Challenges in mitigating the energy performance gap in the Dutch office stock

A case study research on sustainable adaptations to the existing stock considering different stakeholders' perspectives

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Preface

September 2018, I started with the graduation laboratory of the master track Management in the Built Environment at the Delft University of Technology. From then on, I started working towards this final P5 report that lies in front of you. I will shortly explain where this report is about and why I conducted this research.

This P5 report is part of the graduation trajectory, which includes a research proposal with a literature review, empirical research, synthesis, and conclusion on the theme of adaptations to the existing stock. The theme of adaptive reuse focuses on upgrading existing buildings to suit new conditions. This specific P5 report dives into the topic of energy consumption of the existing Dutch office stock. Since Dutch legislation obliges all office spaces to have at least an energy label C by 2023 major challenges arise. Apart from that, it seems that buildings with better energy labels tend to consume more energy than expected by the label. This so-called energy performance gap, where it is caused by, and how to mitigate it is where this research is about.

After years of studying at the faculty of Architecture, it was now time to make the last main decision during my time as a student, choosing a graduation topic. Personally, I am very interested in the whole energy transition that is going on. The role of sustainability in every project or development has become of significant importance. There are major challenges when it comes down to reducing carbon emissions and energy savings considering the climate agreements and long-term goals of 2050. However, the real estate sector is known for being rather slow and conventional when it comes to changes and innovation. Due to the long lifespan, major challenges arise to create a more sustainable existing stock. Apart from constructing energy efficient buildings, I am very interested in how to actually make sure that buildings and its users consume less energy. This can be done in innovative ways with all the new possibilities we have nowadays. That is why I wanted to focus on mitigating the energy performance gap in the existing Dutch office stock.

This research required energy performance data on office buildings, which is not openly accessible. Therefore, I am grateful that CBRE gave the opportunity to conduct this research by providing the required data. Apart from that, I would like to sincerely thank my supervisors, Hilde, Ilir, and Minyoung, for their accurate feedback and support during the entire graduation trajectory. I believe that their input from different angles resulted in a much more complete thesis and I would like to thank them for all the meetings and consults we had. Also, I would like to thank all the interviewees for their time and input. Lastly, I would like to thank Charlotte and my family for their support and feedback during this graduation trajectory. I am satisfied to deliver this final master thesis, and I hope you will enjoy reading it!

Otte van der Pluijm
Rotterdam, 2019

Abstract

Currently, clear European and Global climate goals, such as the Paris Agreement and the European Energy Efficiency Directive, are in place to stimulate more efficient use of resources and lower emissions. The built environment can play a significant role in reaching these objectives in the future since it consumes around 40% of the total energy consumption (Šjan, 2016). Also, approximately two-third of the existing stock in the Netherlands will be in use within the timeframe of these goals. Therefore, a major challenge is to adapt the existing stock to become more energy efficient or even neutral. The Dutch government obliges office space to have at least label C by 2023 (RVO, 2018). Real estate technologies can enhance the energy efficiency of these buildings by providing data on actual energy consumption. Nowadays, an energy performance gap exists between the actual and theoretical energy consumption stresses the need for more insights on a building level (Sipma, Kremer & Vroom, 2017). Therefore, this research investigates to what extent this energy performance gap can be bridged by adaptations to the existing office stock in the Netherlands and what possible drivers and thresholds are for different stakeholder. A literature study has provided input for the development of a theoretical framework and the selection of the research methodology. A case study research has been conducted to underperforming office buildings in the Netherlands. Four case studies were conducted based on their energy performance gap, two buildings of energy label A and B will be researched. The research is focussed on buildings characteristics and stakeholder attitudes towards certain adaptations, either structural or behavioural. Findings of this research indicate that structural adaptions are rarely preferred by the investor due to possible loss of value. Tenant often lack insight into their own energy performance and are therefore unaware and unable to make decision on behavioural adaptions. A framework has been developed that provides steps to take fostering the process towards more sustainability in the built environment.

Keywords – Adaptions, stakeholders, real estate, offices, energy labels, energy efficiency, energy performance gap, sustainability, case studies

Executive summary

In this chapter, the general outline of this thesis will be elaborated upon. The different aspects of the research phases and the main findings per phase will be addressed. The aim is to provide a dense and complete picture of the entire research. For a more elaborate explanation, please consult the relevant chapter.

Introduction & Problem Statement

The built environment in Europe consumes approximately 38% of all energy. This consumption also has an impact on the emission levels of greenhouse gases. In order to mitigate the impact from the built environment, national and international agreements and policies are in place. In the Netherlands, the EPC labelling method is used to assess sustainability based on theoretical equitation on energy consumption per building. By 2023, all office buildings will need to obtain an energy label C, or they will face legal obsolescence. However, previous research indicated that label A and B buildings consume more than what is expected based on their energy label, see figure a. This so-called energy performance gap seems to counterwork the expected reduction of emissions. In order to achieve the climate goals stated, it is of importance to critically look at the existing stock and research possibilities the mitigate this energy performance gap so that theoretical and actual consumption is aligned.

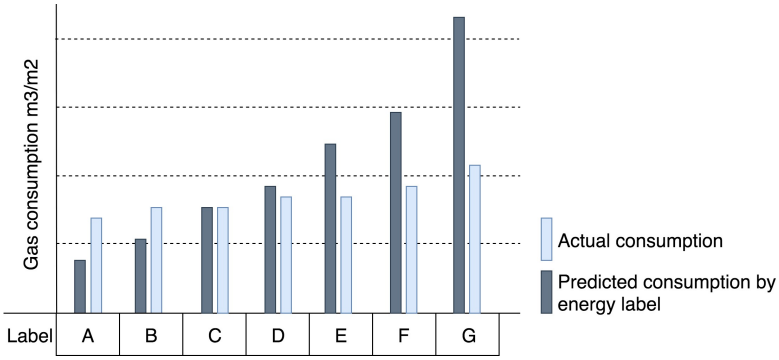

Figure a. Schematic visualisation on the energy performance gap in the Dutch office sector for gas consumption, based on Sipma et al. (2017)

Research Questions & Design

Buildings in the operating phase deal with several stakeholders. Therefore, the attitude of the three main stakeholders, investor, property manager, and tenant are of relevance for this research. Also, more insight into the possible adaptions will be obtained by conducting research with the following main research question.

How can adaptations contribute to enhance energy efficiency in the Dutch office stock in order to mitigate the energy performance gap of energy label A & B buildings considering different stakeholders' perspectives?

To be able to answer the main research question, three sub-questions were formulated. All questions required qualitative input and were studied through literature and empirical research. The sub-questions are stated in table a.

Table a. Sub-questions

Sub-question	Type of Data	Research Method	Data Collection
1. How are national energy policies affecting the existing Dutch office stock?	Qualitative	Literature Study	Academic literature online available through Scopus, Scholar etc. and 'grey' literature.
2. How are user and building characteristics related to the energy performance gap?	Qualitative	Literature Study & Case Studies	Academic literature online & data from conducted case studies and by interviewing stakeholders
3. What are drivers and barriers for investors, property managers and tenants for implementing adaptations to mitigate the energy performance gap in the existing office stock?	Qualitative	Case Studies	By interviews with investor, property manager and tenant.

Theoretical Underpinnings

The literature study consists of four topics that form the theoretical background for this research, climate agreements & energy policies, energy performance, adaptations, and stakeholders.

Climate agreements & energy policies

The built environment is still consuming around 38% of the total energy consumption in the EU. The Paris Climate Agreement and the European Energy Efficiency Directive are in place to collectively work towards a reduction of 80-95 % of the greenhouse emissions by 2050. Since the replacement rate in the built environment is low, it is of crucial importance to foster sustainability in the existing stock.

Energy Performance

The Dutch government is using the Energy Performance Coefficient as a method to assess sustainability and energy consumption. This method is linked to a labelling system from G to A++. National policies are clear for 2023, all office buildings need to obtain energy label C at least. If this is not reached within time, the property will face legal obsolescence. For 2030, the objective will be obtaining energy label A.

Nowadays, there is a quite substantial discrepancy between the theoretical consumption of the energy labelling system and the actual energy consumption by the property and the users themselves. This is the so-called energy performance gap and tends to be bigger for better labelled buildings. Since national policies are based on those calculations, it is of importance to mitigate this performance gap so that emissions from the built environment are as expected or less.

Adaptations

The use of technical innovations and adaptations enable the process of fostering sustainability in the real estate sector. Smart real estate technologies can contribute to finding where the energy performance gap is caused by and could help to solve it. Two types of adaptations can be distinguished, structural and behavioural adaptions.

Stakeholders

In order to implement changes, costs and benefits of different stakeholders need to be balanced. Due to the phenomenon of split-incentives stakeholders find it hard to make progress in fostering a sustainable office stock.

Based on the literature and a theoretical framework was developed with themes that are of relevance for empirical research. The following themes will be input for the semi-structured interviews.

- Insight into energy performance
- Structural adaptations
- Behavioural adaptations
- Drivers for adaptations towards sustainability
- Barriers for adaptations towards sustainability
- Stakeholders view on current and future situation
- Preferred adaptations

Methodology

A literature study was the starting point for conducting this. Derived from the findings in literature, the methodology was chosen for the conduction of the empirical research. The case study method by Yin (2014) was selected for conducting the research on four selected office buildings. Per case, the building characteristics were collected to obtain a better understanding of the buildings and its performance. The second part of the case study consisted of interviewing the three main stakeholders based on the semi-structured interview proforma derived from topics in literature. The different cases were cross-case analysed in order to abstract the essence of per topic. This case study research method is presented in figure b.

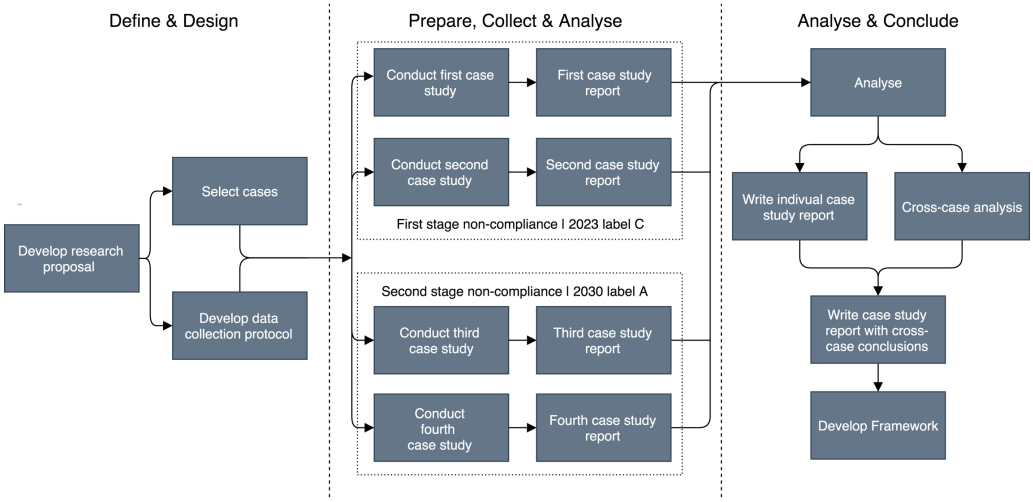

Figure b. Schematic visualisation on the used case study method

Empirical research

The empirical part of this research consisted of two main parts, the collecting of building characteristics and the conduction of interviews with the investor, property manager, and tenant. In order to conduct this research, buildings were assessed along the case study selection criteria. Based on the level of underperformance, the following buildings were selected for this research.

Table b. Selected buildings for conduction of case study

Case 1	Case 2	Case 3	Case 4
Infinity	Adam Smith Building	Casuariestraat	Beechavenue
			
Label A building that is non-complying in the first stage based on current gas consumption	Label B building that is non-complying in the first stage based on current gas consumption	Label A building that is non-complying in the second stage based on current gas consumption	Label B building that is non-complying in the second stage based on current gas consumption

For each case, a large set of building characteristics was collected. The building characteristics were analysed and cross-case compared. A summary of the most important building characteristics is given in table c. Striking is that case 1 & 2, and case 3 & 4 show several similarities such as their size, opening hours and costs related to the energy performance gap of natural gas consumption.

Table c. Key figures on building characteristics

Key figures	Case 1 Infinity A-D	Case 2 Adam Smith B-D	Case 3 Casuariestraat A-B	Case 4 Beechavenue B-C
Total m2	18240	20784	3500	2500
Rental price	€350	€224	€173	€130
Energy performance gap (Gas) %	96,7%	63,8%	38,1%	39,2%
Energy performance gap (Electricity) %	324,4%	246,2%	93,1%	174,8%
Costs epg gas m2/year	€3,88	€3,09	€1,88	€2,14
Percentage costs to tot. energy costs	14,4%	12,7%	11,5%	9,1%
Percentage costs to rent price	1,1%	1,4%	1,1%	1,65%
Office hours (weekly)	70	65	50	50
M2 per employee	23,8	24,0	20,7	28,6

During the interviews with the stakeholders, seven topics derived from literature were addressed. The interest and answers of each stakeholder was cross-case analysed. The elaboration on these findings can be found in chapter 5. Based on the answers given, a step-by-step plan was developed. The step-by-step plan clearly indicates the ‘what’ and

'how' of the collaborative process of aiming for higher levels of sustainability within the existing office stock. The eight steps to be taken derived from this research are as follows:

- Step 1: Mapping the current situation
- Step 2: Create awareness amongst all the stakeholders on the performance
- Step 3: Discuss & Aim collectively for a certain level of energy reduction
- Step 4: Division of costs amongst the different parties
- Step 5: Implement the suggested adaptations
- Step 6: Check whether the adaptations performing as expected
- Step 7: Benchmark the year result with comparable projects
- Step 8: Steer or Maintain

Limitations

- Due to data availability, only a part of the Dutch office stock could be analysed in order to find suitable case study objects.
- The conducted interviews were all based on the semi-structured interview proforma that has been developed. As a result of this type of interviewing, different follow-up questions have been asked as a reaction to the interviewee's answers. This could have resulted in the omitting of relevant information.
- The interviews themselves were held in Dutch, which might result in information being lost in translation.
- All property managers that were interviewed were working for CBRE. Preferably this should have been avoided to minimise the risks of advertising, incentivising, and avoidance of bias.
- The EPG has been postponed for an unknown period. This could have had a major impact on the answers provided by the stakeholders.
- Lastly, the service costs were not available at the moment of collecting. Therefore, no complete indication could be given on the total costs of occupancy

Conclusions

One of the key deliverables of this research is the step-by-step plan, which can be found in sub-section 5.2.

