

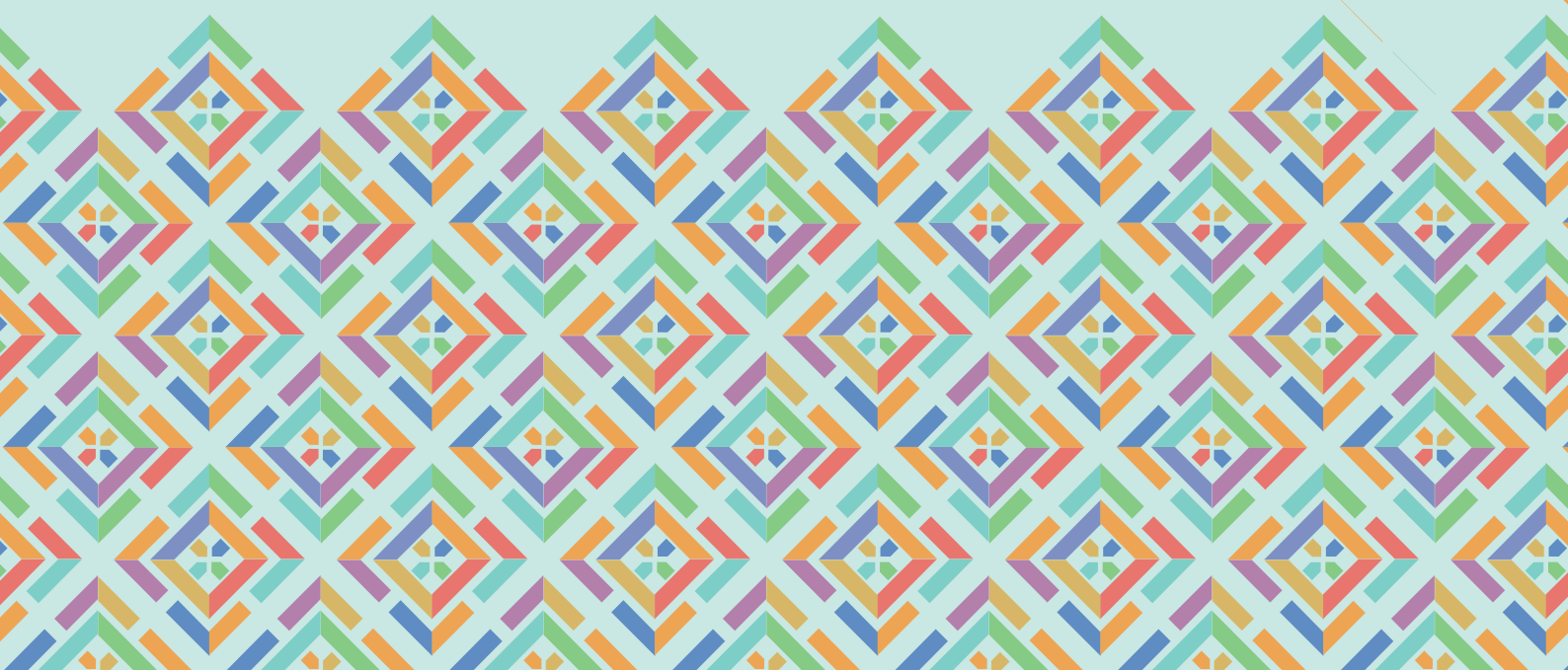
# USE THE USER

Achieving energy reduction of  
an office building by activating  
pro-environmental behaviour  
of office users

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Master Thesis

26th of June 2019





## COLOPHON

*Graduation Master Thesis*



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" In theory, theory and practice are the same. In practice, they are not"  
- *Jan L.A. van der Snepscheut*-



## **PREFACE**

In front of you lies my thesis concerning the activation of pro-environmental behaviour of office-users to reduce the energy performance of an office building in use.

This report is a result of my hard work during my graduation period and ending of my Masters. During this period, I have learned a lot about myself and the technical world around me. I can safely say that I am proud of my accomplishment. The research was born from a personal interest during my traveling and leads to learning more about the impact office buildings have on the environment. However, this research also shows that a lot of change needs to be made in the world and that we have a long way to go. I hopefully can say that you, as the reader, can learn just as much about this topic as I have.

This leaves me with the opportunity to thank all the persons who has helped me over the last months to make this research possible. In particular I want to thank my mentors Philip Koppels and Laure Itard for consulting and motivating me during the process. I also want to thank Bert Elkhuisen for his help with calculating the energy performance gap with the E-nolis software, the interviewees, the participants of the delphi panels and all participating companies for the cases. Finally, the DGBC “end-user” workgroup and especially Yvette Watson from PHI accelerator for the support, continuous interest, network resources and challenging discussion.

Annabel Jansen  
July 2019

## SUMMARY

The Dutch government claims that upgrading office buildings to an energy label C building is enough to reduce the environmental footprint of companies for now. Research has shown that when a building receives an energy label, it does not mean that the operational energy use of the building is in line with the received energy label; this results into an energy performance gap. The gap consists of the building-related energy use or the user related energy use. This research focusses on how the behaviour of office users can be influenced to reduce the energy performance of an office building in use.

This research is divided into four parts. First the energy performance gap is discussed, afterwards measures which influence the energy performance of an office building are researched, followed by which factors stimulate pro-environmental behaviour and finally which methods are effective to implement the measures and behavioural changes.

First, the energy performance gap can be explained by the difference between the theoretical energy label and the operational energy use. There are two possible causes for this gap: the building related energy use or the user related energy use. This research focusses on how to reduce the user-related energy by activating the user behaviour.

Secondly, during this study a measurement list is developed to show possible measures to reduce the energy performance and environmental impact of a building. Significant change can be achieved, not by implementing these measures on a small scale (one office), but on a large scale (all offices). It is also the case that these types of measures will not always have a significant effect the environmental impact of the building or the energy use of the building, this depends on the current building characteristics. When a building already implements that measure, the impact will be less significant than when they do not use the measure.

The expectations from an expert on the impact of the introduced measures are higher than the actual impact of the measures according to literature. This leads to a gap between the expectations of measure impact and the actual impact. The facility managers and the company expect that they will perform more sustainably than they actually do. There are not many effective user-related measures on the market which significantly reduce the environmental impact of an office building.

Third, pro-environmental behaviour (PEB) is a behaviour type that focusses on minimizing the negative impact of the consequences of human behaviour on the environment (V. Blok et al., 2015). There are several factors which influence the pro-environmental behaviour of the user. There are two types of factors; external factors and internal factors. Social norms and economic factors are considered external and intention to act and environment knowledge are considered internal. The behaviour factors can be divided into three different degrees of influence. Based on literature, interviews and Delphi panels one behaviour diagram is introduced.

Trough literature, interviews and the delphi panels it can be concluded that comfort, economic and intention play an important role in shaping pro-environmental behaviour (Kollmuss & Agyeman, 2002). The factors which do have the highest impact on encouraging and stimulating Pro-environmental behaviour according to the users and experts are:

- Intention to act
- Perceived behaviour control
- Social norms
- Eco-communication

Finally, methods to activate these factors are related to the measure and how this measure affects the behaviour factors. In this research three examples of implementing measures are given. The three main methods to reduce the environmental impact of an office building and thereby activating the pro-environmental behaviour of the user are:

1. Pro-environmental behaviour guidelines
2. Eco- communication platform
3. Social incentives

Combining the methods will get the optimum result of the measures which are implemented.



These four parts combined answers the research question: How can the behaviour of office users be influenced to reduce the energy performance of office buildings in use?

Looking at office building scale the impact of the introduced measures are less significant than in comparison to the household scale. Low impact on office scale can mean a reduction of 1% where, the same low impact of 1% is equal to the energy reduction of 15 households. It is important to conclude on the right perspective.

There are different conflicting behavioural factors which have influence on the daily decisions of users. Behaviour factors such as perceived behaviour control have a strong relation to the environmental awareness and environmental knowledge of a person. The intention to act, social norms and eco-communication are three other behavioural factors with high influence on the behaviour of the office user. The behavioural factors influence the personal decision-making process of the user. To act pro-environmentally these factors needs to be activated, which results in pro-environmental behaviour

The behaviour of the office users can be influenced by implementing high impact measures with a method which activates the pro-environmental behaviour of the office users. Results from this research show that the behaviour of office users can be influenced to reduce the energy performance of office building, but the impact differs in each situation. During this research examples of measures and methods are given. Examples include implementing pro-environmental behaviour guidelines, an eco-communication platform and social incentives to activate the behavioural factors in a pro-environmental matter.

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# 01 PROBLEM

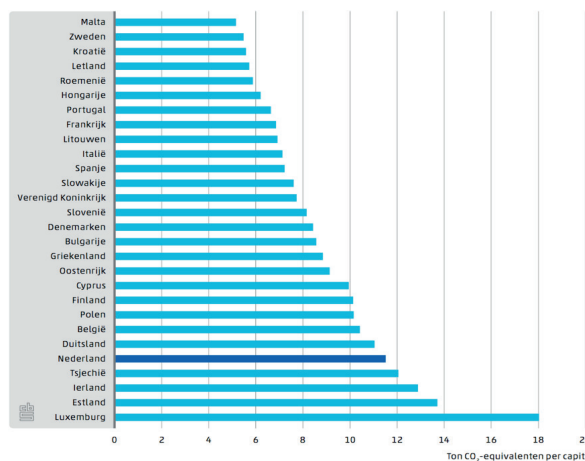
Human kind has a high impact on the habitability of the earth, which creates an actual field of research (V. Blok et al., 2015). The impact people have on environment is a highly discussed topic among researchers and citizens. What role does the behaviour of people on earth have on reducing the environmental impact? Minimizing the negative impact on the environment by behavioural changes is considered pro-environmental behaviour. Does the way people act influence the environmental impact on the planet?

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In most offices on the market the operational energy use is higher than the theoretical energy use based on the received energy label. The difference between the operational energy use and theoretical energy use can be influenced by the behaviour of the users in the office building. The government tries to keep up with the environmental changes to introduce measures for the office buildings to reduce their environmental impact. This chapter has the following structure. First the law changes and vision perspective of the Dutch government will be explained. Secondly, the relevance of the study will be discussed, which leads to the problem identification, problem statement and goals of the study. Finally, the research questions will be introduced.

## 1.1 LAW AND VISION

In 2012 the United Nations introduced the sustainable development goals (SDG). These goals are a platform of knowledge and all participants in the UN are improving their nation's goals in order reach these global sustainable development goals. In total there are 17 goals ranging from affordable and clean energy to gender equality ('Eurostat, your key to European statistics', 2018; United Nations, 2017). Annually, the results of these improvements are reviewed and published by the Statistics Netherlands (CBS), the official national institute for statistics. Recent publications show that the Netherlands is not sustainable enough to keep up with other European countries. The Netherlands is in 24th place when it comes to total greenhouse gas emissions per inhabitant and in 25th place for the sharing of renewable/new green energy, out of the 28 countries in the European Union as seen in figure 1.1 (CBS, 2018; Veenkamp, 2016). The Netherlands must improve their implementations in order to keep up with the other nations and the UN goals. Together with countries all over the world the climate agreement on energy for sustainable growth was created in Paris. The Paris Proof agreement is a Dutch initiative to reach the climate agreement earlier. The goal of the Paris Proof initiative is a fully sustainable energy supply, an office building may only use 50 kWh per square meter per year (de Jong, Elkhuisen, & Kool, 2018).



Bron: EEA. Figure 1.1: Ranking greenhouse gas emissions per inhabitant (CBS, 2018)

The Netherlands was one of the promoters of creating a sustainable future. The goal of the climate agreement is to create a sustainable future for the next generation (SER, 2013b, 2013a).

In accordance with the Paris agreement, the governments have to make all their utility building energy neutral by 2050. The Dutch Green Building Council (DGBC) implemented goals using these guidelines. The target is to reduce the maximum energy consumed by office buildings to 50 kWh per square meter by 2050 (DGBC, n.d.). The Dutch government took smaller steps by requiring office buildings to have an energy-label A by 2030 (an energy index of 1,0) and an energy-label C in 2023. The government attempts to achieve this goal by making it mandatory to have an energy efficient office (JLL & ADK, 2018; Rijksoverheid, 2016).

For office buildings consisting of more than 100 square meters, this goal is strictly enforced. If the goal is not met, the building must be abandoned, transformed or even demolished (S. A. Blok, 2016).

There are some exceptions. For example, when buildings already have plans to be renovated for increased sustainability, are going to be demolished within a time period of 2 years, when the financial cost of upgrading the building will not be regained within a 10 year time period, or when it is a monumental building (JLL & ADK, 2018,Arnolddussen, Zwet van, Koning, & Menkweld, 2016; Heijden van der, Poll van der, & Harrison, 2017). The changes that influence the current law and vision of the Dutch government are visualized in figure 1.2. The timeline shows the changes on three scales: World, Europe and The Netherlands.

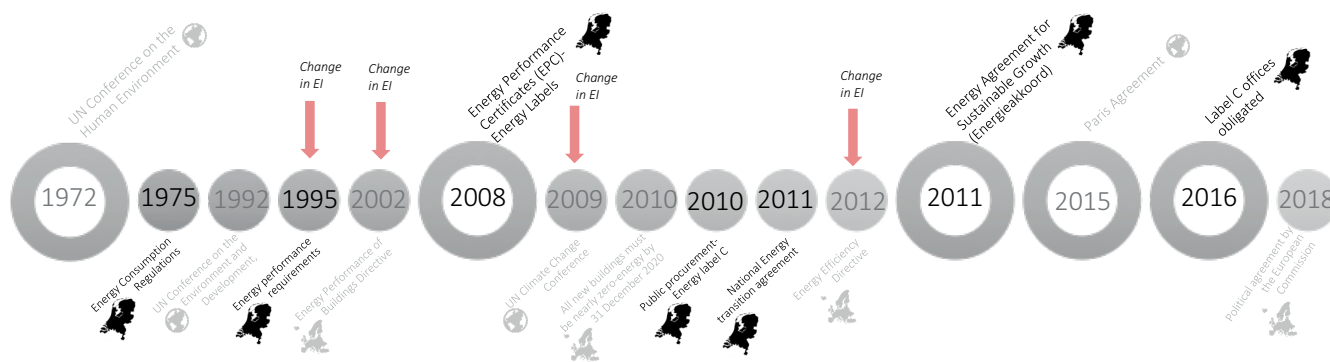


Figure 1.2: Timeline Dutch government related to sustainability (Own illustration)

## 1.2 RESEARCH RELEVANCE

The publication of the results of the sustainable development goals by CBS and Eurostat, marked a clear shift in societal relevance at the sustainable department of the Netherlands. The results published for the Netherlands were shocking. They came in 5th for most polluting countries of Europe, where polluting is defined as the total greenhouse gas emission per inhabitant in 2015 (CBS, 2018; Veenkamp, 2016). These publications confronted the government with the fact that the Netherlands is one of the least sustainable countries in Europe and that change is necessary to contribute to the sustainable future of the world.

Research shows that greenhouse gas emission contributes to global warming (National Geographic, n.d.; Palanichamy, 2011). A popular trend among the inhabitants of the Netherlands (and other countries) is living more sustainable (Chavan, 2017). GFK performed a study among consumers in the Netherlands about the sustainable contribution of companies (GFK, 2017). This study resulted that the society agrees that companies are not putting enough effort in acting more sustainable (GFK & b-open, 2017).

The growing demand of the inhabitants of the Netherlands and the goals that the Dutch government leads to the introduction of new laws and changes that are adding value to the sustainability of buildings (Arnolddussen et al., 2016; S. A. Blok, 2016). The law targeting minimal energy labels is an example of a law that makes the issue of pollution relevant to almost all companies who own or rent an office building. The concept of energy labels is introduced by the Dutch government to stimulate energy efficient changes, which indirectly stimulate the environmental awareness of the society (Europees parlement en de Raad, 2010). This shows that reducing the energy usage of offices has societal relevance for the companies, society and government.

Until now, minimum research has been conducted on environmental impact of energy label change for office buildings: a study by Majcen, Itrad and Visscher (2013) on the energy consumptions of dwellings and a study by TNO on the energy usage of utility buildings. The TNO research follows up on the research of Hoes- van Oeffelen, Spiekman, & Bulavskaya (2013) where the difference between the theoretical and operational energy use of utility buildings is first introduced. This research describes the problem, but does not propose a solution to reduce this noticed energy performance gap. Because of this energy gap, predicted energy savings are generally much less than achieved ones. This may be partly caused by the occupant's behaviour.

## 1.3 PROBLEM IDENTIFICATION

The energy agreement (2013), SDG's and the Paris agreement all have an influence on the future of the office supply. In 2016, the office supply was at its highest, and it was predicted that it would reduce by a small amount in the upcoming decade (Arnolddussen et al., 2016; Heijden van der et al., 2017). Due to the new energy law, it is uncertain whether it will reduce by just a small amount, or if the reduction will be larger. The law states that: **When an office does not meet the new requirement of owning the minimum label C it will be permanently closed or even demolished** (K. H. Ollongren, personal communication, 2018). Current researchers cannot predict clearly how many buildings will have their sustainability level upgraded before 2023 (Arnolddussen et al., 2016).

A market has come into existence in which companies offer ways to change the building into an energy efficient building as a service, to deal with this problem. Changing the office building into a sustainable building can be divided into two parts. Part one is changing the building technically and part two is changing the way people use the building.

The Dutch government claims that upgrading office building to an energy label C building is enough to reduce the environmental footprint of companies. Research has shown that when a building receives an energy label it does not mean that the operational energy use of the building is in line with the received energy label (Bortoluzzi, Costa, & Casciati, 2017; de Jong, Elkhuizen, & Kool, 2018). Owning a flexible, smart and sustainable building brings new facilities and user behaviour with it. There is a discrepancy here: the owners of the building expect an energy reduction due to the energy label C, but with ineffective use of the building this may result into an energy label E building (de Jong, Elkhuizen, & Kool, 2018).

An office building can be energy efficient, but maybe not energy efficient in use on the long-term. The government's point of view is that the energy label is not an energy prediction tool or supporting tool to predict the energy use, but the goal is to give a point of view on the energetic quality of a building in comparison to similar buildings and provide insight into potential energy-saving measures (Hoes- van Oeffelen, Spiekman, & Bulavskaya, 2013; Majcen, Itard, & Visscher, 2013).

The environmental performance gap has two possible reasons, augmented building specific energy use or user specific energy use. This research focuses specifically on the possible energy savings of the user-related energy use. On how the energy performance gap use can be minimised by changing the behaviour of office user.

This problem has impact on the government and the owner of the buildings, companies, building owners and the office-users. The energy performance gap influences the sustainable implementations on the building, the real estate, the ambition of the companies and the user's behaviour. Assuming that the building-related energy use is correct, the change can be made in the user-related energy use to reduce the energy performance gap between the theoretical energy label and the operational energy label.

To make change of user-related energy use possible, the behaviour of the user needs to be altered. Anti-environmental behaviour needs to be changed into pro-environmental behaviour. By having a pro-environmental behaviour, the negative impact of actions on the environment will be minimized by the behaviour of the person. When a user has a pro-environmental attitude, they constantly seek to minimize the negative impact.

To make clear who this research relies on, the understanding of user needs to be clarified. There are different levels of users contributing to this problem. It can be divided into three levels: 1) company board, 2) facility manager and 3) end-user or employee. During this research, there are two types of users. The company board and facility manager combined and the end-user. In this case the end-user (employee) is the person who should execute the measures, while the board and facility manager are the level that implements the measures. In the research, there is a clear division between the end-user (seen as employee) and the board / facility manager (seen as employer or management).

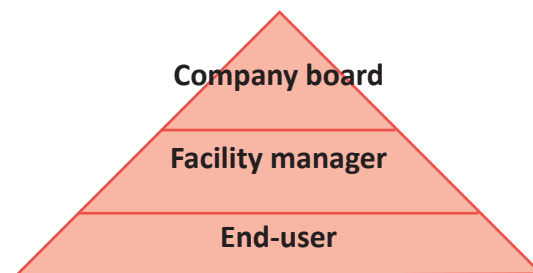


Figure 1.3: User Level (Own Illustration)

## 1.4 PROBLEM STATEMENT

The mismatch between the theoretical energy use as predicted by the energy label and operational energy use creates an energy performance gap. This gap results into a mismatch between expectation of the building's owners, users and the government. Office buildings are using more energy than estimated and with changes focused on user's behaviour, ambition, real estate choice or sustainable implementations this can be reduced. By introducing a method and measures on what activated the users to behave pro-environmentally, the total energy-costs of the user-related energy use will be reduced. This results in reduction of the energy performance gap due to the reduction of the operational energy costs.

## 1.5 GOALS

This research aims to give insight in ways to reduce the energy performance gap. The DGBC is a promotor of sustainable buildings in Netherlands. With different initiatives their mission is to make the built environment more sustainable (DGBC, n.d.). They developed the "end-user" workgroup, with the focus on what the end-user can change to make the office buildings industry more sustainable and innovative. The user in this workgroup are the facility manager and the office user as end-user. They are trying to develop a protocol for the period after the start of making office more sustainable. As participant in this workgroup the message of these research results can be widely distributed under participants.

The goal is to reduce the energy performance of office buildings in use, by changing the behaviour of the users in the buildings.



## 1.6 RESEARCH QUESTIONS

The main question this thesis answers in relation to this problem statement is: *How can the behaviour of office users be influenced in order to reduce the energy performance of office buildings in use?* The sub questions will scientifically support the main question in order to obtain the required result.

The body of this work is divided into four parts, each answering a sub-question.

### **Part 1: Energy performance gap**

*To what extent can the difference between the theoretical energy use and operational energy use, the so-called energy performance gap, be explained by occupant behaviour?*

### **Part 2: Measures to take**

*Which measures, technical, behaviour or organizational, are most effective at reducing the energy performance of an office building?*

### **Part 3: Behaviour stimulation**

*How can pro-environmental behaviour of the user be encouraged and stimulated?*

### **Part 4: Effective methods for influencing behaviour**

*How should the introduced measures be implemented to activate the pro-environmental behaviour of the user and thereby reducing the energy performance of an office building?*



# 02 METHODOLOGY

Four research methods are used during this study. By combining the methods a mixed study is created to answer the sub-questions. The research methods form a connection between the theory and the practice. Published literature, information retrieved from experts, case studies and Delphi panels are the base of this literature and empirical study. The theory combined with an empirical research results in answers to the main question. These study types make up the research design which is the body of this study.

