Dobbelsteen

The expectation that transformation strategies would profit from the inclusion of the ESL seems to be rejected by this research as the inclusion of the ESL actually tipped the balance the other way. When comparing the environmental load excluding the ESL, transformation had the lowest environmental load per year, but after inclusion of the ESL demolition & new-build performed better.

This may be caused by the method used to determine the ESL factors and therefore the ESL value of each strategy. As the assessment of the building and the translation to ESL factors is not described by Van Den Dobbelsteen, these methods cannot be compared. Another reason that can explain these differences is that the case of Van Den Dobbelsteen was more fit to be transformed because it used fewer materials or had a lower energy use per year. These ratios will be different for each building that is assessed. Unfortunately the Greencalc$^+$ scores of the RWE building are not described and cannot be compared.

15.6 The three separate cases

As mentioned before the three separate cases will not be named, due to confidential building information. The results of the three cases will be discussed here.

15.6.1 Input

The Greencalc+ scores of the three cases can be found in the appendix. In the table below the ESL scores of the cases are given.

Case	Structure	Facade	Market position	Vacancy rate	Enquiry	Measurements
1	5	4	3	4	3	4
2	4	2	3	4	2	3
3	8	7	4	4	2	3

Table 15.8: ESL scores other cases

The results of the three cases are:

Case	Most sustainable strategy
1	Demolition & new-build sustainable dwellings
2	Demolition & new-build sustainable dwellings
3	Sustainable transformation

Table 15.9: Results of the three cases

To see if the ESL determination was of any influence on this score all cases have also been tested with all ESL scores of the original building 10 or all scores 0. This represents the situation that the building is in either a very good or very bad condition and has a long or short ESL. This influenced the results in all three cases. For example in case 1, the tipping point was between 9 and 10 for structural quality; if the structural quality was 9 or lower, demolition & new-build of sustainable dwellings proved best. If the structural quality was higher than 9, transformation to sustainable dwellings was most sustainable.

Since a score 10 can only be assigned in retrospect this does not affect the possibilities for this building. No matter how good the structure is, it will be more sustainable to demolish the building and build sustainable dwellings instead. This is defined by the Greencalc+ scores of the strategies.

When a different deduction method is assumed the tipping point changes. For a positive annuity the tipping point lies between 8 and 9. For a negative annuity the tipping point remains between 9 and 10.

Case		Deduction method: Positive annuity	Linear	Negative annuity
1	Normal	D&N SUS DW	D&N SUS DW	D&N SUS DW
	Tipping point ESL	Str. 8/9	Str. 9/10	Str. 9/10
2	Normal	D&N SUS DW	D&N SUS DW	D&N SUS DW
	Tipping point ESL	Str. 8/9	Str. 8/9	Str. 8/9
3	Normal	TR SUS DW	TR SUS DW	TR SUS DW
	Tipping point ESL	Str. 7/8	Str. 7/8	Str. 6/7
A	Normal	D&N SUS DW	D&N SUS DW	D&N SUS DW
	Tipping point ESL	Str. 6/7	Str. 5/6	Str. 5/6

Table 15.10: Result summary three cases

15.7 Effect of the remaining environmental load and deduction method

As stated before this research assumes a linear deduction but, to give a more complete overview, the other deduction methods have also been calculated through. The effect of the remaining environmental load, and what happens if you do not take this into account, is also discussed in this chapter.

15.7.1 Effect of the remaining environmental load.

As explained in paragraph 15.4 the ESL only has an effect on the materials components of a strategy, as the energy and water components are already an annual load.

$$Env.L.{}^{p}/_{y}\ strategy\ x =$$
$$\frac{Remaining\ Env.L. + Total\ once\ off\ load}{ESL} + Env.L.Energy\,{}^{p}/_{y} + Env.L.Water\,{}^{p}/_{y}$$

Formula as explained in paragraph 13.2

Because the ESL can differ a lot between the strategies this effect on the materials component can also strongly differ. In case A, transformation to sustainable dwellings has an ESL of 125 years, whereas demolition & new-build has an ESL of 201 years. This means that the environmental load caused by materials can be deducted over a much longer time period and therefore the environmental load per year will be much lower; The bigger the difference between the ESL's of de different strategies, the bigger this advantage for strategies with a longer ESL will be.

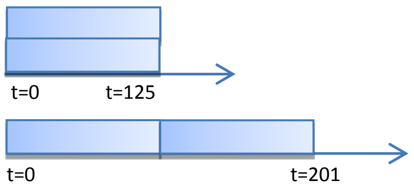


Figure 15.5: Effect of a longer ESL

This means that, the higher the materials load is, the more strategies with a longer estimated service life will be advantaged.

The argument that what happened in the past cannot be changed, and therefore should not be taken into account in the current decision making process, can be used as an argument to leave out the remaining environmental load. However, this principle cannot be applied to a financial mortgage. Even though this was accepted as a financial load in the past, it still influences the decisions of today, as the bank will not accept a cancelation of payments. Therefore the remaining environmental load has been taken into account in this research.

The effect of leaving out the remaining environmental load can be simulated in the model by assuming the load to be paid off. This can be done by assuming that the building has outlived its reference lifetime. For an office this means assuming that the building is older than 50 years, for dwellings older than 75 years. This has been simulated in the model by adjusting the building year to 1900. The building would then be 112 years old and the environmental load would be paid off.

For case A this did change the results of the model. Instead of demolition and new-build of sustainable dwellings, transformation to sustainable dwellings has the lowest environmental load.

Building year	Linear	Positive annuity	Negative annuity
1982	Demolition & new-build to sustainable dwellings		
1900	Transformation to sustainable dwellings		

Table 15.11: Changing the building year

This can be explained by the effect of the ESL. Because a higher ESL reduces the environmental load per year caused by materials more than strategies with a lower ESL, it also reduces the "penalty" caused by the remaining environmental load. Therefore the effect of the longer ESL on the demolition & new-build strategies as opposed to the transformation strategy is magnified when the remaining environmental load is included. In case A this effect is as follows:

Building age		Remaining load	ESL	Effect per year
1982	TR	170.660	125	1.365
	D&N	170.660	201	850
1900	TR	0	125	0
	D&N	0	201	0

Table 15.12: Effect per year of the remaining environmental load

Because it is the 'environmental load per year' that is compared in the model this has an effect on the end result. The load per year originally calculated, including the remaining environmental load, was 24.521 for transformation and 24.066 for demolition and new-build. Because these are quite close together the effect of the remaining environmental load is important

Strategy	Original env. load per year	Part caused by the remaining env. load	Env. load if the remaining env. load is not taken into account.
Transformation SUS DW	24.521*	1.365*	23.156*
Demolition & new-build SUS DW	24.066*	850*	23.216*

Table 15.13: Effect of the remaining environmental load

*These numbers have been rounded off, causing a slight difference with the numbers in the model.

The table above shows that the 'penalty' caused by including the remaining environmental load tipped the scale. If the remaining environmental load is not taken into account, transformation to sustainable dwellings is more sustainable than demolition & new-build to sustainable dwellings.

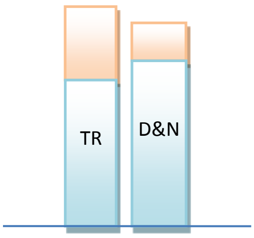


Figure 15.6: Effect of the remaining environmental load

This effect is caused by the large difference in the ESL for transformation as opposed to demolition & new-build although the Greencalc+ scores for the two strategies do not differ as much.

Effect of the building's conditions

The ESL is determined by the hand of score tables that judge the buildings condition. This is therefore also a factor of influence in the model. If the building's condition is very good, the transformation ESL will be much closer to the new-build ESL, in which everything is assumed up to standard. Therefore the assessment of the existing building and the assumptions on the quality of the new to be build building are very important. This needs more research to see if the use of the score tables as they are now is sufficient to determine the quality of an existing building. And more research on whether or not the assumptions made for a new building are actually achieved after construction.

15.7.2 Effect of the deduction method

In chapter 11 the three possible deduction methods were discussed:

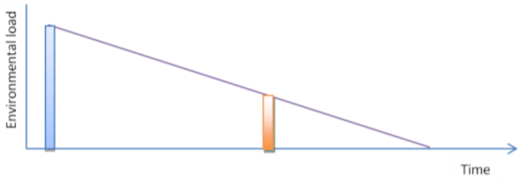
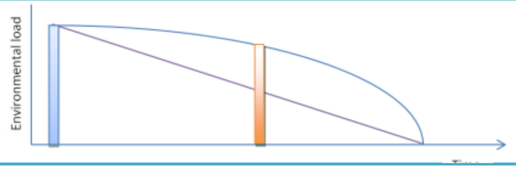
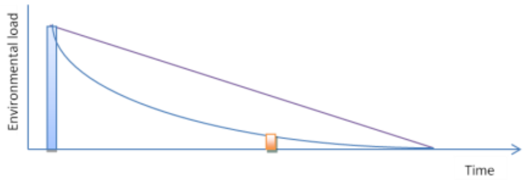
Deduction method	Description	Figure
Linear deduction	This is the standard assumption in current ESL research	
Positive annuity	This assumes that the environmental load reduces very slowly at first, the biggest part of the load is paid back at the end of the ESL	
Negative annuity	This assumes that the environmental load reduces very fast in the beginning, but is paid off very slowly at the end of the ESL	

Table 15.14: Three deduction methods

The choice for a deduction method directly influences the calculation of the remaining environmental load and therefore the effect of the ESL described in the last paragraph.

When choosing a positive annuity the remaining environmental load will be higher as opposed to a linear deduction. With a negative annuity the remaining environmental load will be lower. Therefore, the effect caused by the ESL will be greater in the case of a positive annuity and smaller in the case of a negative annuity.

Structural quality score: 5		Remaining load	ESL	Effect per year
Linear	TR	170.660	125	1.365
	D&N	170.660	201	850
Positive annuity	TR	342.414	125	2.739
	D&N	342.414	201	1.704
Negative annuity	TR	28.818	125	231
	D&N	28.818	201	143

Table 15.15: Effect of the remaining load, structural quality score: 5

These tables show the differences that occur if the quality of the building, in this case the structural quality of case A is assumed better. The table above shows the effect caused by the remaining environmental load in the different deduction methods. In the table below the changes that occur if the structure is assumed better are shown.

Structural quality score: 6		Remaining load	ESL	Effect per year
Linear	TR	170.660	150	1138
	D&N	170.660	201	850
Positive annuity	TR	342.414	150	2283
	D&N	342.414	201	1704
Negative annuity	TR	28.818	150	192
	D&N	28.818	201	143

Table 15.16: Effect of the remaining load, structural quality score: 6

The difference caused by the chosen deduction method is therefore:

Deduction method		Score: 5	Score: 6	Difference
Linear	TR	1.365	1.138	227
	D&N	850	850	0
Positive annuity	TR	2.739	2.283	456
	D&N	1.704	1.704	0
Negative annuity	TR	231	192	39
	D&N	143	143	0

Table 15.17: Effect of the remaining load, 'penalty' per strategy

In the figure below the consequences of changing the structural quality to a score 6 can be seen. When a linear or negative annuity is used, transformation to sustainable dwellings will be most sustainable. When a positive annuity is used demolition & new-build of sustainable dwellings will have the lowest environmental load per year.

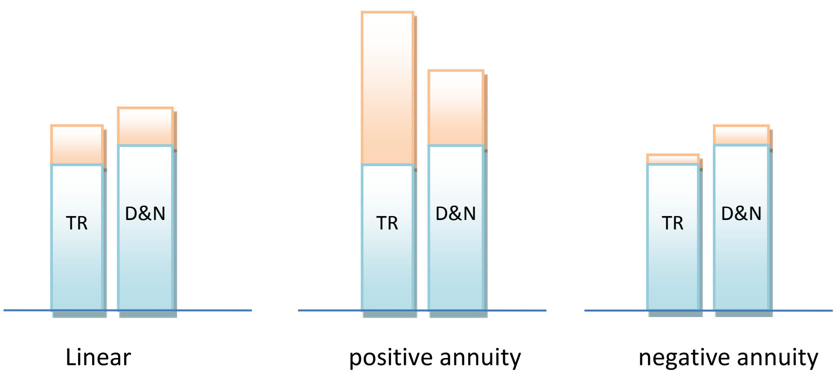


Figure 15.6: Effect of the deduction method, structural quality score: 6 .

Part 5: Conclusions & recommendations

16 Conclusions & recommendations

In this chapter the conclusions of the research are represented and recommendations for further research are given. The main research question is answered and a reflection on the hypothesis is given.

16.1 Main research question

Main research Question:

What effect does the Estimated Service Life (ESL) have on the measurement of the sustainability of possible real estate strategies for vacant office buildings?

In order to find the answer to the main research question the research has applied an averaged case and three real cases to the sustainability model Greencalc+ and a newly developed model. In the newly developed model the estimated service life (ESL) is taken into account, so that the effect caused by the ESL can be seen.