As every building in each case study is unique and depends on a variety of factors such as location, type of tenancy, and architectural design, it can be challenging to draw general conclusions on the building characteristics. However, the findings clearly hint on a correlation between long office hours, amenities, size, and the level of discrepancy between the actual and theoretical consumption.

The national legislation has a relatively great impact on the pace of transferring towards a more sustainable office stock in the Netherlands. At this stage, the proposed EPG is not concerning for the investors or tenants since the enforcement has been postponed. However, the main drivers for implementing adaptions towards sustainability remain legal obsolescence, rentability, tenant satisfaction, lowering OPEX, adding value to the asset, CSR-vision, and comfort.

The division of CAPEX and OPEX is considered as the main barrier. In general, structural adaptations are considered to be promising by all stakeholders. However, often, the end of the technical lifespan has not been reached yet, which withholds investors from

implementing certain adaptions. In theory, behavioural adaptations are promising, according to most stakeholders interviewed for this research. The challenge is to provide transparency and insight into the actual energy performance of the buildings. Implementing real-time monitoring would help to create awareness, to steer on behavioural adaptations. In general, the investors were found to be well-willing to invest in better monitoring to stimulate behavioural adaptations. Besides, property managers could have a more informing or consulting role in order to stimulate collaboration between tenants and investors in creating a more sustainable office stock.

Recommendations for further research

Further research could be conducted on the following topics

- The precise content of the proposed assessment method and how the new method would differ from the current legislation and the effects on the labelling.
- The impact of the elimination of gas in the built environment and its impact on energy consumption and energy labelling.
- This research has been focussed on the Randstad area in the Netherlands. Researching this topic on a national or even international scale might provide new insights. These insights could also be of use for policy makers to be able to set up a more accurate assessment method.
- In order to be able to mitigate the performance gap, possible adaptations and their savings will need to be researched more precisely. When more insight is obtained on potential savings and costs, stakeholders can more carefully weigh the pros and cons of the adaptions.

Table of Contents

1 | Introduction

1 | Introduction

In this first section, the research topic and field will be introduced starting with the problem statement wherein the motivation for this research is addressed. Thereafter, the relevance to a societal and academic point of view for this topic will be motivated. This results in the main and sub-research questions that will lead towards the conceptual model and hints on the methodology which will be elaborated upon more extensively in chapter 3.

1.1 Problem statement

Not long ago, the first energy neutral and even energy supplying office buildings have been developed in the Netherlands, which can be considered to be a milestone. The existing building stock in the Netherlands is lagging in reaching the stated climate goals for the future (EIB, 2016). Climate agreements such as the Paris Agreement and the European Energy Efficiency Directive (EED) are in place to have international objectives on the reduction of energy consumption. However, the built environment in the Netherlands does not seem to be successful in reaching these goals in time soon (Filippidou, Nieboer & Visscher, 2017; Sipma et al., 2017). Therefore, action within the built environment is required to create more sustainable and future-proof buildings that match the governmental objectives.

Policy instruments in the Netherlands such as building codes regulate the energy requirements of dwellings and utility buildings to enhance the energy performances. The legislation towards a more sustainable built environment mainly focuses on newly to be constructed buildings. Often, the existing stock is exempted from new regulations and only has to comply with the building codes of the moment of construction (Díaz, Wilby, & González, 2013). With the knowledge and technology available today, it is possible to construct rather energy efficient buildings but also to enhance the energy performance of the existing stock. Regarding the Paris Climate Agreement, which states a reduction of 80 to 95% of the carbon emissions by 2050, the challenge is to make the existing stock more energy efficient since around 87% of the currently existing stock will still be in use by 2050 (Wilkinson, Remøy & Langston, 2014). Currently, the built environment is responsible for around 38% of the total energy consumption in Europe according to the European Parliamentary Research Service (Šjan, 2016). This makes it rather interesting to investigate how to make the existing stock more energy efficient.

The Dutch national government has several energy-related policies in place for different types of real estate. One of them is to reduce the energy consumption of the Dutch office stock. This policy entails that every office space should comply with at least an energy label C by 2023 (EIB, 2016). Unlike most of these policies, this energy label C also means that current tenants of office space should comply with this label even though they are not the owner of the property. Currently, more than half of the existing Dutch office stock

is not complying with this energy label C yet (EIB, 2016). Therefore, in the coming years, energy reductive renovations and adaptations will be required for existing office buildings to prevent them from being declared unusable and facing legal obsolescence

The Dutch energy labelling system is based on an energy performance coefficient, EPC. Every step in the labelling system is expected to have a certain energy consumption per m2 per year due to the underlying calculations that have been set for the energy policies. Based on those calculations, the target for the Dutch office stock has been set on an energy label C by 2023. However, a certain energy label is not always reflecting the actual consumption of the property, this is the so-called energy performance gap (van den Brom, P., Meijer, & Visscher, 2018). If buildings are complying with the energy label but do not consume the amount of energy as estimated, this energy policy seems to be questionable for its effectiveness. A report by the ECN (2017) indicates the existence of such a performance gap in the Dutch office sector, see figure 1.1. This figure visualises the discrepancy between actual and theoretical gas consumption. What is striking is that the higher label classes such as A and B are underperforming and using more energy than expected, while the lower labels use significantly less energy than is predicted by the energy label.

Due to the national legislation on energy efficiency of offices buildings, all office properties will have to obtain the minimum of energy label C by 2023. As visualised in figure 1.1, label C seems to be a tipping point from whereon labels A and B are underperforming. On average, a label A office building consumes around one third more than expected. This energy performance gap requires more attention and further research since only little is known on this topic. Therefore, this research will focus on mitigating the energy performance gap in the Dutch office stock by studying the building characteristics and adaption possibilities of label A and B office buildings towards more sustainability.

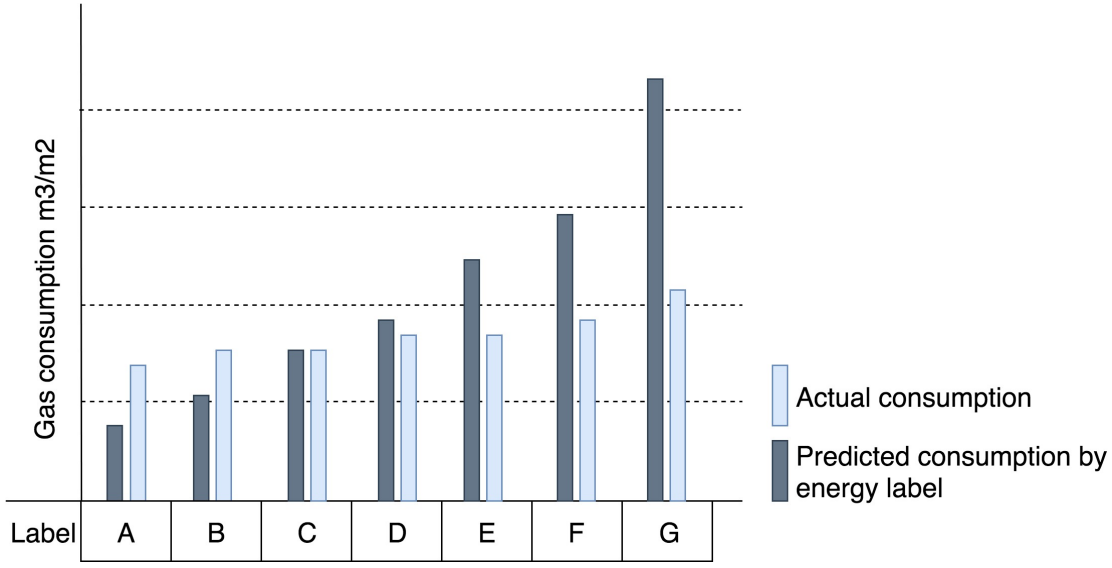

Figure 1.1. Schematic visualisation on the energy performance gap in the Dutch office sector for gas consumption, based on Sipma et al. (2017)

1.2 Relevance

The aim of this research is to contribute to the body of knowledge and further explore the field of energy consumptions and sustainability within the Dutch office stock. A focal point is the energy performance gap in label groups A and B, which indicates a difference in actual and theoretical consumption. In this section, the relevance will be discussed, from two perspectives: societal and scientific.

Societal relevance

In the following paragraphs, the societal relevance will be explained of which more background information can be found in the chapter on the theoretical underpinnings.

Climate agreements & decreasing carbon footprint

Clear global and European climate agreements have been to reduce the overall energy consumption to reduce polluting emissions. The built environment is consuming approximately 38% of the total energy (Šjan, 2016). Therefore, lowering the energy consumption of the built environment is of significant importance to achieve climate goals. Today, the Dutch built environment is lagging when it comes down to achieving these climate goals (Filippidou et al. 2017). Emissions decrease by consuming less energy which will result in a smaller environmental footprint. So, apart from the inevitable need for a more sustainable built environment, there is also the urge to reach the stated climate goals. There is still a long way to go towards the sustainability goals of 2050, and there are only 31 years left to reach this, which is relatively little considering the lifespan of an average building.

Energy policies in the Netherlands

The current Dutch national policy is steering to stimulate energy efficiency in the built environment. One of the main consumers of energy are utility buildings that include office spaces, which account for 13% of the total energy consumption (European Environment Agency). The national policies force owners and tenants of office spaces to adapt or renovate their property towards sustainability to obtain the required label C. Finding the right interventions for reducing the energy consumption can be challenging. Therefore, more insight into actual energy performance seems to be favourable. Apart from mitigating the performance gap, this topic is also relevant to investigate further because of a change in policies that will be put into effect relatively soon. In this new policy, a criterion will be added to the existing labelling system that will also take actual consumption into account when assessing a building. Because of this new policy, it becomes more relevant to have a lower actual energy consumption for a property owner than it is right now where the energy label is only based on building characteristics.

Insight and awareness for owner and tenant

Today, often property owners but also users are not aware of their actual consumption due to a lack of information and a proper way to access the data. A lot of developments regarding smart energy tools are now able to provide better insight on a detailed level. A large part of reducing energy consumption is possible by adjusting the tenant's behaviour by making them aware of the consumption (Energiesprong, 2016). Therefore, more insight in on the actual performance seems to be favourable

Financial benefits owner and end-user

The energy consumption comes with a price tag. With increasing energy tariffs and taxes on natural gas, reducing the demand becomes more urgent from a business and financial perspective for the end-user. Also, owners are incorporating the level of sustainability more and more in the rental prices to make major renovations possible. By this, the challenge of sustainability is becoming a tenant's issue (Baum, 2017). The new energy labelling system, EPG that will be in place by 2020 also take actual consumption into account when calculating the energy label. A large energy performance gap might mean that the label A office buildings could be depreciated to B/C, which could result in a lower value for the property.

Energy Performance gap

Currently, the existence of an energy performance gap is known in the residential and office sector. Wherein buildings with a better energy label are tending to perform less energy efficient than expected (Filippidou et al., 2017; EIB, 2016). As the existence of this performance gap is known it now becomes of relevance to mitigate this gap as much as possible and to steer towards a more sustainable stock. The origin of the energy performance gap should become clearer to be able to address it. Therefore, further research into this relatively unknown field is required.

The next step

The relevance from a societal perspective has been mentioned in the paragraphs above. By executing the research to this topic, the intention is to generate a framework that is operable for different cases and is thus more widely applicable. This framework should provide a piece of advice on the process on adaptations for the existing property considering the different stakeholders.

Scientific relevance

Apart from the societal perspective, academic relevance will be elaborated upon in this section.

Insight on actual versus theoretical consumption

The existence of an energy performance gap is known and addressed in several pieces of research and reports (Sipma, 2016; Filippidou et al., 2017). A report by Jones Lang LaSalle in collaboration with Better Building Partnerships in 2012 even concluded that there is only little correlation between the EPC and the actual performance of office

buildings in the UK (JLL, 2012). Because of the complexity of this problem, there does not seem to be one solution to solve it. Currently, not a lot is known on how to address this energy performance gap. However, it is becoming easier to collect data on energy consumption due to technological developments such as smart meters (Energiesprong, 2016). A gap is present in the literature about how the mismatch between theoretical and actual consumption might be solved. Therefore, the problem seems to be known. However, concrete plans for reducing the energy performance gap seems to be still missing.