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2.5.2 Delphi User Panel	

## 2.1 RESEARCH DESIGN

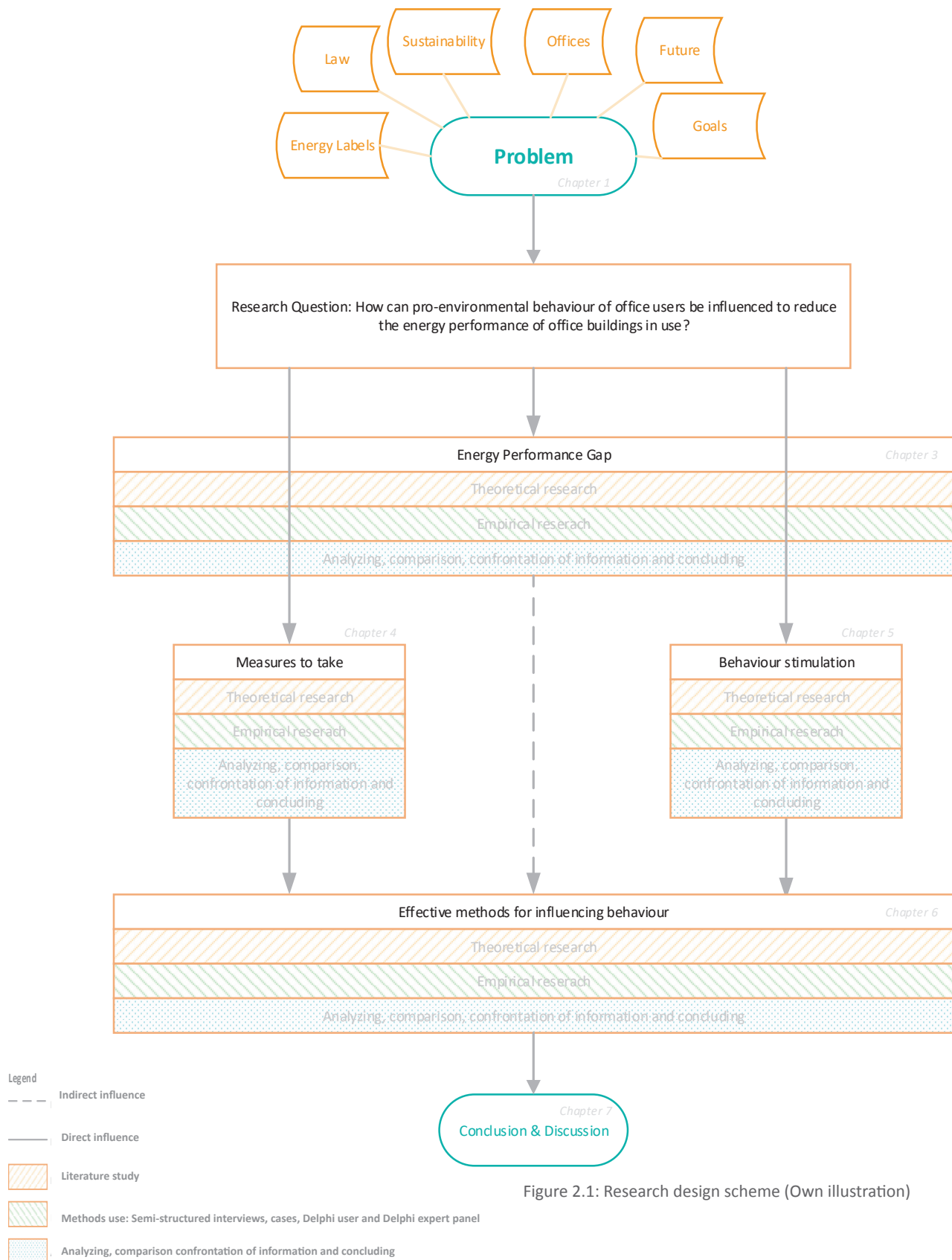


Figure 2.1: Research design scheme (Own illustration)

Each research question is divided into two parts, theoretical part and an empirical part. The parts are about observing and understanding the behaviour in relation to the research questions.

The theoretical part uses literature study as research type. As demonstrated in the research design the empirical research part consist of semi-structured interviews, case-studies and two types of delphi panels. The general information about the interviews, case-studies and delphi panels are presented in this chapter. The conclusions drawn from the analysed information are used in the sub chapters.

## 2.2 LITERATURE STUDY

The topics; energy performance gap, sustainable measures and behaviour stimulation are explained through literature research. The literature study is the basis for the theoretical framework of the research. This study does not contain one main theoretical framework, but each chapter contains a smaller theoretical framework.

## 2.3 SEMI-STRUCTURED INTERVIEWS

The first method of the empirical research is a series of five semi-structured interviews, which were held with five professionals. A semi-structured interview is defined as a meeting where the interviewer does not strictly follow a list of questions. All these professionals are experts in different areas such as facility management, implementation of pro-environmental behaviour, energy performance gap or changes in the workplace. Table 2.1 shows the main expertise of each interviewee and table 2.2 the main structure of the interview.

The two chosen facility management experts participate in the DGBC workgroup. Both experts are driven in promoting sustainable changes within the company they work for. Both experts are also involved with large parties who want to improve on sustainability. E-nolis is a company which researches and manages the energy performance gap constantly. The expert on the energy performance gap is the development director of E-nolis. Finally, two researchers with the expertise in the implementation of pro-environmental behaviour and behaviour workplace management are selected because of their past research.

The interviews are structured into five parts.

Depending on the expertise of the interviewee a

combination of topics is made. The discussion is the guide through the research in which the question is the guideline for the interview.

In the background & general knowledge part: the background of the research topic and current vision of the government and goals such as Paris Proof, SDG's and "het energie akkoord" were discussed in general. From there the energy label discussion started and explanation about the energy performance gap was asked. The following three parts were on the topic of pro-environmental behaviour, discussing aspects such as, what it is, possible measures and their implementation.

For example, with the two facility management experts all parts are discussed whereby with the interviewee specialised in implementation of pro-environmental behaviour the energy performance gap is not discussed and the vision of the government and goals were only briefly discussed. The main structure of the interview questions can be found in Appendix 1 and the transcripts of the interviews in Appendix 2.

The results of the interviews are presented with respect to the five main parts of the interview. The results are presented in two different ways. The first method is presenting the answers per topic. From these answers different statements are derived and together with the answers of all the interviewees a cross analysis is made. Some question results were redistributed to the correct topic, because of the lack of clear structure in the semi-structured interview format.

Table 2.1: Expertise overview

Interviewee:	Specialized in/ research done about:
Guido Meijer	Facility manager 1
Bert Elkhuisen	Energy performance gap specialist
Harm van de Boogaard	Facility manager 2
Renate Wesselink	Implementation of pro-environmental behaviour specialist
Margriet van Lidt	Behavioural workplace management specialist

Table 2.2: Interview structure

Parts
1. Vision & General knowledge
2. Energy Performance gap
3. Pro-environmental behaviour
4. Pro-environmental behaviour measures
5. Pro-environmental behaviour implementations

Table 2.3: Cross-analysis example

Topic	Facility manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behaviour specialist	Behavioural workplace specialist
Statement	X		(X)	-	X

When the interviewee agrees with the statement it is shown as “x”. “(x)” means that the interviewee agrees with the statement but has his concerns about it and the third options when no “x” is shown the interviewee does not agree with the statement or this particular statement is not discussed. When the particular part is not discussed with the interviewee due to the expertise this is shown as a “-”. Table 2.3 shows an example of the cross-analysis table.

## 2.4 CASE-STUDY

The second empirical study method used is case-studies, during this research three cases are used to represent the office market. The cases are chosen to represent different parts of the market. The representations range from energy label C until energy label A+ and not all cases have sustainability as their main focus.

In this research, the third case will function as an example case. The owners of this building have a sustainability focused vision based on building technical aspects and behavioural aspects.

The received information input is presented in this chapter. There is no direct relation between the participating cases and the performed semi- structured interviews. The case information is based on retrieved information from all four cases, the question list of each case can be found in Appendix 3.

All participating cases are office building, housing a single tenant. All cases provided information based on four topics

- General information
- Building specifications
- Energy specifications
- Behaviour specifications

### 2.4.1 CASE 1

#### General information

Case 1 is a building with a floor area of 37.350 m<sup>2</sup> consisting of a high rise of 22 floors and an overall floor height of five floors. The main function of the building is an office building with partly call-centres.

This building is built in 2 parts, the delivery of part one was in 1997 and the delivery of part two was in 2002. In 2011 the building had its sustainability upgraded to improve their current energy performance.

#### Building specifications

In this case people mainly work with laptops. The building has a wide range of openings hours, but the occupation rate is not always 100%. An 100% occupation rate only occurs Tuesday and Thursday, on Monday, Wednesday and Friday it sits between 60-80%. In the evenings and on Saturday the occupation rate is 10%. Which leads to the total building hours of 77 hours per week with partly 10 hours extra.

The building is based on 95% active based working, the additional 5% works traditional. There are 2.300 workplaces in the building and a total of 3.300 users. The building has additional facilities such as an employee cafeteria, elevators and escalators.

Opening hours:

Monday to Friday: 06:45-22:00

Saturday: 08:00-18:00

(Call-centre part)

#### Energy specifications

This office building owns an energy label C certificate. Between 2019 and 1997 the case added sustainable modifications to lower the energy label, which resulted in different energy consumption before the modifications and after the modifications. The modifications took place in 2011, and the energy consumption of 2011 and 2018 are as follows.

Table 2.4: Total energy use case 1

	Total	Per m <sup>2</sup>	Households per year*
<b>2018</b>			
<b>Gas consumption</b>	323.267 m <sup>3</sup>	4,56 m <sup>3</sup>	215
<b>Electricity consumption</b>	5.179.422 kWh	138,67 kWh	1523
<b>2011</b>			
<b>Gas consumption</b>	478.961 m <sup>3</sup>	12,82 m <sup>3</sup>	319
<b>Electricity consumption</b>	7.298.452 kWh	195,40 kWh	2146

\* General gas use of 1.500 m<sup>3</sup> per household and electricity of 3.400 kWh per household ('Hoe hoog is het gemiddelde energieverbruik | Essent', n.d.)

The main sustainable systems of the buildings are a Heat-cold storage, heat pump and LED-lighting.

#### Behaviour specifications

The company tries to promote sustainability in the behaviour of the office users. The experience of the facility manager indicated that even with this promotion the people do not care, especially because the work is activity based.

They also promote pro-environmental behaviour of the user by promoting the ambition towards a sustainable direction for the company, an example is the awareness program management. It is noticed that behavioural changes have occurred since the sustainable modifications in 2011.

## 2.4.2 CASE 2

### General information

This case consists of three smaller buildings which are connected to each other. The buildings have a floor area of 32.255 m<sup>2</sup> and are five floors high. The main function of the building is an office building.

The buildings consist of three parts, the delivery of building one was in 2001, building two in 2010 and building three in 2014. Case 2 did not upgrade their building sustainable the last couple of years, but owns a BREEAM-in-use certificate.

### Building specifications

In this case the main work method is supported by laptops. The building has a wide range of openings hours, but occupation rate is never 100%. On the Tuesday and Thursday it is around 80-90 %, on Monday, Wednesday and Friday lays between 70-60%. The evenings and Saturday the occupation rate is 5%. Due to a re-organisation, there are more workplaces (1328) than users (1058), occupation

which leads there never being an occupation rate of 100. The total building hours are around 50 hours per week.

The building is based on 5% active based working, the additional 95% works traditional. The building has additional facilities such as an employee cafeteria and elevators.

Opening hours:  
Monday to Friday: 06:00-22:00

### Energy specifications

The building consists of three smaller parts which leads to three energy labels. Building 1 owns energy label C, building 2 and 3 owns energy label A. The energy use of all three buildings cannot be separated from each other, thus this case will be treated as one big building and not 3 separate small buildings.

Table 2.5: Total energy use case 2

	Total	Per m <sup>2</sup>	Households per year*
<b>2018</b>			
<b>Gas consumption</b>	169.846 m <sup>3</sup>	5,27 m <sup>3</sup>	113
<b>Electricity consumption</b>	3.361.248 kWh	104,20 kWh	988

\* General gas use of 1.500 m<sup>3</sup> per household and electricity of 3.400 kWh per household ('Hoe hoog is het gemiddelde energieverbruik | Essent', n.d.)

The main sustainable systems of the buildings are a Gas fired central, Heat pump, heat meter and LED-lightning.

#### Behaviour specifications

This case does not promote sustainability from a corporate level, but they do promote pro-environmental behaviour of the user. If a user has an initiative the management will take into consideration.

### 2.4.3 CASE 3

#### General information

The owner of this building has as progressive sustainability goals for their buildings and their users. This building has a floor area of 24.750 m<sup>2</sup> and is 12 floors high. The main function of this building is an office building.

The building was delivered in 2010. This case did not upgrade their building the last couple of years, but it was built with sustainable goals in mind. This office building owns a BREEAM-in-use certificate.

#### Building specifications

In this case the main work method is supported by laptops. The building has a wide range of openings hours, but occupation rate is never 100%. There are around 4.000 users in the building and 2.700 workplaces. The total building hours are around 115 hours per week, due to the high percentage of users and wide range of openings hours is the occupation rate is high.

The building is based on 100% active based working. The building has additional facilities such as an employee cafeteria and elevators.

Opening hours:

Monday to Friday: 06:00-01:00

Weekend: 09:00-19:00

#### Energy specifications

This building owns an energy label of A+. The main sustainable systems of the building are a heat pump, heat cold storage and LED-lightning.

#### Behaviour specifications

This case has set three major sustainability objectives (zero waste in 2020, CO2 neutral in 2025 and fully circular in 2030). Promoting sustainability is important to achieve these objectives.

Currently this is happening in areas such as electric driving, stimulating public transport, reducing flights / CO2 tax, SDG Dome (interactive session in which employees / external parties are included in SDGs and their importance) and circular catering.

Table 2.6: Total energy use case 3

	Total	Per m <sup>2</sup>	Households per year*
<b>2018</b>			
<b>Gas consumption</b>	10.706 m <sup>3</sup>	0,43 m <sup>3</sup>	7
<b>Electricity consumption</b>	2.553.814 kWh	103,18 kWh	75

\* General gas use of 1.500 m<sup>3</sup> per household and electricity of 3.400 kWh per household ('Hoe hoog is het gemiddelde energieverbruik | Essent', n.d.)

### 2.4.4 CASE 4

#### General information

The building consists out of four building parts and has a total floor area of 10.230 m<sup>2</sup> spread over three floors. The main function of this building is an office building.

Building part 1-3 were delivered in 1985 and building part 4 was delivered in 2002. This building has been upgraded over the last couple of years.

#### Building specifications

In this case the main work method is supported by laptops.

There is a normal range of opening hours which leads to building opening hours of 60 hours per week



In this building, there are 500 users and 450 workplaces. The building is based on 70% active based working, because of the partly activity based working the occupation rate is not 100%. In the mornings, the general occupation rate is 70%, the rest of the day it is 35-50% is. This is a low percentage. The building has additional facilities such as an employee cafeteria and elevators.

Opening hours:  
Monday to Friday: 06:00-18:00

### Energy specifications

This building owns an energy label of A. The main sustainable systems of the buildings are a PV installations and LED-lighting.

### Behaviour specifications

This company is aware of behavioural change and tries to promote sustainable change and promoting PEB.

Table 2.7: Total energy use case 4

	Total	Per m <sup>2</sup>	Households per year*
<b>2017</b>			
<b>Gas consumption</b>	81.402 m <sup>3</sup>	7,95 m <sup>3</sup>	54
<b>Electricity consumption</b>	1.030.110 kWh	100,68 kWh	30

\* General gas use of 1.500 m<sup>3</sup> per household and electricity of 3.400 kWh per household ('Hoe hoog is het gemiddelde energieverbruik | Essent', n.d.)

## 2.4.5 SUMMARY

In each case two topics were thoroughly addressed. The sustainable ambitions of each case and the energy use per m<sup>2</sup>. This subchapter shows an overview of all these results for each case.

The Sustainability ambitions each case has are shown in the table below. The sustainability level for each case it is also presented. The used definition of the sustainability level is if the main policy of the company has a focus on sustainability.

Table 2.8: Summary sustainability case 1-4

	Case 1	Case 2	Case 3	Case 4
<b>Sustainability level</b>	Neutral	Low	High	Neutral
<b>Sustainability goals</b>	Energy neutral office housing  Use of Circular products	Implement recognised guidelines	Zero waste in 2020  CO2 neutral in 2025  Fully circular in 2030	Score high on CO2 performance ladder  Sustainable use of materials

Secondly, the total energy consumption for each case is as follows.

Table 2.8: Summary energy use case 1-4

Energy per m <sup>2</sup>	Case 1	Case 2	Case 3	Case 4
<b>Gas consumption</b>	4,56 m <sup>3</sup>	5,27 m <sup>3</sup>	0,43 m <sup>3</sup>	7,95 m <sup>3</sup>
<b>Electricity consumption</b>	138,67 kWh	104,20 kWh	103,18 kWh	100,68 kWh

## 2.5 DELPHI PANEL

The third empirical study method is two different variations of a Delphi panel. A Delphi panel is a research method where a panel of experts are retrieved. This carefully chosen panel answers questions in several rounds. The results of each round will be reported back (anonymously) to the experts. The goal of the rounds and feedback of the rounds is to come to a consensus about the topic. The first Delphi panel is an "expert" Delphi panel consisting of facility managers. The second panel is a "user" panel consisting of office users. Both panels will have two rounds of questions, both with a survey as research method.

### **2.5.1 DELPHI EXPERT PANEL**

This panel consist of 11 participants, all with a background in facility management, their experience of sustainability level and building types is diverse. Not all the managers are 100% involved in transforming their building into a sustainable building, because of this the opinions may differ. The contacts of the DGBC and workgroup are used to distribute the survey and recruit participants.

#### ROUND ONE

The first survey consists of two parts, one part is what the experts think about pro-environmental behaviour and a pro-environmental environment. During this part 12 statements were represented based on interviews and literature research and the participants could judge these based on a five-point scale.

The second part of the survey consists of ranking measures. Measures were presented and these needed to be ranked from high impact to low impact. Three type of measures were presented; energy related measures, sustainability measures and all measures combined. The results of this part of the survey are used in chapter X, measures to take. The questions and results of this survey can be found in appendix 5.

#### ROUND TWO

Round two starts by communicating the results of round one to the participants, followed by a survey. The survey is divided into two parts, part one feedback on the first round and a presentation of the retrieved results. Part two contains a discussion about obscurities from the previous round.

### **2.5.2 DELPHI USER PANEL**

This panel consists of 10 office employees from 10 different companies, the participant where selected random so the company they work for is not taken into consideration. The participants where contacted via LinkedIn and personal connections. The office type of each participant is diverse, some working in an activity based work environment, and other not.

#### RESULTS ROUND ONE

The survey consists of two parts. Part one is on sustainable behaviour related to sustainable measures. The first part will discuss the participants behaviour in the office. This part can be related to the second part of the "expert" panel. The behaviour of the participants with regard to the behavioural aspects of measures from the expert panel where asked. For example, it the users would change the temperature in the room or put on a sweater when it is cold. The second part is based on activation of pro-environmental behaviour in the workplace. This part focusses on whether the company has a pro-environmental environment.

The exact questions and the results of the survey can be found in Appendix 4.

#### ROUND TWO

Round two starts by communicating the results with the contestants of round one to the participants, followed by a survey. The survey is divided into two parts, part one feedback of the first round and a presentation of the retrieved results. Part two contains a discussion about obscurities from the previous round.

# 03

## ENERGY

## PERFORMANCE

## GAP

This chapter researched the so-called energy performance gap, which is indicated by the difference between the theoretical energy label and the operational calculated energy label. This chapter has the following structure. First the energy label is explained, which leads to the theoretical and operational energy use. After that the gap between the theoretical energy label and operational energy use is explained. Finally, the possibility of energy performance gap reduction will be explained.

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### 3.1 ENERGY LABEL

In the last century sustainability, global warming and energy control where researched and investigated numerous times. The government is implementing new methods to control the impact of these environmental issues, which leads to the implementation of the Energy Performance Building Device (EPBD) in 2008 by the Dutch government. The EPBD is a set of guidelines developed by the Council of the European Union to improve the energy performance of buildings. To monitor these guidelines and the energy performance of existing, new housing and real estate stock the Dutch government introduced energy labels (Spiekman & Dijk, 2012; van Vliet, 2008; Visscher, Meijer, Majcen, & Itard, 2016).

In the Netherlands, energy labels are used to indicate energy performance of existing and newly built buildings. There are different valuation degrees of the energy label, different methods and area's an energy label can be received. The energy label developed for utility buildings, based on the so called energy performance advice – Utility (EPA-U), and an energy label for housing, based on the energy performance advice – Housing (EPA-W) ('Wat is EPA?', n.d.). The result of the EPA value is an energy label ranked from G until A++++. Label G is the lowest achievable energy label and A++++ is the highest achievable energy label. An energy label indicates how sustainable and energy efficient the building is at a specific moment in time. The goal of the energy label is to give a point of view on the energetic quality of a building in comparison with similar buildings and to provide insight into potential energy-saving measures. The intention of the energy label is not to predict the energy-use of a building, but to make it more comprehensible what the energy use of the building is (Hoes- van Oeffelen et al., 2013).

The EPA , therefore also the energy label of buildings, is based on to the energy-index (EI) or Energy Performance Coefficient (EPC) (Visscher et al., 2016). The EI is a way to express energy efficiency of an existing building in a number and the EPC is a way to express the energy efficiency of a newly build building in a number. Both methods are used in different situations, which leads to different calculations. The measures used to calculate the values differ from each other due to unknown information in the existing buildings. If information is unknown when calculating the value, assumptions are made (Rijksdienst voor Ondernemend Nederland, n.d.; Spiekman & Dijk, 2012). For buildings, there are different methods and types of energy labels. The structure of the energy label is explained in figure 3.1 and table 3.1 shows the EI and EPC index related to the energy labels.

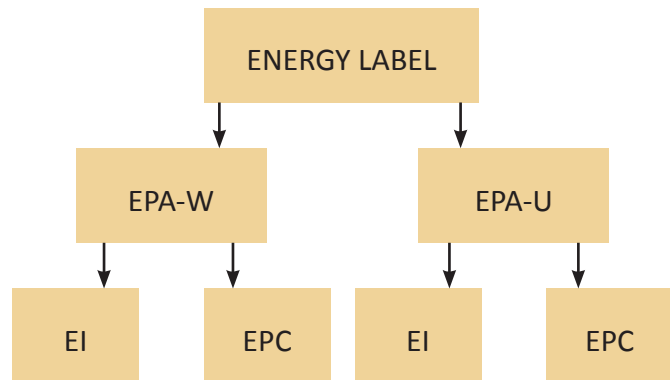


Figure 3.1: Energy Label Structure (own illustration)

Table 3.1: Ei and EPC index's ('EnergieLabel C kantoren', n.d.; 'Tekst en uitleg EnergieLabel utiliteitsbouw', 2014; Koppels & Van der Erve, 2013; Snoei, 2008)

	EI	EPC (2009)
<b>A++</b>	≤ 0,50	≤ 0,55
<b>A+</b>	0.50 < EI ≤ 0.70	0.56 < EPC ≤ 0.77
<b>A</b>	0.70 < EI ≤ 1.05	0.78 < EPC ≤ 1.16
<b>B</b>	1.05 < EI ≤ 1.15	1.17 < EPC ≤ 1.27 *
<b>C</b>	1.15 < EI ≤ 1.30	1.28 < EPC ≤ 1.43 *
<b>D</b>	1.30 < EI ≤ 1.45	1.44 < EPC ≤ 1.60 *
<b>E</b>	1.45 < EI ≤ 1.60	1.61 < EPC ≤ 1.76 *
<b>F</b>	1.60 < EI ≤ 1.75	1.77 < EPC ≤ 1.93 *
<b>G</b>	> 1.75	> 1.94 *

\*= It is not allowed by law to build new building with an EPC value higher than 0.8 for office buildings (Rijksdienst voor Ondernemend Nederland, n.d.-a). These numbers are outdated and will not be updated, because old buildings will be graded trough the EI and not the EPC.

To receive a theoretical energy label, different elements are used to calculate the EPC or EI. Calculations are based on 13 elements focussed on building specifications. Table 3.2 shows the 13 elements. The exact measurement specification differs if the EPC or EI is calculated (Nobel & Haartsen, 2011) (Stichting ISSO, 2013).

### 3.2 THEORETICAL AND OPERATIONAL ENERGY USE

The EI or EPC value is used to write an energy performance advice, which leads to an energy label. The received energy label is based on the valuation of the year they measure the building. The years after the measurement the building does not receive a new energy label.

It is not required to update the label every year, but only when sustainable measures were taken, which contribute to the energy performance of the building. The energy label is an expectation of how sustainable the building is, not if the building actually sustainable is. During this report, the received energy label is called the theoretical energy label.

The elements used for the calculation of the EI/EPC (table 3.2) is based on building-specific characteristics. The data used for calculating energy labels is based on the building's specifications. Behavior and consumption of its occupants is not taken into account during the energy performance advice phase. In conclusion, this means that the theoretical energy label is based on building specific elements (Nobel & Haartsen, 2011).