16.2 Greencalc+ results

In Greencalc+ a standard reference service life of 50 years is assumed for offices and 75 years for dwellings. This means that no ESL determination is made and this reference service life is equal for all strategies.

The results generated by Greencalc+ for the main case showed sustainable transformation as most sustainable strategy, even though demolition & new-build of sustainable dwelling had the lowest energy use. This was compensated by the lower materials use, but the difference was very small.

Strategy			Materials	Energy	Water	Total
Original building		Office	8.533	30.883	683	40.100
Renovation		Office	1.477	27.700	683	29.860
Extensive renovation		Office	5.333	23.100	580	29.013
Transformation	Traditional	Residential	4.733	19.833	3.800	28.367
Transformation	Sustainable	Residential	4.567	19.500	2.160	***26.227***
Demolition & New-build	Traditional	Office	8.167	24.100	630	32.897
Demolition & New-build	Sustainable	Residential	5.567	19.833	4.000	29.400
Demolition & New-build	Traditional	Office	6.633	21.767	***460***	28.860
Demolition & New-build	Sustainable	Residential	4.900	***19.300***	2.087	26.287

Table 16.1: Greencalc+ scores case A

16.3 Including the ESL

To see what happens if the reference service life is replaced with the estimated service life (ESL) a model has been developed. Contrary to the reference service life the ESL does take into account the differences between the strategies. The current state of the building is assessed and if it proves to be in a bad condition this has an effect on the estimated service life.

In order to include the ESL the following formula has been used.

$$Env.L.^{p}/_{y}\,strategy\ x = \frac{Remaining\ Env.L. + Total\ once\ off\ load}{ESL} + Env.L.Energy^{p}/_{y} + Env.L.Water^{p}/_{y}$$

Because the environmental load caused by the materials is a once-off load this has to spread out over the estimated service life of the building to find the annual load caused by materials. The annual load for energy and water use are given by Greencalc⁺.

16.4 Effect of the ESL

The formula shows that the ESL only has an effect on the annual load caused by the materials. This total materials load is consist of two components; the remaining environmental load and the total once-off load needed to implement the strategy. This total once-off load is automatically calculated in the model form the Greencalc⁺ results of materials.

If the ESL is higher, the materials load will be divided over a higher number. This means that the load per year will be smaller. If the ESL is lower, the materials load will be divided over a lower number and the load per year will be higher.

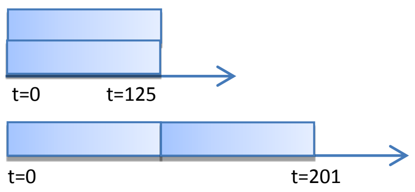


Figure 16.1: Effect of a longer ESL

In case A, transformation to sustainable dwellings has an ESL of 125 years, whereas demolition & new-build has an ESL of 201 years. This means that the environmental load caused by materials can be deducted over a much longer time period and therefore the environmental load per year will be much lower; The bigger the difference between the ESL's of de different strategies, the bigger this advantage for strategies with a longer ESL will be.

16.4.1 Effect of the remaining environmental load

The remaining environmental load is building specific and concerns the load that has not yet been paid off at the moment of intervention. This is calculated using the lifespan accounting model by Van Den Dobbelsteen (2004).

Including the remaining environmental load influences the results of the model because it amplifies the effect of the ESL. This create a "penalty" for all strategies. The total penalty for the complete ESL of the building is equal in all strategies but, due to the differences in the ESL, the penalty per year differs. If the Greencalc⁺ results of the strategies are in the same range, this penalty can influence the end result.

16.4.2 Effect of the deduction method

The lifespan accounting model by Van Den Dobbelsteen (2004) assumes a linear decrease of the remaining environmental load. However, this load can also be deducted as a positive or negative annuity.

This directly influences the remaining environmental load and therefore also influences the effect of the ESL. Since the remaining environmental load will be higher if a positive annuity is used, this will benefit strategies with a higher ESL. These strategies will be able to divide the extra penalty caused by the higher remaining load over a higher number of years. This means that the extra environmental load per year will be lower than in a strategy with a lower ESL.

Deduction method		Score: 5	Score: 6	Difference
Linear	TR	1.365	1.138	227
	D&N	850	850	0
Positive annuity	TR	2.739	2.283	456
	D&N	1.704	1.704	0
Negative annuity	TR	231	192	39
	D&N	143	143	0

Table 16.2: Effect of the remaining load, 'penalty' per strategy

A positive annuity will reverse this effect. The remaining environmental load will be lower, and therefore the difference in the annual penalty between the strategies will be smaller.

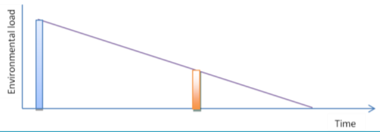
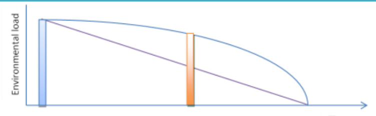
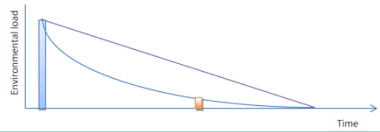
Deduction method	Description	Figure
Linear deduction	This is the standard assumption in current ESL research	
Positive annuity	This assumes that the environmental load reduces very slowly at first, the biggest part of the load is paid back at the end of the ESL	
Negative annuity	This assumes that the environmental load reduces very fast in the beginning, but is paid off very slowly at the end of the ESL	

Table 16.3: Deduction methods

16.5 Answer to the research question

Main research Question:

What effect does the Estimated Service Life (ESL) have on the measurement of the sustainability of possible real estate strategies for vacant office buildings?

The effect of the estimated service life on the measurement of sustainability is that is favours strategies with a longer service life. If a strategy has a longer service life the once-off load can be deducted over more years, decreasing the load per year. The energy and water use is an annual load and is therefore not influenced by the estimated service life.

After assessing the cases no general conclusion can be drawn on which strategy is most sustainable in general. This depends on many building specific factors and therefore has to be assessed per case. To do this the developed model can be used.

The inclusion of the remaining environmental load and the choice to use a linear deduction do influence the end results. Including the remaining environmental load increases the total once-off load caused by materials and therefore increases the effect of the ESL. This creates a heavier "penalty" for strategies with a shorter ESL then for strategies with a longer ESL. As the deduction method directly influences the remaining environmental load this also influences the effect of the

ESL. A positive annuity deduction results in a higher remaining environmental load and therefore in a higher "penalty" for shorter ESL strategies. A negative annuity will result in a lower remaining environmental load and will cause a smaller difference. The assumed linear deduction lies between these extremes.

16.6 Reflection on the hypothesis

A longer estimated service life has a positive effect on the sustainability of a strategy.

A longer estimated service life does have a positive effect on the sustainability of a strategy, as this means the load per year will be lower. The stated hypothesis is therefore correct.

However, the effect of including the remaining load and the chosen deduction method is also of great influence on the sustainability of a strategy, which was not included in the hypothesis. This means that the ESL is only one factor of influence. The most important factor is the chosen calculation method and therefore this should be researched in further detail and preferably be standardized.

16.7 Recommendations

This research shows that there are many factors of influence when assessing the sustainability of possible strategies for vacant office buildings. The most influential factor is the chosen calculation method. The main factors in the calculation method are whether or not the remaining load should be included and which deduction method should be used. The first recommendations therefore are:

1) More research is needed on which calculation method to use when assessing the sustainability of possible strategies.
    a. Including the remaining environmental load or not.
    b. What deduction method is to be used to calculate the remaining environmental load.
2) Standardize this calculation method so that results of researches from different actors can be compared.

Since the estimated service life has proved to be very influential on the end results, this should also be further researched. The ISO standard to use the factor method for the determination of the ESL is a good start but can be further improved. Especially the assigning of ELS factors to an existing building needs more research and needs to be standardized to ensure the all actors use the method in the same way.

3) More research on assigning ESL factors to existing buildings and ambition levels of strategies; e.g. further research on the use of score tables.
4) Standardisation of assigning ESL factors to existing buildings and ambition levels of strategies.

No general conclusion could be drawn from this research on which strategy is more sustainable in general. In order to see if such a general conclusion can be made at all more cases need to be researched. Preferably these cases would also include buildings which have already been transformed or cases in which the demolition & new-build process is already completed. If such cases are included the use of ambition levels and the probability that an intended ambition level is also realised can also be evaluated.

17 Critical reflection

In this chapter a critical reflection will be made on the product, process and planning of the described graduation research. This will consider how the research was conducted and why it was relevant. What did and did not work will be specified and the learning points of the graduation process will be described.

17.1 Product

The final products of the graduation research are the report and the developed model.

17.1.1 How

To create these products several research methods were specified at the start of this research. These were:

- Literature study
- Simulation
- Case study
- Interview (/ expert panel)

These research methods are often used in the methodical line of approach of the graduation laboratory. This was the laboratory of Real Estate Management (REM) within the master of Real Estate & Housing. Because these are often used there was a lot of knowledge available on these methods and they could be executed correctly.

The theme of the REM laboratory is very broad as it concerns real estate as a resource that plays an important role in the organisation’s overall strategy, and not only on financial/economic factors and functionality. This research has connected to the laboratory by considering the sustainability of real estate strategies. This is important to organisations as sustainability is more and more often a part of an organisations strategy.

17.1.2 Why

Why the research should be done at all was described in the scientific and societal relevance. The scientific relevance was that it would add to the body-of-knowledge on the sustainability of transformation. This evolved during the research to include the sustainability off all possible strategies for vacant office buildings.

The societal relevance was indicated by the current discussion on what to do with the high vacancy in the office market, which was also expressed by the ‘Actieprogramma leegstaande kantoren’. The main proposed action point of this program is to reduce the number of square meter vacant office space by either transforming or demolishing these. Many actors have the intuitive feeling the transformation should be more sustainable due to the reuse of materials, although others feel that new-build buildings can be so much more energy efficient that it will counter this effect. The problem was that the previous researches did not include the ESL and/or made an unequal comparison of designs. Since these two factors greatly influence the calculation method, and therefore the results, more research was needed to study the effect of including or excluding these factors.

Previous researches encountered remarks on their calculation methods because they did not perform a sensitivity analyses on the effect of their calculation method. The added value of the research therefore is not only that it studies the effect of the inclusion of the ESL, but it also shows what the effect is of the used calculation method

17.1.3 Did it work?

17.1.3.1 Research methods

By using the proposed research methods the main question of the research was answered. The literature study proved to be a good method to get an overview of the existing knowledge on the subject, though this also showed that there was less knowledge available the assumed at the start of the research. There was no documentation on how to asses an existing building to be able to assign an ESL factor. This meant that a method had to be developed within the research.

The S^3 model was developed by using simulation as a research method. By simulating several strategies these could be compared on their sustainability. By also simulating the effect of in or excluding the different factors the effect of these factors became clear. The use of case studies was essential in this process as the use of this research method clarified the results. The case studies also showed where to model could be improved to include all relevant factors and show the effect that these factors had on the end result.

The expert meeting resulted in a better representation of reality in the model, and a clear view on how the assumptions of the research influenced the results. This was therefore an important research method. The choice to see al experts at once during an expert meeting, instead of using separate interviews, saved a lot of time and also resulted in a discussion between the experts. This discussion led to more feedback that could be processed in the model. This effect could have been even greater if two expert meetings would have been organized. In that case the progressed comments of the first meeting could be reviewed in the second meeting and the model could have been fine-tuned even more. However, in the time schedule of the graduation process there was no room for a second meeting.

17.1.3.2 Problem solved?

The problem statement in this research was the absence of the ESL in current sustainability methods and an unequal comparison of designs. By developing a model that does include the ELS and replaced the design with ambition levels this problem was solved.

However, after conducting the research a bigger problem has become clear. There is no commonly accepted way of assessing the sustainability of strategies and there is also no consensus on how the ESL of a complete building should be determined. The conducted research has definitely contributed to solving this problem by showing the effect of including or excluding important factors such as the ESL, remaining environmental load and deduction method. But this research alone is not enough to be able to draw a definite conclusion on what calculation method is best.

The developed model works only within the boundaries of the research and the given framework. This means that it does not necessarily represent reality. How much the results were affected by using this framework and whether or not this framework should be changed in a follow-up research remains to be seen. The exclusion of social and financial factors means that the model is but a small part of the decision making process. It must therefore always be used as an advisory model and the results should be placed in the bigger picture of a building's life cycle.

17.1.4 Learning points

The following learning objectives concerning the end product were named at the beginning of this research:

To obtain…

1. Knowledge about sustainability in general and how this term is used in the building industry.
2. Knowledge about the effect of the estimated service life on the sustainability of a building and how this can be measured.
3. Knowledge about the different models that exist in the building industry that are used to assess the sustainability of a building and their differences.

By researching and comparing the existing sustainability models I have definitely gained knowledge on how sustainability is used in the building industry in general and how it is assed. By developing the model and comparing the output if the ESL is included or not knowledge on this topic was also acquired.