Contribute to the body of knowledge on the Dutch office market
Even though the Dutch office market is monitored closely, this research can still contribute to the body of knowledge. This research will focus on adaptations to the existing stock considering the current conditions and policies enforced. Also, this research is looking ahead to the influence of the change on policies and how this would influence the adaption process or energy labelling of existing buildings. The aim is to acquire more knowledge on making the existing stock more sustainable by well-founded adaptations. By conducting four case studies insight will be obtained on the possible drivers and barriers that different stakeholders might experience when considering the implementation of energy saving adaptions.

1.3 Research Questions

In this paragraph, the research questions will be further explained. First, the main research questions will be given after which the sub-questions are stated. Second, the type of study and data collection will be provided in an overview. Lastly, the conceptual model will visualise the research.

Research Question

As stated, the existing stock should be considered to be a focal point in reaching the climate goals for the built environment. Since there are several types of real estate, this research will focus on offices in the Netherlands. Mainly, because there is a concrete point on the horizon namely energy label C in 2023 with a certainly expected consumption of energy. Given the problem statement of the energy performance gap and the regulatory context, the main research question is as follows.

Main research question:
How can adaptations contribute to enhance energy efficiency in the Dutch office stock in order to mitigate the energy performance gap of energy label A & B buildings considering different stakeholders' perspectives?

To be able to answer this main research question several other sub-questions need to be answered to come to a well-founded answer. Therefore, three sub-questions are stated in table 1.1. For each sub-question, the research objective and methodology is mentioned. Further explanation of the methodology and data sources can be found in the methodology chapter.

Table 1.1. Sub-question & Research objectives

Sub-question	Research objective	Research methodology
1. How are national energy policies affecting the existing Dutch office stock?	To obtain more insights into the current energy labelling systems that are available and how they differ from each other. Besides, a better understanding is required of the Dutch national energy policy that is in place for office buildings now and in the near future.	Literature Study Type: Qualitative
2. How are building characteristics related to the energy performance gap?	The aim is to obtain more insight into the contribution of the users and building characteristics on the energy performance gap. A thorough understanding of the building is required to find possible causes and solutions for mitigating the discrepancy.	Literature Study & Case Studies Type: Qualitative
3. What are drivers and barriers for investors, property managers and tenants for implementing adaptations to mitigate the energy performance gap in the existing office stock?	To know what adaptation is realistic and feasible, stakeholders should give input on their drivers and barriers for taking steps towards more sustainability. This might lead to new insights or preferred adaptions from different parties involved.	Case Studies Type: Qualitative

1.4 Conceptual Model

To obtain a clear picture of the structure of the research, a conceptual model provides an overview. The conceptual model starts with the context, in this case, the existing stock whereon several forces have their influence. One of them is the energy policy with the energy labelling of buildings. A comparison to the actual consumption leads to the underperforming group of buildings that will be researched for this thesis. Each building will be analysed on building characteristics and the role of stakeholders on the adaption possibilities. The findings should provide more insight into how to address the energy performance gap to ultimately stimulate sustainability. The research can be summarised in the following conceptual model as visualised in figure 1.2.

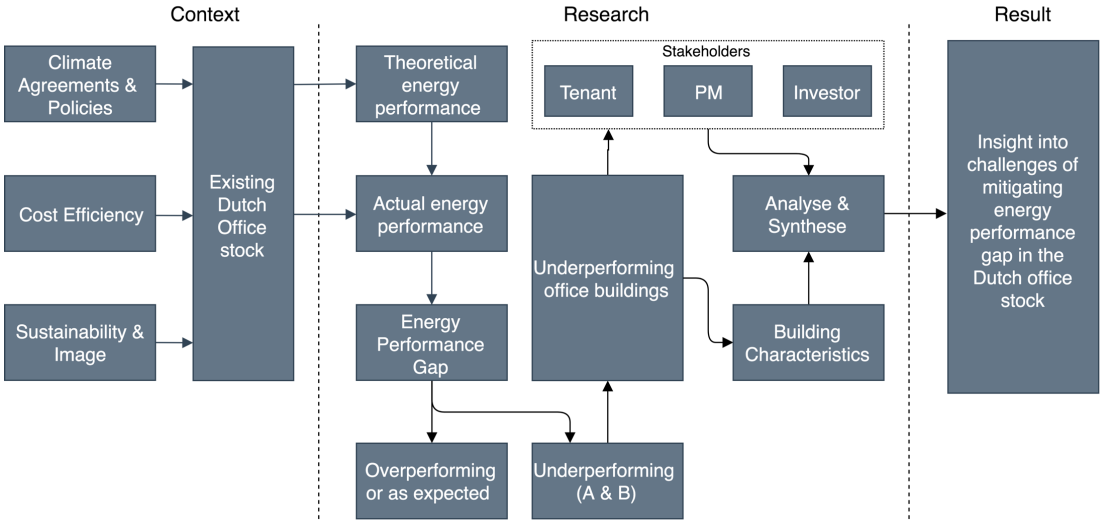

Figure 1.2. Conceptual Framework

2 | Theoretical Underpinnings

2 | Theoretical underpinnings

In order to obtain a better understanding of the research topic, a literature study was conducted. For this literature study, several themes needed to be investigated more in depth. Although a lot of the literature can be considered to be background information. The literature study initially focuses on climate agreements and policies to obtain more knowledge on the exact national and international agreements and legislation that is in place. Also, the performance of the Dutch office stock will be elaborated upon and whether the Netherlands is on track for reaching the objectives of these agreements. Thereafter, a closer look is given to the current sustainability assessment methods that are available to assess energy performance and how they differ from each other. The third section will focus on the energy performance gap, the reason that it exists, and what adaptations might mitigate this performance gap. The fourth section is mapping different stakeholders' perspectives related to the issue of sustainability. Last, a theoretical framework and summary will be provided which is the foundation for the empirical research.

2.1 Climate Agreements & Energy policies

Over the years global welfare and industrialisation have led to a higher global energy demand than ever before. Nowadays, most of the energy that is required for industry, buildings or transport is still generated by the use of fossil fuels. Through the years the effects of the emissions of fossil fuels have become clearer. The so-called phenomenon of global warming is mostly related to high levels of CO_2 in the atmosphere that cause global heat to stay within the atmosphere, heating up the planet eventually. In order to minimise the global and the impact related to this issue is addressed in policy documents globally. The goal of these policies is to mitigate the effects of the energy consumption. The Trias Energetica strategy by Duijvestein (1996) stresses the importance of prioritising to accomplish a more sustainable living environment, visualised in figure 2.1. The first step is to reduce the demand for energy consumption by rethinking processes and use more energy efficient techniques. The second step is to use renewable energy sources if energy is required anyway for certain activities. Since renewable energy itself has no emission impact on the environment when energy is being generated, it may only contain embodied energy. Embodied energy is the energy that has been consumed in order to create a certain product due e.g. fabrication and transportation. The third step is to use fossil fuels if more energy is required and when this cannot be generated or provided through renewable sources.

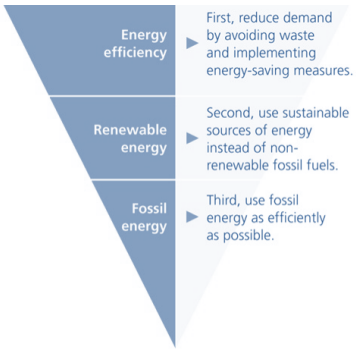

Figure 2.1. Trias Energetica concept based on Duijvestein (1996)

In order to minimize the impact of greenhouse gases by the increasing energy demand, ambitious plans are on the political agenda. The well-known Paris Climate Agreement states the ambitions for member states of the United Nations by 2050 (2015). One of the ambitions is to keep global warming below 2 °C. Globally, the built environment accounts for approximately 30% of the carbon emissions which stresses the importance of further development towards sustainability in this sector (Pérez-Lombard, Ortiz, González & Maestre, 2009). Also, recent studies indicate that more effort and action is required to reach the stated objectives of the climate agreements that are in place (Rogelj, Den Elzen, Höhne, Fransen, Fekete, Winkler, Meinshausen, 2016).

The European Union is trying to steer towards more sustainability through obligatory national policies on energy efficiency and reducing emissions. The goal for the EU is to reduce 80-95 % of their greenhouse gasses, compared to 1990, by 2050 (Šjan, 2016). The most recent numbers on energy consumption are stated in table 2.1. The built environment includes the sector households and services which accounts for a 38,25% on the total energy consumption in 2016 according to the European Environment Agency.

Table 2.1. Energy consumption per sector in the EU in 2016 based on European Environment Agency

Industry	Transport	Households	Services	Others
24,99%	33,15%	25,71%	13,54%	2,6%

As all the EU member states can be considered to be developed countries and therefore technical life expectancy of a building is between 50 to 100 years (Fay, Treloar, & Iyer-Raniga, 2000). This means that around 87% of the existing built environment will still be in use by 2050 (Wilkinson et al,. 2014). With a replacement rate of about 1% in the Netherlands, this brings major challenges to reach the climate goals of 2050 because often, new or more strict building codes do not apply for the existing stock. Therefore, the need for stricter building regulations resulted in the Energy Performance of Buildings Directive (EPBD) in 2010. This directive has led to the standard of nearly zero-energy buildings (nZEB) that is applicable to all new buildings from 2021 onwards. Concluding, a lot of energy is being consumed by the built environment. With a low replacement rate, this leads to major challenges to reach climate objectives. All the member states can fill in their own national energy policies as long as they are in line with those of the EU.

The Dutch government is able to state their own policies as long as they are in line with the European Union climate objectives. In the Dutch *Energieakkoord,* Energy agreement, the national government states clear objective for 2023, 2030 and 2050. The Dutch national government uses the energy labelling method to calculate energy performances of buildings. Today's policy obliges an owner to have an energy label for a building when it is constructed or it is being sold. The current labelling systems entails the use of letters to indicate its level of sustainability, wherein label A is most sustainable and G is the least sustainable. Each label is based on the outcomes of the assessment method and contains a certain bandwidth per label step. There are differences between the bandwidth of energy labelling requirements for residential and utility buildings due to a different type of use and thus assessment method. Since this research focuses on offices the most relevant points in the national policy will be elaborated upon.

For office owners, investors, asset managers, property managers and tenants, 2023 is a specific point on the horizon. The national policy for office buildings obliges all office spaces to obtain an energy label C by then. Currently, approximately 50% of the office buildings are not complying the label C norm of 2023 (EIB, 2016). This means that in the coming four years major adjustments will be required to take place, otherwise, the property will not be allowed to be used as office space anymore which results in legal obsolescence. When an office building is being adapted or renovated, environmental sustainability is the most mentioned factor to be considered by the decision-making stakeholder (Bullen, 2007). The national policy on energy consumption is clear for 2023 with its label C as a minimum. However, there are some exceptions of buildings that will be exempted to comply with this label C standard.

- If the office space is below 50% of the total space of the used surface
- If the office space is smaller than 100m^2
- If the office space is listed as a national monument
- The measures that have to be taken that have a payback time over 10 years

The next point on the horizon is energy label A of the current assessing method by 2030. After that, an energy neutral built environment will be demanded by the national government by 2050, see figure 2.2. The current policies are clear when it comes to the EI that should be met in a certain year. However, this policy is not considering the actual consumption when the building is in use, because the label is based on certain parameters that do not include actual energy consumption. So, the labelling just expresses the theoretical consumption of a building based on the input of building characteristics. Since the Dutch government assesses buildings with this method the main driver becomes to meet a certain building quality level rather than knowing the actual performance and consumption of the built environment.

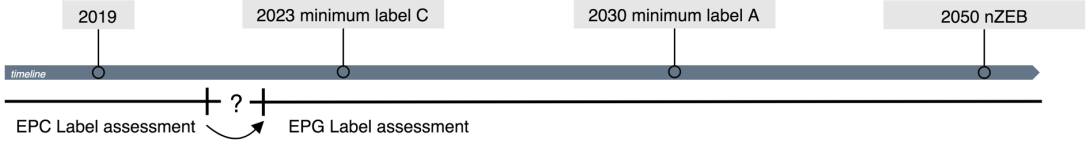

Figure 2.2. Timeline of legislation and energy labelling

The EU prescribes that the member states should have an assessing method which takes the actual performance into account. Therefore, the EPC method will most likely be replaced by the Energie Prestatie Gebouwen (EPG), energy performance for buildings. The initial plan was the EPG to be in force by 2020. However, this introduction of the EPG has been postponed for an unknown period. The EPG method is in line with the European Energy Performance of Buildings and will be expressed in kWh/m2 per year (Bouwbesluit, 2018). To foster energy efficiency, policy tools should not focus on one aspect such as only theoretical performance. Policy tools should also on the financial, social and behavioural aspect (Dietz, Gardner, Gilligan, Stern & Vandenbergh, 2009). This EPG method as it is currently proposed may have a severe impact on underperforming buildings when the actual consumption is included in the assessment. A higher actual consumption could result in a lower label of the building. So, this new labelling might lead to depreciation of the existing energy labels, which is related to the building value (Chegut, Eichholtz & Kok, 2014). Therefore, complying and balancing the energy consumption with the label becomes a significant importance for owners or investors as well.

2.2 Energy Performance

As mentioned, each member state of the EU can use their own method of assessing a building on energy efficiency. Various energy performance methods are available, of which BREAAM, GPR and EPC are the most commonly used in the Netherlands. Therefore, this part focuses on the energy labelling systems and the energy performance of the Dutch office market. In order to obtain a better understanding of how sustainability is being measured and assessed in the Netherlands, the different energy labelling systems will shortly be introduced to understand their differences.