The operational energy use is the total energy use that is charged at the end of the year. The total operational energy use of a building exists of two parts; the building-related energy use and the user-related energy use. The building related energy use is all the energy needed to maintain the building itself, no influence from behaviour or outdoor climate will change this energy use. The user related energy use indicates the energy consumption of the building's users (Blom, Itard, & Meijer, 2011; Nobel & Haartsen, 2011; Stichting ISSO, 2013; Henri & Journeault, 2010).

The yearly energy consumption is not separated into user-related and building related energy use. The invoice does not describe the energy consumed by computers or ventilation systems. This makes it hard to separate the building- and user related energy at the end of the year. Even if this was possible researcher argue that it is hard to completely separate building and user-related energy use because there is an interaction between the building and its users which influences the energy consumption (Blom, Itard, & Meijer, 2011; Elkhuisen, 2019; Gatersleben, Vlek, & Steg, 2002; Steg & Vlek, 2009). The first challenge is to visualize the problem and separate the user related energy use and building related energy use (Blom et al., 2011).

The following energy performance diagram is used to explain the variations on improving the energy performance gap. This scheme (shown in figure 3.2) assumes that the energy performance of the building related energy installations is according to expectations.

Table 3.2: Building specification

Building specifications
Building layout
General data
Thermal shell
Climate system
Heating
Cooling
Ventilation
Circulation
Humidification
Water
Green energy generation
Lighting

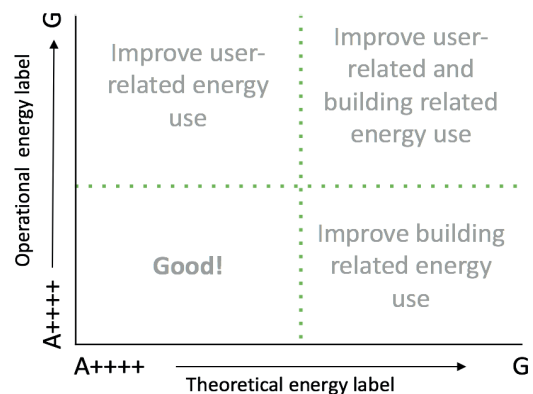


Figure 3.2: Energy performance diagram(Own illustration)

Table 3.3: Building related energy use vs user related energy use(Sipma, 2016; Sipma, Kremer, & Vroom, 2017)

Building-related energy use	User-related energy use
Heating (19° – 21°)	Room Lightning
Cooling (19° – 21°)	ICT facilities (computer screen, computer, electricity of laptop)
Lightning (inside and outside)	Individual change of heating (> 21°)
Warm water	Individual change of cooling (<19°)
Ventilation systems	Printer and Copy machine
Humidification	Coffee and Tea machine
Elevators	Cafeteria (Dishwasher, water tap etc.)
Escalators	Toilets
	Automation equipment
	Emergency power supply

There is no line defined between the building related energy use and user-related energy use. As mentioned before, the building related energy use is defined as all energy use needed to maintain the building itself, while the user related energy use is defined as the energy use based on the users' behaviour and their preferences. Table 3.3 gives examples of building related energy use and user related energy use.

The two main energy use consumers are the annual gas and power consumption. Sipma et al. (2017) performed a research based focused on the total gas consumption and power consumption of office buildings. This research showed that the EPA calculation of gas consumption is not reliable. It was concluded that the m<sup>3</sup> gas use calculated is much higher than the actual energy use, which creates a standard difference between the operational gas consumption and the theoretical gas consumption. The bandwidth of gas consumption of office buildings is large. A possible explanation of the large differences in gas consumption of office buildings, is that the climate systems are not used incorrectly. In this case the gas consumption is higher than necessary. The direct impact of the user related energy consumption on the gas consumption is lower than the user's impact on electrical power consumption. The main focus of this report will be on reducing the electrical power consumption, where there is a significant influence difference of the user-related energy cost (Sipma et al., 2017).

### 3.3 THE ENERGY PERFORMANCE GAP

The difference between the theoretical energy use and the operational energy use creates a gap, because the expected energy use and the operational energy use are not in line with each other. This creates a mismatch in energy performance which is called the Energy Performance gap (Blom et al., 2011; Csutora, 2012; de Jong et al., 2018; Elkhuisen, 2019; Meijers, 2019; Steg & Vlek, 2009; van de Boogaard, 2019). Research of Carbon Trust (2011) shows that the energy performance gap can vary from an 500% more on the theoretical energy use to 16% less than the expected energy use. The placement of the gap depends on the energy performance and behaviour of the building and its users (Bortoluzzi et al., 2017; Carbon Trust Organization, 2011).

The energy performance gap influences the goal of the energy label. Due to the energy performance gap the energetic quality of buildings is hard to compare with each other and potential energy-savings are not always accurate. To calculate the gap, the theoretical energy use needs be to calculated and compared to the operational energy use. There are different methods to calculate this gap. E-nolis is a company that developed software to calculate this gap. In 2018 the organization of e-nolis wrote a guide to achieve the Paris Proof goal. In this guide they also came to the conclusion that there is an energy performance gap and they explained the reasoning behind the gap. During their research, de Jong, Elkhuisen and Kool (2018) developed a software system, the Energy Navigator, that can calculate visualize a benchmark of the difference between the theoretical and operational energy label (de Jong et al., 2018). There are various of software systems on the market to calculate the energy performance gap. ECN (2017) researched the difference between the theoretical energy use and operational use of office buildings. They concluded that the EPA-U calculation methods calculated a large surplus in gas usage, causing the difference between the theoretical and operational energy label to be larger than required related to the total gas consumption (Sipma et al., 2017). The software of E-nolis used these conclusions to their advantage and took these results into account while developing the Energy Navigator.

### 3.4 EMPIRICAL STUDY RESULTS

The semi-structured interviews and case-studies are used to research the energy performance gap. During the interviews, the vision of the government and the energy performance gap are discussed with the interviewees. The results of these interviews related to the vision and energy performance gap are presented. The case-studies are used to confirm the energy performance gap expectations.

#### 3.4.1 SEMI-STRUCTURED INTERVIEWS: VISION & GENERAL KNOWLEDGE

The introduction of the interviews started with the general knowledge about the vision of sustainability from the government. Firstly, the SDG's, Paris Proof and "het energie akkoord" and their feasibility were briefly discussed. Secondly, the involvement of the government and changes by law making were discussed.

## INTERVIEW ANSWERS

### Vision

Table 3.4: Transcript summary topic vision

Topic	Facility Manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behavior specialist	Behavioural workplace specialist
Good vision	The vision is there.	The vision is there.	The current vision is very ambitious, but I think it needs to be.		A goal is only a good goal when it is ambitious and feasible.
Change is required	but the desires are not met yet. There is a division; there is a leading group busy with development to a sustainable work environment, there is a middle group slowly catching up and finally a backlog of people who are not changing much	Only the way to meet this vision not yet.		I really want that the vision is feasible, but I do not know if it is. Things need to change!	When it is not ambitious people attend to not be interested. The goal is to formulate the goals good that people will be interested. I think the vision is there, the goal is ambitious and feasible. I think that many plans are still to abstract and uninteresting to take action.

### Law & Government

Table 3.5: Transcript summary topic law & government

Topic	Facility Manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behaviour specialist	Behavioural workplace specialist
User vs building related energy use	The government does not distinguish building-related and user-related energy use. The structure of the government related to sustainability is difficult due to separation of interest and departments.				

Focus on operational	The is a system default within the government and building sector.	It should focus on the operational energy use, not the theoretical. They should combine the energy label steps and integral requirements to reach the goal. Keeping the current way of calculating is not the solution. Operational energy should be the new calculation.			
Not developing fast enough	The new law about the offices requires energy label C by 2023. This makes sure the laggards will keep up or are cut off. It is clear and a great rule.	The new law is a start but we are far from the end, the rule differs 4 times as much as the set goals, and in 2030 with energy label A it is still 2 times as high.			
Change of the Law	The “erkende maatregellijst” is not very innovative	The government prescribes to much rules, which all together do not match to required wishes. My proposal: All operational energy labels should not deviate more than 1-2 energy label from the theoretical You need to put a restrain on the gap it is no goodwill anymore it is a commitment	The social responsibility grows, the government should respond on this request. The law should be a playing field, legal requirements are the start to make the goals succeed.	The ambitions are there but it is not going fast. With our current way of thinking and the political choices I think it is not feasible. Change should be made.	It is hard for the government to achieve the goals. The current laws do not support it.
Subsidies			The playing field can be expanded using subsidies.		High costs will be made. when the government expects companies to apply certain measures it can be encourage trough subsidies. The law can substantiate change within companies. It is a strong tool.



## CROSS-ANALYSIS

Table 3.6: Cross-analysis vision & general knowledge

	Facility manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behaviour specialist	Behavioural workplace specialist
<b>Vision</b>					
The ambition and vision is good!	X	X	(X)	X	X
Change needs to be made to reach the vision.	X	X	X	X	X
<b>Government &amp; Law</b>					
The government does not make a clear distinction between building-related and user-related energy use.	X	(X)			
The focus should be on operational energy use not only theoretical energy use.		X	X		
The office energy label C in 2023 rule, is there for the companies who are not developing fast enough.	X	X	X		(X)
The laws should change, so that it will meet the ambitions goals.	X	X	X	X	X
Subsidies to activate and maintain sustainable measures is a possible solution.			X		X

## INTERVIEW ANALYSIS

The conclusion of the interviews is that goals set by the government are ambitious but not unfeasible. Between 2050 and now big changes in the behaviour and sustainable facilities of people, companies and the government need to be met.

According to the interviewees it is possible to guide these goals by law but not impose these laws too much. The Netherlands has a culture in which most of the building requirements are set by law, these laws need to be innovative and not obsolete as they are currently.

Activation by rules or subsidies are possible solutions, it is about reaching the SDG's, Paris Proof and "het energie akkoord" at the end. Upgrading law to the new set of goals is an opportunity to create a platform.

### 3.4.2 SEMI-STRUCTURED INTERVIEWS: ENERGY PERFORMANCE GAP RESULTS

Not every interviewee had knowledge about the energy performance gap because of not all interviewees answered these questions. The interviewees who did not participate in this part are recognizable by a (-) mark.

## INTERVIEW ANSWERS

### Energy performance gap

Table 3.7: Transcript summary topic energy performance gap

Topic	Facility Manager 1	Energy performance gap specialist	Facility manager 2
<b>GAP is a mismatch</b>	The energy performance gap can exist because of the behaviour of users but also the building specific installations. In the later case, it may be that the theoretical energy label and operational energy label do not match with each other.		The energy label is a theoretical label that buildings use when they want to sell their building, when the systems are not correctly used or the behaviour of the use is not in line with the expected behaviour. This creates a gap between the theoretical and operational energy label.

<b>Lack of Knowledge</b>	The gap can be explained because of ignorance of the gap, lack of knowledge about the energy label and influencing factors on the energy label.	Not enough attention for this problem, E-nolis developed a software system which visualized the energy performance gap of buildings.	
<b>Caused by behavioural use</b>		Upgrading a building on sustainability does not automatically mean that the energy use will be less, the behaviour of users and the way of controlling the systems have influence on the operational energy use. The gap can be explained because of - Wrong behavioural use	The behaviour of the use is not in line with the expected behaviour
<b>Caused by building systems</b>	Example: We measured and calculated one of our real estate buildings, where the main conclusion was that during the night the energy use was high. Looking at the building this was logical because of the data centre that was inside of the building. The GAP exist depending on the function of the building.	The gap can be explained because of - Incorrect use of building systems.	When the systems are not used correctly

## Energy label

Table 3.8: Transcript summary topic energy label

<b>Topic</b>	<b>Facility Manager 1</b>	<b>Energy performance gap specialist</b>	<b>Facility manager 2</b>
<b>Awareness of the energy label</b>	People do know what the energy label is, due to the comparison with refrigerators and cars. Some consumers are more aware of this than others.		
<b>Influence of choice</b>	Because of the energy label people are more aware of the use, it may influence certain choices people make related to sustainability		
<b>No relation</b>		I never saw a relation between the knowledge of energy label and the behaviour users have in an office building.	I don't think people will act more sustainable when they know what the energy label is.
<b>Knowledge may work counterproductive</b>		It is possible that when people know a place is sustainable, it has a counterproductive effect on them. They don't put in the effort to perform	I believe that this knowledge works counterproductive. When people know they are in a sustainable building they think that they don't need to act sustainable due to the perks of staying in a sustainable building.

## Finance

Table 3.9: Transcript summary topic finance

Topic	Facility Manager 1	Facility manager 2	Behavioral workplace specialist
Sustainable investment	It may happen that due to financial reasons, sustainable investments will not happen because it is not feasible within a X number of years	The financial incentive to choose the unsustainable choice is at this moment in time higher than the sustainable choice.	
Financial incentives from government	When an investor hires a company to maintain the building, this company will not be paid to focus on sustainability. Therefore, they will not do it. Energy costs is only a small part of the total cost of a building.	Financial incentives from the government's perspectives is required. For example: CO2 Taxes or full cost pricing	Financial incentive can be a cause of Pro-environmental behaviour (PEB) but will never be the power behind the change. The government should play a part in this.

## Elusive of energy

Table 3.10: Transcript summary topic Elusive energy

Topic	Facility Manager 1	Energy performance gap specialist	Facility manager 2	Behavioural workplace specialist
Energy is elusive	Energy is elusive and invisible which makes it hard to rely on. The tangible measures are easier to apply, because people can see the change, while electricity is elusive. For example: Companies tend to have a higher energy use at night, due to the unknown energy use of lights burning during the night. Because energy is so elusive, it is hard to expect the user to act pro-environment related to implementing measures.	Energy is invisible, using cardboard coffee cups is not. How do you make energy visible?	Energy is invisible, a coffee cup is visible.	Making energy visible is important, this can be done by communicating and focusing on eco-feedback.

## Knowledge

Table 3.11: Transcript summary topic knowledge

Topic	Facility Manager 1	Energy performance gap specialist	Facility manager 2
Lacking knowledge	The last decade the technical knowledge within companies has declined. There is almost no energy or technical knowledge present. This makes it difficult to create a sustainable environment.	Communication keeps coming back, in conjunction with that, it is important that the person who is communicating also has knowledge about the subject.	People do not know that sometimes their building owns a heat-cold storage which is sustainable

## CROSS-ANALYSIS

Table 3.12: Cross-analysis energy performance gap

	Facility manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behaviour specialist	Behavioural workplace specialist
<b>Energy Performance gap</b>					
The gap is a mismatch between theoretical energy use and operational energy use.	X	X	X	-	-
Lack of knowledge about sustainability.	X	(X)		-	-
Partly caused by Behavioural use.	X	X	X	-	-
Partly caused by incorrect use of building systems.	X	X	X	-	-
<b>Energy Label</b>					
Users are aware of the energy label.	X			-	-
The energy label influences the choice of users.	X			-	-
There is no relation between the energy label and the choice of users.		X	X	-	-
Knowledge of a sustainable building may work counterproductive, which leads to acting not sustainable in a sustainable environment.		X	X	-	-
<b>Financial</b>					
Sustainable investments are related to the yield of the investment over time.	X		X	-	
Financial incentives from the government.			X	-	X
<b>Elusive of energy</b>					
Energy is elusive which makes it hard for users to relate to.	X	X	X	-	X
<b>Knowledge</b>					
The knowledge about sustainable measures is lacking at companies.	X	X	X	-	

## INTERVIEW ANALYSIS

The definition of the energy performance gap and how it exists was for all participant interviewees clear. Not all participants were asked these questions because Renate Wesselink and Margriet van Lidt are experts in behaviour and have only small knowledge about the energy performance gap and energy label itself, during the interview the energy performance gap was explained.

All three remaining experts are aware that the energy performance gap exists and that it is related to the behaviour of the users and the building systems. By recognizing the problem of the energy performance gap, the behaviour use or building systems can be tackled.

Related to the energy performance gap is the energy label. The opinion about whether the energy label influences the choice people made are diverse, some agree that the energy label can be an activation to act pro-environmental. While other experts experience it as a counterproductive action; when a person is aware that they are in a sustainable building it is possible that he will not act sustainable because he could think that, because the building does it for him, he doesn't need to act in a sustainable way. This relates to the fact that companies nowadays have less knowledge about systems within their building and what effective sustainable measures are. The knowledge of technicians is lacking and the knowledge of the user is limited.

Finally, all the experts agreed that elusiveness of the energy is a big problem. The elusiveness of the energy makes it hard for users to relate to. How to change something when you do not see it? General measures such as coffee cups are visible, where energy specific measures are less visible. How can energy be made less elusive?

### 3.4.3 CASE-STUDIES

The software of E-nolis is used to visualize the energy performance gap of the four cases. The expectation is that the case 3 will have a match in the theoretical and operational energy label due to their ambitious goals of a sustainable office and changing the pro-environmental behaviour of their users. They constantly try to change their behaviour and set three main sustainability objects each with another achievement year; zero waste by 2020, CO2 neutral by 2025 and totally circularity by 2030. With these objectives in mind they need to achieve the theoretical energy label of A+ or even higher by now. The E-nolis software will show if this expectation is actually true.

The Energy Navigator is the software that is used to visualize the energy performance gap. With the help of Bert Elkhuizen it was possible to calculate this gap. The results of the cases are as follows:

#### Case 1

The theoretical energy label is label C. The calculated operational energy label is label G, this label is based on the supplied annual energy use and the opening hours of the building. This calculated energy performance gap concluded that this case has an energy performance gap of 3 energy labels as shown in figure 3.3.

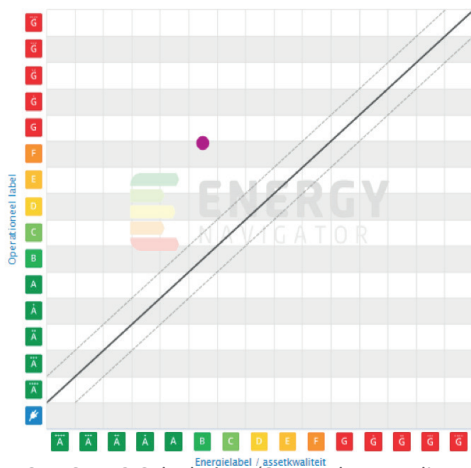


Figure 3.4: Case 2 Calculation (Screenshot E-nolis software)

#### Case 3

The theoretical energy label is label A+. The calculated operational energy label is label A, this label is based on the supplied annual energy use and the opening hours of the building. This calculated energy performance gap concluded that this case has an energy performance gap of 1 energy labels as shown in figure 3.5. The energy performance gap in this case is very small, compared to the three other cases.

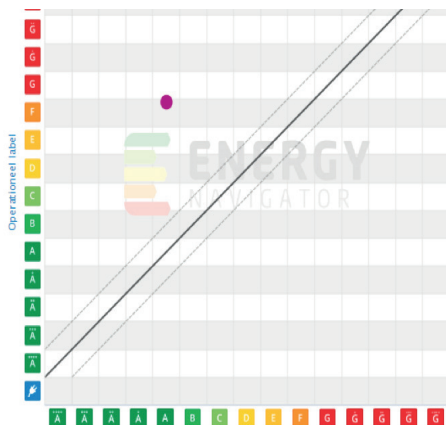


Figure 3.6: Case 3 Calculation (Screenshot E-nolis software)

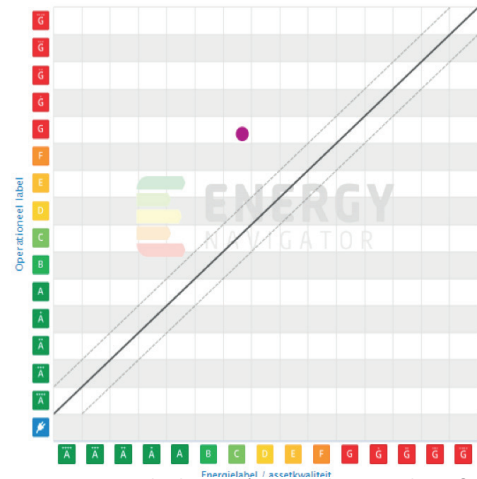


Figure 3.3: Case 1 Calculation (Screenshot E-nolis software)

#### Case 2

The theoretical energy label is label B. The calculated operational energy label is label F, this label is based on the supplied annual energy use and the opening hours of the building. This calculated energy performance gap concluded that this case has an energy performance gap of 3 energy labels as shown in figure 3.4.

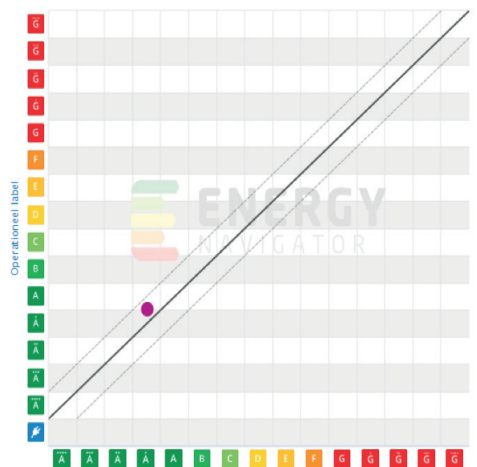


Figure 3.5: Case 3 Calculation (Screenshot E-nolis software)

#### Case 4

The theoretical energy label of the fourth case is energy label is label A. The calculated operational energy label is label F, this label is based on the supplied annual energy use and the opening hours of the building. This calculated energy performance gap concluded that this case has an energy performance gap of 4 energy labels as shown in figure 3.6. The energy performance gap is the biggestst out of four.

The total overview of all the cases is visualized in figure 3.7. The software analyses shows that all the cases have remarkable differences between the theoretical energy use and the operational energy use. It can be concluded that in these cases the energy performance gap is present. As expected, case 3 has the most sufficient theoretical operational relation. Where the other three cases the gap is more extant. The results of these calculations show that there is a difference between the theoretical energy use and the operational energy use which is commonly known as the Energy Performance gap.

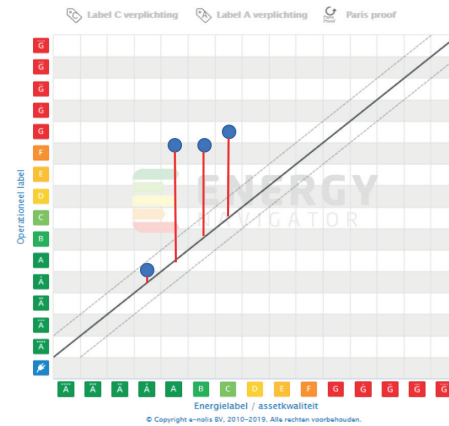


Figure 3.7: Alle cases overview (Screenshot E-nolis software)

### 3.5 REDUCING THE ENERGY PERFORMANCE GAP

Studies show that if during the design and building phase the energy performance gap is taken into consideration it is possible to reduce the gap, it is not easy but it needs to be addressed from the start of the development (Bortoluzzi et al., 2017; Majcen et al., 2013). This conclusion has no added value on the current office stock, but only on the future office stock. This does not solve the current problem of the energy performance gap (de Jong et al., 2018).

The cause of the gap happens because of a difference in the building related energy use part or the user related energy use part (Blom et al., 2011). The research of E-nolis (2018) found three main reasons behind the energy performance gap.

1. The basis energy use is too high, the grounding energy use arises from the behaviour of the user.
2. Insufficient or no shutdown of ventilation systems.
3. Heating and cooling of the building at the same time.

These findings have influence on the previously explained energy performance diagram (figure 3.2), which result into change in this figure. Including the influence of incorrect use of building related energy use the energy performance diagram is shown in figure 3.8.