Besides from these expected learning points I also encountered other learning moments while conducting this research. First, I learned that I had been to biased towards transformation myself when I started this research, and that this had led to the exclusion of other possible strategies in the model. Initially only transformation and demolition & new-build were compared, excluding other realistic option such as renovation. If I were to conduct the research again I would incorporate all possible strategies from the start. This would probably results in even more strategies than those incorporated now, although too many strategies would have been problematic. Especially the inclusions of just demolition (and no new-build) would have improved the model.

Another important learning point was the realisation of how much the results are influenced by the framework of the research. Defining and updating this framework therefore proved very important when presenting the results or discussing the subject with fellow students. In a next research I would therefore try to define my framework from the start and discuss this with as many people as possible, so that I would know exactly what the framework is and why it should be that way.

17.2 Process

The process of the research concerns everything from the first idea of the graduation subject to the final delivery of the report and the model.

17.2.1 How

The graduation process is divided in 5 parts, which are specified by the faculty of architecture. These parts are concluded with a presentation.

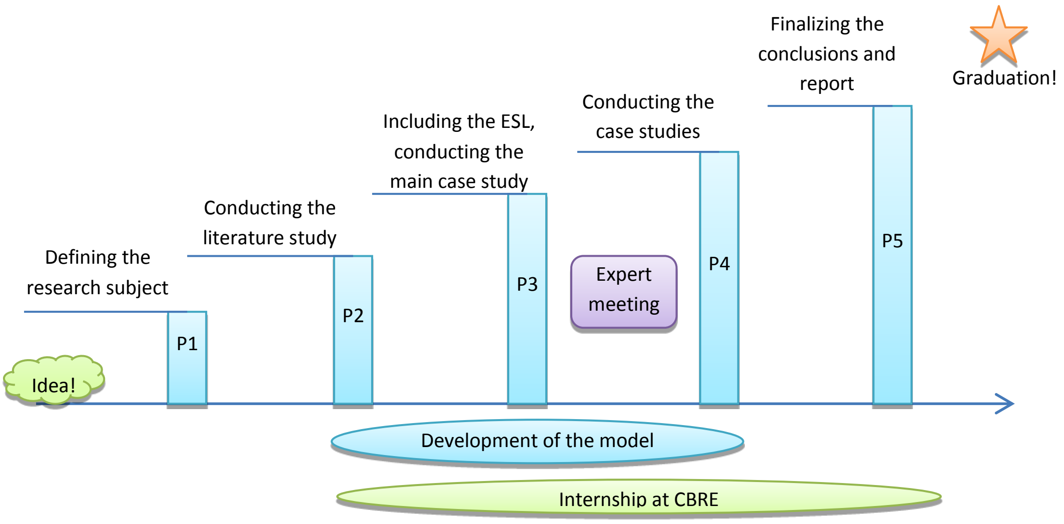


Figure 17.1: Graduation process

The graduation starts with an idea about the subject that is to be researched at the first presentation (P1) this idea is crystallized and presented. At this point the main mentor is appointed a start on the literature study is made. At the second presentation the literature study has to be almost complete and a second mentor is also appointed to guide the research process. After P2 the model had to be developed in order to stay on schedule with the planning. The internship at CBRE also started after P2 and would continue all the way to the final presentation. At P3 the model included the ESL, but a lot still had to be done to troubleshoot the model. This presentation showed the problems in the model and how these should be solved. The main case had been conducted to develop the model. Halfway between P3 and P4 the expert meeting was held. At this stage the model was up and running, but still needed some serious fine-tuning. The expert meeting provided enough input to complete the model. At P4 the model was presented again and the preliminary results were discussed. The final conclusions, recommendations and critical reflection were made to complete the report.

17.2.2 Why

By planning the initial development of the model from P2 to P3 there was time left to fine-tune the model between P3 and P4. Especially in combination with the expert meeting this worked very well, as a lot of the input from the expert meeting could still be included in the model. The wish to conduct all the case studies before P4 with a finalized model created a higher workload between P3 and P4. However, this did result in a very complete P4 presentation and enough time to improve my conclusions. This also created a time frame in which I could reflect on my results and place my conclusions in a broader perspective.

17.2.3 Did it work?

The approach to follow the strict regulations and presentation schedule of the faculty definitely worked to maintain an even workload throughout the process. By starting the internship after P2 a clear overview could be given to the company on what the research would be about. Because the company provided all the necessary information needed for the case studies it was possible to focus on the development of the model first. This saved a lot of time since the information was easily accessible.

The expert meeting between P3 and P4 was a success as it provided enough feedback to improve the model and create a final product. This did however mean that there was less time available to conduct the case studies in order to be able to make all the improvements in the model. This extra time needed for the model might have been reduced if the expert meeting had been held earlier in the process, although the model presented at the meeting would then have been less detailed.

Holding on to the planning that the case studies should be finished at P4 resulted in a heavier work load between P3 and P4, but this was compensated by the possibility to step back from the research a bit after P4. This resulted in a better understanding of the results and conclusions and therefore a better end product.

17.2.4 Learning points

The following learning objectives concerning the process and personal development were named at the beginning of this research:

To obtain:

1. Experience in an internationally oriented company through a graduation-internship.
2. Experience in writing a research design and doing a research.
3. Experience in processing theories in a way that creates a practical model that can be used by others.

During the first stages of the graduation I also followed an elective course to improve my skills in writing a research design. (MOT2002, Preparation for master thesis.) This helped me to define my topic and to be able to explain it to people who are not familiar with the subject. This eventually resulted in a research design that was feasible and a graduation internship.

By following a graduation internship at CBRE I gained experience in an internationally oriented company which has improved the final end product. Because they could provide all the information needed for the case studies this saved a lot of time. A maybe even more important factor was that they were able to see the practical problems, such as a general absence of some information required by sustainability models. This helped me to avoid these problems and create a model that can really be used in the initiative phase of a project.

Because of the interaction with my mentors, external examiner and graduation company I realized that there is a balance to be found between theory and practice. Especially the influence of assumptions, boundaries and conditions became clear in these discussions. I realize that I still have a lot to learn in how to translate a theory into a practical model as this research made clear to me how difficult that can be. By translating the ESL theories into score tables that can be used in practice I learned the value of an objective standard that is accepted by all actors.

17.3 Planning

The planning of the project can be found in the appendix.

17.3.1 Did it work?

The planning of the research was made in the beginning of the process and finalized at P2. The planning was based examples of finished graduation researches and consultations with the mentors of the research. Because the work to be done was not yet known in detail the planning was kept at a global level and mainly indicated the milestones to be reached before each presentation. This worked well because it kept the planning flexible enough to implement the graduation internship, but rigid enough to be sure that the required products could be delivered. This resulted in the project being on schedule at (almost) all times and all products present at the appropriate presentation.

A possible point of improvement is to make several schedules; one general planning like the one made in the appendix and one between each presentation that describes the activities in more detail. During this research these separate schedule were also made to identify the work to be done. By also assigning intermediate deadlines for these activities the planning could have been tighter, but would have been less flexible.

References

References

AGENTSCHAP-NL 2010. Kiezen voor nieuwbouw of het verbeteren van het huidige kantoor. Utrecht: Agentschap-NL.

ANON 2003. Sustainable building and construction: facts and figures. *UNEP Industry and Environment,* April – September.

ANON 2011. Triple P model. *In:* PPP.JPG (ed.). Facilicom.com.

BIJLEVELD, M. 2012. *RE: Telefoongesprek greencalc materialendatabase.* Type to JANSZ, S.

BLAKSTAD, S. H. 2001. *A Strategic Approach to Adaptability in Office Buildings.* Doktor Ingeniør Thesis, Norwegian University of Science and Technology.

BRIS. 2011. *BRIS toezicht* [Online]. Rotterdam: BRIS. Available: http://www.bris.nl/producten/bristoezicht/overzicht.html [Accessed 20-05-2012 2012].

BRUNDTLAND 1987. Report of the World Commission on Environment and Development: Our Common Future. *In:* NATIONS, U. (ed.). New York: United Nations.

CBRE 2012. Leegstand op de nederlandse kantorenmarkt. *In:* WOLTERS, M. (ed.). Amsterdam.

D. MEADOWS, H. D. 1972. The limits to growth; a report for the Club of Rome's project on the predicament of mankind. New York: New American Library.

DE GROOT. 2011. *Hoe woningen het duurzame antwoord worden op het kantorenoverschot.* Msc, Universiteit Twente.

DE JONGE ET ALL 2009. *DAS Framework - Corporate Real Estate IVianagement,* Delft, department of real estate & housing.

DEN HEIJER & DE JONGE 2004. Sturen van vastgoedprocessen. *Inleiding vastgoedmanagement.* Delft: TU Delft, faculteit bouwkunde.

DGBC 2011. DGBC Operations Manual for BREEAM-NL assessments. Rotterdam: Dutch Green Building Council.

DGBC. 2012a. *BREEAM-NL* [Online]. Rotterdam: Dutch Green Building Council. Available: http://www.breeam.nl/breeam/breeam [Accessed 28-02-2012 2012].

DGBC 2012b. BREEAM-NL Bestaande Bouw en Gebruik 2011 v2.1. *Beoordelingsrichtlijn Bestaande Gebouwen.* Rotterdam: Stichting Dutch Green Building Council.

DHV 2011a. Duurzaamheidsanalyse belastingkantoor Utrecht: Analyse van scenario's voor transformatie en sloop/nieuwbouw. Amersfoort: DHV.

DHV. 2011b. Sloop-nieuwbouw belastingkantoor Utrecht duurzamer dan transformatie. Available: http://www.dhv.nl/Nieuws/Persberichten/2011/2011-09-19-Sloop-nieuwbouw-belastingkantoor-Utrech [Accessed 18-10-2011].

ELKINGTON 1997. *Cannibals with forks,* Oxford, Capstone Publishing Limited.

FIKSE, R. 2008. *Transformatietools uncovered.* Msc, TU Delft.

GEMEENTE AMSTERDAM 2002. Grachtenpanden2. Amsterdam: Gemeente Amsterdam.

GERAERDS & VAN DER VOORDT. 2007a. Leegstandsrisicometer. Available: https://blackboard.tudelft.nl/bbcswebdav/courses/22525-111201/22525-111201_ImportedContent_20110819113937/18657-101101_ImportedContent_20110725034836/Course%20Documents/Transformatie/Leegstandsrisicometer/leegstandsrisicometer_GeraedtsVoordt.pdf [Accessed 18-10-2011].

GERAERDS & VAN DER VOORDT. 2007b. Transformatiepotentiemeter. Available: https://blackboard.tudelft.nl/bbcswebdav/courses/22525-111201/22525-111201_ImportedContent_20110819113937/18657-101101_ImportedContent_20110725034836%281%29/Course%20Documents/Transformatie/Transformatiepotentiemeter/transformatiemeter%20Geraedts_VanderVoordt.pdf [Accessed 18-10-2011].

GROAT & WANG 2002. *Architectural research methods*, John Wiley & Sons.

H.W. KUA & S.E. LEE 2002. Demonstration intelligent building—a methodology for the promotion of total sustainability in the built environment. *Building and Environment,* 37.

HUIZENGA, C. A., S.; ZAGREUS, L.; ARENS, E. Year. Air Quality and Thermal Comfort in Office Buildings: Results of a Large Indoor Environmental Quality Survey. *In:* Healthy Buildings 2006, 2006 Lisbon.

JANSZ, S. N. 2012. Expert meting. *In:* JANSZ, S. N. (ed.) *Remoy, H. Sandberg, B. Korbee, H. Eeckhoven, E. Cao, D. Van Linder, J.* Rotterdam.

JIN, R. K. 2003. *Case Study Research, design and methods,* Londen, Sage publications.

JONES LANG LASALLE. 2010. Gebruikersvisie op duurzame huisvesting. Available: http://www.joneslanglasalle.nl/Netherlands/nl-nl/Pages/ResearchDetails.aspx?ItemID=3698 [Accessed 14-12-2011].

M.H. SCHULTZ VAN HAEGEN 2011. Actieprogramma Aanpak Leegstand Kantoren. *In:* MILIEU, M. V. I. E. (ed.). Den Haag.

MALTHUS, T. 1798. An Essay on the Principle of Population. *In:* WW (ed.). London: www.esp.org.

METZ, T. 11-10-2011 2011. *RE: Resultatenbespreking DHV onderzoek belastingkantoor utrecht.* Type to JANSZ, S. N.

MOSER & EDVARDSEN. 2002. Engineering Design Methods for Service Life Prediction. Available: http://www.irbdirekt.de/daten/iconda/CIB9324.pdf [Accessed 10-10-2012].

MULLER, R., SOETER, 2009. Structurele leegstand 4% lager. *Real Estate Research Quarterly,* April 2009.