BREEAM

The Building Research Establishment's Environmental Assessment Method abbreviated BREEAM is a worldwide used method to assess the level of sustainability of a building. There are two types of BREEAM certifications, BREEAM for New Buildings and BREEAM In-Use. The BREEAM New Buildings has the following assessment criteria, see table 2.2.

Table 2.2. Different BREEAM-NL criteria and their weighting based on DGBC (2016)

Management	Transport	Waste
12%	8%	7,5%
Health & Comfort	Water	Land-use & Ecology
15%	6%	10%
Energy	Materials	Pollution
19%	12,5%	10%

Striking for this method is that is considering more than just the building itself and its condition. Also, BREEAM In-Use provides a method to assess the existing stock. The calculations for BREEAM In-Use are more complex and exist out of three themes, Asset, Property Management & Use. The same criteria will be assessed. However, different weightings are given to per theme (DGBC, 2014). The foundation Dutch Green Building

Certificates is able to issue the BREEAM certificates. Nowadays, more investors want to obtain a BREEAM certificate since it is considered to be a balanced indicator for sustainability and add value to the building (Chegut et al., 2014). After assessing the following rankings can be given to a property.

- Pass *
- Good **
- Very good ***
- Excellent ****
- Outstanding *****

GPR

Another method that is used relatively often is the GPR Method. The GPR method can be considered to be quite similar to the BREEAM. It considers five different components that can be ranked from 1-10. Per theme, there are several sub-criteria that need to be assessed to come to a final score. The method is based in the three P's of people, planet profit (GPR, 2018). When comparing this method to BREEAM, GPR leaves out the managerial and transport component. GPR is a software tool that could be used in the design, build and operate phase of a building. The main themes of this assessment method are as follows.

- Energy planet
- Environment planet
- Health people
- User Quality people
- Future Value profit

Energie Prestatie Coëfficient (EPC) & Energy Index (EI)

The Dutch national government is using the well-known Energie Prestatie Coëfficient (energy performance coefficient), EPC, as their methodology to measure the sustainability of buildings. The EPC is used to calculate the energy performance prior to the construction. When a building is already constructed the Energy Index (EI) will be used. The formulas of both are mentioned below. Linked to the outcome of the formula a certain label can be provided to the building from A++ to G, wherein A++ is the best performing label. In table 2.3, the different labels steps and their bandwidth for utility buildings are shown (RVO, 2018). Because of the bandwidth per label, an exact estimated energy performance per m2 is not given upfront since it can vary within the same energy label

Energy Index formula

EI= (ECtot * 0,84) / ((248 x Af) + (87 x Aloss) + 5844)

Energy performance coefficient formula

EPC = ECtot / ((330 x Af) + (65 x Aloss) + 1/Cf)

ECtot = the total energy consumption [MJ]
Af = floor area [m2]
Aloss = building envelope [m2]
Cf = correction factor

Table 2.3. Energy Performance for Utility Buildings in the Netherlands

Energy label	Bandwidth Energy Index	
	from	to
A++	<0,51	
A+	0,51	0,70
A	0,71	1,05
B	1,06	1,15
C	1,16	1,30
D	1,31	1,45
E	1,46	1,60
F	1,61	1,75
G	>1,76	

As mentioned in the problem statement there is a discrepancy between the predicted and actual energy consumption in the Dutch real estate sector. This is often referred to as the energy performance gap and basically entails that the building is under or over performing in terms of gas and electricity consumption (Majcen, Itard, & Visscher, 2013). A study by JLL (2012) indicated that there is only a small deviation between the actual consumption of different energy labels groups in the UK. Remarkable is that some B labelled buildings consume more than the average D labelled building and vice versa. This indicated that the labelling system is not providing a representative image of the actual performance in the UK which has a relatively similar assessing method compared to the Netherlands.

Also in the Netherlands, there is a quite similar situation in the office sector. Every energy label is expected to have a certain bandwidth of energy consumption per m2. However, the actual consumption differs significantly from the theoretical consumption. In figure 2.3 & 2.4 the predicted energy consumption for natural gas and electricity is visualised in red while the actual consumption is plotted with a black line with a sample size of over 1000 office buildings (Sipma et al., 2017). It is clear that also in the Dutch office market an energy performance gap is present. The gas consumption per m2 is more than expected from label C onwards to label A and B. While at the same time, labels D to G consume significantly less than expected. This observation will form the basis of the population of the study, which can be found at the end of the methodology chapter. The energy labelling system only takes into account the primary energy consumption. Primary energy consumption is defined as the energy required for heating, cooling, ventilation, hot water and lightning in the Dutch EPC. Since gas can only be consumed for primary purposes namely heating, figure 2.3 provides a proper representation of the average performance gap in the Dutch office sector. The actual electricity consumption will always more due to the fact that the prediction on the energy label is only taking into account the primary electricity consumption. This means that an energy performance discrepancy is present due to activity or user related consumption. This can be caused by the use devices or appliances needed to perform business activities e.g. IT-servers, monitors and elevators. Therefore, it is needed to look at a building level to determine whether there is an electricity related performance gap or not. Due to lack of data points this information is often not available

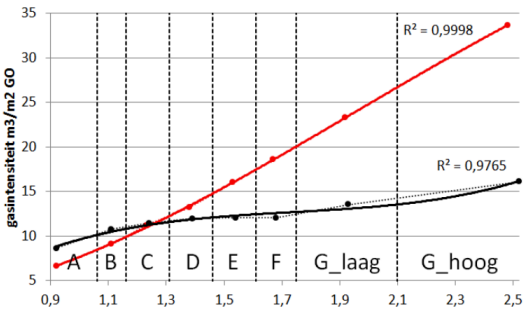

Figure 2.3. Theoretical (red) versus actual (black) natural gas consumption in m3/m2 per label step (Sipma et al., 2017)

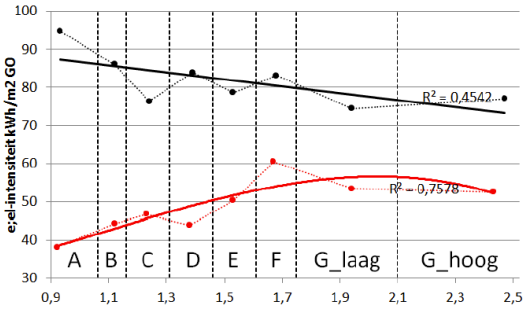

Figure 2.4. Theoretical (red) versus actual (black) electricity consumption/m2 per label step (Sipma et al., 2017)

The Dutch office market will shortly be described based on some number and figures. The office sector consists of 85-million m^2 lettable floor area, which is divided of among 67.000 buildings with a vacancy rate of 15,9% (Rijksoverheid, 2017). In figure 2.5, the percentage of each energy label compared to the total office stock is visualised. It is clear that the largest group is still energy label G, which is alarming regarding the label C policy of 2023 (EIB, 2016). A side note is that this report was published in 2016 so the division of label percentages might have shifted already towards a larger percentage that will meet the legal requirements of 2023. According to this report, *verplicht energielabel voor kantoren*, approximately 50% of the office stock is not yet complying with the label C minimum that is mandatory by 2023. It is clear that converting the existing building stock towards sustainability has the greatest contribution to reducing energy consumption compared to newly built buildings (Itards, 2008). Especially because the technical lifespan of buildings is rather long and therefore the replacement rate is low. Most existing buildings are exempted from new or adjusted building legislation or building codes, this phenomenon is also referred to as 'grandfathering' (Díaz, Wilby, & González, 2013). However, partly due to the label C legislation, in 2017, 17% of the office spaces undertook renovation activities to reduce energy demands (RVO, 2017). Therefore, the obligatory energy label seems to have an impact on the renovation pace.

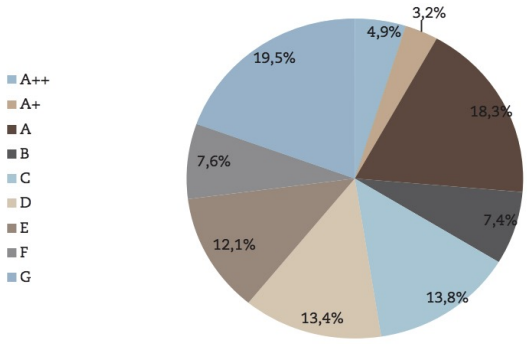

Figure 2.5. Energy labels of the office stock in the Netherlands calibrated in 2016 (EIB, 2016)

3.3 Adaptations

The concept of adapting the existing stock is not new but is still gaining traction. That adapting the existing stock was found to be key in fostering the built environment more sustainable was already mentioned by Bullen (2007). As long as the project remains viable, adaptations to the building are considering by its owners it instead of demolishing and developing a new building. Through the years, sustainability and reducing energy consumption have become more important factors when accommodation office users (Remøy & Van der Voordt, 2014). This stresses the demand for a more sustainable office spaces and improvement towards more sustainability in the existing stock. Usually, the property owner would need to make investments in sustainability measures while the tenant would have the profits, a lower utility bill or service costs. However, it is becoming more common to transmit the burden for developing a more sustainable built environment into the rental pricing per square meter (Baum, 2017). When buildings are being adapted and reused the most considered factor is the opportunity for technical innovations (Bullen & Love, 2011). So, this emphasises that the technological and sustainability possibilities of properties are of significant importance for accommodation office users or during their location-decision process.

Adapting the existing stock in order to enhance sustainability has a broader impact than a reduction of energy consumption. There are several benefits to the environmental, economic and social domain. An overview of these benefits is stated below (Taylor, 2013)

Environmental Benefits
- Enhanced and protected biodiversity and ecosystems
- Improved air and water quality
- Reduced waste streams
- Conservation of natural resources

Economic Benefits
- Reduced operating costs
- Expanded markets for green product and services
- Improved occupant productivity
- Optimized life-cycle economic performance

Social Benefits
- Enhanced occupant comfort and health
- Heightened aesthetic qualities
- Minimized strain on local infrastructure
- The improved overall quality of life

In order to tackle the problem of the energy performance gap, one should first be able to identify such a performance gap. Due to technological developments, it has become easier to map the actual energy performance of a building. New technologies allow us to gather more data than ever before. This is also the case in the real estate sector. Real estate technologies are able to process and give meaning to the data that is collected. Thanks to the internet of thing a lot of things can be measured to provide new insights on building characteristics and tenant's behaviour. Sensors can measure presence to optimise the use of space. For which, techniques such as Bluetooth, WiFi & CO_2 sensors can be used (Valks, Arkesteijn, den Heijer & Vande Putte, 2016). Also, smart meters can provide more insight into the energy consumption in the real estate sector (Cook et al., 2012). By collecting meter readings frequently and analysing them, more insight can be obtained by a smart tool, for a visualisation see figure 2.6. Easy access and insight on energy consumption were found to be of crucial importance to raise awareness for the issue of sustainability and could lead to energy savings (Energiesprong, 2016).

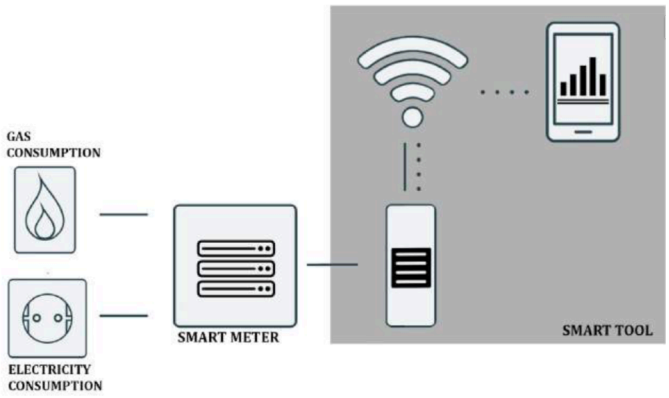

Figure 2.6. Schematic representation of functioning of smart meter and smart tool to obtain insight into actual consumption

Once the cause of the performance gap has been located, action can be taken to mitigate it. Depending on how major the energy reduction should be, different steps can be taken to solve the problem performance gap. In terms of terminology, there are several types of renovations or adaptations found in the literature. With deep renovations, an energy reduction up to 75% is accomplished, for major up to 50% and minor up to 30% reduction of its initial consumption (Economidou, Atanasiu, Despret, Maio, Nolte & Rapf, 2011; Shnapp, Sitjà & Laustsen, 2013). Depending on the aimed reduction different adaptations can be implemented. Two types of adaptations can be distinguished, structural and behavioural adaptions.

Building themselves do not consume energy without the input or activity of the occupier. Therefore, four main contributors to the energy performance can be determined, see figure 3.7. The building envelope is of crucial importance for its energetic performance and is in the EPC labelling the focal point for determining the level of sustainability. The plug loads refer to the energy consumption that takes place apart from the primary energy consumption that is needed for HVAC, lighting. Microgeneration refers to the capability of generating some of the consumed energy by the building's installations such as solar panels. The occupier behaviour is often mentioned as the most influencing factor. From this concept, the building envelope and its installations can be considered to be the structural component in the equation while the occupants behaviour counts for the behavioural aspect and possible adaptations (Janda, 2011).