The reasoning behind the gap are divided into user related energy use (1) and building related energy use (2 & 3). The user related energy waste arises because of inefficient system use. This influences around 30% of the energy use (de Jong et al., 2018). Out of research may be concluded that there are building related steps to take and users related steps to reduce the energy performance gap. The following steps are developed to monitor and reduce the energy performance gap.

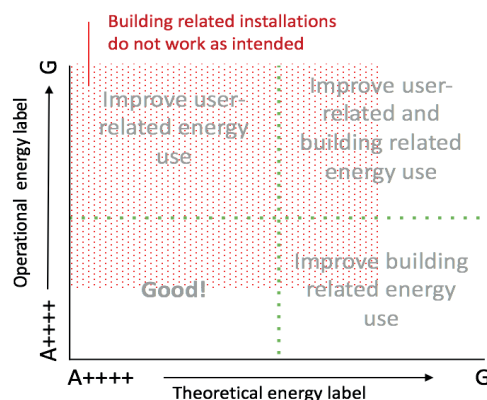


Figure 3.8: New energy performance diagram (Own Illustration)

1. Analyse the current status of the building, research how big the energy performance gap is.
2. Energy clean-up, checking all the systems if they are used right and re-adjust the systems where needed.
3. Investing in sustainable building-related measures
4. Analysing user related behaviour. What is the user's behaviour and what is not energy friendly about it.
5. Implementing sustainable measures and activating change in behaviour of users into pro-environmental behaviour.

(de Jong et al., 2018; van Lidt, 2019; Wesselink, 2019)

Step one to three are building related, these steps are explained in various research (de Jong et al., 2018; Katzeff, Broms, Jönsson, Westholm, & Räsänen, 2013; Sipma et al., 2017). Where step four and five are less researched, further on these steps will be discussed on which measures, how to change behaviour and which measures have the highest impact to reduce the energy performance gap. These steps are the focus of this report.

### **3.6 CONCLUSION**

In conclusion, the energy performance gap can be explained by the difference between the theoretical energy label and the operational energy label. The difference can be found in two places; the building related energy use or the user related energy use.

The main roadmap available for reducing the energy performance gap, is focused on reducing the building related energy use. Which start with analysing the current energy performance gap and as second step checking and adjusting the systems when needed. These measures focus on the building related energy use.

Minimal research is done about the impact of the user-related energy use and how to reduce the user-related energy by changing the user behaviour. This research focusses on how to reduce the user-related energy by activating the user behaviour.





# 04 MEASURES TO TAKE

Every choice has an impact, which may lead to a chain reaction. There are measures which benefit the environment and those which can reduce the sustainability of a building. These measures are divided into technical, behavioural and organizational measures, each having a different impact on the energy performance of the building. In this chapter, sustainable measures from literature are discussed and a measurement list is developed. All these measurements are reviewed and tested with the cases, interviews, delphi experts and the delphi users.

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## 5.1 INTRODUCED MEASURES BASED ON LITERATURE

In this decade sustainability is becoming more important every day. Different measures came on the market to promote sustainable development. These measures can be divided into building related measures and behaviour related measures. A measure list has been compiled based on literature, the measures are split into different area's; measures related office trends, sustainable measures introduced by the government and measures implemented by companies. This list is discussed in the following paragraphs.

### 4.1.1 OFFICE TRENDS

The office environment has evolved over the last couple of years, today's workplace is not the same as a decade ago. The environment changes and the office trends change along with it, there is a strong relationship between the introduced measures and the current trends in the work environment. Keeping up with a trend shows innovation to new employees and the likelihood of future changes in the work environment. Research shows five trends in the current workplace environment, which will be explained below (Arnoldussen et al., 2016; V. Blok et al., 2015; Buckman, Mayfield, & Beck, 2014; Crawford-Marks, 2018; Global Influences, n.d., n.d.; HOK, N.d.; Lombardi, 2018). The five main trends for this decade are:

1. The well-being of the employee: This is currently considered an important factor for feeling comfortable at the workplace. If the employee is not happy with the external influence of their working environment, they are less productive than when they have a positive relationship with their environment (Crawford-Marks, 2018; Global Influences, n.d.; HOK, N.d.; Lombardi, 2018).
2. Sustainable work-environment: This trend includes all sustainability aspects around employees and the office. Today's employees are aware that companies need to go green, because of the environmental impact (V. Blok et al., 2015; HOK, N.d.).
3. Flexibility in places of work: With the current trend in flexibility, there is a strong shift in the interpretation of workplaces. The traditional way of working was sitting at a desk, this resulted in a solid structure in the office. Around 2005, a shift began, and work places became more like a network, more interactive and shared with each other. These changes were possible due to the introduction of laptops, this made activity based working (flex working) interesting. Employees don't have their own place anymore and share all the required spaces and supplies (den Heijer, 2018; Meyer, 1997; Van Meel, 2015).
4. Smart, Intelligent and Technology trends: Buckman, Mayfield & Beck (2014) wrote a paper on what a smart building is, in which they discuss the difference between smart and intelligent buildings and why they are implemented in the wrong way. They conclude that intelligent buildings focus solely on the intelligent systems, for examples automatic lighting or comfortable air conditions for a room without users that needing to manually change it. Smart buildings are an evolution of intelligent buildings. They integrate the construction, materials and use if the entire building system. It is driven by the progression of a building energy efficiency, comfort and satisfaction of the users (Buckman et al., 2014; Snoonian, 2003). In this trend, the use of new techniques is also included (Crawford-Marks, 2018).
5. Comfort of the employee and interaction with each other: Striving towards improvement of the comfort of the employee is a common trend. This trend is in line with the trend around the well-being of the employee. A happy employee is an employee who works harder and produces better results (Oswald, Proto, & Sgroi, 2015). The comfort of the employee is related to social interaction with colleagues and comfort amenities (Cernel, 2018; Global Influences, n.d.). The collaboration and relationship between colleague's will be strengthened and the bond between people will grow stronger (Lombardi, 2018; Oswald et al., 2015).

There is a relationship between the measures and the office trends. Applying these measures amplifies the impact of trends.

#### 4.1.2 GOVERNMENT TRENDS

In 2015, after the introduction of “het Energie Akkoord”, the government introduced a measures list to stimulate energy consumption reduction. This list is called the Erkende Maatregelen Lijst (EML). The EML is a list for 19 different business sectors such as offices, retail and hotels and restaurants. The EML does not make a distinction between building-related energy measures or user-related measures but considers them all to be energy efficiency measures every sector should take. The EML is not mandatory but the Dutch government introduced an energy reduction duty.

This duty gives the company three options:

- Introducing energy reduction measures with an earn back time of less than 5 years
- Introducing all measures from the EML
- Introducing a part of the EML, but for every non-taken measure an equal or better alternative should be taken.

Table 4.1: EML measurement list (based on the EML)

Number measure	Description measure	Year valid	Topic
GD2	Regulate temperature per room	2019	Heating
GE1	Unnecessary illumination of outside lighting	2019	Light use
FF1	Energy efficient printing / copying	2019	Printing & Copying
32	Energy efficient ICT at the workplace	2018	Computer use
9	Unnecessary illumination of lights in break rooms and outside of office hours	2018	Light use

\*There is no financial contribution such as tax benefits possible for implementing sustainable measures, the government see it as a must. (de Jong et al., 2018; ‘Energiebesparingsplicht | RVO.nl’, n.d.; ‘Erkende maatregelen voor energiebesparing’, n.d.)

35 measures are introduced on the EML, 30 of these measures are building-related energy reduction based. Five of these measures are user-related energy reduction based: two measures where included in 2018 but not accurate in 2019, however these measures can still be used as energy efficient measures. The other three measures were introduced in 2018 and are still valid in the EML of 2019. An overview of the measures is visualised in table 4.1

#### 4.1.3 COMPANY TRENDS

Blok et al. (2015) researched how to encourage sustainability at the workplace and introduced topics of measures. Combined the EML, the office trends and studies on implementing sustainable measures at the workplace give form to a measures list. The measures list is subdivided into the main topic’s and the taken measures seen in table 4.2.

The grey coloured boxes do have an influence on the energy performance of the user, but do not have a direct impact on the total energy use of the building. Further referred to as non-energy saving sustainability measures.

### 4.1.3 MEASURE COLLECTION

Table 4.2: Measurement list (based on research)

Topic measure	Stages	Measurements	Office trends	Erkende maatregelen lijst	19 Tips Milieubewust op kantoor, 2016	Blok et al, 2015	Blom et al. 2011	Gatersleben et al. 2002	van den Adel & van Luttervelt, n.d	Vlees, Vis & Vega, n.d.	Csutora, 2012	Own knowledge
Heating	Technical	Temperature regulated per room	X	X		X	X	X				
		Reducing the heating in unused rooms	X	X		X	X	X				
	Behavioural	Dressing warmer, instead of heating up the room	X	X		X	X	X				
Printing & Copying	Technical	Energy efficient (Energy star – GEEA-label) printers		X	X	X			X			
	Behavioural	Print & copy Recto verso, black and white		X		X			X			
		No printing: Paperless office		X		X			X			
		Recycled Paper		X		X			X			
Material use	Organisational	FSC or recycled office supplies			X							
	Behavioural	Recycle used office supplies			X							X
Drinking	Behavioural	Use mugs or recycled paper cups; no plastic cups			X	X						
Sustainable shopping	Organisational	Purchases of sustainable services			X							X
		Provide bio food options and less meat				X			X	X		
	Behavioural	Choose No meat options, less environmental impact				X			X	X		
		Choose bio or local options, less environmental impact				X			X	X	X	
Computer use	Technical	Energy efficient ICT	X	X	X							
	Behavioural	Turn off screen				X	X					
		Unplug laptop adapter				X	X					
		Turn of Laptop/Computer				X	X					
Way of working	Organisational	Implement Activity based working	X		X							
	Behavioural	Implement Activity based working	X		X							
Electronic devices	Behavioural	Un-plug every night, no stand-by modus				X	X					
Light use	Behavioural	Unnecessary burning of lights (breakroom, toilet, at night & places where nobody comes)		X	X	X						
Recycling	Behavioural	Recycling of paper, glass, plastic, batteries, chemical office waste & kitchen and garden waste			X	X						
Food waste	Organisational	Reducing the food waste by actions or marketing strategies									X	
Transport	Organisational	Stimulating carpooling, cycling and public transport	X		X			X	X			
	Behavioural	Use carpooling, cycling, public transport.	X		X			X	X			
Toilet use	Technical	Using wastewater as a flush solution.	X									X

Implementing changes can happen at three different stages; the technical stage, the organisational stage and the behavioural stage (see figure 4.1). The stage related to the measure is visualised in the second column of the measurement list in Table 4.2.

The technical stage contains measures which are related to technical changes in the building. These measures can be implemented when technically possible. For example, using less toilet water is only possible when a technical change within the building specifics is made. So, the technical stage is the stage where without specific technical changes the measure cannot be carried out. These measures imply a financial investment.

The second stage type is organisational, this stage focusses on measures that need to be taken by the management of the company. The facility manager and the board need to implement these changes into the structure of the company. As with the technical stage, they need to provide the opportunity to carry out these measures. In this stage it is not needed to apply technical changes but the policy of the company needs to be adjusted. Without policy changes from the management it is hard to implement these measures and they are therefore unlikely to succeed. This stage has a minimal required financial investment.

The final stage is the behavioural stage. This stage contains measures focused on the behaviour of the user. To accomplish these measures minimal organisational or technical changes are required, mainly a pro-environmental behaviour change is required. This stage also has a minimal required financial investment.

In the compiled measures list, several measures will have a direct impact on the energy use of a building, whereas others only have an impact on the sustainability of the pro-environmental behaviour of a company and users. This separation leads to two different umbrella measures. Table 4.3 shows the direct impact of the energy saving measures on the energy use and required financial investment of each measure. Table 4.6 shows the impact of the non-energy saving sustainability measures and their financial investment. The impact of the total energy use is indicated through literature sources related to the average energy use of the cases in this research. According to the sources the impact is a X kWh per year, this is compared to the average energy use of the cases, which resulted into a impact percentage.

Table 4.3: Energy saving measures (based on research)

Topic measure	Environmental Impact	Impact of total energy use	Financial investment	Source
Heating	By reducing the temperature for 1 degree an effective energy reducing can be achieved.	1-2%	€ 0,-	
Copying & Printing	Owning an energy efficient printer has an impact 50% less energy use than traditional printers. From 5 kWh in standby modus to 2 kWh.	0 %	€ 1000,- (Per printer)	(Mick, 2016; ProOffice, 2018)
Computer use	This impact varies related to the number of users or workstations, four calculations are made based on cases. See table 5.4-5.5.	0,1-2 %	€ 0,-	(Mick, 2016; Mulder, 2011)
Way of working	By working Activity based, the amount of m2 of the building can be reduced because optimum use of the space is achieved. With a total of 60 kWh/m2 of electricity and 17 m3/m2 of Gas consumption. This measure has a strong relationship with the users and the m2 of the building.	1-10%	€ 150,- per m2 * creating another structure and design	('Energieverbruik kantoor', n.d.; Sipma, 2016)

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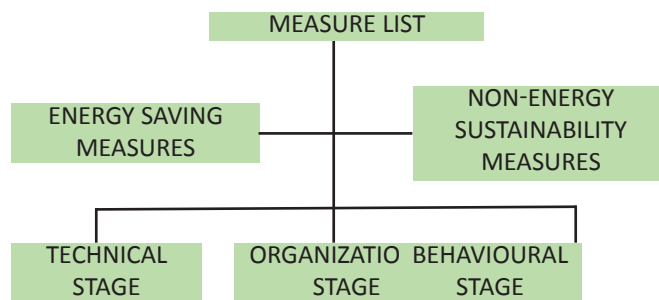


Figure 4.1: Stages diagram (own illustration)

Electronic devices	A coffee machine on stand-by uses around 5 kWh, when turned off this is 0 kWh.	0 %	€ 0,-	(Mick, 2016; Mulder, 2011)
Light use	A regular lamp uses around 60-40 watt where a LED lamp uses 10-15 watt. Changing these lamps is a building specific measure which results in savings of between 1-6% of the total energy use. The behavioural part is turning the lights off in unoccupied rooms. The impact of this depends on the type of lamps currently in the building and the behaviour of the users. The impact can vary from 0,1%-1% of the total energy cost.	0,1-1 %	Investing in led lights depends om the number of lights.  Changing the behaviour of employees: € 0,-	('Led lampen calculator, bereken hier snel hoeveel u bespaart', 2009)
Toilet use	9-6 L water per toilet use, 3-6 L non-drinking water. With this measure less drinking water will be used but is has no direct impact on the total energy use.	-	€ 3.000,- - € 10.000,- (Depending on the number of toilets)	('Feiten en liters... in cijfers', 2014)

### Computer use calculations:

Table 4.4: Assumptions Case 1

Assumptions for Case 1:			
number of workstations	2300	60% did not shut down their facilities	1380
5% desktop computer	115	60% left charger of phone in wall outlet	1380
95% Laptop	2185	50% left adapter of laptop in wall outlet	1150
25% Extra screen (assumption)	575	Use of facilities (h.w.) *	65
Printer & Scanner	30	No-use of facilities (h.w.) *	103

\*This is an indication based on the opening hours and the assumption that people work 40 h.w. 52 weeks, because this facility is not closed during the holidays.

Table 4.5: Computer use calculations (based on research)

Type	Active consumption in W/h	Inactive consumption in W/h	Inactive consumption per year per person	Inactive consumption per year, per person and type
Desktop computer	60-250	5	26780	3079700
Extra screen	17-31	3	16068	9239100
Laptop	15-45	2	10712	23405720
Printer & Scanner	20	2,5	13390	401700
Phone	5	1	5356	6159400

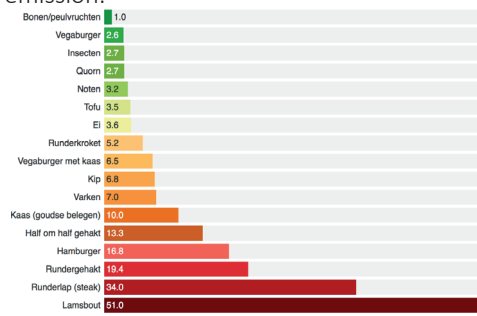
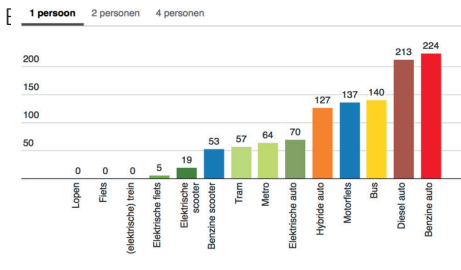
#### Total kWh energy saving cost of case 1

42.286 kWh per year which leads to around 10.000 euro's energy costs. This is around 1% of the total energy use per year. This kWh reduction is the equivalent of the yearly consumption of 12 households. Assuming a household uses 3.400 kWh per year ('Hoe hoog is het gemiddelde energieverbruik | Essent', n.d.).

The total energy savings for case 2 and 3 where calculated using the same method. For case 2 this results in a decrease of 0.5% on the total energy use (5 households per year) and in case 3 this results in a decrease of 2% of the total energy use (14 households per year). Case 4 has the potential to have an energy use decrease of 0,% (3 households per year).

Table 4.6 shows the non-energy saving sustainable measures and the impact on the scale of low, medium and high impact and their required financial investment. An impact is considered low when the change as no or minimal impact on the environment based on the development process. This impact is based on the retrieved literature. An impact is considered high when the change has a significant impact on the environment according to literature.

Table 4.6: Non-energy saving sustainability measures (based on research)

Topic measure	Environmental Impact	Impact	Financial investment	Source
Printing & copying	On average 6,7 kg of paper is printed per person per year, 1/3 of this is thrown away within the week. Printing less means wasting less paper. 300 kg of paper can be made from one tree which means that a company of 300 employees, which uses 2010 kg of paper, uses 7 unnecessary trees yearly.	Medium impact	€ 0,-	(‘Papier weetjes   Papier & Karton’, n.d.; ‘Slimmer printen op kantoor’, n.d.)
Material use	Energy friendly material use leads to buying and investing in less new materials. Re-using has no environmental impact	Low impact	€ 0,-	
Drinking	Using paper or bio cups is more environmentally friendly, because of their recyclability. The environmental impact is half when cups are being reused.	Low impact	Exchange Don’t buy plastic, buy paper cups	(van der Harst, Potting, & Kroeze, 2014; ‘Wegwerpbeertje of mok’, n.d.)
Sustainable shopping	Less impact on the environment. Meat production has a high impact on the environment and CO2 production. Eating less meat leads to a lower CO2 emission. 	Medium impact	€ 0,-	(‘Vlees, vis of vega?’, n.d.)
Recycling	By recycling: <ul style="list-style-type: none"> <li>- Less resources are needed (trees, oil, water)</li> <li>- Less landfill waste</li> <li>- 10% less energy is needed to recycle than to produce new materials</li> <li>- Less pollution</li> </ul>	High impact	€ 0,-	(Kinhal, n.d.)
Food waste	Less production needed and less recycling	Low impact	€ 0,-	
Transport	Car: High environmental impact, when carpooling the impact is medium environmental Public transport: medium environmental impact  *Numbers are based on one person	High impact	€ 0,-	(‘Fiets, ov of auto’, n.d.)

From both impact tables it can be concluded that the impact per measure is minimal, and when all these measures are applied the total impact may still be insignificant. Looking at these same measures at a household scale the impact is much higher. The energy savings may have a small impact on the energy use of the building, but it may be a big influence for a household. It also shows that one person or a single company has a small impact whereas if a large number of people or companies apply these measures the impact can be significant. The measures according to literature were proposed during the interviews and the delphi expert panel to evaluate the impact and implementation methods. The Delphi user panel and case studies were used to chart all the implemented measures in practice.

## 4.2 EMPIRICAL STUDY RESULTS

In this section, the measures introduced to the market were assessed by the interviewees and the delphi expert panel and rated by their impact on the environment, users and companies.

### 4.2.1 SEMI-STRUCTURED INTERVIEWS: MEASURES

During the interviews with the experts the measures were briefly discussed.

#### INTERVIEW ANSWERS

Figure 4.7: Transcript summary topic measures

Topic	Facility Manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behavior specialist	Behavioural workplace specialist
Monitoring	Monitoring the energy of the building		Monitoring the energy of the building and implementing change where needed. Monitoring the use.	Starting competitions and collecting points for rewards = sustainable lunch.	The management should also facilitate all the options. In that case, less choices must be made.
Heat cold	Do not heat and cool at the same time			Creating more awareness	
Doors open	Do not keep doors open unnecessarily.				
Energy reminders		Send a reminder to turn off the light and computer during lunch.			
Skype meetings			More Skype meetings, Discount on Wednesday and Friday to spread even the week pressure. On Wednesday & Friday day guaranteed a desk or parking space.		
Awareness of waste		Making people aware that living in a sustainable building does not mean it is always sustainable.			The word 'wasting' works better than the word 'saving', because people associate it with something bad. They are more likely to change due to it.



<b>Controlling energy use</b>	Research shows that outside of openings hours a lot of energy is lost.				
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### Opening hours

Table 4.8: Transcript summary topic opening hours

Topic	Facility Manager 1	Energy performance gap specialist	Facility manager 2
<b>Reducing opening hours</b>	Reducing opening hours can be very helpful to reduce the energy use of a building.	With E-nolis we see that a lot of buildings have a high energy expense outside of openings hours. Everything that is on stand-by still uses energy, because of cases like this we conclude that the electrical power usage at night is higher than expectation. Most of the time it is in the techniques of the software or systems	When there are less opening hours less energy is used. It is important that the optimum is reached with regard to the openings hours and preventing half days.

### CROSS-ANALYSIS

Measures	Facility manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behaviour specialist	Behavioural workplace specialist
Monitoring the energy of the building.	X	X	X		
Do not heat and cool at the same time.	X				
Do not keep doors open unnecessarily.	X				
Daily energy reminders.		X		(X)	(X)
Skype meetings.			X	X	X
Make people aware of the waste.				X	X
Opening hours					
Reducing opening hours.	X	X	X		
Controlling the energy outside of openings hours.	X	X	X		

Table 4.9: Cross-analysis measures

### INTERVIEW ANALYSIS

During the interviews some measures were mentioned. The main result of the conversation is how to implement and stimulate these measures. It has made it clear that most of these measures do not make a lot of difference but are just small changes. It is good that people become aware and see the changes, but it raises the question is: will small changes make a difference?

### 4.2.2 IMPACT OF THE MEASURES - DELPHI EXPERT PANEL

The measures from literature were presented to the delphi expert panel. During this session they gave an indication of the expected impact of each measure. This resulted in a list of impact according to the experts. Results are divided into energy saving measures and non-energy saving sustainability measures. The impact list from the delphi expert panel shows a clear opinion which measures do have impact on the sustainability or energy use of the company and which do not. The results from literature shown in table 4.10 and 4.11 differ from the results from practice, which indicates that the expectations are not in line with the reality. This could also develop into a gap.

Table 4.10: Impact of energy saving measures according to the delphi expert panel (Own table)

Measure Topic	Low impact	High impact
Heating & cooling		●
Computer use	●	
Way of working		●
Light use		●
Toilet use	●	
Eco-communication		●

Table 4.11: Impact of non-energy saving measures according to the delphi expert panel (Own table)

Measure Topic	Low impact	High impact
Printing & Copying	●	
Sustainable shopping		●
Way of working		●
Working behaviour		●
Recycling		●
Food waste		●
Transport		●

### 4.2.3 IMPACT PRACTICE VS. THEORY

In the following diagram the expectations of the experts are compared to the results from literature. Table 4.12 and 4.13 show an overview of the gap between the expectations and reality of the measures. The black dot is the impact according to the delphi expert panel and the green dot is the impact according to the literature, seen in table 4.12 and 4.13.