NIBE. 2002. Monetarisering. Available: http://www.greencalc.com/monetarisering.pdf [Accessed 06-03-2012].

OLTHOF & JANSZ 2012. Improved improved factor method. Delft. (see appendix)

P. NEALE, S. T., C. BOYCE. 2006. PREPARING A CASE STUDY: A Guide for Designing and Conducting a Case Study for Evaluation Input. Available: http://www.pathfind.org/site/DocServer/m_e_tool_series_case_study.pdf [Accessed 27-12-2011].

RENOOY, P. H. 2008. Leegstand en kraken. Amsterdam: Regioplan.

RIBA. 2011. *Westborough Primary School's Cardboard Building scoops two special RIBA awards* [Online]. Available: http://www.architecture.com/NewsAndPress/News/AwardsNews/Press/2002/WestboroughPrimarySchool.aspx [Accessed 21-11 2011].

RIJKSOVERHEID. 2012a. *Energiebesparing* [Online]. Den Haag: Rijksoverheid Nederland. Available: http://www.rijksoverheid.nl/onderwerpen/energiebesparing [Accessed 28-02-2012 2012].

RIJKSOVERHEID. 2012b. *Energielabel woning* [Online]. Den Haag: Rijksoverheid. Available: http://www.rijksoverheid.nl/onderwerpen/energielabel-woning [Accessed 28-02-2012 2012].

STICHTING BOUWKWALITEIT. 2012. *Nationale Milieudatabase Stichting Bouwkwaliteit* [Online]. Rijswijk: Stichting Bouwkwaliteit. Available: https://www.milieudatabase.nl/index.php?id=nieuws [Accessed 28-02-2012 2012].

SUREAC. 2010. *GreenCalc+* [Online]. Rotterdam: DGBC. Available: http://www.greencalc.com/index.html [Accessed 28-02-2012 2012].

TECHNIPLAN ADVISEURS. 2010. *Duurzaamheidslabels Achtergrondinformatie* [Online]. Rotterdam: Techniplan Adviseurs. Available: http://www.kiesuwlabel.nl/duurzaamheidslabels/ [Accessed 28-02-2012 2012].

VAN AGTMAAL. 2012. *A user-centred re-design of indoor comfort.* Master, Delft University of Technology.

VAN DEN DOBBELSTEEN 2004. *The Sustainable Office, an exploration of the potential for factor 20 environmental improvement of office accommodation,* Delft, Copie Sjop.

VAN DER VOORDT ET ALL 2004. *Inleiding vastgoedmanagement,* Delft, TU Delft, faculteit bouwkunde.

VAN NUNEN 2010. *Assessment of the Sustainability of Flexible building,* Boxtel, AEneas.

VASTGOEDMARKT. 2011. Crisis houdt beleggers in de greep. Available: http://www.vastgoedmarkt.nl/nieuws/2011/09/22/Crisis-houdt-beleggers-in-de-greep [Accessed 18-10-2011].

VIJVERBERG 2004. De levensduur van vastgoed. *Inleiding vastgoedmanagement.* Delft: TU Delft, faculteit bouwkunde.

WE ADVISEURS. 2012. *GPR Gebouw* [Online]. Utrecht: WE Adviseurs. Available: http://www.gprgebouw.nl/website/default.aspx [Accessed 28-02-2012 2012].

WILLIAM MCDONOUGH, M. B. 2007. *Cradle to Cradle - afval = voedsel,* Schiedam, search knowledge scriptum.

Appendix

18 Appendix

Index:

18.1 Olthof & Jansz, 2012; Improved[2] Estimated Service Life

Currently several methods are available for estimating the service life of a building. The general standard is set by the factor method where the service life of a building is estimated by taking the service life of a reference building and adjusting that by multiple factors.

For instance, if the building climate is inferior to that of the reference building and scores a 0.8 vs. the 1.0 of the reference building as a result the ESL of the building under investigation is reduced by 20%. Multiplying by several different factors for the different aspects of a building the following formula is obtained (Van Nunen, 2010).

$$ESL = RSL * \ A\ B\ C\ D\ E\ F\ G\ T\ R$$

A = Aspect Factor for the quality of components
B = Aspect Factor for the design level
C = Aspect Factor for the work execution level
D = Aspect Factor for the indoor environment
E = Aspect Factor for the outdoor environment
F = Aspect Factor for usage conditions
G = Aspect Factor for the maintenance level
T = Aspect Factor for trends
R= Aspect Factor for the related components

When applying this factorization method all factors have the same weight factor. This is not necessarily a good representation of reality. After a survey of a large number of experts in the field a proposal was made to give the different aspect factors a different weight. Thus an improved aspect factor (IAF) is calculated out of the original aspect factor (OAF)

Out of those different weight factors the following model was developed by Van Nunen (IESL):

$$ESL = RSL \ * \ A'B'C'D'E'F'G'\ T'R'$$

with

$$A' = \ 1 + (A-1)a_0$$
$$B' = \ 1 + (B-1)b_0$$
$$C' = \ldots$$

Where A, B, C etc are the OAFs and A', B', C' etc are the IAFs.

An example of the relationship between A and A' (weighing factor larger than 0) and i.e. D and D' (weighing factor smaller than 0) can be seen in figure 1 and 2 respectively.

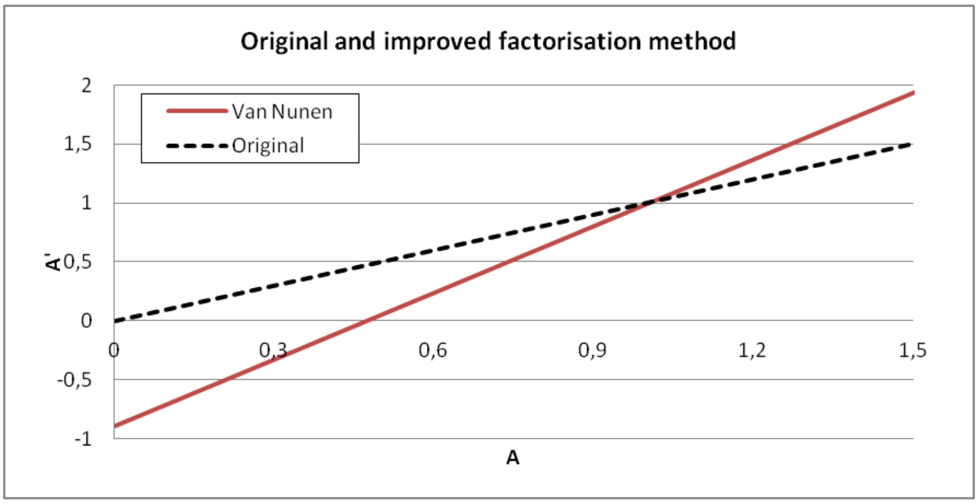


Figure 1: Original factorisation method as well as that for van Nunen where the latter has a weight factor larger than 1

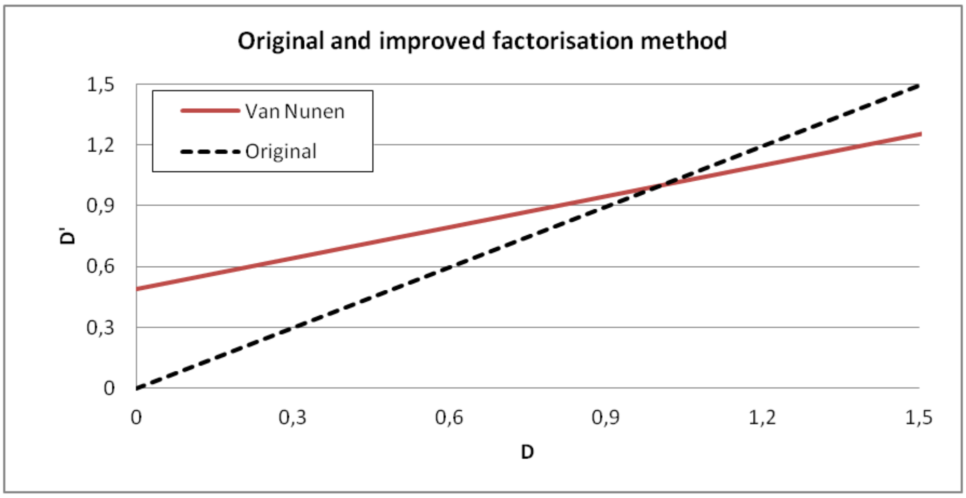


Figure 2: Original factorisation method as well as that for van Nunen where the latter has a weight factor smaller than 1

The weight factors a_0,b_0 etc used for the model can be found in the table below.

Factor	Description	Weight
A	Quality of components	1.89
B	Design level	1.62
C	Work execution level	1.14
D	Indoor environment	0.51
E	Outdoor environment	0.79

Factor	Description	Weight
F	In-use conditions	0.95
G	Maintenance level	1.06
T	Trends	1.19
R	Related components	0.85

Table 1: weighting factors

Using this improved factorization method one can make a more accurate estimation of the service life remaining. This method works well for aspect factors close to unity. However, for small aspect factors (especially smaller than 0.5) the model produces unwanted and unrepresentative behavior.

For instance in figure 1 it can be seen that if the weight factor is larger than 1 that for low aspect factors a negative service life is predicted (For instance: A=0.4 and B, C, D, E, F, G, T, R=1 leads to a negative ESL which would be -0.13 *RSL)

Furthermore there are some more unintended effects. Close to the point where the adjusted aspect factor (A’) crosses the x-axis, small variations in original aspect factors cause big variations in estimated service life. For instance an original aspect factor of 0.5 gives an adjusted aspect factor of 0.055, whereas filling in 0.6 yields an adjusted aspect factor of 0.244. The resulting predicted ESL will thus be over 4 times larger filling in 0.6 rather than 0.5 for the original aspect factor. An unintended and non-representative behavior just like the prediction of negative estimated remaining service life.

Since this model should be well applicable to old buildings, which do have low aspect factors this behavior is relevant to real practice application. In other words, the model should be corrected for this behavior.

Just as much as a weight factor larger than 1 leads to unwanted behavior, so does a weight factor smaller than 1. For instance, a building with an original aspect factor of 0 on any of the aspects would lead only to a reduction of ESL of 50% for a weight factor of 0.50 (i.e., for D). However, even if one of the aspects scores a 0, one would expect that the building would not be suitable to the market, no matter what the score on the other aspects is. Obviously the model should be corrected for this behavior as well.

These conclusions lead to the following notion:

An improved model is needed that has the following properties:

- If the original aspect factor is 0, the adapted aspect factor is 0 as well.
  (Building is not suitable for market)
- In the original aspect factor is 1, the adapted aspect factor should be 1 as well.
  (Building aspect is the same as for the reference building, hence ESL should not be adapted versus RSL)
- If the original aspect factor is close to 1, the adapted aspect factor should be weighed.
  The weighing model by van Nunen is quite fit for this, as it weighs the deviation from 1, hence the deviation from the reference building.
  In other words, for an original aspect factor close to 1, the improved model should approach the van Nunen model.
- The improved method would use the same weight factors as the van Nunen method in order to use the existing research that was done in the field.
- The improved factorization method would still use a simple multiplication of improved factors once they have been calculated from the original aspect factors according to:

$$ESL = RSL \; * \; A'B'C'D'E'F'G' \; T'R'$$

For a model to comply with all these requirements a second order method is required for an original aspect factor between 0 and 1. For original aspect factors larger than 1 the method by Van Nunen can still be applied. This leads to the following improved factor method:

$$A' = \begin{cases} 1 + (A-1)a_0 & for\ A > 1 \\ a_1A^2 + a_2A & for\ A \in [0..1] \end{cases}$$

$$\text{where } \begin{matrix} a_1 = a_0 - 1 \\ a_2 = 2 - a_0 \end{matrix}$$

and similar for B, C etc

(a0, b0 will be the same as for the improved factorization method by van Nunen)

As this function is specifically designed to give a 0 value for A' when A is zero, one need not worry about (high) estimations for service life for very poor buildings. However, it needs to be checked that no negative ESLs can arise from this set of functions as well.

It can be shown that for $a_0 \in [0 \dots 2]$ no values exist for A which give a negative value for A'. Since all of the weighing factors lie in this domain (see table 1), this function can be used without further warning for negative estimated service life.

The resulting relationship between A and A' as well as the relationship between D and D' has been depicted below.