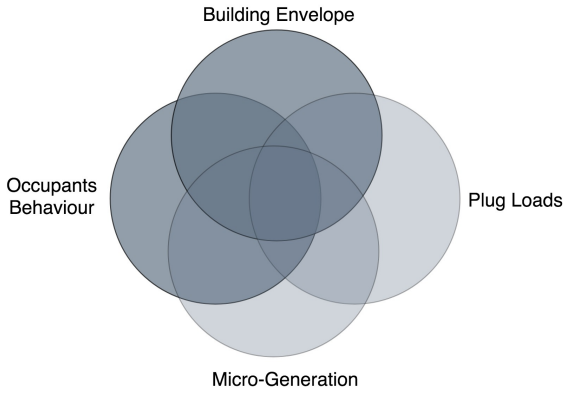

Figure 2.7. Schematic representation of the four main contributors to the energy performance, based on Killip 2009

Structural adaptations focus on either the building envelope or the building installations. For instance, structural adaptations might be enhancing the level of insulation or amount of daylight that is able to enter the work floor. The moment for planning and executing structural adaptations is often related to the technical life-span. When the end of the technical life-span is reached it means that the façade or installation is no longer able to deliver the technical qualities and characteristics as they are expected to. This will result in the need for replacement of this part of the building. The Shearing layers theory distinguishes six layers in buildings that have the influence of the technical condition of a building. The layers that have been distinguished are: stuff, space plan, services, skin, structure, site (Brands, 1994). All these layers have different have lifespans which are visualised in figure 2.8. Based on the expected lifespan, investment decisions will be made whether structural adaptations fit into the long-term maintenance plan. From an investors perspective, it would not be favourable to make off-cycle adaptations, before the expected life-cycle end, since the return on the investment is not optimised (Lacovidou & Purnell, 2016). Therefore, often the end of the expected life-cycle is used by investors to upgrade a building to a higher level of sustainability.

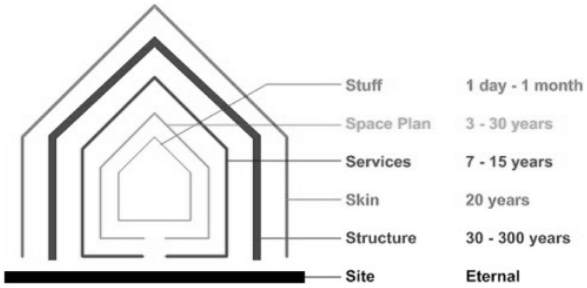

Figure 2.8. The Shearing layers of a building with the expected lifespan (Iacovidou & Purnell, 2016).

Because the energy labelling is focussing on some the building characteristics such as R-value of the façade it is not assumable that this causes the energy performance gap. Due to this, it is of relevance to conducting further research into this performance gap with a focus on user behaviour. The number of working hours can have a major influence on energy performance just like the occupancy rate and the type of work or activities that take place in the office building. (Yu, et al., 2011). Therefore, these user characteristics should be considered when conducting the research.

One could argue that inside the stuff layer of the shearing layers, figure 2.8 an extra layer could be added that symbolises the tenant or occupier of a building. Because it is not the building itself that consumes the energy, it is the user that causes energy consumption by its behaviour (Janda, 2011). The potential of adapting behaviour of tenants is promising and can reduce energy consumption relatively quickly (Pacala & Socolow, 2004.) Since the potential of energy savings by adaptations in behaviour can easily to savings of 20%, it is relevant to map key elements that can contribute to behavioural change. A study distinguishes five elements that have can foster behavioural change towards more sustainability. The five elements are as follows (Fink, 2011):

- Information and education – Educate the occupier on energy efficient behaviour and create access to energy consumption related information.
- Financial incentives and energy services – Provide direct and indirect financial incentives for tenants and energy suppliers to convert to renewables or adapt their behaviour to reduce energy consumption.
- Modern technologies and sustainable design – Innovation drives more energy efficient technologies and buildings should be designed with a holistic approach towards energy efficiency considering these innovations and related behaviour.
- Social and community norms – From a societal level, there should be a demand for more sustainable building as it is becoming the social norm. Also, it should become 'common-sense' to behave and consume in an energy efficient manner.
- Biophilia contact with the natural environment – Being close to nature stimulates the sense of responsibility to maintain it and therefore has impact on the behaviour.

2.4 Stakeholders

To be able to work towards a more sustainable existing building stock several stakeholders need to share this ambition, its risk, and benefits. So far, the current market shortfalls in investing in energy reduction due to the conflicting interest of different stakeholders (Van der Heijden, 2015). As mentioned, property owners are often not able to have gains from their investments in sustainability measures. This is because of the division of rental prices and service costs in rental contracts. The rental price is set for a certain period of time while the service costs depend on the provided services to the tenant such as a receptionist and the consumed energy. Because of this division, the tenant would experience the financial benefits from energy saving adaptations while the investor will need to financially invest into those adaptations. Therefore, property owners and investors have little to no incentive to make these investments if they are not residing in the building themselves (Gillingham, Newell & Palmer, 2009). Also, the government can play a role in this transition, by providing incentives to developers, owners or tenants to reduce their energy consumption. However, often nobody dares to take the first step in the process, the so-called vicious circle of blame (Cadman, 2007). Whereby the investor claims there is no demand for sustainable buildings from occupants, the developer does not commission a sustainable building, the contractor claims there is no sustainable project to be built, the occupant claims there is no sustainable supply. On the other hand, the adaptive reuse of the existing building is considered to be one of the key concepts of sustainability by building owners (Bullen, 2007). What is clear is that all stakeholders have to be on the same page to start making progress in the energy transition of the built environment. Several stakeholders that have an influence on the adaption decision-making are stated in table 2.4, based on Wilkinson et al. (2014).

Table 2.4. Decision makers or influencers in building adaptions

Decision maker	Possible type of stakeholder	Involved stage
Investors	Pension funds	Early stage, long commitment
Producers	Facility manager	Operating phase
Marketeers	Broker	Selling phase
Regulators	Local authorities	Permit stage
Policymakers	Federal government	Indirect effect
Developers	Central point in development	Initiative to completion
Users; corporate residential	Business organisations	From completion onwards

Concerning the existing stock, several of the above mentioned will have less influence or less interest in adapting an existing building. Depending on the type of adaptions some will be excluded. However, when adapting an existing office building either structural or in the way it is being used, three main stakeholders can be identified namely, the owner/investor, the property manager and the tenant. The owner will probably outsource the property and facility management to a third party that will have direct contact with the tenant. When adaptions are required concerning the energy performance, the interest of these three stakeholders will need to be aligned accordingly. In figure 2.9, a schematic representation is given on the relation between the stakeholders.

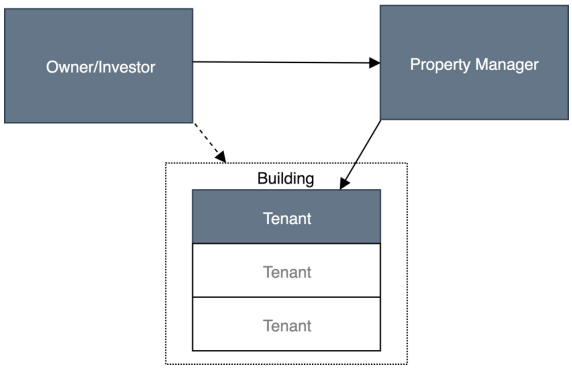

Figure 2.9. Schematic representation of important stakeholders for adaptations

As mentioned, often split-incentives for implementing sustainable adaptions slow down the adaptation process. However, recent studies indicate that there is a growing demand for more green and sustainable office spaces (Warren, 2010). Even though there is a global push for more sustainability, rent premiums do not seem to increase significantly which is remarkable because of the higher costs related to developing a more energy efficient building (Warren-Myers, 2012). Therefore, further field research is demanded to further map drivers and barriers in this adaptation process in order to foster the process towards more sustainability.

This research focusses on mapping the perspectives of the three main stakeholders regarding their energy performance gap and challenges related to this. In order to answer the sub questions for this research, semi-structured interviews will be conducted. Existing literature and studies provide input for the interview protocol on mapping possible drivers and challenges in the fostering a more sustainable office stock. Several topics are of

interest to the different stakeholders. However, due to the nature and general objectives of these stakeholders, their interest in certain topics may vary. Therefore, a generic description of each of these stakeholders is given to be able to provide an estimation of their level of interest in the mentioned topics, based on Edwards & Ellison (2009)

Investor

The investor is an important stakeholder in the Dutch real estate sector. Investors invest their capital in commercial real estate such as offices, retail and logistics. The general main objective of an investor is to maximise the return on investment. This can be reached through several strategies such as creating value by upgrading the building and its value but also by contracting corporate tenants for a longer period of time which will guarantee a certain cashflow from the building. Also, economical markets have an impact on the value of real estate. Dutch real estate investments are considered to relatively stable in terms of return on investments. That is why a large part of the Dutch commercial real estate is owned by private and institutional investors such as insurances and pension funds that account for 75 billion euros in 2016 (Klapwijk, Nijskens, & Buitelaar, 2017). Often, the real estate acquired by an investor will be under management of an asset manager who will try to optimise the value for its owners since this their main objective (Edwards, et al., 2009)

Property management

On a property level, the property manager's role is to achieve the business objectives related to a certain property. The investor or owner of a property can be considered the client of a property manager. Therefore, achieving business objectives of mostly related to the objectives of the investor. Property managers should act on behalf of the investor but is also closely linked to the tenants and their user satisfaction. The role of the property manager is to maintain the building and its installations according to the long-term maintenance plan and has an orchestrating role during the execution phase of works. Also, providing services and anticipating to the business's needs of tenants to increase tenant satisfaction is of importance (Edwards, et al., 2009). So, property managers mainly help to align the investors objectives while anticipating on tenant's needs and maintaining the technical condition of the property.

Tenant

For a tenant, a building is one of the required resources to be able to perform their business activities. The type of business activities has a major impact on the needed space, the outfit of spatial plans and installations. This research will focus on office buildings and thus office related business activities which mainly involves desk workplaces. In general tenant have rental contracts for 5 to 10 years which means that after these years they could either prolong and stay or move to another place if the property is not supporting their business's activities or demands as requested. So, for a tenant, it is most important that their business strategy is supported by the use of office space in cost efficient manner (Edwards, et al., 2009).

2.5 Theoretical framework

From conducting the literature study several themes were distilled that are of relevance for answering the sub-research questions. Based on the themes mentioned in the theoretical framework, the semi-structured interview protocol was formulated which can be found in the methodology chapter.

The literature that has been consulted regarding every theme is stated in the literature column in the framework. Aside from that, a brief description is given on the elementary aspects of each theme based on previous studies. In the right-hand column, an indication of interest per stakeholder is given which is established based on the stakeholder's objectives in general and findings in the literature. A further explanation of the indication of interest per theme per stakeholder is given after the theoretical framework. The theoretical framework can be found in table 2.5.

Table 2.5. Theoretical framework (legend on next page)

Theme	Literature	Description	Interest
Insight into energy performance	Energiesprong, 2016; Sipma, Kremer & Vroom, 2017; Janda, 2011	Literature suggests that often stakeholders lack access to energy performance data. Providing insight in energy consumption is mentioned as one of the possibilities raise awareness of the stakeholders. Because of more awareness and accessibility to data energy efficient behaviour is stimulated.	I: + P: ++ T: ++
Structural adaptations	Majcen, Itard & Visscher, 2013; Janda, 2011; Killip 2009; RVO, 2018; Warren, 2010; Bullen & Love, 2011; Brand, S. (1994).	Structural adaptations are physical adaptations to the building and could either involve the building envelope or the installations. As Dutch legislations is still mainly focussed on structural adaptions characteristics, this is often the measure of preference for investors since it contributes to the value of the property and prevent legal obsolescence. Structural adaptations and renovations can have a major impact on the energy consumption.	I: ++ P: ++ T: +
Behavioural adaptations	Fink, 2011; Haldi & Robinson, 2011; Majcen, Itard & Visscher, 2015; Janda, 2011; Killip 2009; Pacala & Socolow 2004;	Through the years behavioural adaptations are considered an area the make quick-wins without a lot of investments upfront. By adapting the tenant's use and activities a building can increase its energy efficiency. The potential of adapting behaviour of tenants is promising and can reduce energy consumption relatively quickly.	I: +/- P: + T: ++
Drivers for adaptations towards sustainability	Eichholtz, Kok & Quigley, 2016; Eichholtz, Kok & Yonder, 2015; Devine & Kok, 2015; Fuerst & McAllister, 2011a; Van der Voordt & Koppels, 2013	Important drivers from literature for tenants are a reduced OPEX or Corporate Social Responsibility (CSR). A well performing has reputational benefits which are also of interest for asset managers and investors especially when *EPG* assessment would be introduced. For investors their social responsible investments (SRI) increased rental income and value creation might be key drivers in adaptations towards sustainability.	I: + P: +/- T: +
Barriers for adaptations towards sustainability	Iacovidou & Purnell, 2016; Fuerst & McAllister, 2011a; Filippidou, Nieboer, & Visscher, 2017; Cadman, 2007	Costs are the most mentioned downside of sustainability measures. Also, some adaptations will have a long pay-back time while technologies keep evolving and often become cheaper. Changes in legislation are also mentioned to be a relatively unpredictable factor. To increase the level of sustainability of buildings several stakeholders are involved which requires a shared objective or benefit for all.	I:+ P:+/- T:+
Stakeholders view on situation and future	Cadman, 2007; Filippidou, Nieboer, & Visscher, 2017; Dietz, Gardner, Gilligan, Stern & Vandenbergh, 2009	The concept of split-incentives is often mentioned to be a threshold for taking steps towards sustainability. To get a better understanding the stakeholders will be asked to share their vision on the situation and future in relation to the national policies that are in place for the years to come. All stakeholders would need to share the same ambition in order to break out of the vicious circle of blame.	I:+ P:+ T:+
Preferred Adaptations	Bullen, 2007; Bullen & Love, 2011; Taylor, 2013	Some research stress the important factors and preferred adaptations to building. However, these adaptations are often related to structural adaptation. Therefore, researching both structural and behavioural adaptions as an option for less energy consumption can be of interest for all involved stakeholders.	I:+ P:+ T:+

Legend of table 2.5

Investor:	I	high interest to theme:	++
Property manager:	P	medium interest to theme:	+
Tenant:	T	low interest to theme:	+/-

Explanation on interest

In theoretical framework the interest per stakeholder is mentioned. Based on literature study and the related findings of other studies in so-called grew literature, an indication is given on the interest or the relevance per stakeholder for each of these topics. The relevance expresses to the level of interest by each of the stakeholder wherein I stands for Investor, P for the property manager and T for the tenant. The level of interest or relevance expresses to what extent the stakeholder may be interested in this topic or whether they consider themselves to be an important stakeholder in relation to energy savings possibilities. The scale to indicate interest consists of three levels, low (+/-), medium (+) and high (++) interest to the theme.