The trend is that the expected impact of a measure on the building environment is higher than the literature shows. The biggest expectation gap is with the energy saving measures. This leads to a bigger energy performance gap for a building when the facility manager expects more benefit from measures than actually occurs.

Table 4.12: Impact of energy saving measures according to the delphi expert panel combined with literature (Own table)

Measure Topic	Low impact	High impact
Heating & cooling		●
Computer use	●	●
Way of working		●
Light use	●	●
Toilet use	●	●
Eco-communication		●

Table 4.13: Impact of non-energy saving measures according to the delphi expert panel combined with literature (Own table)

Measure Topic	Low impact	High impact
Printing & Copying	●	●
Sustainable shopping		●
Way of working		●
Working behaviour		●
Recycling		●
Food waste	●	●
Transport		●

## 4.3 MEASURES RELATED TO PRACTICE

Consciously and subconsciously companies already implement measures such as previously introduced in the measurement list (table 4.2). These measures were tested with the cases and the delphi user panel to indicate which measures have been implemented in the field and which are not.

### 4.3.1 MEASURES RELATED TO THE CASES

The measures were analysed with respect to the cases. Each case could indicate if they performed the measure or not. When they tried to, but the impact is still insignificant it is listed as neutral. Both the energy saving measures and non-energy saving sustainability measures were tested on the cases. The results are presented in table 4.14 and 4.15.

Table 4.14: Impact of energy saving measures in the cases (Own table)

Measure Topic	Measure	Case 1	Case 2	Case 3	Case 3
Heating	Temperature regulation individually per room	Yes	Yes	Yes	No
	Reducing the heating in unused rooms	No	Yes	Neutral	No
Printing & Copying	Energy friendly printers	Yes	Yes	Yes	Yes
Computer use	Turning laptops off	Yes	Yes	No	No
	Adapters unplugged	Yes	No	No	No
Way of working	Activity based working	Yes	No	Yes	Yes
Light use	Manual light switches	No	No	No	No
	Turning light off in unused rooms	Yes*	Yes*	Yes*	Yes*
Toilet use	Using wastewater as a flush solution	No	No	No	No

Table 4.15: Impact of non-energy saving sustainability measures in the cases (Own table)

Measure Topic	Measure	Case 1	Case 2	Case 3	Case 4
Printing & copying	Print & copy Recto verso, black and white	Yes	Yes	Yes	Yes
	Recycled paper	Yes	No	Yes	Yes
Material use	Recycle used office supplies	No	No	No	Neutral
Drinking	Recycled coffee cups/ paper cups	Yes	Yes	Yes	Yes
Sustainable shopping	Sustainable services	Yes	No	Yes	Yes
	Bio- meatless options in cafeteria	Yes	Neutral	Yes	Yes
	Circular catering	Neutral	No	Yes	Neutral
Recycling	Paper, Glass, battery, plastic and green	Yes	Yes	Yes	Yes
Toilet use	Using wastewater as a flush solution	No	No	No	No

This analysis shows that some of the measures on the market are already used in these cases. These cases represent just a fraction of the market, when the measures are applied in these cases it does not mean that this is the case everywhere. With the implementation of these measures energy performance gap is still clearly present.

This review shows that case 1, case 3 and case 4 are more experienced in implementing the measures than case 2, but the energy performance gap of case 1, 2 and 4 are just as big as shown in the energy performance calculation in chapter 2. It shows that some measures are already implemented in some work environments and in these cases still show an energy performance gap. This means that even with the implementation of these measures a significant change is required.

#### 4.3.2 MEASURES RELATED TO THE DELPHI USER PANEL

The measurement list based on literature is also tested with the delphi user panel. It is asked these measures are implemented whether in their work environment. The results indicate to what level the measures are already applied according to users. The results are divided into energy saving measures and non-energy saving sustainability measures.

Table 4.16: Implementation measures according to delphi user panel (Own table)

Measure Topic	Measure	Never	Once in a While	Regularly	Mostly	Always
<b>Energy saving measures</b>						
Heating	Controlling temperature	X				
	Heat adapting	X				
	Warmer cloths			X		
Computer use	Turning computer off		X			
	Adapter plugged out		X			
	Night time computer turned off				X	
	Extra screen out		X			
Way of working	Activity based working			X		
Light use	Turn light off when leaving the room		X			
<b>Non- energy saving sustainability measures</b>						
Printing & Copying	Print & copy Recto verso, black and white				X	
	Printing less				X	
Drinking	Paper cups		X			
	Mugs				X	
Recycling	Paper					X
	Plastic			X		
	Glass		X			
	Batteries		X			
	Green	X				
	Remainder waste			X		

The final part of the delphi panel was focused on transport, 75% travels mainly by car and 25% travels by bike or public transport. This gives an indication of the transportation methods the participants use.

From this analysis it can be concluded that many measures are in implemented to some extent in different work environments. The results are too diverse to come up with an average. The given average is just an indication but it depends on the work environment the employee is in, whether they apply the measure or not.

#### 4.4 CONCLUSION

It can be concluded that there are not many effective user-related measures which reduce the environmental impact of a building. This contrasts with the expectation that the measures would have significant impact on the energy use of the building.

The expectations of the experts are higher than the actual impact of the measures according to literature. This leads to a gap between the expectations of measure impact and the actual impact. This gap feeds the energy performance gap. In this case, not from theoretical and operational perspective but through the expectation of the facility managers or company based on the sustainability of a building. The facility managers and the company expect that they will perform more sustainably than they actually do.

Significant change can be achieved, but not by implementing these measures on a small scale, it must be on a large scale. It is also the case that these measures will not have a significant effect the environmental impact of the building or the energy use of the building. However all small changes help in performing more sustainably in this environment. A change of 1% for an office building may not look significant but when translated to

equivalent households it becomes an energy reduction of 5-15 households (depending on the size and current energy use of the building). If every office building achieves an energy reduction of 10 households each year, the impact will be significant.

This report will look further into two energy saving measures and how to implement them within a company. Stimulating the correct behaviour plays a big role in implementing these measures. The two energy saving measures with the highest impact will be used for this process.

- Computer use – behaviour aspect
- Way of working – behaviour aspect



# 05 BEHAVIOUR STIMULATION

Pro-environmental behaviour (PEB) is a type of behaviour that focusses on minimizing the negative impact of the consequences of human behaviour on the environment (V. Blok et al., 2015). Minimizing this negative impact on the environment the behaviour of the users, are considered pro-environmental. Icek Ajzen (1991) developed the theory of planned behaviour where he conducted a research about the behaviour of people and how this can be manipulated to benefit the goals that needs to be achieved (Ajzen, 1991; Csutora, 2012; Kollmuss & Agyeman, 2002). Different research projects used theory to explain pro-environmental behaviour with the goal of stimulating pro-environmental behaviour of the end-user to make progress in reducing the user-related energy costs (V. Blok, Ringersma, & Wesselink, 2017; V. Blok et al., 2015; Kollmuss & Agyeman, 2002). The pro-environmental behaviour of employees needs to be stimulated, in order to succeed in implementing sustainable change in the work environment. In this chapter, the theory behind PEB in explained and tested on the empirical study.

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## 5.1 THE THEORY OF PLANNED BEHAVIOUR

The theory of planned behaviour (TPB) by Icek Ajzen (1991) does not focus particularly on pro-environmental behaviour, but focusses on behaviour in general. TPB is a method designed to explain and predict human behaviour on all different topics, such as on losing weight or job search. The theory explains the relations between the intention, attitude, perceived behavioural control and subjective norms of human behaviour. The three predictors (attitude toward behaviour, subjective norms and perceived behavioural control) together form the individual's behavioural intentions (fourth predictor) which leads to behaviour change, as shown in figure 5.1.

These first three predictors represent the control people's character or choices have on their behaviour.

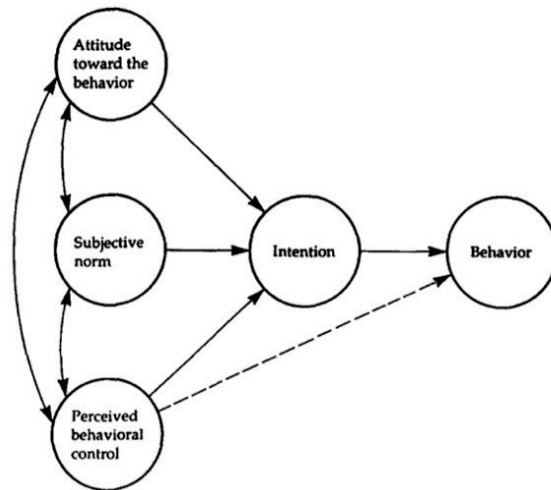


Figure 5.1: Theory of planned behaviour (Ajzen, 1991)

The first predictor focusses on what the attitude is towards the behavioural change (Ajzen, 1988, 1991). The attitude towards the behaviour includes positive and negative criticism of the personal behaviour of the person in question, it concerns the consequences of specific acts. An example is the midyear-appraisal of employees, this is a specific moment where employees get negative or positive feedback from their employer.

The second predictor is subjective norms of human behaviour and is considered to be a social factor. It describes the social pressure of the environment on the person. The effect on the behaviour of a person by means of social pressure can either have a positive impact by stimulation of group pressure or a negative impact by a counterproductive. Group beliefs are strongly represented in this predictor (Ajzen, 1988, 1991).

The third predictor in TPB is perceived behavioural control, this means the control over a situation. The control people have when expected to act a certain way and the pressure people feel when change of behaviour is controlled. The perceived behavioural control is related to the locus of control people own. The locus of control is the perception an individual has whether he or she has the belief that they have influence on change with their own behaviour. A persons with a strong internal locus believe that their actions have a big consequence in make change, where a person with an external locus of control the believe has that their actions impact are inconsiderable (Ajzen, 1988, 1991; Kollmuss & Agyeman, 2002).

The final predictor towards change of behaviour is intention. The intention to behavioural change is about the motivation for a person to change (Ajzen, 1988, 1991). Ajzen (1991): "The stronger the intention is to change, the more likely it is that it will be executed".

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*Icek Ajzen (1991; p. 188): "As a general rule, the more favourable the attitude and subjective norm with respect to a behaviour, and the greater the perceived behavioural control, the stronger should be an individual's intention to perform the behaviour under consideration"*

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Controlling all or some of these predictors makes it, according to the TPB, possible to change or manipulate the human behaviour (Ajzen, 1991).

## 5.2 PRO-ENVIRONMENTAL BEHAVIOUR

The theory of planned behaviour focusses on the change of behaviour in general. During this report, the main focus is changing behaviour in a pro-environmental way. Pro-environmental behaviour contributes to the change in user-related energy use, because the user behaviour has as its main goal to minimize the impact on the environment. Csutora (2012) explains in her research that a more pro-environmental behaviour does not automatically lead to lower energy use. The measures, that make the pro-environmental behaviour using less energy, need to be stimulated as well.



### 5.3 Relation between TPB and PEB

The results of Kollmuss & Agyeman (2002) on a systematic literature review on pro-environmental behaviour research: why people act environmentally, are used in this research combination with the TPB. The research of Kollmuss & Agyeman (2002) did not introduce new theories, however it collected numerous of theoretical frameworks which were made to explain the gap between pro-environmental behaviour, environmental awareness and pro-environmental knowledge. Kollmus & Aggyeman (2002) concluded that shaping pro-environmental behaviour only has complex solutions and that these results cannot be joined into one framework. They managed to analyse factors which have influenced the pro-environmental behaviour of people. The analysed factors were based on the analysis of eight different pro-environmental theories. The question here is, is there a relation between TPB and PEB?

During the research of Kollmuss & Agyeman (2002) introduced three main factors that are in relation to controlling PEB. The three main factors are demographic factors, external factors and internal factors. They will be explained separately hereafter.

#### External Factors

The external factors exist out of three factors; institutional, economic, social norms.

The institutional factors are the facilities needed to make the change possible, such as recycling bins are needed to recycle.

The economic factor is related to the financial benefits of the behaviour. The influence of the economic factor is very complex and poorly understood, but it has a strong influence on the behaviour and decisions of a person. The economic factor is a strong factor due to the fact that in the current economic environment money plays an important role (Csutora, 2012; Kollmuss & Agyeman, 2002).

The final factor consists out of social norms, which show the opinion of people with strong beliefs. It depends on cultural beliefs, cultural values and the country these people live in. When the social or cultural beliefs do not allow for change, it is more likely that it will not happen. Related to social norms is social pressure, specifically from the society around the person it affects (Kollmuss & Agyeman, 2002).

#### Internal Factors

The internal factors exist out of seven different factors; intention to act, environmental knowledge, Environmental values, Attitude towards PEB, Environmental awareness, personal norms and perceived behaviour. The intention to act, attitude and perceived behaviour control are derivatives from the TPB

The first factor, the intention to act, is a complex factor and can be divided into selective motives or primary motives. Selective motives are personal needs that motivate a person to act a certain way, this may include financial benefit from the situation. Primary motives are environmental values, that are the values each person has, according to his/her environment. The intention to act is a factor shaped by clarity and direction.

The second factor is environmental knowledge. From research it has been concluded that most people possess the knowledge about environmental issues and the relation between acting pro-environmental. It is important that this knowledge is activated if people do not possess this knowledge. It needs to be thought and explained.

The third factor is environmental values. It is a complex factor because it includes personal values. The values a person tries to live by during their life, are based on their emotional connection to environmental issues (V. Blok et al., 2015; Kollmuss & Agyeman, 2002).

The fourth factor is the attitude towards pro-environmental behaviour. A person can see this as a positive or a negative feeling, the attitude towards pro-environmental behaviour is a factor what influences the PEB directly.

#### EXTERNAL FACTORS

- INSTITUTIONAL FACTORS
- ECONOMIC FACTORS
- SOCIAL NORMS

#### INTERNAL FACTORS

- INTENTION TO ACT
- ENVIRONMENTAL KNOWLEDGE
- ENVIRONMENTAL VALUES
- ATTITUDE TOWARDS PEB
- ENVIRONMENT AWARENESS
- PERSONAL NORMS
- PERCEIVED BEHAVIOUR CONTROL

The fifth factor is environmental awareness. This factor explains the awareness people have about the environmental impact. Environmental awareness is based on five sub factors: 1) environmental knowledge 2) environmental values 3) environmental attitudes 4) willingness to act 5) actual behaviour (Csutora, 2012).

The sixth factor consists of personal norms of which it is believed that the stronger the emotional connection is between the environmental issue and the implementation the more likely it is that the person will be preoccupied with acting pro-environmental. The norms a person sets personally have a strong relation to the emotional connection which influence the choice (V. Blok et al., 2015; Kollmuss & Agyeman, 2002).

The final factor is perceived behaviour control which relates to the locus of control (V. Blok et al., 2015; Kollmuss & Agyeman, 2002).

### Demographic Factors

The demographic factors exist out of gender and the years of educations. Gender is concluded as a factor because of the emotional relation to being a female or a male. Females tend to be more emotional and vulnerable to indirect factors, where males are less vulnerable for indirect factors. The years of educations have influence on the environmental knowledge of a person. Research does not have a clear conclusion for this as in some cases education has influenced the outcome and in some cases it has not. Therefore education is considered to be an unreliable factor (V. Blok et al., 2015; Kollmuss & Agyeman, 2002).

### DEMOGRAPHIC FACTORS

- GENDER
- YEARS OF EDUCATION

Many of these factors may conflict or complement with each other, but these factors are part of the reasoning behind daily decisions and actions related to pro-environmental behaviour. Kollmuss & Agyeman (2002) systematic literature report reviewed of over 14 pro-environmental behaviour theories.

According to Blok et al. (2013) the TPB cannot explain PEB completely, there are relations between TPB and PEB according to factors. The TPB does not involve with the factors which influence PEB such as environmental knowledge and environmental awareness, this is because TPB does not have as main focus environmental behaviour. The environmental specific factors are not included in the TPB diagram.

In this research, the external and internal factors will be taken into account. The demographic factors will not be taken into account, because of the factors gender, even if this has an emotional relation. It is very important for today's society to become gender-neutral and thus it should not matter whether you are a boy or a girl. During this research the results will not be implied on genders but organisations. Also research concluded that it is unclear if the years of education has any influence on the PEB, the results are not in line with each other (Duerden & Witt, 2010; Kollmuss & Agyeman, 2002; Steg & Vlek, 2009).

## 5.4 HOUSEHOLDS VS. WORKPLACE

The biggest issue with the current PEB diagrams is that these explain PEB in households, not specific PEB in workplaces. Blok et al. (2015) concluded that there is a literature gap between PEB in households and PEB in the workplace. It is harder to make changes within a workplace environment, one of the reason is that employees have the feeling that they are in a sense of powerless (Ajzen, 1991).

According to literature the main difference between households and the workplace environment is that in the workplace environment more facts are needed to justify the taken actions. Whereby the results of households are more directly reflected on the energy bill. Households gain directly more from it, because the personal (financial) benefit from it is higher than in the workplace, which makes it easier to achieve a goal (Gatersleben et al., 2002; Nye & Hargreaves, 2010). This all relates back to the economic factors; this behaviour shows the importance of economic factors.

The theory related to the difference between households and the workplace from literature is discussed during the interviews and with the delphi user panel. The results of their experience are as follows:

Facility manager 1, energy performance gap specialist and behavioural workplace specialist where the interviewees who, were interviewed about this topic.

### INTERVIEW ANSWERS

#### Households vs. Workplace (Split incentive)

Table 5.1: Transcript summary topic Split incentive

Topic	Facility Manager 1	Energy performance gap specialist	Behavioural workplace specialist
Split incentive	On households the influence is more direct than with the workplace, you see the change directly on the energy bill.	People in an office tend to act differently because they are not aware of the financial consequence.	The power of the workplace are the colleagues. The power of social pressure is there. I that the financial incentive has an influence, but the motivation should not be there because of the money but for the environment.

### CROSS-ANALYSIS

Table 5.2: Cross-Analysis households vs. Workplace

Households vs. Workplace (Split incentive)	Facility manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behaviour specialist	Behavioural workplace specialist
Split incentive is the cause of the fact that people act different at home than at the workplace.	X	X	-	-	X

### INTERVIEW ANALYSIS

The majority of the experts is of the opinion that the split incentive, is the problem between households and the workplace. A split incentive means that the intentions in both environments of the users are not the same. In the workplace, the user does not see the direct impact in the harm they do, whereas at home, they see it reflected in their energy bill. The incentives of both situations for the user are not the same. The motivation should not be there for the money, what you currently see, the intention should be there for the environment.

The results of the delphi user panel does not completely support the statement from literature. The question asked to the user is: "Do you act more environmentally conscious at home than on the work floor?" The results are presented in figure 5.2. The results of this question indicated that people think they act less pro-environmental on the workplace than at home.

The diagram shows that half of the participants are aware that they act less pro-environmental on the workplace than at home, a quarter thinks it is hard to indicate if they do and the final quarter knows that they act the same in the workplaces as at home.

#### HOUSEHOLDS VS WORKPLACE

■ Yes ■ Neutral ■ No

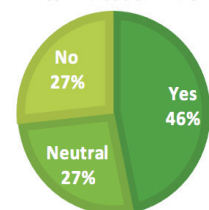


Figure 5.2: Acting pro-environmental between households and workplace (own illustration)

It can be concluded that sustainable behaviour in households differs from pro-environmental behaviour on the workplace. Experts do have an indication to explain this problem, but users do not see this relation as strong. Overall, experts, users and literature are aware of the problem. The expectation is that when the motivation of the users changes into intention to act pro-environmental, this problem will not be focussed on the economical factor anymore.

## 5.5 PRO-ENVIRONMENTAL BEHAVIOUR FACTORS IN THE WORKPLACE

Researchers are trying to determine why some people show more PEB than others, they used different fields of perspectives to do this, such as psychological, behaviour and educational (V. Blok et al., 2015). The research of Blok et al. (2015) focussed on the introduced factors of Kollmuss & Agyeman (2002). These factors were researched, together with the relation between TPB and PEB and whether these factors differ between the workplace factors or household factors. More research about the relation between TPB and PEB was done by Nye & Hargreaves (2010) and Rioux (2017) which showed that TPB can be applied in the workplace environment (Nye & Hargreaves, 2010; Rioux, 2017).

The research of Blok et al (2015) focussed on the internal and external factors and which of these factors have a direct or an indirect impact on the PEB in the workplace. The results of this research were factors used during this research. The study explained that TPB can be applied in the workplace environment. However, the study did not take into account other important factors and is therefore insufficient. Those other factors that need to be considered, focus more on social norms and leadership support. These relation between factors are used, to develop a PEB in the workplace diagram. Figure 5.3 shows the diagram based on literature.

The diagram is based on the previously discussed factors which are based on a variation of studies by Kollmuss & Agyeman (2002). The only exception was that this research did not focus completely on PEB on the workplace. The factor leadership support was added. These factors show the influence employers have on their employees. This includes sharing their personal and company values, inspirational motivation, PEB stimulation and working on the relationship with their employees (V. Blok et al., 2017, 2015).

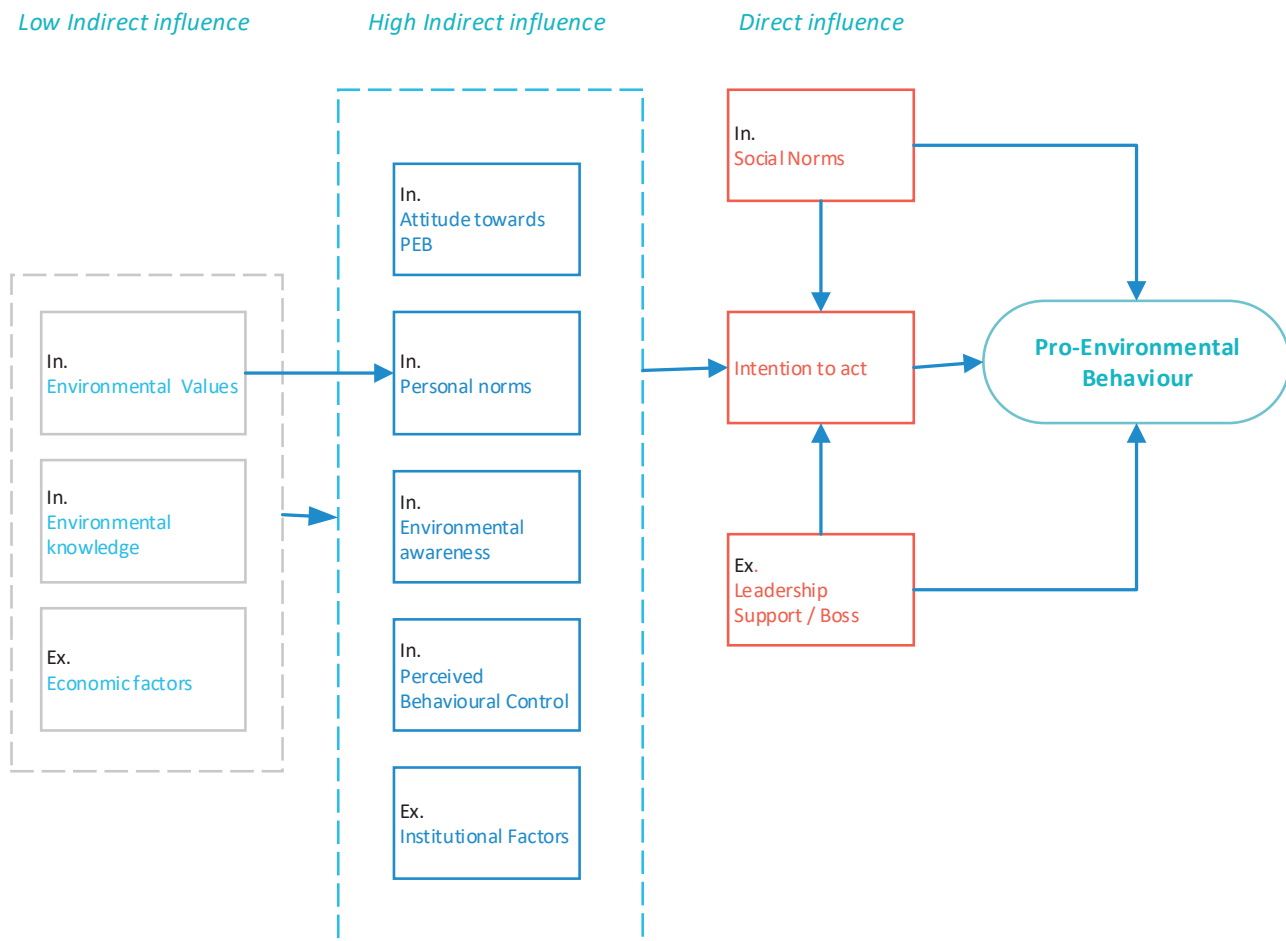


Figure 5.3 :Pro-environmental behaviour diagram based on literature (own illustration)

The research by Blok et al. (2015) resulted in conclusions such as: the intention to act is the most significant factor to explain PEB in the workplace. This factor does not explain PEB in the workplace completely however, as other factors, such as social norms and leadership support influence the behaviour of employees too. The research of Kollmuss & Agyeman (2002) concluded that some factors have more impact on the PEB of the users than others.