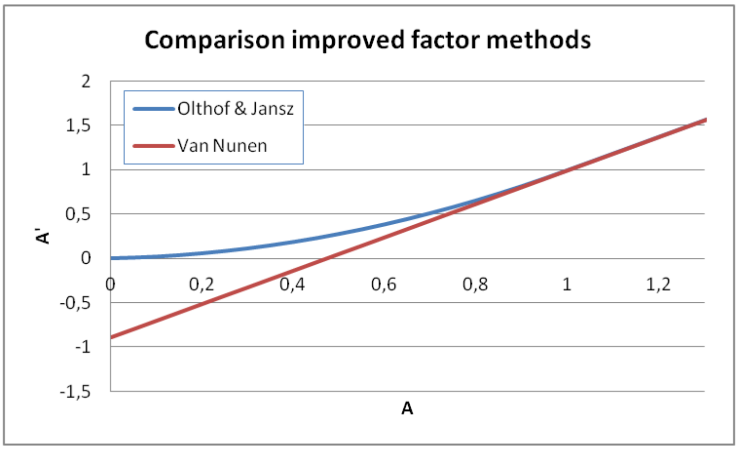


Figure 3: Relationship between A and A'

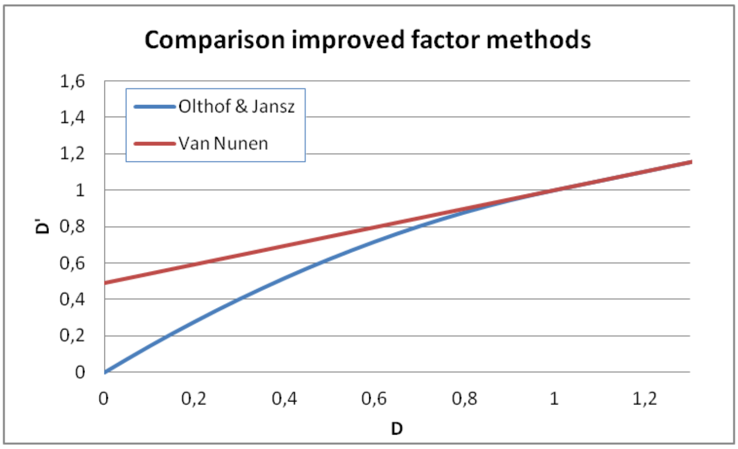


Figure 4: Relationship D and D'

18.1.1 Model derivation

For the derivation of a proper model of the function piece of OAF = 0… 1 we need several constraints for the function. Using A and A’ as an example for OAF and IAF we get the following requirements

1. If the original aspect factor is 0, the adapted aspect factor is 0 as well.
   (Building is not suitable for market)
   $$A = 0 => A' = 0$$
2. If the building is the same as the reference building the estimated service life is the same as the reference service life:
   $$A = 1 => A' = 1$$
3. Close to an OAF of 1 the New Function should behave like the model by van Nunen.
   $$\left(\frac{dA'}{dA}\right)_{New} = \left(\frac{dA'}{dA}\right)_{Van\ Nunen} \quad when\ A = 1$$

These three requirements lead to a minimum requirement of a second order model.

When starting from a generic second order model, using the three constraints above, the model constants for the new IAF model can be derived.

$$A' = a_1 A^2 + a_2 A + a_3$$

When incorporating constraint 1 this leads to

$$0 = a_1 0 + a_2 0 + a_3$$

$$0 = a_3$$

This simplifies the model to:

$$A' = a_1 A^2 + a_2 A$$

Applying constraint 2 leads to:

$$1 = a_1 + a_2$$

Whereas applying constrain 3 leads to

$$a_0 = 2a_1 + a_2$$

A simple rearrangement of the 2 equations above leads to:

$$\begin{aligned} a_1 &= a_0 - 1 \\ a_2 &= 2 - a_0 \end{aligned}$$

As a result a new model is derived based solely on the constraints above and the weighing factors already determined by Van Nunen.

$$A' = \left\{ \begin{array}{ll} 1 + (A-1)a_0 & for\ A > 1 \\ a_1 A^2 + a_2 A & for\ A \in [0..1] \end{array} \right\}$$

where $\begin{aligned} a_1 &= a_0 - 1 \\ a_2 &= 2 - a_0 \end{aligned}$

18.1.2 Model limitations

As can be seen in the graphs below the new model does comply with the constraints that were set for the model, regardless of the weighing factor being larger or smaller than 1.

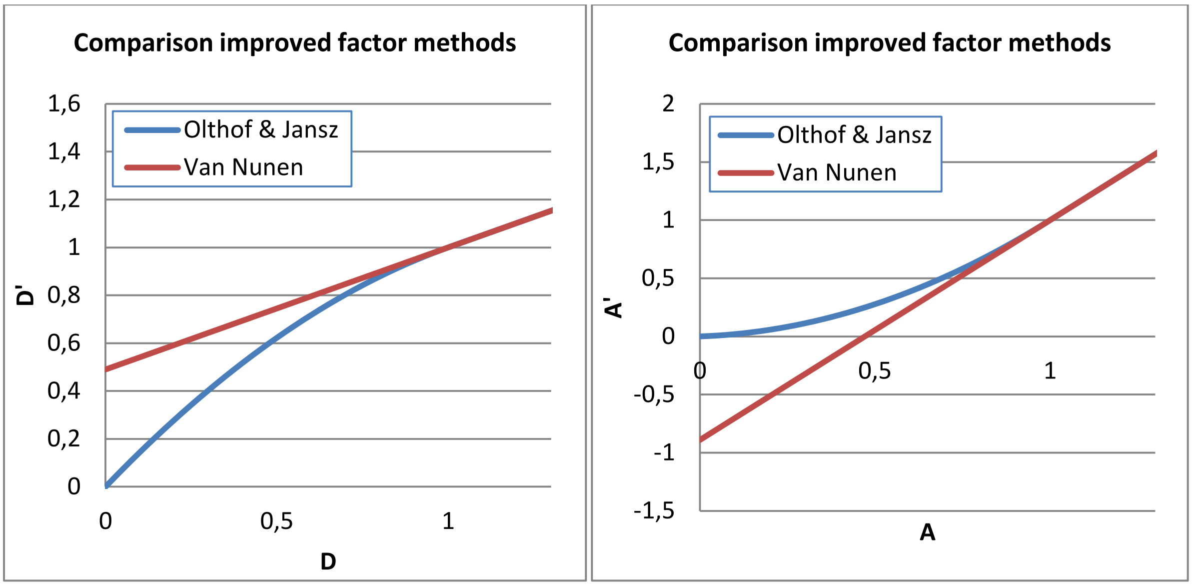


Figure 5: Weighting factors larger or smaller than 1

However, this does not necessarily mean that it leads to a positive ESL for every weighing factor applied. As the function applied is a second order function, it can potentially cross the x-axis twice depending on the weighing factor. As can be seen in the graph below, for instance this happens at a weighing factor of 3 (for an imaginary factor X). Even though the behavior is better than the Van Nunen model, it is still not desired behavior:

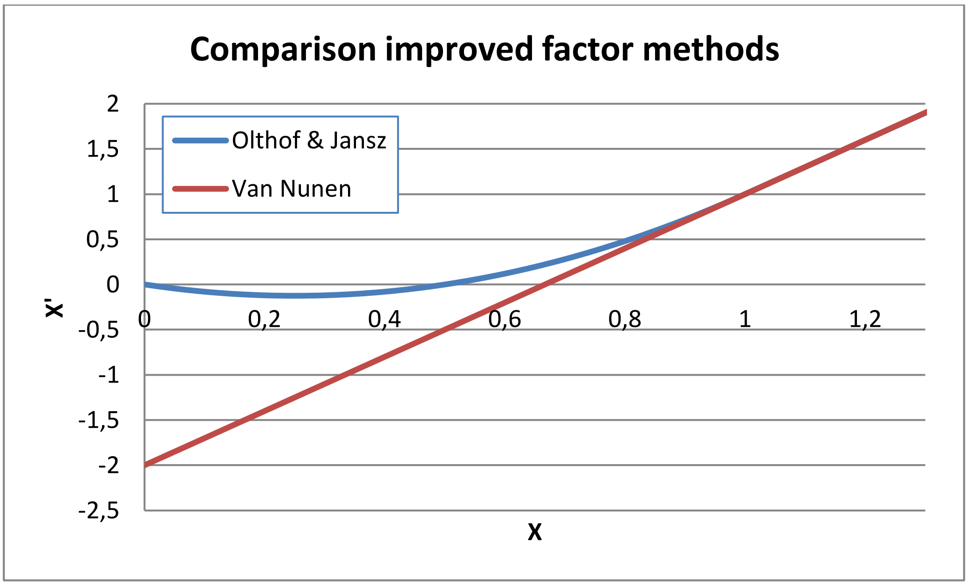


Figure 6: Comparison with Van Nunen

This leads us to a fourth constraint for the model function. The predicted IAF should be larger than or equal to zero for all values of OAF. For the function part where the OAF this is trivial and satisfied already. Since no OAF smaller than 0 are relevant this constraint can thus (using A' and A as an example again) be simplified to:

$$A' \geq 0 \quad for \quad A \in [0 \dots 1]$$

The solution to this problem is most easily found by determining the second value for A where A'=0. (The other point is obviously for A=0).

For any second order function $A' = a_1A^2 + a_2A + a_3$ the points A'=0 can be found by:

$$A_{1,2} = \frac{-a_2 \pm \sqrt{a_2^2 - 4a_1a_3}}{2a_1}$$

Since $a_3 = 0$ this simplifies to

$$A_{1,2} = \frac{-a_2 \pm a_2}{2a_1}$$

Or:

$$A_1 = 0$$
$$A_2 = -\frac{a_2}{a_1}$$

Substituting the values found for a_1 and a_2 found before this is rewritten to (only A_2 is relevant)

$$A_2 = -\frac{2 - a_0}{a_0 - 1} = \frac{a_0 - 2}{a_0 - 1}$$

Analyzing this function we find for A_2

$A_2 > 1$ for $a_0 \in [0..1]$

$A_2 \leq 0$ for $a_0 \in [1..2]$

$A_2 \in [0 \dots 1]$ for $a_0 > 2$

(for a_0 <0 we don't investigate since this is an invalid range to the real world situation)

Therefore the new model is only valid only for values of a_0 smaller or equal to 2.

As can be seen in table 1 there are no weighing factors larger than 2, so the model complies with the validity constraint formulated in this section. However, in the future if the weighing for any of the factors is increased to a value larger than 2 an adjustment of the model is required to maintain model validity.

18.2 Vacancy risk meter Case A (Geraerds & Van Der Voordt, 2007a)

Yes = 1, No = 0

18.2.1 Veto criteria

ASPECT	VETOCRITERIUM	GEGEVENS	Oor-deel
LOCATIE			
1 Gemeentelijk beleid	1 Pand ligt in gemeentelijk prioriteitsgebied voor woningbouw	Gemeentelijk beleid	0
2 Parkeren	2 Capaciteit eigen terrein/directe nabijheid ≤ 1 pp/200 m² BVO	Ter plaatse, makelaai	0
GEBOUW			
3 Huurprijs (concentratie panden met lage huur)	3 Huurprijs ≤ 90,- euro/m² BVO (peildatum medio 2006)	Literatuur, makelaars	0

18.2.2 Gradual criteria vacancy risk meter (Geraerds & Van Der Voordt, 2007a)

18.2.2.1 Location

ASPECT	GRADUEEL CRITERIUM	GEGEVENS	Oor-deel	Ge-wicht
LOCATIE				
1 Geografische ligging	1 Plaats ≤ 50.000 inwoners	VNG	0	3
2 Ligging in specifiek stadsdeelgebied	2 Bijvoorbeeld in Rotterdam: Rotterdam Noord, -Zuid, en -West Wijnhavenkwartier, Marconiplein	Literatuur, onderzoek	1	3
3 Concentratie panden met lage huurprijs	3 Meerdere panden in omgeving met huurprijs ≤ 90,-/m² BVO	Literatuur, makelaars	1	3
4 Ruimtelijke en functionel kwaliteit	4 Niet integraal ontworpen locaties; monofunctioneel	Plattegrond; ter plaatse	0	3
5 Bereikbaarheid auto, openbaar vervoer	5 Auto: afstand tot snelweg ≥ 5 km	Stadsplattegrond	0	3
	6 NS station/intercity: afst. ≥ 2 km	Idem	0	3
	7 NS tussenhalte: afstand ≥ 1 km	Idem	0	3
	8 Bus/tram/metrohalte: afst. ≥ 1 km	Idem	0	3
6 Bereikbaarheid voorzieningen	9 Afstand restaurants voor zakenlunch/diner ≥ 500 m.	Plattegrond; ter plaatse	0	3
	# Afstand bank, postkant. ≥ 500 m.	Idem	0	3
	# Afstand ontspannings- en recreatiemogelijkheden ≥ 500 m.	Idem	0	3
	# Afstand winkel voor dagelijkse behoeften ≥ 500 m.	Idem	0	3
7 Openbare veiligheid	# Sporen van vandalisme in directe omgeving	Info ter plaatse	0	3
	# Gevels belendende gebouwen besmeurd met graffitti	Idem	1	3
	# Aanwezigheid van zwerfvuil in directe omgeving	Idem	0	3
	# Aanwezigheid van randgroepen in directe omgeving	Idem	0	3
8 Hinder omgeving	# Slagschaduw ≥ 50% van kantoortijden	Info ter plaatse	0	3
	# Hinderlijke stankoverlast ≥ 100 dagen/jaar	Idem	0	3
	# Hinderlijke windturbulenties ≥ 50 dagen/jaar	Idem	0	3
	# Hinderlijke geluidsoverlast ≥ 2 uren/kantooruren	Idem	0	3
9 Ruimtelijk visuele kwalite	# Type omgeving: industrieterrein, kantorenpark	Makelaars, info ter plaatse	0	3
	# Uitstral. omgeving: eenvoudig, weinig groen, geen samenhang	Idem	1	3
	# Afwerking terrein: eenvoudig; tegels, gras, grind e.d.	Idem	1	3