Insight into energy performance

I	+	The investor will primarily be concerned about the energy label since the energy label represents value in the current label system, some generic insight suffices
P	++	One of the tasks is to monitor the property's energy performance and act upon it and have a duty to report when the building is malfunctioning
T	++	Tenants consume the energy and pay for it and therefore will be interested in having insight on their own consumption

Structural adaptations

I	++	Structural adaptations will be financed by the investor and probably have an impact on the energy performance and label so therefore are of high relevance to investor
P	++	The property manager will be involved in mapping possible structural adaptations but is also involved during the execution phase
T	+	Tenants most likely will not be investing in structural adaptations since structural adaptations have a long payback time, they might experience nuisance during executing phase

Behavioural adaptations

I	+/-	The investor is currently only concerned on the energy label and therefore has a low interest on the actual consumption and possible behavioural changes of the tenant
P	+	The property manager might be interested in providing tools to stimulate energy efficient behaviour if this a demand from the occupier
T	++	The tenants will be paying the service costs for the energy they consume so they benefit if they adapt their behaviour in a more sustainable manner as long as business activities continue

Drivers for adaptations towards sustainability

I	+	In the current situation there are little incentives for investors to invest in sustainability measures except for legal obligations and possible commercial benefits
P	+/-	The property manager has little interest in creating a more sustainable built environment due to the serving role to tenant and investor
T	++	Tenant experience the benefits from a more sustainable building in lower operation expenses and therefore might have a high interest in adaptations towards more sustainability

Barriers for adaptations towards sustainability

I	++	Current adaptations are often not feasible from their perspective. Rethinking the barriers and the division of the financial burden might mitigate barriers and add value to their asset
P	+/-	Property managers have a serving role and therefore experiences little barriers for implementing sustainability measures
T	++	Tenants may demand a higher level of sustainability but are depending on the building owner and therefore could critically look at their own business's efficiency and their financial share

Stakeholders view on current and future situation

I	++	As legislation develops, investors are pushed to keep on improving the technical state of their assets. The EPG assessment could make them more involved in the actual performance
P	++	Related to the obligatory adaptation from a legal perspective, property managers will have a responsibility towards owner and tenant to keep a building legally complying
T	+	Tenant will probably be most concerned about the continuation of their business's activities and is unaware of the legislation objectives concerning the property they occupy

Preferred adaptations

I	+	Considering the legislative outlook adaptation might be required
P	+	Since the property manager will have the best overview on the technical state of the building and the adaptations within reach for all stakeholders
T	+	Tenants are the experienced users of space and adaptations will have impact on their business

2.6 Summary

This literature study consists of four topics that form the theoretical background for this research. The built environment is still consuming around 38% of the total energy consumption in the EU. The Paris Climate Agreement and the European Energy Efficiency Directive are in place to collectively work towards a reduction of 80-95 % of the greenhouse emissions by 2050. Since the replacement rate in the built environment is low, it is of crucial importance to foster sustainability in the existing stock.
The Dutch government is using the Energy Performance Coefficient as a method to assess sustainability and energy consumption. This method is linked to a labelling system from G to A++. National policies are clear for 2023, all office buildings need to obtain energy label C at least. If this is not reached within time, the property will face legal obsolescence. For 2030, the objective will be obtaining energy label A.
Nowadays, there is a quite substantial discrepancy between the theoretical consumption of the energy labelling system and the actual energy consumption by the property and the users themselves. This is the so-called energy performance gap and tends to be bigger for better labelled buildings. Since national policies are based on those calculations, it is of importance to mitigate this performance gap so that emissions from the built environment are as expected or less.

The use of technical innovations and adaptations enable the process of fostering sustainability in the real estate sector. Smart real estate technologies can contribute to finding where the energy performance gap is caused by and could help to solve it. Two types of adaptations can be distinguished, structural and behavioural adaptions. In order to implement changes, costs and benefits of different stakeholders need to in balance. Due to the phenomenon of split-incentives stakeholders find it hard to make progress in fostering a sustainable office stock. Based on the literature and a theoretical framework was developed with themes that are of relevance for empirical research. The following themes will be input for the semi-structured interviews.

- Insight into energy performance
- Structural adaptations
- Behavioural adaptations
- Drivers for adaptations towards sustainability
- Barriers for adaptations towards sustainability
- Stakeholders view on current and future situation
- Preferred adaptations

3 | Methodology

3 | Methodology

This chapter elaborates on the way of conducting the research. In the research design, an overview will be given on the overall research steps that will be taken. After which the different research phases and data collection criteria will be mentioned. Also, the population of the study is explained in this chapter. The aim is to provide a clear overview of the case study research that will be conducted.

3.1 Research Design

This research focuses on the energy performance gap between theoretical and actual consumption of office buildings in the Netherlands and how to adapt towards more sustainability. To be able to conduct proper research on this topic, different types of input and data are required. First, the required data and data source will be given per sub-questions. After that, a short description will be given about the different types of methods that will be used for conducting this study.

Main research questions: *How can adaptations contribute to enhance energy efficiency in the Dutch office stock in order to mitigate the energy performance gap of energy label A & B buildings considering different stakeholders' perspectives?*

Table 3.1. Sub-question & Methodology

Sub-question	Type of Data	Research Method	Data Collection
1. How are national energy policies affecting the existing Dutch office stock?	Qualitative	Literature Study	Academic literature online available through Scopus, Scholar etc. and 'grey' literature.
2. How are user and building characteristics related to the energy performance gap?	Qualitative	Literature Study & Case Studies	Academic literature online & data from conducted case studies and by interviewing stakeholders
3. What are drivers and barriers for investors, property managers and tenants for implementing adaptations to mitigate the energy performance gap in the existing office stock?	Qualitative	Case Studies	By interviews with investor, property manager and tenant.

The aim of this research is to obtain more insight into the preferred energy saving measures in order to mitigate the energy performance gap in relation to the different stakeholders. To be able to draw meaningful conclusions, this graduation research trajectory is divided into several stages. At first, the theory will be consulted to obtain the necessary background information and to find relevant prior studies that were conducted. This leads to the theoretical underpinnings and forms the foundation for the population of the study. The empirical part consists of conducting four case studies based on the criteria that were established from the literature. Before conducting the case studies interviews, case study preparations will take place to gather the necessary data on the

building/user characteristics. Also, the potential case study objects were mapped and selected along with the case study selection criteria conditions. First, the collected information on the building characteristics and from the interview will be reported per case. The following step is to syntheses and performs a cross-case analysis. The results of this will contribute to the final reporting, conclusions and recommendations. The overall research design is visualised in figure 3.1.

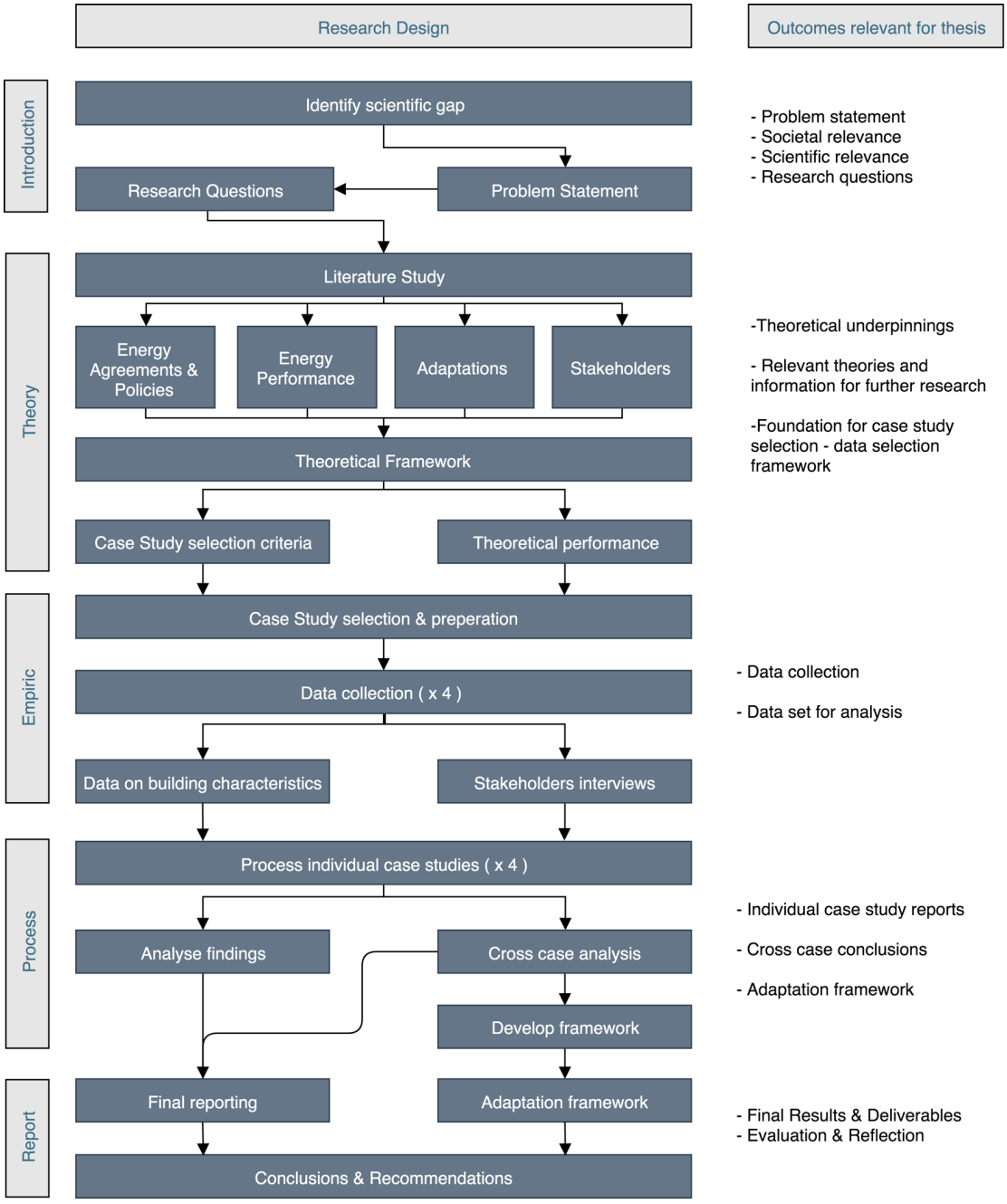

Figure 3.1. Research Design

Based on figure 3.1, a distinction can be made into four phases of the graduation research. The phases are as follows.
Phase 1: Literature Study
Phase 2: Qualitative research
Phase 3: Processing, analysing and comparing
Phase 4: Reporting & Synthesis

Phase 1: Literature Study

The first phase of this research is to conduct a literature study. To aim of the literature study is to collect relevant background information and more in-depth knowledge on the research topics. Also, it provides the underpinnings for several sub-research questions and forms the foundation to the semi-structured interview protocol.
In order to obtain a broad overview of relevant studies for this research, literature will be consulted mainly through digital platforms such as Scopus and Google Scholar. The search for relevant articles was conducted by using keywords that are linked to academic literature. Keywords that have been used are: climate agreements, sustainability, energy performance real estate, energy labels, energy performance gap, adaptive reuse, adaptations, behavioural adaptations, occupier's behaviour, structural adaptations, stakeholders real estate, barriers sustainability, drivers sustainability.
Based on the literature search on keywords many articles were found. The next step was to extract the essence of these articles to determine whether it would be of interest to acquire more insight into the study. The selection for this was conducted through abstract scanning which enabled to map relevant studies to this research.
While acquiring more insight knowledge on the topics related to this research, a distinction was made into four themes so that the found literature could be categorised. The four themes for this research and their sources to form the theoretical underpinnings are stated in table 3.2.