*“The easier it is to perform in a pro-environmental way, the more likely it is that people will actually perform pro-environmental behaviour.” Kollmuss & Agyeman (2002; p.254)*

During research in 2015, Blok et al. noticed that not all factors were considered. The management part has a big influence in PEB in the workplace but was not strongly represented in the afore mentioned research. They performed a new research in 2017 named: Pro-environmental behaviour in the workplace and the role of managers and organisation, because they discovered that the relation between the intention to act –PEB and leadership a strong influence has on each other. The factors that influence daily changes in PEB of employees were researched. Blok et al. drew different conclusions from both researches, some conclusions contradicted each other. The outcomes of both research projects differ from each other, without a clear explanation. Results such as; there is no relation between intention to act and PEB or leadership does not have a significant effect on the PEB were concluded. These results do not agree with previous research, therefore the factors that influence this behaviour were added to the diagram and the result was taken into account but was not considered to be decisive (Blok et al., 2017). This results into an additional factor in the diagram, Perceived Organisational Support to – Act environmental (POS-E). Research also showed that increasing the awareness and knowledge of the person did not automatically lead to pro-environmental behaviour (Kollmuss & Agyeman, 2002).

POS-E has according to Blok et al. (2017) a direct impact on the PEB. POS-E is “the specific belief held by employees concerning how much the organisation values their contribution towards sustainability” ( Blok et al., 2015). The addition of POS-E to the diagram makes the schema as shown in figure 5.4.

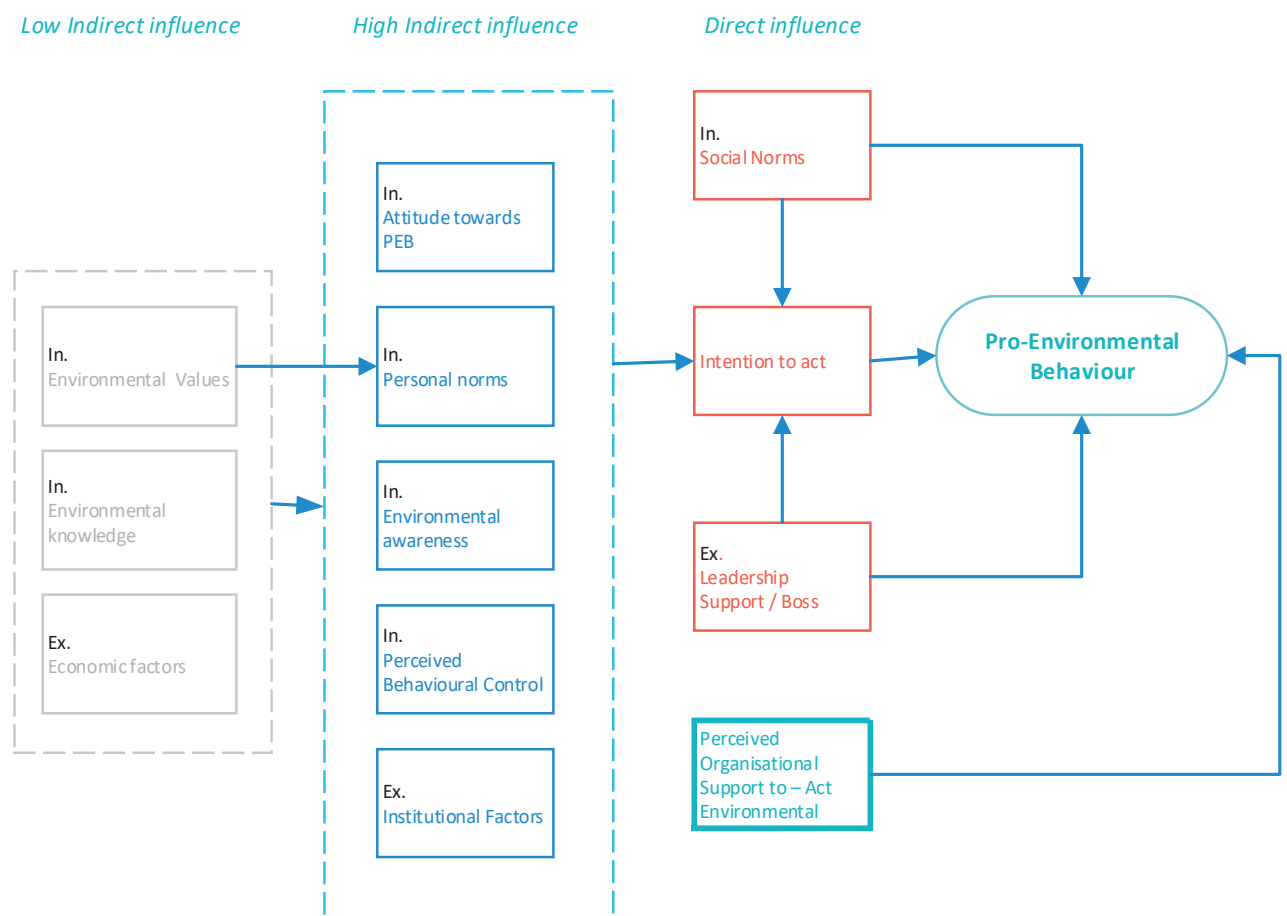


Figure 5.4 :Pro-environmental behaviour diagram based on additional literature (own illustration)

This diagram will be the result from the literature study and thereby the basis for further research. The following parts a relation between the empirical study and this diagram will be developed through the interviews and delphi panels.

## 5.6 EMPIRICAL STUDY: ACTIVATING PRO-ENVIRONMENTAL BEHAVIOUR FACTORS

The results of the empirical study are visualised in four different behaviour diagrams, each of these results will be presented separately. And finally, all the developed diagrams (literature and empirical) will be compared to each other. The factors with the highest influence will be considered for use further on in the research.

### 5.6.1 PRO-ENVIRONMENTAL BEHAVIOUR FOR THE INTERVIEWS

The semi- structured interviews focussed on PEB and how this can be stimulated or motivated. Scenarios involve financial motivation, initiative from user perspective and employer perspective, behaviour, example function and stimulation initiative of the users.

#### INTERVIEW ANSWERS

##### Initiative users

Table 5.3: Transcript summary topic initiative users

Topic	Facility Manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behavior specialist	Behavioural workplace specialist
Stimulation	<p>The current interest of the end-user is good. They are starting to take initiative to make a change. You can call it consumer behaviour, and it triggers organizations to change, as consumers are no longer satisfied. It is still just a small change, but still a change.</p> <p>Because of the elusiveness of energy, it is hard to expect initiative from the user.</p>		<p>Initiative from users should be encouraged and the possibility to perform should be given.</p> <p>Example: idea box for employees, the best sustainable solution will be executed.</p>	PEB from the users should be stimulated by the managers of the company.	
Social pressure		Social pressure from colleagues is important to trigger initiative of users.		Less should come from management perspective, more should come from behaviour, communication and initiative from users and the stimulation of this.	<p>The influence of colleagues is a powerful source. People are constant comparing themselves to others, use this to your advantage.</p> <p>The choice employees have should be limited, but there should be a choice. The main factor is that these choices should benefit the comfort of the user.</p>

<b>Impact awareness</b>	It is important that you should not bother the user too much with influence, it should be done for them.	If people start behaving in an energy-efficient way in an energy-efficient building that it comes less from the user but more from the company.	If users notice what kind of impact they can have, probably they would make a change, but they are not aware of it. Why are they not aware? As it is not their concern, it is another department's.		
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Initiative of the employer

Table 5.4: Transcript summary topic initiative of the employer

<b>Topic</b>	<b>Facility Manager 1</b>	<b>Energy performance gap specialist</b>	<b>Facility manager 2</b>	<b>Pro-environmental behavior specialist</b>	<b>Behavioural workplace specialist</b>
<b>Provide options</b>	The employer should adjust the buildings techniques, so that the options of the users are limited.		The employer should motivate the initiative and budget it.		Employees should make change possible and motivate change. The law can help here.
<b>Employers initiative</b>	The energy saving measures should come from the employer's initiative, where implementing the general sustainable measures should come from the users.		Employees should also have a vote; it is the power of the people.		
<b>Company wants to change</b>	If the CEO sets an ambition and commits to it 100%, it is more likely to succeed.	If people start behaving in an energy-efficient way in an energy-efficient building that it comes less from the user but more from the company.  Only when a company is willing to make the change, it is possible to make that change.		Less should come from management perspective, more should come from behaviour, communication and initiative of users and the stimulation of this.	
<b>Good example</b>			The choice made in the work environment should be done by the management.	You cannot force employees or employers to act pro-environmental	Comfort is the most important factor. The facilities should be there for the comfort of the user. The choice employees have should be limited, but there should be a choice.

<b>Movement user</b>	The movement of the user should be stimulated by the employer.		The employees and employers should work together to make the change effective.		
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Economical factor

Table 5.5: Transcript summary topic economical factor

<b>Topic</b>	<b>Facility Manager 1</b>	<b>Energy performance gap specialist</b>	<b>Facility manager 2</b>	<b>Pro-environmental behavior specialist</b>	<b>Behavioural workplace specialist</b>
<b>Investment Cost</b>	The cost of these measure should not be higher than the profit. If so, it is more likely companies will invest in it.	Measures may not cost too much.			<p>You need to ask yourself where lays the responsibility. With the company or the user?</p> <p>The options presented to the users or companies should not vary much from each other. When this varies too much people are less likely to choose for the environmental friendly option because it will cost too much.</p> <p>Financial position makes a big difference. When people do not have a big budget to spend. It does not create the right incentive to act pro-environmental</p>
<b>Financial reward</b>	At home the split incentive does not exist. Which means that people are more likely to act pro-environmental because they financially benefit from it.	Financial reward may act in a positive way on users. When you get a bonus at the end of the year because users have acted pro-environmentally it is more likely that they will act accordingly.	Financial benefits are a tool to motivate pro-environmental behaviour.		



<b>Reward with the wrong intention</b>			but should not be the motivation.	I don't think the economic aspect (financial aspect) can be a driver to show more pro-environmental behaviour.  We do not have the right intentions. Priority is still financial benefits or social benefits not environmental benefits.	People are willing to pay for convenience when that is one of the options.
<b>Positive feedback</b>		People will act different when it has consequences in the long term. This includes acting pro-environmental. There are two things people are sensitive to their financial status and positive feedback from their boss.			People are more sensitive for compliments than financial benefits. Especially looking at the current market, it is more important to fit in with a company than the financial bonus.  The green option should not be more expensive.

## Behaviour

Table 5.6: Transcript summary topic behaviour

<b>Topic</b>	<b>Facility Manager 1</b>	<b>Energy performance gap specialist</b>	<b>Facility manager 2</b>	<b>Pro-environmental behavior specialist</b>	<b>Behavioural workplace specialist</b>
<b>Stimulated PEB</b>		There are two types: Type 1: tries to let technology fix the problem Type 2: Tries to change the user behaviour.  Behaviour can be motivated though campagnas and keep reminding people to change.  You cannot rely completely on technology, you always should check it.	many people are not concerned with it. It is about the click, if people have the right mind-set to change.	The impact is not high because people think that their impact is nil	You try to let people make the right choice, by let them make the morel/ social right choice. When there are two options, people will choose for the cheap one, When both options are just as expensive people tend to choose the easier option. The green option should not be more expensive.

<b>Awareness</b>	I am happy with the initiative toward pro-environmental behaviour, the start of being aware is there.	People are often not even aware of energy-efficient behaviour, but it is more about habits.	When a person sees the change, it is more likely that they will change.  Monitor the entire behaviour of employees shows where the problem is.	People need to be made aware of their behaviour.	Before the change are normal, people will fall back in what they think is "normal" just keep reminding them what is right.
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Stimulation of Pro-environmental behaviour

Table 5.7: Transcript summary topic stimulation of pro-environmental behaviour

<b>Topic</b>	<b>Facility Manager 1</b>	<b>Energy performance gap specialist</b>	<b>Facility manager 2</b>	<b>Pro-environmental behavior specialist</b>	<b>Behavioural workplace specialist</b>
<b>Board stimulated PEB</b>	The facility manager should stimulate the user to act pro-environment.  Pro-environmental behaviour should be explained to users.	Implementing by setting targets and challenges is possibility.			
<b>Higher sustainable standards</b>		In some cases, stimulating PEB comes with the building, because it is expected from the users.	Optimizing the performance of the building may lead to stimulation of the users.  Stimulating ideas of user is good! Or simulating by giving them compliments.	In a playful way pointing the problem out to people. There change matters!	Let the users make choices, but make sure that the default options are always the best choice.
<b>Stimulation from colleagues</b>				Stimulating should come from colleagues. A method is to set targets or challenges.	I think that especially what others do compared to yourself (so what colleagues do) is very important  Internal competition is a method.

Example function

Table 5.8: Transcript summary topic example function

Topic	Facility Manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behavior specialist	Behavioural workplace specialist
Good example leads to integrate changes	Sometimes you see that a good example helps to integrate changes, this can be the example of the managements or even colleagues.				
Change matters		Show a good example, show that change matter!			
Good example board	This can be the example of the managements or even colleagues.		The government tries to give a good example, they are starting with their own portfolio.	The manager should be clear about why they make those changes, and what they gain from it.	The management should give a good example and showing the consequences is important
Good example colleagues	This can be the example of the managements or even colleagues.		An example can come from colleagues but also management	Also, being the good example to show all the possibilities.	What I think is even stronger is when an equal is showing the good example, not the boss.

## CROSS-ANALYSIS

Table 5.9: Cross-analysis pro-environmental behaviour

	Facility manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behaviour specialist	Behavioural workplace specialist
<b>Initiative users</b>					
Initiative from the user should be stimulated and the possibility to preform should be provided.	X		X	X	(X)
Social pressure from colleague's is a good method.		X	(X)	(X)	X
Employees should be more aware of the impact they have.	X	X			
<b>Initiative employer</b>					
The employer should provide the options to act pro-environmental.	X	(X)	(X)		X
Energy saving measures should come from the employer's initiative.	X		(X)		
The company needs to be willing to change.	X	X	(X)	(X)	(X)
The employer should give a good example for the employee.			X	X	X
Movement of the user should be stimulated.	X		X		
<b>Economical factor</b>					
Investments of the sustainable measure should be lower than the yield.	X	X			(X)
Financial reward to employees is a tool act pro-environmental.	X	X			(X)
Financial reward to employees will not motivate them in with the right intention, in the long run.	(X)	(X)		X	X
People are more sensitive to positive feedback than financial incentive.		X		X	X
<b>Behaviour</b>					
The behaviour of users should be stimulated to pro-environmental behaviour.	X	X	X	X	X
People are sometimes not aware of their behaviour; you need to make them aware.		X	X	X	X
<b>Stimulation</b>					
The facility manager / board should stimulate the user to act pro-environmental.	X	X	X	(X)	(X)
Optimizing of the building performance leads to a higher sustainable standard which leads to stimulation of the users.		X	X		
Stimulation should come from colleagues .				X	X
<b>Example function</b>					
Good example leads to integrate changes.	X			(X)	
Show that change matter.		X		X	X
Good example of the board/FM/management.	X	(X)	X	X	X
Good example of the colleagues.	X	(X)	X	X	X

## INTERVIEW ANALYSIS

There are various motives behind pro-environmental behaviour such as financial motives and initiative motives. These motives are most of the time related to other behavioural factors. Pro-environmental behaviour of a company can be divided into PEB of the users and PEB of the management. Both divisions have different behaviour motivations because the intention to act differs in both cases. This diagram conducted from the interviews shows the interaction with each motive.

The results of the interviews were linked to the literature factors to create a diagram which can be compared to the literature diagram. Two factors were missing according to the interview experts, namely the factors law and eco-communication. These factors were added to the diagram according to the interviews. These factors can make a significant difference in the relation between PEB and the company. Due to legislature a new additional factor is added to this diagram, because of the relation with pro-environmental behaviour of the management. The factor eco-communication is added and can be seen as an important factor to convey the message of PEB. Without communicating with each other it is unclear what the status of the measure is and how pro-environment behaviour can be stimulated.

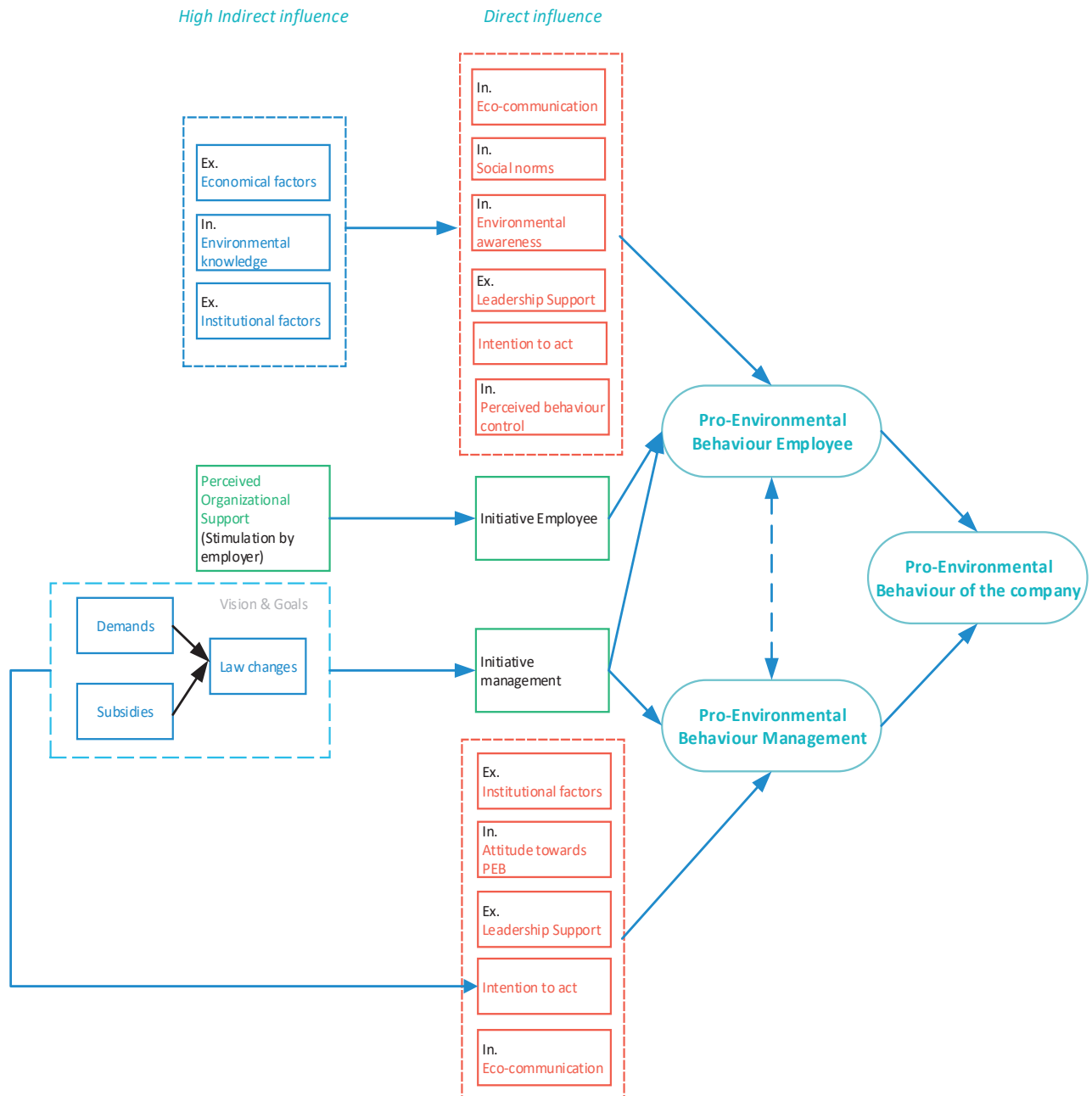


Figure 5.5 :Pro-environmental behaviour diagram based on interviews (own illustration)

There are three kinds of methods to activate a company to act pro-environmental. Firstly, to activate the whole company this can be done by activating the management who activates the employee. Secondly, by activating PEB of the employees which influences the PEB of the management and thereby the company. Finally, by activating the management which influence activates the employee and thereby the whole company as visualised in figure 5.5. Figure 5.5. shows the relations between the PEB factors according to the interviews.

Each factor in the diagram has a In. or Ex. abbreviation where In. indicates internal factors and Ex. indicates external factors.

According to the interviews, the PEB of the employee can be directly activated through three different ways. Firstly, initiative by the management, this is indicated by new measures being implemented. When the measures are implemented by the management, change in PEB of the employee will occur due the new rules. The second method is by initiative of the employee, it is important that the initiative of the employee is stimulated by the employer which leads can perceived organizational support. The final method is by influencing behaviour factors. Not all behaviour factors were discussed during the interviews. The following six factors where indicated as direct influence factors which have the most impact on the pro-environmental behaviour of the employee. Three other factors where implemented as indirect influence.

### **Direct influence**

- Eco-communication: by communicating on eco-friendly level employees become more aware of what happens around them.
- Social norms: when colleagues act pro-environmentally, it is more likely that the person will also act pro-environmentally.
- Environmental awareness: being aware of pro-environmental behaviour activates the intention.
- Leadership support: it is important that the management shows a good example. Just like social norms, this will motivate the user to act pro-environmentally.
- Intention to act: should be there to motivate the user. This can be used to motivate the user at home.
- Perceived behaviour control: the user is aware of their locus of control.

### **Indirect influence**

- Economic factors: Financial motivation is not leading for the user.
- Environmental knowledge, knowledge user have is important to act pro-environmental but not leading.
- Institutional factors, the user should have the possibility to take measures so the management should provide the possibility, but these changes do not have a direct impact on the behaviour of the employee.

The PEB of the management can directly be activated in three different ways. Firstly, by behavioural change of the employee, where the employer activates the employee the employee can activate the management. The second way is to implement new initiatives from the management. A possible reason for this change could be a governmental vision and goal. When the government changes laws and sets out rules, the initiative of the management changes, which influences the intention of the management and company. Finally, the behavioural factors. Not all behavioural factors were discussed during the interviews. The following five factors were indicated as factors which had the most impact on the pro-environmental behaviour of the management.

- Institutional factors; it is important for the management when they do not provide the possibility to change, the impact of changes will not occur. In this case, this factor also involved the technical knowledge needed to implement and achieve measures.
- Attitude towards PEB; the attitude from the management towards PEB should be toward PEB to influence the company and their employees.
- Leadership support; by supporting their own initiatives it is more likely change will stick and the user will change as well.
- Intention to act; should be there even if it is influenced by legislature. When a company wants to change, their intention to act will influence the pro-environmental behaviour of the company.
- Eco-communication; by communication on eco perspective to the management and the users, people will be more aware of the change. Which influence the PEB of the company.