18.2.2.2 Building

GEBOUW							
	ASPECT		GRADUEEL CRITERIUM	GEGEVENS	Oor-deel	Ge-wicht
#	Bouwjaar	1	Bouwjaar tussen 1960 en 1980	Literatuur, makelaars	1	3
#	Ruimtelijk-visuele kwalite	2	Verouderde (gedateerde) verschijningsvorm	Foto's, info ter plaats	1	3
		3	Geen eigen identiteit t.o.v. andere gebouwen/gebruikers	Idem	1	3
		4	Eenvoudige afwerking exterieur (beton, plaatmaterialen)	Idem	0	3
		5	Entree niet goed zichtbaar of herkenbaar	Idem	1	3
		6	Afwerking entree eenvoudig	Idem	1	3
#	Uitstraling, identiteit	7	Vandalismesporen aan gebouw	Foto's, info ter plaats	0	3
		8	Gevels besmeurd met grafitty	Idem	0	3
		9	Gebouw verpauperd	Idem	0	3
		#	Gebouw niet representatief	Idem	1	3
		#	Specifiek gebouw voor (semi)overheid	Makelaars	1	3
#	Technische kwaliteit buitenschil	#	Slechte kwaliteit dichte geveldelen	Foto's, info ter plaats	0	3
		#	Slechte kwaliteit open geveldelen	idem	1	3
		#	Slechte kwalit. daken (bedekking)	Idem	0	3
#	Technische kwaliteit drager/inbouw	#	Slechte kwaliteit draagconstructie (kolommen, wanden, vloeren)	Makelaar, foto's, ter plaatse	0	3
		#	Slechte kwaliteit inbouwpakket (binnenwanden, deuren, cellen)	Idem	1	3
#	Technische kwaliteit installaties (ouderdom)	#	Verwarming ≥ 10 jaar	Makelaar, eigenaar, t	1	3
		#	Koeling ≥ 10 jaar (of ontbreekt)	Idem	1	3
		#	Luchtbeh. ≥ 10 jaar (of ontbr.)	Idem	1	3
		#	Water/riolering/koeling ≥ 12 jaar	Idem	1	3
		#	Verlichting ≥ 10 jaar	Idem	1	3
		#	Communicatie ≥ 5 jaar (of ontbr.)	Idem	1	3
		#	Beveiliging ≥ 7 jaar (of ontbreekt)	Idem	1	3
		#	Gebouwbeheerssysteem ≥ 5 jaar	Idem	1	3
		#	Infrastructuur ≥ 10 jaar	Idem	1	3
#	Milieukwaliteit	#	Slechte energieprestaties (enkel glas, onvoldoende isolatie)	Makelaar, eigenaar, t	1	3
		#	Slechte geluidsisolatie	Idem	1	3
		#	Milieuonvriendelijk/ongezond	Idem	1	3
#	Functionele kwaliteit	#	Slechte verticale indeelbaarheid (verd.hoogte ≤ 2.70 of ≥ 3.70 m)	Makelaar, eigenaar, t	0	3
		#	Slechte horizontale indeelbaarheid (wandplaatsing ≥ 3.60 m)	Idem	0	3
		#	Unitgrootte voor afstoten of bijtrekken gebouwdelen ≥ 900 m²	Idem	1	3
		#	Niet/nauwelijks herindeelbaar (geen flexibel inbouwpakket)	Idem	1	3
		#	Aantal liften ≤ 1 per 1350 m² BVO	Idem	0	3
		#	Gangbreedte ≤ 1.70 m	Idem	0	3
		#	Gebouw niet zelfstandig toegankelijk voor gehandicapten	Idem	1	3
		#	Nuttige vloerbelasting ≤ 3,5 kN/m²	Idem	0	3
		#	Geen flexibele voorziening voor elektra en communicatie	Idem	1	3

18.2.3 Vacancy risk class

Leegstandrisicoscore	Leegstandrisicoklasse		
Locatie+Gebouw = 0 - 136	1 = Zeer geschikt voor behoud als kantoor	Tot. score A + B:	292
Locatie+Gebouw = 137 - 272	2 = Geschikt voor behoud als kantoor		
Locatie+Gebouw = 273 - 408	3 = Beperkt geschikt voor behoud		
Locatie+Gebouw = 409 - 544	4 = Nauwelijks geschikt voor behoud		
Locatie+Gebouw = 545 - 678	5 = Niet geschikt voor behoud als kantoor	Leegstandrisicoklasse:	3

18.3 Transformation potential meter Case A (Geraerds & Van Der Voordt, 2007b)

Yes = 1, No = 0

18.3.1 Veto criteria

In Case A there is no initiator yet, therefore it is not known if there are internal demands from the initiator. Assessing the transformation potential is still useful because the results can be used to convince interested parties to become the initiator.

ASPECT	VETOCRITERIUM	GEGEVENS	Oor-deel
MARKT			
1 Vraag naar woningen	1 Er is geen woningvraag van lokale doelgroepen	Makelaar/gemeente	0
LOCATIE			
2 Stedelijke ligging	2 Bestemmingsplan laat geen wijziging toe	Best.plan/beleid gem.	0
	3 Ernstig gevaar voor volksgezond-heid (milieu, lawaai, stank)	Makelaar of ter plaats	0
GEBOUW			
3 Afmetingen casco	4 Vrije plafondhoogte < 2.60	Makelaar of ter plaats	0
ORGANISATIE			
4 Initiatiefnemer	5 Afwezigheid enthousiaste initiatiefnemer	Lokaal onderzoek	1
5 Interne vetocriteria ontwikkelaar	6 Niet kunnen voldoen aan eisen t.a.v. regio/locatie/bereikbaarheid	Initiatiefnemer	?
Het niet kunnen voldoen aan specifieke eisen	7 Niet kunnen voldoen aan eisen t.a.v. gebouw/grootte/uitstraling	Initiatiefnemer	?
6 Eigenaar/belegger	8 Geen bereidheid tot verkoop van kantoorgebouw	Overleg met eigenaar	0

18.3.2 Gradual criteria

18.3.2.1 Location

LOCATIE					
ASPECT		**GRADUEEL CRITERIUM**		**GEGEVENS**	**Oor-deel**
FUNCTIONEEL					
1	Stedelijke ligging	1	Kantoor op afgelegen industrie-terrein of kantorenpark	Plattegrond gemeent	0
		2	Geen/zeer slechte bezonnings-mogelijkheden	Ter plaatse	0
		3	Slecht uitzicht t.g.v. andere bebouwing bij > 75% vl.opp.	Ter plaatse	0
2	Afstand/kwaliteit voorzieningen	4	Winkel voor dagelijkse boodschappen > 1 km.	Buurtonderzoek ter plaatse	0
	Opmerking: De kwaliteit van voor-	5	Buurt-ontmoetingsplaatsen (plein, park) > 500 m.	Idem	0
	zieningen kan beschreve worden in termen van	6	Horeca (van snackkar tot café/restaurant) > 500 m.	Idem	0
	goede staat, brede	7	Bank/postkantoor > 2 km.	Idem	0
	variëteit en aantal verschillende	8	Medische basisvoorziening (huisarts/wijkcentrum) > 5 km.	Idem	0
	voorzieningen.	9	Sportacc. (van fitnessclub tot zwembad/sportpark) > 2 km.	Idem	0
		#	Onderwijsacc. (van peuteropvang tot universiteit) > 2 km.	Idem	0
3	Bereikbaarheid met oper	#	Afstand tot station > 2 km.	Plattegrond	0
	baar vervoer	#	Afstand bus/metro/tram > 1 km.	Plattegr. of OV dienst	0
4	Bereikbaarheid met auto en parkeren	#	Veel obstakels/belemmeringen; slechte doorstroming	Ter plaatse	0
	Obstakels: versmallinger drempels, bruggen	#	Afstand tot parkeerplaatsen > 250 m.	Ter plaatse of nieuw ontwerp	0
	Doorstroming: 1-richting verkeer, park.verb., files	#	< 1 parkeerplaats per 100 m² te realiseren VVO	Ter plaatse of nieuw ontwerp	1
CULTUREEL					
5	Representativiteit	#	Ligging buiten of tegen stadsrand (b.v. langs snelweg)	Plattegrond of makelaar	0
	Opmerking: Oordeel ligging afhankel van doelgroep	#	Geen andere gebouwen aanwezig in directe omgeving	Plattegrond of makelaar	0
	b.v. jongeren niet in	#	Levenloze omgeving	Ter plaatse	0
	monofunctionele wijk	#	Afwezigheid van buurtgroen	Ter plaatse	1
	b.v. 55+ niet aan stadsrand	#	Slechte reputatie sociaal milieu, imago, vandalisme	Ter plaatse en locale pers	0
		#	Gevaar, stank- of geluidoverlast (fabrieken, trein, auto's)	Ter plaatse	0
JURIDISCH					
6	Stedelijke ligging	#	De geluidbelasting op de gevel > 50 dB (grens kantoren 60dB)	Gemeente	1
7	Grondeigendom	#	Erfpacht	Makelaar	0

18.3.2.2 Building

GEBOUW			
ASPECT	GRADUEEL CRITERIUM	GEGEVENS	Oor-deel
FUNCTIONEEL			
1 Bouw- of renovatiejaar	1 Kantoor is recent gebouwd (< 3 jaar)	Bouwjaar	0
	2 Recent tot kantoor gerenoveerd (< 3 jaar)	Renovatiejaar	0
2 Leegstand	3 Kantoor staat gedeeltelijk leeg	NEPROM o.i.d.	1
	4 Kantoor staat < 3 jaar leeg	Idem	0
3 Nieuwe wooneenheden	5 Capaciteit ≤ 20 1p-eenheden realiseerbaar à 50 m²	≥ 1000 m² VVO	0
	6 Geen plattegronden inpasbaar voor lokale doelgroepen	Schetsontwerp	0
4 Uitbreidbaarheid	7 Geen horizont. uitbreidbaarheid mogelijk (aanliggende bebouwing)	Ter plaatse	1
	8 Geen optoppen mogelijk (hellend dak; te lichte constructie)	Ter plaatse	1
	9 Geen mogelijkheden om kelder onder gebouw te realiseren	Ter plaatse en/of makelaar	1
TECHNISCH			
5 Staat van onderhoud	# Veel achterstallig onderhoud, verpauperd	Ter plaatse, buitenschil	0
6 Afmetingen casco	# Kantoordiepte < 10 meter	Makelaar of ter plaats	0
Stramien gevel: plaatsin	# Stramien draagconstr. < 3.60 m	In gebouw; makelaar	0
mogelijkheid wanden	# Verdiepingshoogte > 6.00 m	In gebouw; makelaar	0
7 Draagconstructie (wand	# Staat draagconstr. slecht/gevaarlijk	Ter plaatse, in geb.	0
8 Gevel *Buitenruimtes afhankelijk*	# Geen aansluitmogelijkheden of stramien > 5.40 m	Ter plaatse; makelaa	0
van doelgroep	# Gevel(openingen) niet aanpasbaar	Ter plaatse	0
Monumentale status: beperkte aanpasbaarheid	# Ramen in gevels kunnen niet hergebruikt/geopend worden	Ter plaatse of nieuw ontwerp	0
9 Installaties	# Geen of onvoldoende leiding-schachten realiseerbaar	Ter plaatse of nieuw ontwerp	0
CULTUREEL			
# Representativiteit *Relatie met locatie punt*	# Helemaal niet herkenbaar t.o.v. omringende gebouwen	Ter plaatse	0
Representativiteit	# Helemaal geen eigen woon-identiteit te realiseren	Ter plaatse of nieuw ontwerp	0
# Ontsluiting (entree/liften/trappen)	# Onduidelijke, onveilige, onover-zichtelijke gebouwentree	Ter plaatse of nieuw ontwerp	0
JURIDISCH			
# Milieu *Licht, lucht, geluid,*	# Aanwezigheid van grote hoeveel-heid gevaarlijke stoffen	Ter plaatse of gemeente	0
schadelijke materialen	# Geluidsisolatie vloeren < 4 dB	Ter plaats./nieuw ont	1
	# Zeer slechte warmte-isolatie gevels en/of dak	Ter plaatse of gemeente	1
	# Daglichttoetreding < 10% vloeropp. nieuwe eenheden	Ter plaatse	0
# Bouwbesluiteisen; bereik baarheid; vluchtwegen	# Geen liften aanwezig/realiseerbaar in gebouw (> 4 verd.)	Ter plaatse; makelaa	0
	# Geen (nood)trappenhuis(zen)	Ter plaats./nieuw ont	0
	# Afstand van nieuwe eenheden tot trap en/of lift ≥ 50 m	Ter plaatse of nieuw ontwerp	0