Table 3.2. Division of the literature themes and related articles

Energy Agreements & Policies	Energy Performance	Adaptations	Stakeholders
Duijvestein (1996) Pérez-Lombard (2009) United Nations (2015) Rogelj et al. (2016) Šjan (2016) EIB (2016) Chegut et al. (2014) Bouwbesluit (2018). Wilkinson et al. (2014) Sipma et al. (2017)	DGBC (2014) Majcen, et al. (2013) Itards (2008) GPR (2018) RVO (2018) Sipma et al. (2017) JLL (2012) Rijksoverheid (2017) Díaz, et al. (2013) RVO (2017) Energie sprong (2016)	Janda (2011) Bullen (2007) Remøy, et al. (2014) Baum (2017) Bullen et al. (2011) Taylor (2013) Valks et al.(2016) Energie sprong (2016) Brands (1994) Yu, et al. (2011) Fink (2011) Pacala, et al. (2004) Iacovidou, et al. (2016)	Gillingham, et al. (2009) Cadman (2007) Van der Heijden, (2015) Chegut et al. (2014) Bullen (2007). Wilkinson et al. (2014) Warren, (2010) Edwards, et al. (2009) Warren-Myers (2012) Klapwijk, et al. (2017) Eichholtz et al. (2016)

3.2 Population of Study

The literature study provides the underpinning for the population of the study. As mentioned in the sub-section 'Energy Performance', the focus of this research will be on label A, B office buildings. Since the EPC energy labelling only takes primary energy consumption into account, electricity consumption is not providing a useful framework to base the population of study upon. This is because every label class is underperforming due to the electricity that is required to perform business activities, see table 3.3. By that, there is no further detailed information available on what share can be accounted for primary electricity consumption in the research of Sipma et al. (2017).

Fortunately, the gas consumption in the Sipma et al. (2017) research provides a better framework to conduct further research. Natural gas consumption can only be caused by the demand for heating and a relatively small percentage might be consumed for cooking purposes. According to Wilkinson & Reed (2006), only about 4% of the natural gas consumption is due to cooking in the commercial real estate sector.
The EPC-labelling system only considers the primary energy consumption when an office building is assessed. Therefore, in table 3.4, the energy performance gap for office buildings becomes evident related to the consumption of natural gas. On the right-hand side, the number of studied objects for this research are stated. The objects have been selected randomly and the research was carried out by a governmental institution. Given the research circumstances and the relatively high number of studied objects, one could assume that the results of this research are representative for the Dutch office stock.

Table 3.3. Average electricity performance per label class of Dutch office buildings, based on Sipma et al., 2017

Energy Performance				
Electricity	Predicted Consumption	Actual Consumption	Performance Gap	N total 1073
	kWh/m2	kWh/m2		
Label A	39,3	84,4	114,7%	150
Label B	42,2	75,7	79,4%	88
Label C	45,9	77,5	68,8%	159
Label D	45,3	79,4	75,3%	162
Label E	50,2	73,2	45,8%	150
Label F	50,9	72,9	43,2%	106
Label G low	51,9	73,1	40,9%	133
Label G high	48,1	65,2	35,6%	125

Table 3.4. Average natural gas performance per label class of Dutch office buildings, based on Sipma et al., 2017

Energy Performance						
Gas	Predicted Consumption		Actual Consumption		Performance Gap	N total 1073
	m3/m2	kWh/m2	m3/m2	kWh/m2		
Label A	6,7	65,5	8,62	84,2	28,7%	150
Label B	9,1	88,9	10,77	105,2	18,4%	88
Label C	11,2	109,4	11,44	111,8	2,1%	159
Label D	13,2	129,0	11,94	116,6	-9,5%	162
Label E	16	156,3	12,06	117,8	-24,6%	150
Label F	18,6	181,7	12,03	117,5	-35,3%	106
Label G low	23,3	227,6	13,54	132,3	-41,9%	133
Label G high	33,7	329,2	16,1	157,3	-52,2%	125

As stated in table 3.4, the discrepancy of label C buildings is about 2% on average. The study of Sipma et al. (2017) is not stating whether the researched buildings use natural gas for cooking were excluded from the research. As an average commercial building would consume approximately 4% of the natural gas for cooking purposes, the label C group might not be underperforming on average (Wilkinson et al., 2006). Since the energy performance gap is significantly larger for label A and B building, this entire research will focus on label A and B office buildings see table 3.5.

Table 3.5. Decision-making on the population of the study

	Underperforming Gas	**Underperforming Electricity**	**Suitable for Case study**
Label A	Yes	Yes (?)	Yes
Label B	Yes	Yes (?)	Yes
Label C	No	Yes (?)	No
Label D	No	Yes (?)	No
Label E	No	Yes (?)	No
Label F	No	Yes (?)	No
Label G low	No	Yes (?)	No
Label G high	No	Yes (?)	No

The EPC labelling system works with a certain bandwidth per energy label class. This means that two building with a slightly different energy consumption per year can still fit within the same energy label. However, the current national labelling system is assessing the property on its design performance and not on its actual performance. As announced by the Dutch national government, the way of assessing building will be adopted to the so-called EPG, *energie prestatie gebouwen.* Even though the introduction of this EPG assessment has been postponed recently, the major adjustment of assessing sustainability would be that it also takes the actual energy consumption into account. As shown in table 3.4, label A buildings have average overconsumption of approximately

28% with 8,62 m3/m2 per year. Which is almost the average predicted consumption for label B buildings. This hints that there are label A buildings that are actually performing as B or C buildings which were also addressed by the report of JLL (2012).

Due to the legislation for buildings to obtain a label C by 2023 and label A by 2030, this research will focus on cases that would possibly face legal obsolescence when the EPG assessment method would be enforced. This means that a division is made for potential cases that would not be complying in the first stage, 2023, and in the second stage, 2030. In other words, non-complying in the first stage entails performing worse than label C prescribes, and non-complying in the second stage entails performing worse than label A prescribes.
The sample approach is *critical case sampling* due to the fact that certain cases are selected that are representative of the phenomenon of underperforming office buildings in the Netherlands (Bryman, 2016). A building will be suitable when it either holds an A or B energy label and an energy performance gap is presently based on gas consumption which would lead to legal obsolescence in either the first (worse than C) or the second stage (worse than A). An overview can be found in table 3.6 of the four potential cases. Based on the level of underperforming for each case of the four cases, a building will be selected.

Table 3.6. The four case studies to be conducted

1st stage non-compliance	1st stage non-compliance	2nd stage non-compliance	2nd stage non-compliance
Case 1	**Case 2**	**Case 3**	**Case 4**
Label A building that is non-complying in the first stage based on current gas consumption	Label B building that is non-complying in the first stage based on current gas consumption	Label A building that is non-complying in the second stage based on current gas consumption	Label B building that is non-complying in the second stage based on current gas consumption

In order to map the potential cases, the actual performance needs to be compared with the theoretical EPC performance. The energy labels of offices are openly available. However, the data on energy consumption is often confidential and therefore difficult to obtain. An energy supplier would be a logical place to obtain energy consumption data. However, an energy supplier often lacks a professional relationship with all the main stakeholders that were identified. This would mean that arranging interviews with stakeholders might be too time consuming considering the scope of this research. Therefore, the requested data was collected through CBRE property management. CBRE is able to provide energy performance data and has an established relationship with the tenant and investor. Initially, the energy labels of all the office properties that are being managed by CBRE will need to be collected. After which the actual consumption will be collected over 2018. This is done by consulting different property and technical

managers or energy suppliers. Due to data availability, not the entire Dutch office stock was screened. However, the cases that were found, can be considered to be representative cases for this phenomenon since the selection took place along the case study selection criteria.

3.3 Case study selection criteria

Based on the theoretical framework of the conducted literature study and input from practice at CBRE, the selection criteria for the qualitative research were formulated. This provides a framework for considering and selecting potential case study objects. The *critical case sampling* method of will be used in order to map relevant case studies. For each of the criteria, a short elaboration will be given. The case studies will be selected along the following criteria.

- The office building contains an energy performance gap as explained in table 3.6 of the section population of the study.
  - *Since the upcoming change in the assessment method (EPG), the actual energy consumption becomes of relevance in relation to the energy label. The obligatory label C in 2023 and label A in 2030 will remain enforced. However, the labelling method will change which could lead to legal non-compliance in 2023 and 2030 when label A and B buildings are underperforming which is suggested by the research of Sipma et al. (2017).*

- Consume both natural gas and electricity.
  - *As the Sipma et al. (2017) research took a representative sample of the Dutch office stock, all researched objects consumed both natural gas and electricity. Their research concluded the presence of the energy performance gap related to gas consumption. Therefore, these criteria will be in place during this research. Apart from that, both energy sources are required to perform office-related business activities.*

- Located within the *Randstad* and preferably within the same city. So that costs/benefits are weighed under similar market conditions.
  - *As literature suggests costs and benefits have a major impact on the level of sustainability that is provided by a building owner. There is a relatively high demand for office space in and around the major four cities in the Netherlands, the Randstad (NVM Business, 2017). Therefore, the market conditions within the Randstad is comparable and provide more or less the same financial incentives for sustainability measures.*

- The property has a minimum LFA of 250m2 (Sipma et al,. 2017).
  - *As the obligatory energy label C is enforced for 2023, office spaces of less than 100m2 are exempted from this national legislation. However, the research of Sipma et al. (2017) that mapped the energy performance gaps in the Dutch office stock excluded properties smaller than 250m2. Therefore, also for this research 250m2 will be the threshold for analysing the building performance.*

- The possibility to interview the investor/asset manager, property manager and tenant/FM.
  - *For this research it is of relevance to map the different attitudes of the stakeholders of each building. Since the investor, property manager and tenant have a high interest in adaptations to the building, these three stakeholders will be interviewed to share their opinions on themes extracted from literature.*

- The property has to be rented out for the last year at least, preferably for a longer period.
  - *Since legislation focusses on the energy consumption per m2 per year, the energy consumption data should cover at least one year in order to obtain a realistic view into the actual performance. As vacancy minimises the demand for energy for both electricity and gas, the property has to be rented out for the last year.*

- It is a multi-tenant office building.
  - *The energy consumption data of the offices will be gathered through the property management department of CBRE. Since tenants of single-tenant properties will arrange their own energy supply, the actual energy performance is unknown for CBRE. However, this information is available of multi-tenant offices that are under the management of CBRE.*

- The property is not listed as a *Rijksmonument*, national monument.
  - *Since monumental buildings are exempted from the label A and C legislation these buildings are excluded for further research.*

- The entire property contains office space for at least 50% of the LFA.
  - *Since commercial real estate with less than 50% office space are exempted from the label A and C legislation these buildings are excluded for further research.*

Phase 2: Empirical research

The second part of conducting this research is mainly focused on executing qualitative research to find where the energy performance gap is caused by and what has possible influence on mitigation it. Since the buildings comply with a certain standard but are underperforming, data on energy consumption will be required to determine the actual performance gap per building. In order to have access to this information, four case studies will be selected based on the above-mentioned criteria.

Case Studies

For each case study, the same research elements will be conducted which consists of two main parts, collecting data on the user and building characteristics, and conducting interviews with the stakeholders. Collecting relevant information on the building and user characteristics will be completed upfront as much as possible so that the interviews can possibly be in-depth on certain relevant topics. If in any case relevant information is still missing, information could be added afterward. For every interview, a semi-structured interview proforma will be set up along the guidelines of Bryman (2016). So, empirical research can be divided into two main parts, collecting the building characteristics and conducting the semi-structured interviews. The collected information will be processed into an individual case study reports which is visualised in figure 3.2.

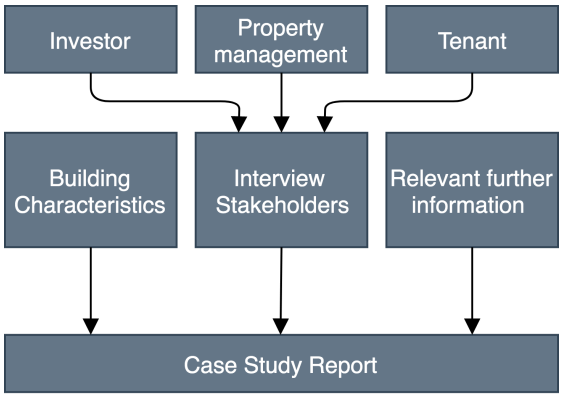

Figure 3.2. Explanation of different components for each case study report based on Steenkamp (2018)

Part 1. Collecting data on building characteristics

As mentioned Part 1 of executing this research is focussed on obtaining the several details and characteristics on the building. The gathered information can be of relevance during the interviewing and every interview might be adjusted to the details of this first part of the case study. The collection of information is divided into several themes that will be gathered for each conducted case. Per case study, the building will be analysed on several topics. The list of building characteristics is inspired by Yu, Fung, Haghighat, Yoshino, & Morofsky (2011) with and includes some additions that are relevant from a Dutch legislation perspective concerning the energy labels. The article by Yu et al. (2011) is chosen because of the aim of the research that entails the impact of behaviour on the energy consumption in real estate which is closely related to this research.

In order to obtain a better understanding of the case study property, five themes will be examined upfront. The first theme is on general information such as size and location.

The second theme is on the involved stakeholders. Thereafter, the energy performances and costs will be mapped concerning the property. The fourth theme is on how the building is being used by the tenant, what kind of activities take place and the use of space. It might be that this information is not available upfront, then it will be collected by interviewing the tenant or its representative. The last theme is on the planned and completed adaptations to the building that are of relevance for the energy performance. A complete list on the building characteristics that will be collected per case study can be found in Appendix A.
Initially, the information will be collected through the property and technical managers working at CBRE. If certain topics remain unknown possible third parties that work for CBRE will be consulted to share their information in order to fill the gaps. Apart from that, prior to the interviews, further questions can be asked on the building characteristics to complete the first part of the case study as far as possible.