### **5.6.2 PEB ACCORDING TO THE DELPHI USER PANEL**

The behaviour diagram shown in figure 5.6 is based on two survey rounds with the Delphi user panel. The first survey round of the user panel consists of two parts. Part one was the measures part, and part two the behaviour part. The second survey round consists of a recap round one and additional questions which are misted in part one.

The internal and external factors where proposed to the users by statements. The answer method was a five-point scale which indicates the impact of the factor for the user. In Appendix 4 the total results of the survey can be found. Table 5.10 shows an analysis of the results which are used for the behaviour diagram from user

perspective. This table shows the impact ratio of the factors according to the users. The ratios used are: high impact is direct influence, neutral is high indirect influence and low impact is low indirect influence of the PEB.

The implementation of each factor depends on the question asked. All the questions were categorised in factors, which results in the impact diagram. The ranking of impact influences the impact on the behaviour diagram by the users.

The results from the first Delphi round show a big difference between this user behaviour diagram and the diagram of literature & interviews. During the second round these differences became less. This can be explained by the method of questioning.

In round one it was remarkable that the intention to act has according to literature and interviews a high influence on the behaviour of the user where the user do not see it that way. During the second round it became clear that this happened because of the question formulation.

Table 5.10: User survey results

	Low impact	Neutral	High Impact
Economic factor	X		
Environmental awareness			X
Perceived organisation support		X	
Environmental values			X
Intention to act			X
Perceived behaviour control			X
Eco-communication			X
Attitude towards PEB		X	
Environmental knowledge		X	
Social norms			X
Leadership support	X		
Institutional factors		X	
Personal Norms		X	

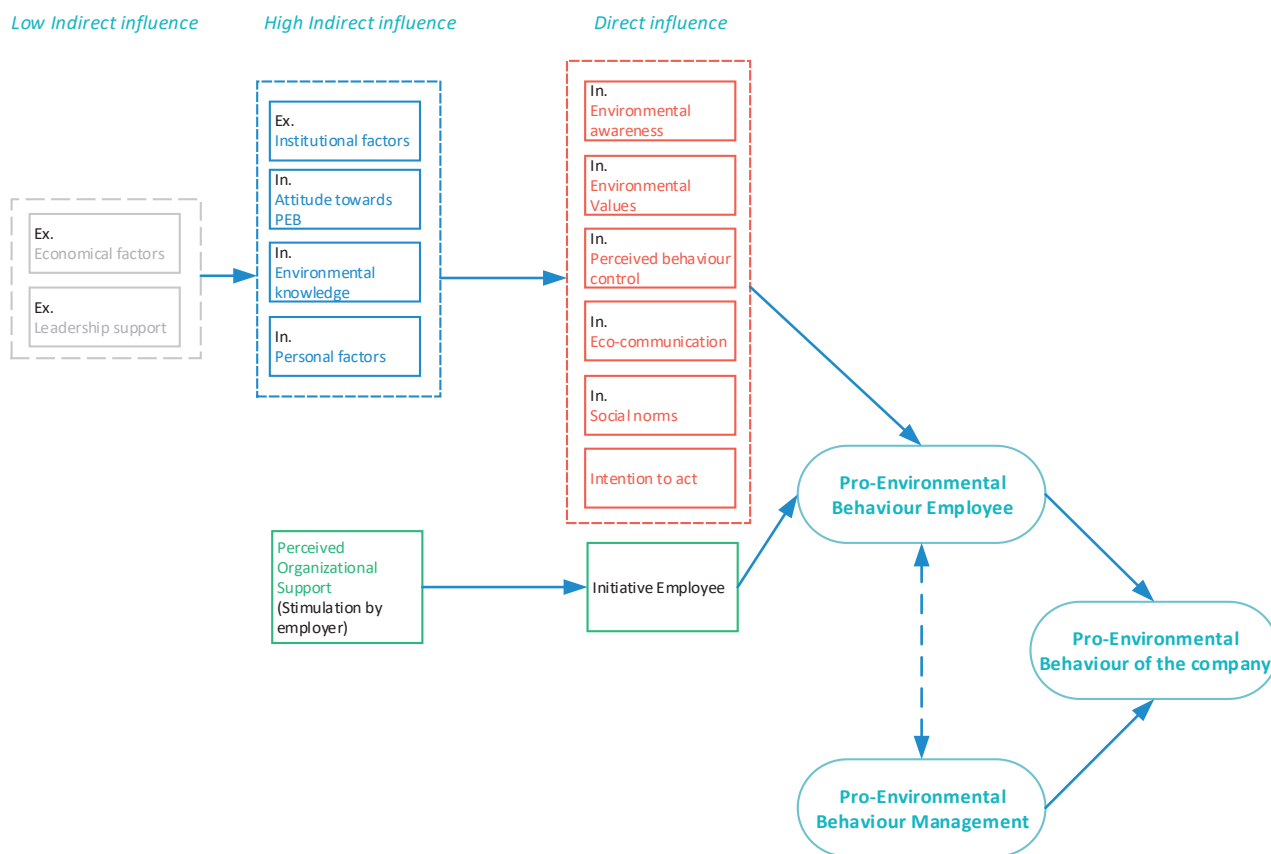


Figure 5.6: Pro-environmental behaviour diagram based on Delphi user panel (own illustration)

### 5.6.3 PEB ACCORDING TO THE DELPHI EXPERT PANEL

The first survey round of the expert panel consists of two parts. The first part consisted of 12 statements each related to a specific behaviour factor, which will be used in developing a behaviour diagram according to the experts/management. These statements are related to the pro-environmental behaviour the management incorporate in their work environment. The second part focusses on types of measures and implementing measures.

The internal and external factors were proposed to the experts by statements. The answer method was a five-point scale which indicates the impact of the factor according to the expert. In Appendix 5 the total results of the survey can be found. Table 5.11 shows an analysis of the results which are used for the behaviour diagram from management perspective. This table shows the impact ratio of the factors according to the experts, the ratio used is high impact is direct influence, neutral is high indirect influence and low impact is low indirect influence of the PEB. The ranking of impact influences the impact on the behaviour diagram by the experts. Figure 5.7 shows the relations between the PEB factors according to Delphi expert panel

Table 5.11: Expert survey results

	Low impact	Neutral	High Impact
Economic factor	X		
Environmental awareness			X
Perceived organisation support		X	
Environmental values		X	
Intention to act			X
Perceived behaviour control			X
Eco-communication			X
Environmental knowledge		X	
Social norms			X
Leadership support		X	
Initiative employee		X	
Law change			X
Personal norms		X	
Institutional factors		X	
Attitude towards PEB			X

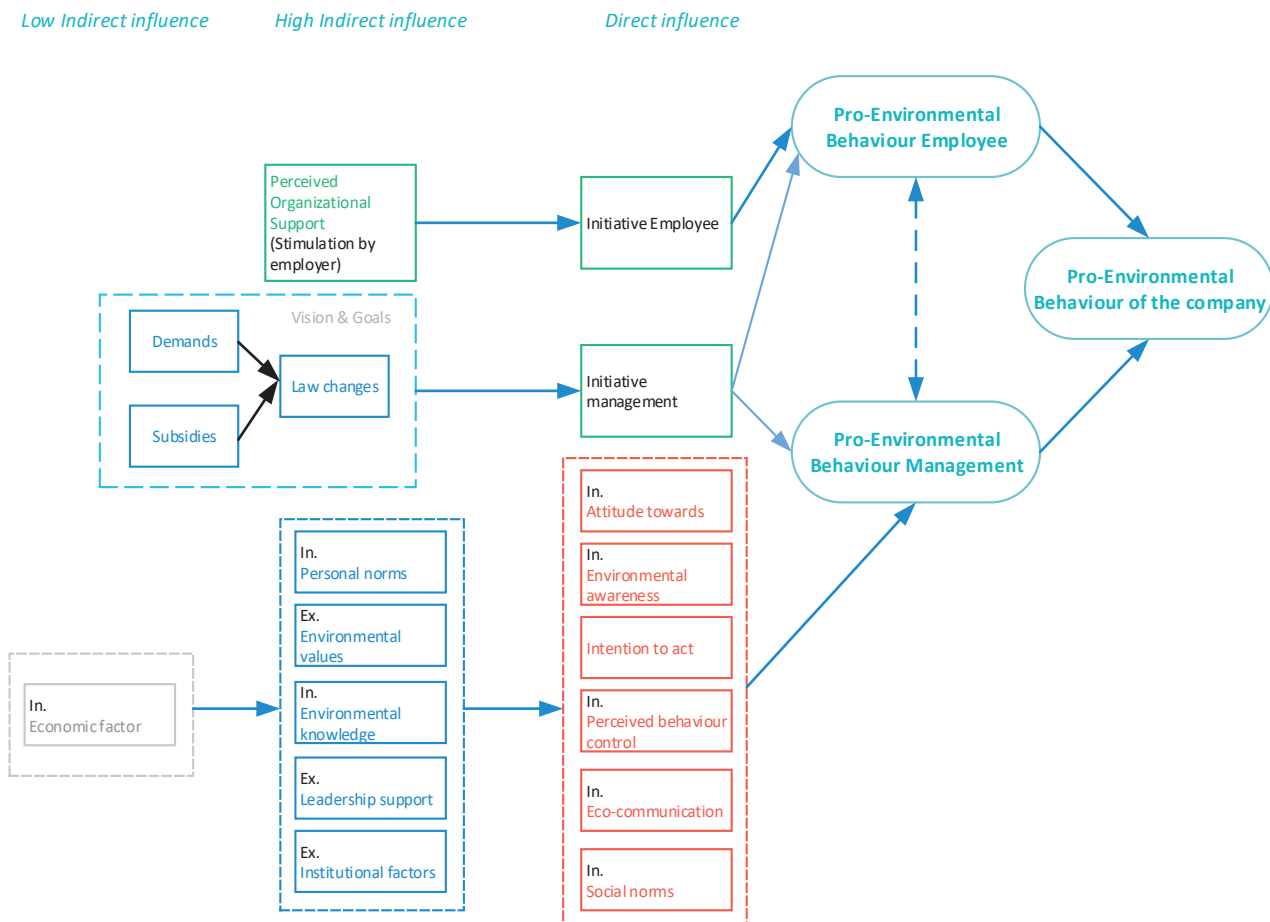


Figure 5.7: Pro-environmental behaviour diagram based on delphi expert panel (own illustration)



Researchers and experts are divided on the economic factor. The financial factor has a high influence on the behaviour of users but should be used in the right way. When the financial factors claim a leading role in change, users expect to get a reward when changes need to be made. This factor should be a supporting factor not a leading factor, otherwise wrong expectations may be set. According to the Delphi expert panel it is a method that works, but it is not the right method to motivate employees.

According to the experts of the interviews, the law has a big influence in motivating companies to act pro-environmental. Especially, when it is about the laggards in the work field will be motivated to make a change. Statements like:

- To get a better picture of energy consumption, the government should focus more on actual energy consumption instead of theoretical energy consumption.
- The new legislation with regard to minimum energy label C in 2023 is outdated and higher expectations must be set.

The general result of these statements where that this will have a high impact on motivating the PEB of companies.

Table 5.12: Result cases

### 5.6.4 PEB ACCORDING TO THE CASES

The implementation of the pro-environmental behaviour factors was compared between each case. Some cases implemented certain behaviour factors where others do not follow the factors within the company. The appreciation is as follows: “yes” when it is implemented within the company, “Neutral” when they try to implement it but with no large success, and “No” when it is not implemented within the company.

	Case 1	Case 2	Case 3	Case 4
Eco-communication	Yes	No	Yes	Yes
Perceived behaviour control	Neutral	No	No	Yes
Economic factor	No	No	No	No
Environmental awareness	Yes	No	Yes	Yes
Perceived organizational support	Yes	Yes	Yes	Yes
Environmental knowledge	Neutral	No	No	No
Leadership support	Yes	No	Yes	No
Intention to act	Yes	Neutral	Yes	Yes
Social Norms	Yes	No	Neutral	Neutral

#### Case 1

Initiative of the user is supported by the organization; it only depends on the proposal and feasibility. When it is feasible it will be stimulated by the organization. The ambition case one presented, changes their intention to act. Their ambitions are:

- Energy neutral
- In organization operation CO2 neutral
- Only buy circular materials and products
- Agreements on inclusion have been made in 5% of the contracts

Within this case eco-communication plays an important role. On the base of example projects and measured impact the result will be communicated to their employees.

#### Case 2

Initiative of employees will be supported by the organization when there is a profitability of the investment within 5 years. The intention to act within case 2 is not big, their ambitions contain implementing known measures. It is noticed that the second case has less environmental goals and subsequently has less implementations than the other three cases.

#### Case 3

This case has high ambitions for the following years such as: zero waste in 2020, CO2 neutral in 2025 and fully circular in 2030. These ambitions influence the intention to act of the company.

#### Case 4

There are three sustainable ambitions created by this company. Firstly, wanting a high score on CO2 performance ladder, sustainable use of wood and develop sustainable shack. These goals are mainly based on the function of the company. Not on the work environment structure.

Out of the cases can be concluded that several behaviour factors are already implemented in companies which do and do not have their main focus set on sustainability. The cases do show that it is possible to implement behaviour factors within the work environment.

## 5.7 CONCLUSION

Literature, interviews, and the panels all have a different views and opinions. It is hard to create one behavioural diagram based on these findings. Some factors such as social norms and the intention to act are evident, because every party thinks it is a direct factor with high influence. Based on the literature, interviews and the Delphi panels an attempt is made to create one behaviour diagram based on the information presented in this chapter.

The cross-analysis method is used to compare the impact scales of the factors. The cross-analysis in table 5.13 is based on the impact degree from all behavioural diagrams, which indicate 1 as direct impact, 2 as high indirect impact and 3 as low indirect impact.

Some of the impact scales are in line with what people find in literature where at other places it is not in line. Possible explanations of the difference can be

- The users or experts do not know it is important
- The theory is incomplete
- The questions of the interviews and Delphi panels were not precise enough
- There is a change in personal opinion.

Table 5.13 Cross analysis diagram of behaviour factors

	Employee					Management			
	Literature	Interviews	Delphi Users	Concluded		Literature	Interviews	Delphi Experts	Concluded
<b>Internal factors</b>									
Intention to act	1	1	1	1		1	1	1	1
Environmental knowledge	3	2	2	2		3	-	3	3
Environmental values	3	-	1	2		3	-	2	3
Attitude towards PEB	2	-	2	2		2	1	1	1
Environmental awareness	2	1	1	1		2	-	1	2
Personal norms	2	-	2	2		2	-	2	2
Perceived behaviour control	2	1	1	1		2	-	1	1
<b>External factors</b>									
Institutional factors	2	2	-	2		2	1	2	2
Economic factors	3	2	3	3		3	3	3	3
Social norms	1	1	1	1		1	-	1	1
Leadership support	1	1	2	2		1	1	1	1
<b>Other</b>									
Perceived organizational support	1	1	1	1		1	-	1	1
Law	-	-	-	-		-	1	1	1
Eco-communication	-	1	-	1		-	1	1	1

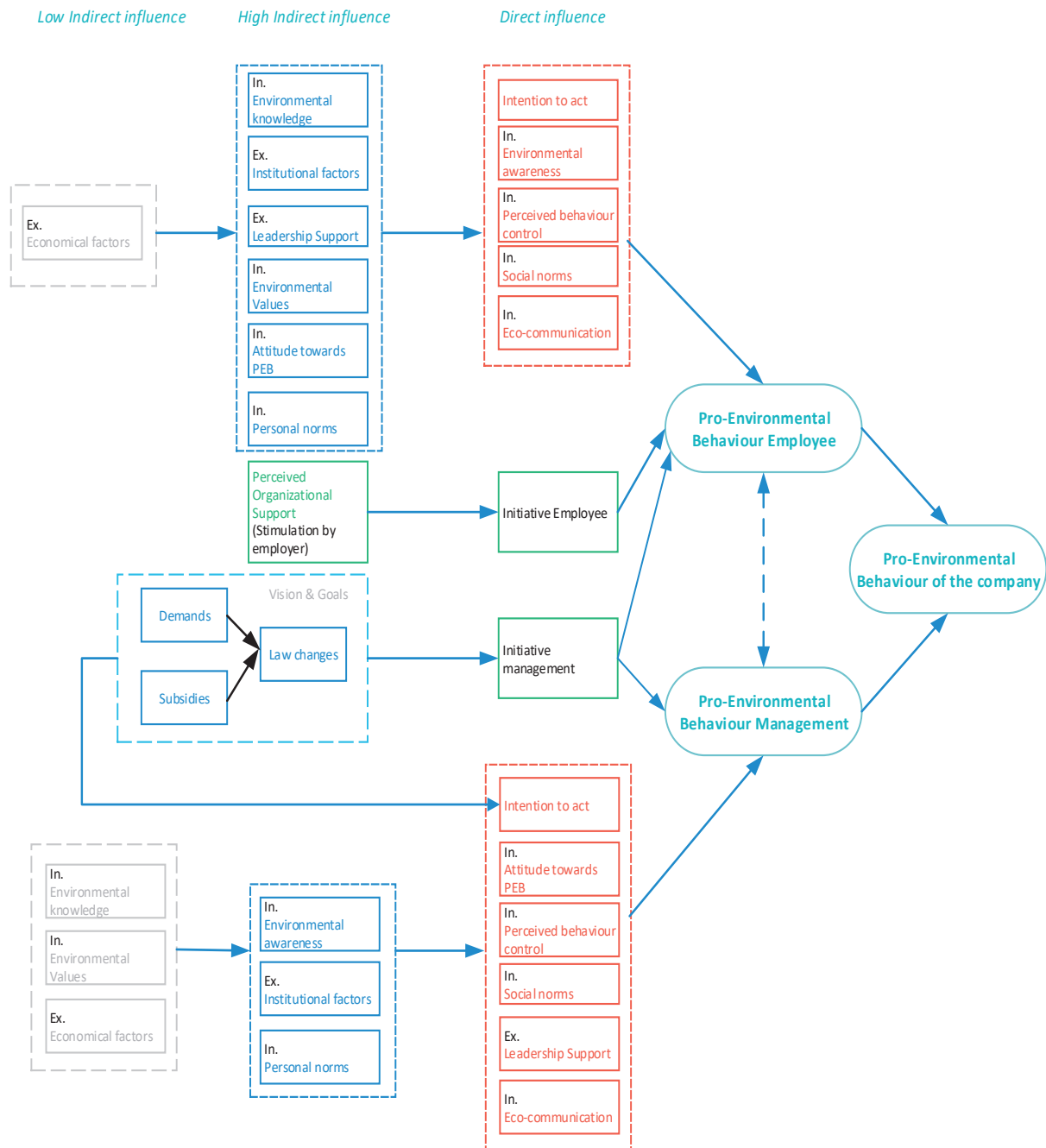


Figure 5.9 Pro-environmental behaviour diagram conclusion (own illustration)

There are many conflicting factors which have influence on our daily decisions and why people act a certain way. Through literature, interviews, and the Delphi panels it can be concluded that comfort, economics and intention play an important role in shaping pro-environmental behaviour (Kollmuss & Agyeman, 2002). The relations between the pro-environmental factors according to literature, interviews and Delphi panels is visualised in figure 5.9.

The economical factor is not as important as previously estimated because it triggers the wrong kind of incentive with the user. The factors which do have the highest impact on encouraging and stimulating Pro-environmental behaviour according to the users and experts are:

- Intention to act
- Perceived behaviour control
- Social norms
- Eco-communication

Methods to activate these factors in combination with high impact measures will be developed in further research.

As a side note: how a person reacts on a factor may differ from person to person. Each person and environment they work in is different, because of all these variations the result may differ in each situation.



# 06

# EFFECTIVE METHODS FOR INFLUENCING BEHAVIOUR

After developing a measure scheme and researching the effect of each measure, it is important to implement these measures the right way. The implementations need to stimulate the correct behavioural factors to activate the PEB of the user. With as focus point the reduction of the environmental impact of the office building. There are different methods to implement the measure itself and to stimulate the behavioural factors.

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## 6.1 EMPIRICAL STUDY: METHOD ACTIVATION

There are different known methods to activate pro-environmental behaviour factors. Some of the methods were discussed in the interviews and others were retrieved from literature and the delphi panels. A combined list of all the actual activation methods is presented.

### 6.1.1 SEMI-STRUCTURED INTERVIEWS: PEB IMPLEMENTATION

During the interviews, the methods which can be used to implement measures and to stimulate behaviour were discussed. All the experts had different ways of looking at the problems and different possible solutions.

#### INTERVIEW ANSWERS

##### Communication

Table 6.1: Transcript summary topic communication

Topic	Facility Manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behavior specialist	Behavioural workplace specialist
Eco Feedback	There is not enough eco-feedback.	Communication about sustainable changes may trigger sustainable change. This may have benefits for the short or long-term perspective.		Communicating on organisational and managerial level with feedback can be effective	Communicating helps to make energy usage visible.
Awareness by communicating	Companies should communicate more about the sustainability within their company with their users to create more awareness.	Keep communicating about the energy use makes it personal.	Communication about the progress is important to motivate users.	I think partly by pointing them out and partly by the playful or nudging-like stimulation, communication can be effective.  The internal motives of users should be stimulated.  There should be less rules from a management perspective, but more communication and initiative from the user and stimulation thereof.	It needs to be made clear how much waste there is.

##### Point of contact

Table 6.2: Transcript summary topic point of contact

Topic	Facility Manager 1	Facility manager 2
Who pays is responsible	The person who pays the bill should be responsible, this is the first change that needs to be made.	The story of the wrong wallet should be solved. The person who pays the bill should be responsible for the energy costs.

## Knowledge

Table 6.3: Transcript summary topic knowledge

Topic	Facility Manager 1	Pro-environmental behaviour specialist	Behavioural workplace specialist
Knowledge influences decisions	The lack of knowledge and lack of good intentions may cause insufficient use.	Creating more awareness is important, the next step is supplying them the knowledge and final step is applying it.	The government should play a protecting roll, they need to choose what is good for the citizen.
More knowledge	Communicating is important, but when you keep communicating the knowledge of the user is also important.	Creating more awareness is important.	More knowledge is needed to come to the right conclusions.

## Monitor energy

Table 6.4: Transcript summary topic monitor energy

Topic	Facility Manager 1	Energy performance gap specialist
Monitoring Energy	Energy usage needs to be monitored, else you will not be aware of what is happening.	With monitoring the cause of the problem can be made obsolete.  Technical installations, especially, need to be checked, it may be the case that they are not used in the right way.

## Technical

Table 6.5: Transcript summary topic technical

Topic	Energy performance gap specialist	Pro-environmental behaviour specialist	Behavioural workplace specialist
Technology	Trying to fix the technology and make it work the way it should.  Example: Two types of wall outlets, one which always gives power, one which stops power at the end of the day.  Technology should be the back-up, not leading	Technology should act as support not have the leading role.	Technology should never have leading role, but more a supporting role to motivate change.

## CROSS ANALYSIS

Table 6.6: Cross-analysis PEB implementation

	Facility manager 1	Energy performance gap specialist	Facility manager 2	Pro-environmental behaviour specialist	Behavioural workplace specialist
<b>Communication</b>					
Eco-feedback.	X	X	X	X	X
Communicating more to create awareness.	X	X	X	X	X
Point of contact.					
The person who pays the bill should be responsible.	X		X	-	-
<b>Knowledge</b>					
Knowledge influences decisions.	(X)			X	X
Knowledge about sustainability should be increased.	X			X	X
<b>Monitoring Energy</b>					
By monitoring energy, the company will be more aware of their energy use and where the problem is.	X	X			
<b>Technical</b>					
Technology should be a supporting role not leading role.		X	(X)	X	X
Implementing competition & targets.	X	X	X	X	X

## INTERVIEW ANALYSIS

The implementation part of the interview is strongly related to the behavioural part. Different implementation methods were fitting for each interviewee. According to the interviewees, two methods that were introduced to make users aware of pro-environmental behaviour and how to implement this in the work environment. These are implementing a competition with the department of company and setting personal targets. Setting personal targets is effective, with a small price to implement and creates a positive way to motivate people and increase their knowledge at the same time. Knowledge about sustainability can be created by communicating with each other.