18.3.3 Transformation class

Transformatiescore	Transformatieklasse
Locatie + Gebouw = 0 - 40	1 = Zeer goed transformeerbaar
Locatie + Gebouw = 41 - 80	2 = Transformeerbaar
Locatie + Gebouw = 81 - 120	3 = Beperkt transformeerbaar
Locatie + Gebouw = 121 - 160	4 = Nauwelijks transformeerbaar
Locatie + Gebouw = 161 - 199	5 = Niet transformeerbaar

Totaal Score A + B:	**33**
Min. score Loc. + Geb. =	0
Max. score = 115 + 84 =	199
TRANSFORMATIEKLASSE:	**1**

18.4 Cases

18.4.1 Main case, input

Greencalc scores

Basis; Do nothing

Basis once off load	8.533	**per year**
Energy load	30.883	**per year**
Water load	683	**per year**

Demolition & new build Traditional Office

Extra once off load	8.167	**per year**
New energy load	24.100	**per year**
New Water load	630	**per year**

Renovation

Extra once off load	1.477	**per year**
New energy load	27.700	**per year**
New Water load	683	**per year**

Demolition & new build Traditional Dwellings

Extra once off load	5.567	**per year**
New energy load	19.833	**per year**
New Water load	4.000	**per year**

Extensive renovation

Extra once off load	5.333	**per year**
New energy load	23.100	**per year**
New Water load	580	**per year**

Demolition & new build Sustainable Office

Extra once off load	6.633	**per year**
New energy load	21.767	**per year**
New Water load	460	**per year**

Transformation TR dwellings

Extra once off load	4.733	**per year**
New energy load	19.833	**per year**
New Water load	3.800	**per year**

Demolition & new build Sustainable Dwellings

Extra once off load	4.900	**per year**
New energy load	19.300	**per year**
New Water load	2.087	**per year**

Transformation SUS dwellings

Extra once off load	2.500	**per year**
New energy load	19.500	**per year**
New Water load	2.160	**per year**

18.4.2 Case 1, input

Greencalc scores

Basis; Do nothing		
Basis once off load	5.812	**per year**
Energy load	20.850	**per year**
Water load	476	**per year**

Demolition & new build Traditional Office		
Extra once off load	5.571	**per year**
New energy load	16.641	**per year**
New Water load	476	**per year**

Renovation		
Extra once off load	929	**per year**
New energy load	19.754	**per year**
New Water load	476	**per year**

Demolition & new build Traditional Dwellings		
Extra once off load	3.687	**per year**
New energy load	13.634	**per year**
New Water load	2.742	**per year**

Extensive renovation		
Extra once off load	3.713	**per year**
New energy load	16.641	**per year**
New Water load	414	**per year**

Demolition & new build Sustainable Office		
Extra once off load	4.601	**per year**
New energy load	14.739	**per year**
New Water load	331	**per year**

Transformation TR dwellings		
Extra once off load	3.104	**per year**
New energy load	13.634	**per year**
New Water load	2.018	**per year**

Demolition & new build Sustainable Dwellings		
Extra once off load	3.274	**per year**
New energy load	12.991	**per year**
New Water load	1.412	**per year**

Transformation SUS dwellings		
Extra once off load	3.090	**per year**
New energy load	13.245	**per year**
New Water load	1.412	**per year**

18.4.3 Case 2, input

Greencalc scores

Basis; Do nothing				***Demolition & new build Traditional Office***		
Basis once off load	12.618	**per year**		Extra once off load	12.031	**per year**
Energy load	50.308	**per year**		New energy load	36.690	**per year**
Water load	1.158	**per year**		New Water load	1.007	**per year**
Renovation				***Demolition & new build Traditional Dwellings***		
Extra once off load	2.254	**per year**		Extra once off load	8.313	**per year**
New energy load	44.283	**per year**		New energy load	30.378	**per year**
New Water load	1.158	**per year**		New Water load	6.719	**per year**
Extensive renovation				***Demolition & new build Sustainable Office***		
Extra once off load	7.842	**per year**		Extra once off load	9.673	**per year**
New energy load	35.254	**per year**		New energy load	33.889	**per year**
New Water load	1.007	**per year**		New Water load	804	**per year**
Transformation TR dwellings				***Demolition & new build Sustainable Dwellings***		
Extra once off load	7.131	**per year**		Extra once off load	7.308	**per year**
New energy load	30.378	**per year**		New energy load	29.579	**per year**
New Water load	6.719	**per year**		New Water load	3.460	**per year**
Transformation SUS dwellings						
Extra once off load	7.097	**per year**				
New energy load	29.579	**per year**				
New Water load	3.674	**per year**				

18.4.4 Case 3, input

Greencalc scores

Basis; Do nothing				***Demolition & new build Traditional Office***		
Basis once off load	7.204	**per year**		Extra once off load	6.883	**per year**
Energy load	21.496	**per year**		New energy load	19.062	**per year**
Water load	412	**per year**		New Water load	412	**per year**
Renovation				***Demolition & new build Traditional Dwellings***		
Extra once off load	1.236	**per year**		Extra once off load	4.690	**per year**
New energy load	18.977	**per year**		New energy load	15.462	**per year**
New Water load	412	**per year**		New Water load	2.619	**per year**
Extensive renovation				***Demolition & new build Sustainable Office***		
Extra once off load	4.502	**per year**		Extra once off load	5.591	**per year**
New energy load	17.218	**per year**		New energy load	16.706	**per year**
New Water load	329	**per year**		New Water load	252	**per year**
Transformation TR dwellings				***Demolition & new build Sustainable Dwellings***		
Extra once off load	4.000	**per year**		Extra once off load	4.140	**per year**
New energy load	15.462	**per year**		New energy load	15.346	**per year**
New Water load	2.719	**per year**		New Water load	1.400	**per year**
Transformation SUS dwellings						
Extra once off load	3.486	**per year**				
New energy load	15.346	**per year**				
New Water load	1.400	**per year**				

18.5 Documents expert meeting

Since all members of the expert panel were Dutch these document were provided in Dutch only.

18.5.1 Agenda expert meeting

Agenda expert meeting

Vacant office buildings: what is the most sustainable solution?

Sascha Jansz, TU Delft Real Estate & Housing, CBRE Building & Workplace consultancy

Tijd: 15.30 – 18.00

Locatie: CBRE Rotterdam

- Introductie 15.30
    - 30 min. presentatie over het onderzoek en de voorlopige resultaten.
        - Onderzoeksopzet
        - Gebruik van Greencalc
        - Lineaire afschrijving of annuïteit
        - Bepaling van de ESL
        - Factoren in de ESL
        - Voorlopige resultaten

- Ruimte voor vragen & discussie 16.00
    - Topic 1: Lineaire afschrijving of annuïteit
    - Topic 2: Factoren in de ESL
    - Topic 3: Voorlopige resultaten

- Invullen feedbackformulieren 17.30

18.5.2 Introduction to the research

Inleiding expert meeting

Vacant office buildings: what is the most sustainable solution?

Sascha Jansz, TU Delft Real Estate & Housing, CBRE Building & Workplace consultancy

Het Onderzoek

Met een huidig leegstandspercentage van 14% (t.o.v. een 'gezond' percentage van 5-8%; CBRE 2012) is leegstand een actueel probleem in de Nederlandse kantorenmarkt. Onder andere het 'Actieplan leegstaande kantoren' streeft ernaar om het leegstandspercentage te verminderen door het onttrekken van leegstaande kantoren aan de markt. Dit kan grofweg op twee verschillende manieren gebeuren:

1) Door sloop
2) Door functie wisselingen

Hierbij word vaak gesteld dat hergebruik duurzamer is dan sloop, maar een ander veelgehoord argument is dat nieuwbouw zoveel energiezuiniger is dat dit het verschil in materiaalgebruik ruimschoots opheft.

Om deze argumenten te kunnen onderbouwen moet een vergelijking worden gemaakt van de duurzaamheid van mogelijke strategieën bij leegstaande kantoorgebouwen. Hierbij kan gebruikt gemaakt worden van bestaande modellen zoals BREEAM en Greencalc, maar deze houden geen rekening met de te verwachten levensduur van een gebouw. In dit onderzoek is de toevoeging van de te verwachten levensduur van het gebouw en de invloed hiervan op duurzaamheid centraal gesteld. Daarnaast is het ontwerp van de verschillende strategieën niet als primaire factor opgenomen omdat dit vaak in de initiatieffase nog niet gemaakt is.

18.5.3 Begrippen

Het begrip levensduur in dit onderzoek is ook te vervangen door het begrip gebruikersduur. Als het gebouw aan het einde van zijn gebruikersduur is betekend dit niet dat het gebouw op instorten staat, maar wel dat het leeg zal staan. Omdat hiermee dan ook de functionele levensduur ten einde is word het overkoepelende begrip levensduur gebruikt. De Engelse term hiervoor is 'Estimated Service Life' oftewel: ESL

Het begrip duurzaamheid in dit onderzoek omvat allen de Planeet kant van het 3-P model. Het houdt alleen rekening met materialen, energie en water. Andere onderdelen van duurzaamheid, zoals gezondheid en winstgevendheid, blijven hier dus buiten beschouwing.

Het onderzoek is uitgevoerd als afstudeeronderzoek aan de TU Delft in de master Real Estate & Housing, afdeling Real Estate Management. Daarnaast is het onderzoek uitgevoerd als afstudeerstage bij CBRE, afdeling Building & Workplace Consultancy.

Functie van de expert meeting

Door het houden van een expert meeting zal het onderzoek extra worden gevalideerd en aangescherpt. Tijdens de meeting zal de opzet en uitvoering van het onderzoek worden toegelicht en de voorlopige resultaten zullen worden behandeld. Hierbij is er veel ruimte voor vragen, opmerkingen en discussie en deze input zal ook worden gebruikt om het onderzoek te verscherpen en af te ronden.

Vraag- en doelstelling

De hoofdvraag van het onderzoek is:

Wat is het effect van de geschatte levensduur (Estimated Service Life, ESL) op het meten van de duurzaamheid van mogelijke strategieën voor leegstaande kantoorgebouwen?

Doel van het onderzoek is dan ook om een model te ontwikkelen wat rekening houd met de te verwachten levensduur van een gebouw. Dit model moet in de initiatieffase gebruikt kunnen worden om mogelijke strategieën te vergelijken op duurzaamheid.

Overzicht van mogelijke strategieën:

De mogelijke strategieën voor leegstaande kantoorgebouwen die in dit onderzoek zijn gebruikt zijn:

Mogelijke strategieën	Beschrijving
Consolidatie	Niks doen
Renovatie	Vervanging van installaties en interieur
Grondige renovatie	Strippen tot het casco en opnieuw inrichten als kantoor
Traditionele transformatie	Strippen tot het casco en ombouwen tot appartementen
Duurzame transformatie	Strippen tot het casco en ombouwen tot appartementen met de ambitie om een A^{++} of BREEAM Excellent label te halen
Traditionele sloop en nieuwbouw kantoor	Sloop en vervangen door compleet nieuw kantoor dat voldoet aan alle bouwvoorschriften
Traditionele sloop en nieuwbouw appartementen	Sloop en vervangen door compleet nieuw appartementengebouw dat voldoet aan alle bouwvoorschriften
Duurzame sloop en nieuwbouw kantoor	Sloop en vervangen door compleet nieuw kantoor met de ambitie om een A^{++} of BREEAM Excellent label te halen
Duurzame sloop en nieuwbouw appartementengebouw	Sloop en vervangen door compleet nieuw kantoor met de ambitie om een A^{++} of BREEAM Excellent label te halen

Werkwijze

Het nieuwe duurzaamheidsmodel zal worden vormgegeven in Excel en zal worden gebaseerd op resultaten uit het programma Greencalc. Hierbij is voor Greencalc gekozen omdat dit een gemonetariseerde output levert die met de levensduur kan worden verrekend. Dit model zal de volgende dingen uitrekenen:

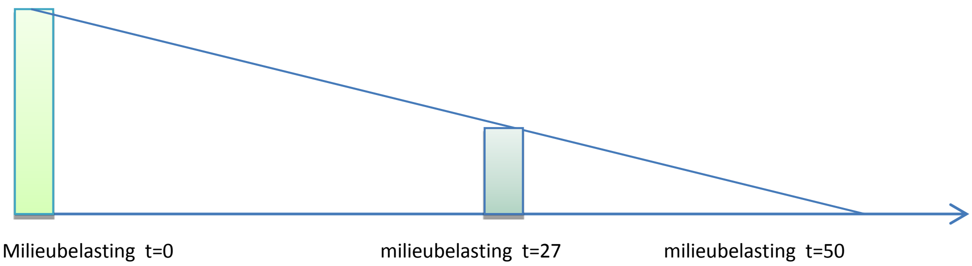
1) De resterende milieubelasting van het originele gebouw
2) De verwachte levensduur (ESL) van de verschillende strategieën.
3) De milieubelasting per jaar na het uitvoeren van de verschillende strategieën.