### 6.1.2 METHODS

The possible activation methods are:

- Communication
- Behavioural guidelines
- Internal incentives
- Increasing the environmental knowledge
- Eco-communication
- Impact visualisation

## 6.2 METHODS TO ACTIVATE PEB

The relationship between the factors are based on the behaviour diagram in figure 5.9. The methods to activate PEB are based on literature, interviews, cases and the delphi panels. The chosen methods are the four previously determined factors with the highest impact. The chosen behavioural factors are the intention to act, perceived behaviour control, social norms and eco-communication.

### 6.2.1 INTENTION TO ACT

According to literature of the TPB, the intention to act is a combination of different factors. The factors are, attitude toward the behaviour, subjective norm and perceived behaviour control combined influence and the intention to act of the users. Other literature, the interviews, experts and users think the intention to act is not influenced by other factors. The intention to act only indicates how certainly people act.



The intention to act can be separated into the intention to act of the management and the intention to act of the user. Both factors can be motivated in different ways. The motivations are as follows:

## MANAGEMENT

There are two ways to change the intentions of a company, governmental regulations and the personal intention to change the world.

Firstly, the government can impose rules on all office owners. An example of this is the implementation of each office requiring energy label C by 2023. This law change, strongly motivates the environmental intention to act because otherwise there are big (financial) consequences for the companies. It is unclear if this motivates the companies to change with the right intentions, to save the environment, or only because they must.

Secondly, the company can be made aware of why they should act pro-environmentally. When they have the intention to act pro-environmental, they are more likely to do so. This method includes several other sub-factors such as making the company pro-environmentally aware, increasing their pro-environmental knowledge and changing their perception of their behaviour.

## USER

Increasing the intention to act of the user is also influenced by other pro-environmental factors. The leading factors are: pro-environmental awareness, pro-environmental knowledge and perceived behaviour control.

Methods to activate the intention to act

- Law changes
- Upgrading knowledge
- Stimulation of eco-communication
- Impact visualisation

### 6.2.2 PERCEIVED BEHAVIOUR CONTROL

The perceived behaviour control relates to the locus of control. A strong internal locus of control leads to people who are aware of what kind of impact their actions have on the environment even if they are small. A strong external locus of control leads to people who do not believe that their actions have any impact, which leads to not performing any actions (V. Blok et al., 2015; Kollmuss & Agyeman, 2002).

To act pro-environmentally the user needs a strong internal locus of control, because this leads to the implementation of the measures. The perceived behaviour control focusses on how to activate a strong internal locus. The user needs to be aware that their changes do make a difference. The perceived behaviour control has a direct relationship with environmental knowledge and environmental awareness. By creating a higher environmental knowledge, the user knows what kind of impact the measures have on the environment. By creating a higher environmental awareness, the user is more aware of what the impact pertains.

Methods to activate the behaviour factor Perceived behaviour control

- Communication platform
- Environment assemblies
- Impact communication
- Impact visualisation

### 6.2.3 SOCIAL NORMS

As we have seen that users, experts and literature ranks social norms highly in importance. Social norms are defined as all the social influence the work environment has on a person. This includes the social and cultural beliefs of a person. Does your culture not allow the change, than it is more likely that it will not happen (Kollmuss & Agyeman, 2002). In this culture is considered as, the environment of the workplace. This leads to a large influence of colleagues, bosses and social pressure on the way one performs.

The behavioural workplace specialist discussed the resource dilemma during her interview. How do you make sure someone makes a choice that not only will benefit themselves but also the surrounding people? The motivation to act socially needs to be activated without giving the user too much choice. For example choices such as technology vs. behaviour or automatic switch vs manual switch.

A person should not have a good or a bad choice, but a good choice and a better choice. All these choices should not influence the comfort or financial factors of the user otherwise it is less likely they will choose that option (van Lidt, 2019).

There are two ways to increase the social pressure of the work environment. The first one is by changing the current work environment into a pro-environmental environment. This means that the culture of the company should change, which will take time to implement. To implement this within the company it is important that guidelines about pro-environment behaviour should be determined by the board. Implementing this measure will also take time and controlling the changes within the company.

The second method is to activate social norms is an internal competition between colleagues. When employees are aware of what they do and what they can do, they are more likely to perform that way. Internal competitions between colleagues can be held to stimulate this. According to several interviews when people are excited changes will appear to begin with. This is the moment when people are busy with the incentives and the change is still new. After a period of time people consider it normal and their attention to the change will fade. At that moment in time they will fall back into old habits. To change these old habits into new habits, they need to be re-activated. At the beginning of the process of implementing changes this will occur several times. Eventually the new change will become a habit and people will do it automatically (Jager, 2003). See figure 6.1 for a change timeline.

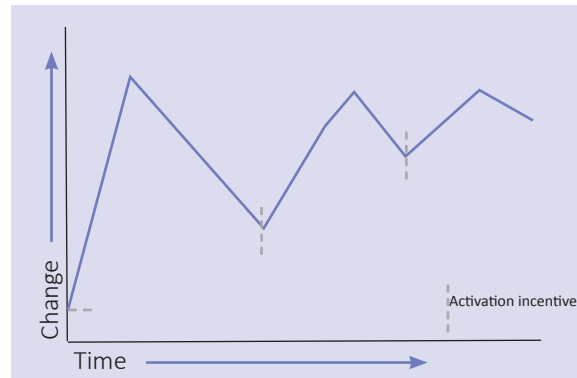


Figure 6.1: Time vs. Change timeline (Own illustration)

Methods to activate the behaviour factor social norms

- Work environment guidelines
- Internal competition / incentives

#### 6.2.4 ECO-COMMUNICATION

The eco-communication factor is not a factor described in literature, but added by the interviewees, experts and users. Eco-communication is defined as the communication to promote pro-environmental behaviour within a company. All communication between employees and the management related to the environmental status of the company is considered eco-communication. Eco-communication has a strong relationship with other pro-environmental factors such as environmental knowledge, pro-environmental awareness, perceived behaviour control and the intention to act. Eco-communication is a factor which can be used to steer the pro-environmental behaviour of the user and at the same time be used as a tool to steer the pro-environmental behaviour of the employee, management and thereby the company.

Methods to activate the behaviour factor eco-communication

- Communication platform
- Communication E-mails
- Internal incentives
- Environment assemblies

#### 6.2.5 SUB-CONCLUSION

It can be concluded that many behavioural factors are related to, and influence, each other. When one factor is activated it is likely that this change has an effect on the other factors. This makes the relation between the factors just as important as which factor has influence on the pro-environmental behaviour of the user.

## 6.3 METHODS TO ACTIVATE THE MEASURES

The two high impact measures related to the behavioural aspects which are used for this part are: computer use and way of working. By steering the behavioural aspects focussed on two of these measures' energy savings of an office building will increase

### 6.3.1 COMPUTER USE

To reduce the offline computer-use, employees need to be reminded to turn their electrical devices off, not on stand-by mode, and unplug the electrical devices from the socket. All four previously mentioned behavioural factors can influence this measure. This indicates that all proposed solutions can be used to reduce the energy used for computer usage.

### 6.3.2 WAY OF WORKING

Changing the way of working, from traditional to activity based working, has a high impact on the energy use of the building due to the fact that less office space is needed. This, in combination with optimal occupancy rate, will result in a lower total energy use for the building. Activity based working does not only contribute to the energy performance and occupancy rate of a building but also supports the communication and interaction between colleagues, which contributes to the work performance of the employee (Brunia, van der Voordt, & De Been, 2016).

When the building has less squared metres of floor space the energy the building uses will be lower. No space will be un-used. Currently it is seen that there are peak hours in an office and low hours. This has a relationship with the personal environment of the users. It is noticed that in general Wednesday afternoon and Friday the office occupancy rate is lower than other parts of the week, this can be related to school hours of children.

By changing the way of working and evening out the occupancy rate, the energy usage of a building will be reduced. There are several ways to implement these changes. The way of working needs to be changed by the management and over time supported by the social norms. Implementing new work guidelines will play a strong roll in these changes of the work structure. However, not all office environments are fit for an activity based work environment (Brunia, van der Voordt, & De Been, 2016).

## 6.4 CONCLUSION

The method to implement a measure relates to the measure and how this measure affects the behaviour factors. In this research three examples of implementing measures are given. The three main methods to reduce the environmental impact of an office building and thereby activating the pro-environmental behaviour of the user are:

1. Pro-environmental behaviour guidelines
2. Eco- communication platform
3. Social incentives

All three methods are related to each other. These methods can also be seen as different levels of implementation of the changes. To activate change people need to be aware of the change but should not be forced to change their circumstances completely.

New behaviour guidelines should be written by the management. These guidelines will be the environmental guide for all employees. The focus of the new behaviour guidelines should be on sustainability. While implementing these changes, the employee should be aware of why the change is made. As mentioned in the social norms section, implementing change is not a one-time action but the persons and company should be constantly aware of the change and be triggered to act upon it. Eco-communication and social incentives are methods to help implementing these guidelines successfully.

Creating a platform where people can communicate with each other about the environmental and where information about the organisation and building can be shared adds value to the awareness and knowledge of the PEB. Creating an interactive eco-communication platform will add value to the behaviour guidelines of the company. On this same platform, social incentives can be started to motivate the employees.

Combining the methods will get the optimum result of the measures which are implemented. None of the given measures were used on the cases.



# 07 CONCLUSION & DISCUSSION

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## 7.1 CONCLUSION

The thesis aimed to contribute to the reduction of energy performance gap for office buildings and specialised on energy use by influencing the behaviour of an office user. Therefore the energy performance gap, energy saving behaviour measures and activation of PEB were researched. The main research question was formulated as follows:

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*How can the behaviour of office users be influenced to reduce the energy performance of office buildings in use?*

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The conducted research consists of literature research and empirical research, which is based on four case studies, five semi-structured interviews and two Delphi panels. The empirical research only represents a small section of the market therefore the result of this research is based on these cases and the information obtained from them.

To reduce the environmental impact of office buildings a distinction is made between building-related energy use and user-related energy use. To reduce the energy performance gap one, or both, of the energy uses need to be reduced.

The introduced measures to reduce the user-related energy use do not have a large impact on the total energy use of an office building. It was expected that the measures would have a significant impact on the energy use of the building but they do not. By focussing on these user-measures the retrieved energy saving is minimal on an office building scale, but significant when compared to households.

It is noticed that the experts have higher expectations than the actual impact of the measures. This leads to another energy performance gap between the expectations of the measures and their actual impact. To reduce the energy performance gap of the building the focus should be on the building-related energy use. The following steps can be taken to control the energy performance gap and reduce the energy use of the building

1. Analyse the current state of the building and visualise the energy performance gap.
2. Energy Clean up and system checking
3. Investing in sustainable building-related measures
4. Analysing user behaviour
5. Implementing sustainable measures and activating change in behaviour of users into pro-environmental behaviour

Behavioural changes have a significant impact when implemented on a large scale. The studied measures will not have a large effect on the environmental impact of the building or the energy use of the building, but all small changes help improve the environmental performance. The office users will be more aware of their behaviour, which may lead to behavioural changes at home. This relates back to the previously discussed scale of office and households. When the impact is translated into households the relative results change. Reduction of 1% on the offices in these four cases is equal to the energy use of 15 households. When 100 offices with the same preferences a reduction of 1500 households can be researched. The impact and effect of the measures is the same, but the scale differs.

That the impact of the behaviour measures is less significant on a small scale does not mean that the behaviour of the office users cannot be influenced. There are different conflicting behavioural factors which have influence on the daily decisions of users. Behaviour factors such as perceived behaviour control have a strong relation to the environmental awareness and environmental knowledge of a person. The intention to act, social norms and eco-communication are three other behavioural factors with high influence on the behaviour of the office user. The behavioural factors influence the personal decision-making process of the user. To act pro-environmentally these factors need to be activated, which results in pro-environmental behaviour

There is not one ultimate method to influence the behavioural factors of office users. There are only different methods to stimulate the pro-environmental behaviour of an office user which, in turn, influences the energy performance of an office building. Possible solutions are implementing pro-environmental behaviour guidelines, an eco-communication platform and social incentives to activate the behavioural factors in a pro-environmental matter.

## **7.2 DISCUSSION**

### **7.2.1 EXPECTATIONS OF THE RESEARCH**

After the first literature study on the topic of influence sustainable measures could have on a building, it became clear that user's behaviour would have an impact on the work environment of employees. The hypothesis was that by reducing the user-related energy use a large part of the energy performance gap would be reduced. After researching the impact of the energy-saving and sustainability measures in literature, it became clear that the impact of these measures was low. The expectation was that the users did not incorporate these measures in their current routine, not that the problem was with the measures themselves or the window of time used to measure the results.

This leads to the conclusion that just behaviour activation of the users would not be enough to reduce the environmental impact of the office building in-use. Structural technical changes within the company should be made. The management of the company is the stakeholder who can have a high impact on the behaviour of the users. By supporting, motivating and stimulating the behaviour of the users the impact of the behaviour grows.

The behaviour of the users can be activated through different factors, most of these factors depend on each other, meaning that activating one factor requires the other factors to be activated as well. By activating multiple factors, the behaviour of a user can transform into pro-environmental behaviour. Pro-environmental behaviour directly influences the energy use of a building, but with the current introduced measures this impact is less significant. Pro-environmental behaviour attitude leads to living a pro-environmental life in the work environment and at home. Indirectly this will motivate the other people in the user's household to act pro-environmental through social norms. While an individual user's impact on the energy performance level within an office building can be low, motivating the user's household makes a significant difference.

This result did not lead to a strategy: how to reduce the energy performance gap of a building, but it indicates that the behaviour of an office user can be influenced to reduce the impact of an office building in use. This step should be the final step in transforming a building to a sustainable building. The first focus should be on reducing the building-related energy use, because the impact of this part will be higher than the impact of the users on an office building.

### **7.2.2 REDUCING THE ENERGY PERFORMANCE GAP**

This research focused on reducing the energy performance gap by influencing the behaviour of the office building's users. There are companies who act pro-environmental out of own interest, but a number of companies do not. To activate the remaining companies, changes law changes need to be implemented. The current laws are not enough to reduce the energy performance gap for the remaining companies.

The energy performance gap exists because of the difference between the operational energy use and the theoretical energy labels. The law itself does not incorporate the operational energy use, but only the theoretical energy labels. This means that laws are tested on a fictional energy use, which gives the government the wrong expectations on the total energy use. By using the operational energy use as leading indicator and not the theoretical energy label, the energy performance gap will not exist. Another solution proposed by energy performance gap specialist is that all operational energy labels should not deviate more than 1 or 2 labels from the theoretical energy use which sets limits on the energy performance gap.

The government set a goal which they want to research by 2050. The current laws do not come close to these future goals of the government. Newly built offices do not contribute enough to the goal of 2050, by changing the laws more drastically, newly built buildings will contribute to the vision of 2050 and not oppose to this goal. A possible solution is to change the law for new building to contribute to the Paris Proof vision and the laws about transformed building slowly improve to this vision which starts with the office energy label C by 2023 as the first step. Changing these laws act as a motivator for the companies, because they are forced to.

The government should use the law to their advantage, not as a tool that does not contribute to the end goal. Another possibility to reduce the energy performance gap is to focus on the technical part of the building. During this research, the focus is on the user's behaviour, which leads to a lower impact energy reduction. This means that reducing the building-related energy use could lead to a high energy reduction. The technical activities in the building should be analysed and monitored. When it is clear which technical activities produce more energy than average the technical problem is found. By solving this problem and creating a more sustainable environment for it the total energy use of the building will be reduced. When the energy performance gap on the technical part is reduced the focus can be on the behaviour part.

### **7.2.3 LIMITATIONS OF THE RESEARCH**

As a result of the scope and process, this research shows some limitations. Mainly focussed on time, resources and testing the theory.

Changing the pro-environmental behaviour of office users is a topic what is not much researched, especially in practice. Literature research is present in the work field but available monitored cases are hard to find. It would have been ideal to find a case where it was possible to view the behaviour of users before sustainable changes and afterwards. In that case, case-studies would be the leading role of the research. It was hard to find companies who wanted to cooperate with this research, because of this I had to settle with the current cases. In the end, the case-studies were not the main research method but the interviews and delphi panels have a larger share in this research.

Finding the correct resources in combination with the large diversity of research methods such as interviews and delphi panels, had a high impact on the time required for the research. During the research, it is noticed that with a few more weeks/months the results would be more accurate and implementing the results into a case would be possible.

To really test the theory, the researched part should be implemented in a test case. Unfortunately, due to time constraints, this was not possible. Implementing and monitoring behaviour change and comparing it to the previous situation would support the theory behind the research question, but would take a lot of time.

### **7.2.4 RECOMMENDATIONS FOR FUTURE RESEARCH**

Specific behavioural change will not make the difference in the total energy use of a building. What you want to achieve is to activate the person to act pro-environmental in the workplace and at home. All the small changes together will have a big impact on the environment.

Some recommendations can be made on further research. Firstly, test the results from this report on a case. To gain optimum result it should be tested on two different types of cases.

- Case option 1: where the building related energy use is according to design, in this case the energy performance gap can only be reduced by the user-related energy use. Which shows the direct impact the measures have.
- Case option 2: where the measures will be implemented and the change before the implementation will be compared to the data after the implementations. This data can provide answers to what the direct impact is of the measures and behavioural change.

Secondly, the relation between the measures implementing in the cases and the change users experience. It was noticed that the cases think they implemented in measure, but do the user of the building agree with that? During this research, the delphi user panel and the users of the cases where not the same person. By researching from the same point of view, the gap in pro-environmental behaviour between the user and its management could be reduced.

Finally, it would be interesting the research what the impact of the behaviour change is when the user is at home. Does the change happen in the household as well? This would lead to a higher environmental impact in the long run.



# 08 REFLECTION

During the P4 fase a reflection about the graduation process is written. In this part personal, product, process and planning reflection is discussed.

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## 8.1 PERSONAL REFLECTION

Starting with HBO Building Engineering, a practical study, already brought me closer to sustainability. Nowadays there is a strong focus on sustainability in class and projects because of the current economical state. In almost every newsletter every day, an article is written about the environmental impact or the consequences of temperatures rising. Last summer I visited Bali, a beautiful island in Indonesia. Unfortunately, it was also one of the most polluted areas I have ever visited during my travels. This made me realise that we are demolishing Earth and unfortunately until now we don't have another Earth to visit. At that moment, I knew I wanted to do research in the field of sustainability.

The motivation for my research on the topic of the sustainability was the change in law, by which offices may no longer have an energy label lower than C from 2023 onwards. This will have a huge impact on the future office supply. Some offices will be no longer be in use, but most of them will need to become more sustainable. Until now, a lot of research has been on this topic, but not yet on what such a transition looks like. Is the building actually as sustainable as assumed? Or, if not, how can it fulfil the expectations?

In the beginning phase of the thesis work I determined my personal study goals. The achievements are divided into technical achievements and personal achievements such as becoming more aware of small sustainable changes, improving my English academic writing and research skills and expansion of my professional network. During the research, the progress and developments of the previously set achievements were reflected. It is interesting to see that unconsciously I have grown a lot during this graduation process in all areas and the established goals were met.

Within one year of time, it was my goal to achieve a result I was proud of. When the P4 period came to an end, that goal came within grasp. It is an end product, which I tell everyone about with pride. This chapter the product, process and planning of this report will be reflected.

## 8.2 RESEARCH PRODUCT

Before the P2 phase I imagined that this report contained more proven research, during this process I realised that time is the biggest enemy. Wanting to do too much would not reach a realistic goal, wanting not enough would not be satisfactory for a master thesis. The project delivered for the P5 phase is the product I am 100% proud of. There is a moment in time you need to say stop and this is that moment.

The structure of the research is well thought out with incorporating the theoretical framework into the chapters. All the information combined in each chapter gives an overview of all the available information for that specific topic, which makes the research easier to read and analyse.

Especially the product of this research was not what I expected in the beginning. My expectation was that a method or strategy could be developed which shows companies what the possible impact was with implementing these changes and changing the behaviour of their users. At the end, this was not realistic. The reality was that the impact of these measures is too low. The significant result I expected in the beginning was not the end result. Other unexpected aspects came to light during the interviews and delphi panels. Especially the involvement of government and how law should be used to advantage in order to make people and companies more aware of the current sustainability problems in the world.

Not all the conclusions were as I expected in the beginning, this was mainly because due to time pressure. The factors and theories needed based on literature were needed to succeed the interviews & surveys. During this process, it is noticed that some factors were not included in this part and thereby also not 100% reliable. Because of the second round for the delphi panels these factors were discussed by the experts and users.

Overall, I am happy with the structure of the research, but the results of the main question were not what I anticipated. This was because of the fact that it does not have a high impact on the environment, luckily other factors such as law, communication and the energy performance gap have.

### 8.3 RESEARCH PROCESS

The process of this research did not go as planned. The expectation of enthusiastic people to cooperate were higher than the actual participating people during the research. At the end, a lot of experts and companies did not have time or the resources to cooperate. So, I am more grateful to the companies and people who did help me during this period.

The research exists out of 4 different research methods; literature, delphi panel's, interviews and cases. All these methods lead to different processing methods, discovering these processes took more time than originally anticipated. Using the four different methods created a wide range of interpretations and factors which were involved during this research. By using all of these methods the user, facility manager, experts and literature would be included in the results. All these stakeholders led to different opinions from different viewpoints, which made the research more reliable by looking at it from different perspectives.

### 8.4 RESEARCH PLANNING

Even with the setback of getting less resources and information from companies, the planning of the project did go as planned. Looking back at the planning I think it was aimed to high. The writing phase at the end was not large which gave a lot of pressure on analysing the retrieved data. Maybe the delphi panel surveys could have been conducted earlier on but the segments for in the surveys where not developed yet so it would have been testing information which was not available yet.

Also, the time period between the P3 presentation and the P4 deadline was shorter than originally expected, due to the fact that my P2 deadline was later on. Which gave a high pressure on the last time period.

### 8.5 FEEDBACK

Originally a survey with a large scale of users was planned, after the P3 report my mentors advised me to look into this method because it would take a lot of time and the added value of this survey was minimal. After developing a plan on what information I wanted to retrieve from this part of the research, a delphi user and delphi expert panel where developed. These methods would retrieve quantitative information from users and experts.

Every other week I would meet with my first and/or second mentor, whenever I had questions or wanted to brainstorm about my topic both mentors were there to do so. The feedback I got from them was taken into consideration and where I felt it would add value, applied. Sometimes it was just developing a new way of thinking to the project and process. The feedback I got from them was in the form of remarks. Most of the feedback given was there to develop my work method and the way I would think about the topic.

During this journey, I learned a lot about doing research, writing a report, planning, setbacks and myself. My life motto is "aim high" but during this time period I sometimes aimed to high which was counterproductive at times.

### 8.6 MASTER TRACK

Sustainability is a topic that is an integral part of modern society. Global warming is everywhere around us and it is positive that people realize that change needs to be made now. My master track management in the built environment has a direct relation to this topic due to the measures that are built environmental related and the user that has a relation to the management part. The studio of choice was real estate management, looking back this study is not a fit for my topic. This topic is partly technical and partly social which does not meet any study of the MBE track. It is a topic that goes beyond the studies and fits partly within the master. By challenging myself, I used the skills I learned the last three years and broadened my knowledge about social experiments such as behavioural change implementation.

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