Resterende milieu belasting

Om het originele gebouw te kunnen construeren is er een bepaalde milieubelasting veroorzaakt. Deze belasting wordt uitgerekende met behulp van de materialen component van het programma Greencalc. Bij de bouw van het gebouw is deze milieubelasting geaccepteerd als noodzakelijk, hierbij in het achterhoofd houdend dat het gebouw de komende 50 jaar, de algemene referentielevensduur voor kantoren, gebruikt zou worden.

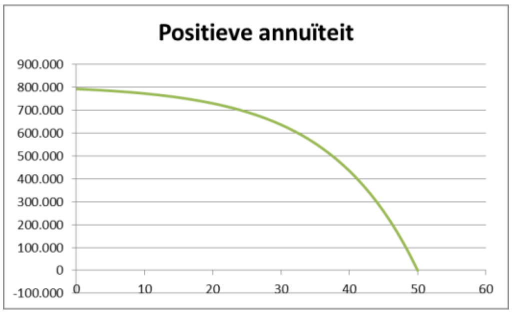
Op dit moment staat het gebouw echter al enige tijd leeg en is de gebouweigenaar op zoek naar een oplossing. Als we aannemen dat het gebouw in 1985 is gebouw is de huidige leeftijd 27 jaar. Dit betekend dat het gebouw nog 23 jaar functioneel zou moeten zijn om aan de oorspronkelijke verwachtingen te voldoen.

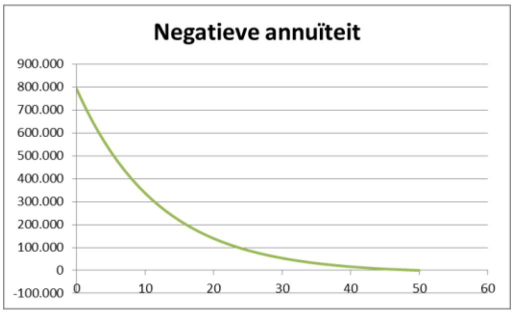
Dit betekend ook dat de originele milieubelasting van het gebouw nog niet volledig is afbetaald. Welk deel hiervan nog over is kan worden bepaald met behulp van het Lifespan accounting model van Andy van den Dobbelsteen (2004).



Lineair of annuïteit?

Een vraag die centraal zal staan is of een lineaire afschrijving van de milieubelasting de beste wijze is om deze af te schrijven, of dat een vergelijking met het annuïteiten model zoals gebruikt bij hypotheken kan worden gemaakt. Ook de invloed van deze keuze op de resultaten zal hierbij worden behandeld.





De te verwachten levensduur; ESL

Om de geschatte levensduur van de strategieën te bepalen wordt gebruikt gemaakt van de 'improved factor method' zoals beschreven door Haico van Nunen (2010). Hierbij worden de factoren die van invloed zijn op de levensduur van een gebouw gewogen vermenigvuldigd om de te verwachten levensduur te bepalen.

Hierbij is de aanname gemaakt dat de locatie in alle gevallen hetzelfde is. Daarnaast zijn ook andere bepalende factoren zoals de kwaliteit van de aannemer en het gedrag van de gebruiker gelijk gesteld. Daardoor kunnen een aantal factoren uit de improved factor method worden weggestreept omdat deze in alle gevallen 1 zijn. De overgebleven factoren en hun weging zijn:

Factor	Weging
Kwaliteit van de componenten	1.89
Trends	1.19
Binnenklimaat	0.51

De statistische verdeling die in the improved factor method word toegepast is in dit onderzoek niet overgenomen omdat een eenduidige schatting duidelijker is. Daarnaast is het model gebaseerd op meerdere geschatte waardes waarbij geen statistische verdeling is gebruikt, zoals de Greencalc scores. De uiteindelijke uitkomst van het model moet dan ook niet als een absoluut getal worden opgevat, maar als vergelijkingsgereedschap voor de verschillende strategieën.

18.5.4 Toekennen van de factoren

Om de ESL te kunnen beredeneren moet er een waarde aan de verschillende factoren worden toegekend op basis van de prestaties van het bestaande gebouw. Hierbij word eerst gekeken naar de kwaliteit van de componenten, dan naar trends in de kantorenmarkt en tot slot naar het binnenklimaat.

Component	Mogelijke score	Betekenis slechtste score	Betekenis beste score
Casco (incl. fundering)	0 -10	Kan niet worden hergebruikt, bijvoorbeeld door aantasting met betonrot.	Zonder aanpassingen word een betere score gehaald dan in het referentiegebouw
Gevel	0 - 10	Kan niet worden hergebruikt omdat deze niet aanpasbaar is om aan de huidige normen te voldoen.	Zonder aanpassingen word een betere score gehaald dan in het referentiegebouw

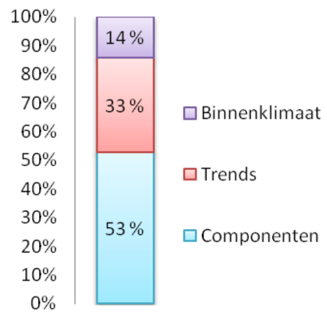
Trends	Mogelijke score	Betekenis slechtste score	Betekenis beste score
Marktpositie	0 - 10	Onderkant van de kantorenmarkt; 90% van de overige kantoren zijn van betere kwaliteit	Bovenkant van de kantorenmarkt; slechts 10% van de overige kantoren zijn van gelijkwaardige kwaliteit of beter
Leegstandspercentage	0 -20 %	(Meer dan) een kwart van de kantoren staat leeg, alleen de beste kantoren vinden een nieuwe huurder	Er is een tekort op de kantorenmarkt waardoor vrijwel alle kantoren nieuwe huurders kunnen vinden.

Binnenklimaat	Mogelijke score	Betekenis slechtste score	Betekenis beste score
Gebruikersbeoordeling	Zeer slecht – zeer goed	Het huidige gebouw veroorzaakt veel klachten bij de (oude) gebruiker en is niet aanpasbaar	Het gebouw veroorzaakt geen klachten
Metingen	Ver buiten de toegestane marge – ver binnen de toegestane marge	Het gebouw voldoet niet aan het bouwbesluit en kan niet zonder grove aanpassing voldoende worden verbeterd	Het gebouw presteert beter dan nodig voor het bouwbesluit

Bepaling van de factoren

De gegeven score van 0 – 10 word in het model omgerekend naar de juiste factor. Deze factoren liggen tussen 0 en 2, waarbij 1 gelijk is aan het gebruikte referentie gebouw. Dit referentiegebouw is een traditioneel nieuwbouwkantoor wat aan alle eisen van het bouwbesluit voldoet maar waarbij geen rekening gehouden is met duurzaamheid.

De opbouw van de ESL wordt bepaald door de wegingsfactoren (zie hiernaast). Het grootste aandeel hierin is de kwaliteit van de componenten, gevolgd door trends. Het aandeel van het binnenklimaat is klein in vergelijking met de andere twee factoren.



Nieuwe milieubelasting per jaar

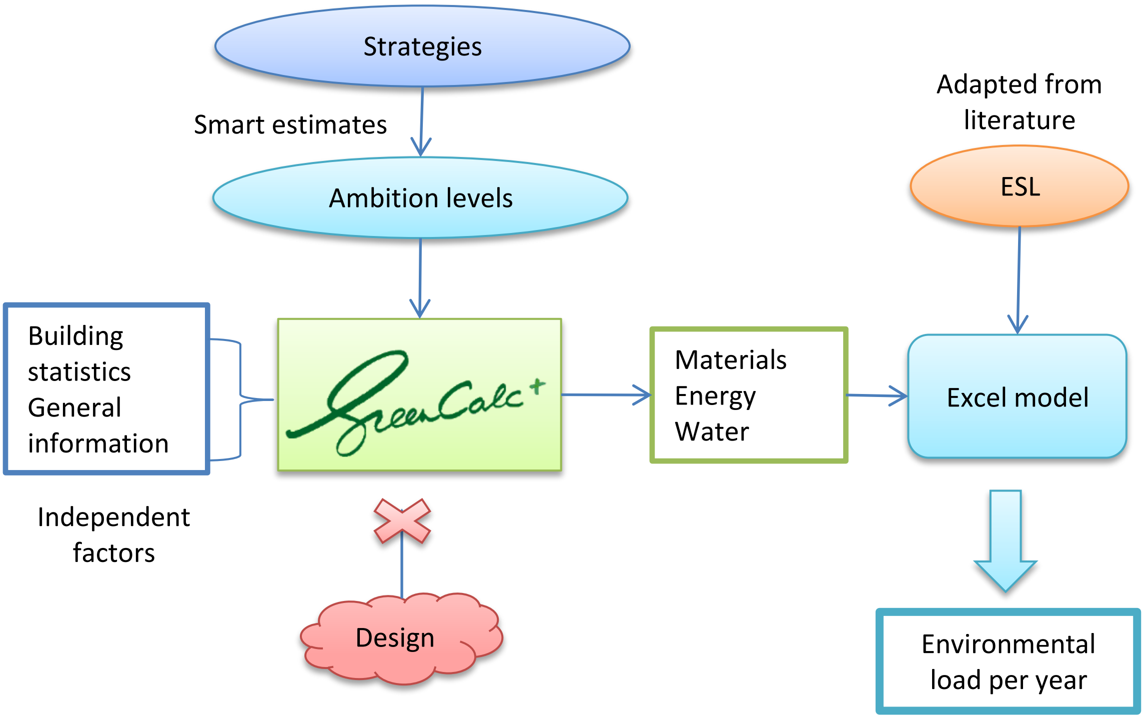
Na het berekenen van de resterende milieubelasting voor materialen voor zowel een lineaire afschrijving als een positieve of negatieve annuïteiten afschrijving wordt het energie- en waterverbruik berekend. Dit gebeurd door de Greencalc scores te vermenigvuldigen met de beredeneerde ESL. Vervolgens wordt dit uitgedrukt in een milieubelasting per jaar waarna de verschillende strategieën met elkaar vergeleken kunnen worden. De strategie met de laagste milieubelasting per jaar is daarbij het meest duurzaam.

Het model

Om uiteindelijk de milieubelasting per jaar te berekenen is het model gebaseerd op de door Greencalc berekende milieubelasting voor materialen, energie en water. Deze worden voor iedere strategie berekend door karakteristieken en installaties in te voeren en deze te combineren met ‘ambition levels’. Deze ambitie niveaus worden gebaseerd op de uitgangspunten voor de strategie:

Beschrijving gebouw	Ambitie niveau materialen (in te voeren in Greencalc)
Bestaand traditioneel gebouw	120 – 135
Traditioneel nieuw te bouwen gebouw	130 – 150
Duurzaam nieuw te bouwen gebouw (A^{++} of BREAAM Excellent)	145 - 170

Deze scores worden voor alle strategieën bepaald en in het model ingevoerd. De opzet van het model is dan als volgt:



Figuur 1: opbouw model

Opzet van het model

Tijdens de meeting zal het model verder worden toegelicht en zullen de voorlopige uitkomsten worden behandeld. Daarna zal er ruimte zijn voor vragen en discussie over de gebruikte methode en wellicht onverwachte resultaten. Hierbij zijn verschillende cases getoetst aan het model.

18.5.5 Feedback forms

Feedbackformulier

Expert meeting Sascha Jansz, 07-05-2012

Dit formulier is bedoeld om een overzicht te creëren van alles vragen en suggesties uit de expert meeting. Dit zal worden gebruikt om alles in het onderzoek en rapport te kunnen verwerken.

Gegevens respondent

Naam:

Telefoonnummer:

E-mail:

Wil graag een kopie ontvangen van het uiteindelijke rapport: Ja/Nee

Discussietopic 1: Resterende milieubelasting: Lineaire afschrijving of annuïteit?

Heeft u naar aanleiding van de presentatie en discussie nog vragen over dit onderwerp?

Heeft u naar aanleiding van de presentatie en discussie nog aanvullingen?

Discussietopic 2: Van gebouwbeoordeling naar 'Estimated Service Life'

Heeft u naar aanleiding van de presentatie en discussie nog vragen over dit onderwerp?

Heeft u naar aanleiding van de presentatie en discussie nog aanvullingen?

Discussietopic 3: Effecten in de praktijk en voorlopige resultaten

Heeft u naar aanleiding van de presentatie en discussie nog vragen over dit onderwerp?

Heeft u naar aanleiding van de presentatie en discussie nog aanvullingen?

Overige opmerkingen

18.6 Planning