Part 2: Conducting interviews with Stakeholders

The second part of the case study entails the interviewing of stakeholders. As mentioned in earlier paragraphs the three main stakeholders that have a large influence on the level of sustainability are investor/asset manager, property manager and tenant/facility manager. These three stakeholders will be interviewed per case by the use of semi-structured interviews. The owners/asset manager is commonly concerned about the return on their investment and will be more focussed on the financial aspect such as the value of the building and cost for sustainable investments. While at the same time, tenants might focus on very different aspects such as a healthy working environment and their corporate sustainability objectives or image. Property managers are situated in the middle as they have contact with both the owner and tenant. Property managers often know most of the details on the buildings and will probably also have their own visions on the steps towards sustainability. Therefore, these three key stakeholders will be interviewed per case study building.

The interviews will be conducted based on the semi-structured interview proforma that will provide guidance during the interviews and might be adjusted based on the findings in part 1, the building characteristics. The aim of interviewing is obtaining more insight into the different perspectives and attitudes of each stakeholder regarding the energy performance gap. From the theoretical underpinnings, topics for the interviews were distilled that are of relevance. It might be that not every topic is of high interest to a stakeholder. In the theoretical framework, table 2.5, for every topic is indicated whether it might be of relevance or not to a certain stakeholder. The key topics that will be discussed during the interviews are: Insight into energy performance, structural adaptations, behavioural adaptations, drivers and barriers for adaptations towards more sustainability, the stakeholders view on the current and future situation, and the preferred adaptions. A more detailed description of these topics can be found in the table 2.5 in the chapter 2 theoretical underpinnings.
Based on the topics derived from literature the interview proforma was formulated which is the backbone during the interviews with the different stakeholders. Since the proforma is semi-structured, per interview there will be room to add extra questions based on the

input that is given from the stakeholder. Also, the interview questions will be slightly adjusted based on the stakeholder for it to make sense. A more detailed structure of the interview proforma can be found in Appendix B. Besides, the summary of the interviews can be found in a separate digital file which can be found in on repository website of Delft University of Technology (https://repository.tudelft.nl/).

Part 3. Collecting of follow-up data

It might occur that during the interview some topics could not be answered by the interviewee or that other relevant information might be of use for this research. In that case, the interviewee can still submit the information, documents or answers which will still be processed in the individual case study report. Also, there is a possibility that certain topics were overlooked even though they are of important relevance to this research. If so, the participating stakeholders might be consulted after the interviews took place.

Phase 3: Processing, analysing and comparing

Per case, each of the above-mentioned points will be processed into a case report. Since this research collects a lot of qualitative data by conducting 12 interviews, it is of importance to structure the processing and analysing of the input from the interviews. Therefore, the interviews will be analysed based on the recursive abstracting guidelines of the Bournemouth Briefing Paper by Polkinghorne & Arnold (2014). These guidelines provide manner to abstract the essence of answers given by the interviewee. Also, an indication of the interest to the topic is given based on the answers. This all combined will conclude the conduction of one case study.

After collecting processing all the necessary data per case the findings will be analysed and compared among the other cases. From this cross-case comparison, conclusions can be drawn on how the energy performance gap might be tackled or how to move forward. In figure 3.3 the different stages of conducting this case study research is visualised.

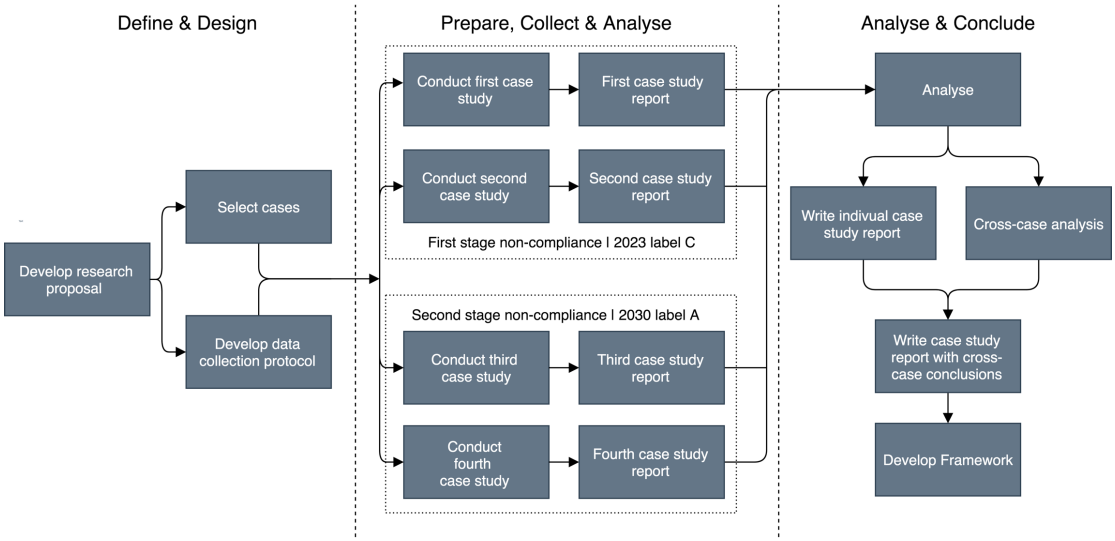

Figure 3.3. Visualisation on the methodology for conducting case studies, based on Yin (2017)

Phase 4: Reporting & Synthesis

After collecting all the required data from the individual case studies a cross-case analysis will be conducted. This is done by abstracting the most essential findings per case and compare these with each other. From this comparison, conclusions can be drawn that give an answer to the main and sub-research questions. In the chapter 5, the cross-case analysis will be elaborated upon and also the discussion on the findings will be addressed. In the chapter 6, the general conclusions and recommendations of this research will be given.

Apart from answering the research question this research aims to develop a framework. This framework provides an overview by considering the three perspectives of investor/asset manager, property manager and tenant. Their actual attitude towards certain topics abstracted from literature will be elaborated upon and also their preferred adaptations either behavioural or structural will addressed. Since the investor will most often have the final call in the decision-making process this framework might be of most value to them. However, also for policy-makers this framework might be of interest when developing national policies or tools to foster sustainability since it provides an overview of the preference of the other stakeholders and mentions possible existing barriers.

4 | Empirical Research

4 | Empirical Research

The literature study provides the theoretical foundation for conducting this research. The second part is to go into the field and actually conduct the proposed study by collecting data. This chapter is on the empirical part that consists of several case study interviews and the collection of other relevant information to the topics. First, the case study selection will provide insight into the selection procedure. Then, the general case study protocol will elaborate on the requested data per case study. Thereafter, the actual case studies will be elaborated upon extensively. For each case study, an individual case study report will be drawn up which is the synthesis of the input provided by the interviewees. All individual reports conclude with the main findings of that case.

4.1 Case study selection

In order to find suitable case studies, insight into energy performance and the energy labelling is required. Therefore, data was made available by a large property management firm in the Netherlands. The starting point was a database with Dutch offices that is under their management and consisted of 246 properties. Along with the guidelines of the case study selection criteria, this list was filtered. The first step was to set up the right region in the Netherlands, the Randstad. This led to the exclusion of 100 properties, so 146 properties were left. The second step was to filter on the type or function of the property. From the selection criteria, the building should at least contain 50% office space. This criterion led to the diminution of the list that now consisted of 121 properties. Since single tenant office arranges their own energy supply, single tenant properties were then excluded resulting in a list of 71. The fourth step was selecting the properties that consume both electricity and gas. Due to the fact that in the *Randstad* city heating is often used and this research focusses on the *Randstad*, the list was shortened to only 30 properties. Of this list, 8 properties were exempted due to their monumental status. The last step was filtering on the energy label. This research focusses on label A, a B building. Eventually, this led to the shortlist of 11 properties that are managed by CBRE that fit the selection criteria apart from their energy consumption which still has to collect over the same period of this. The process of narrowing down to the shortlist of only 11 properties is visualised in figure 4.1.

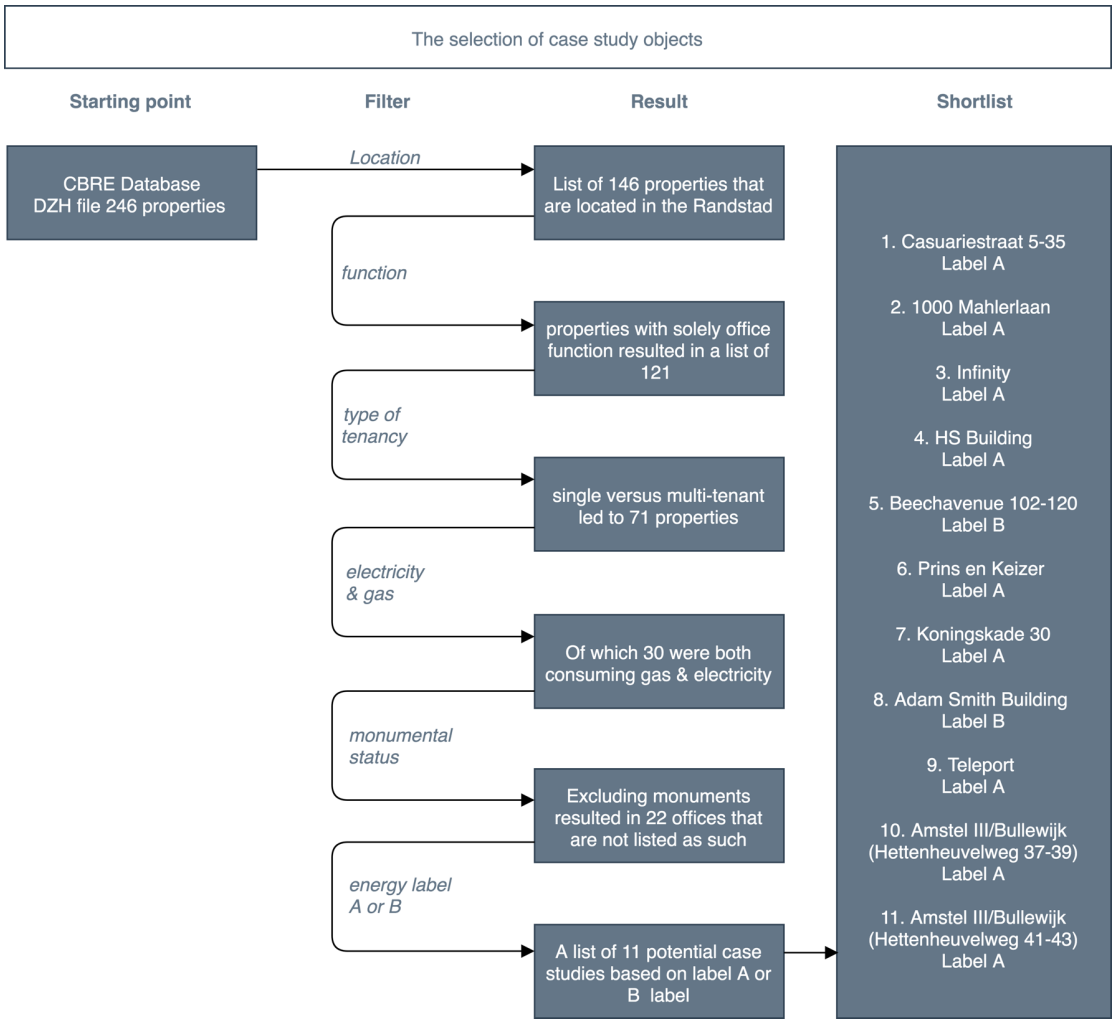

Figure 4.1. The selection steps according to the selection criteria to come to the shortlist for the last selection step

From the shortlist, there was one last step to take to find actual case study properties for this research. The last step entailed collecting the energy performance data, especially on natural gas consumption. The collection of the actual energy performance data was gathered through technical property managers or delivered by energy supplier on demand. Some of the data was found to be incomplete or was not overlapping the requested period of time. Also, the shortlist of the 11 properties included some inaccuracies. Eventually, the collection of the available data led to four case study properties that met the classifications as described in the methodology chapter. An overview of the properties and their actual natural gas consumption in relation to their energy label is given in table 4.1. The table also explains to the reason for not including some properties for further research.

#	Property name	Street	Year of construction	m2	Energy label	Performance gap gas consumption (m3) m2/year	Suitable for case study Yes/No	Remark	Classification	Case
1	**Casuariestraat**	Casuariestraat 5-35	1972	3500	**A**	**2,6**	**YES**	suitable for case study	**A performing as B**	**Case 3**
2	**1000 Mahlerlaan**	Gustav Mahlerlaan 1001-1041	2015	8350	**A**	**n.a.**	**NO**	city heating, not suitable	n.a.	
3	**Infinity**	Amstelveenseweg 500	2002	18240	**A**	**6,5**	**YES**	suitable for case study	**A performing as D**	**Case 1**
4	**HS Building**	Johanna Westerdijkplein 1	2003	21153	**A**	**n.a.**	**NO**	city heating, not suitable	n.a.	
5	**Beechavenue**	Beechavenue 102-120	1999	2500	**B**	**3,6**	**YES**	suitable for case study	**B performing as C**	**Case 4**
6	**Prins en Keizer**	Vijzelstraat 66-80	1973	23000	**A**	**n.a.**	**NO**	new HVAC-system, not suitable	n.a.	
7	**Koningskade 30**	Koningskade 30	1992	5300	**A**	**n.a.**	**NO**	single tenant, no insight	n.a.	
8	**Adam Smith Building**	Thomas R. Malthusstraat 1-3	2001	20784	**B**	**5,8**	**YES**	suitable for case study	**B performing as D**	**Case 2**
9	**Teleport**	Donauweg 2b	2001	4600	**A**	**0,0**	**NO**	in line with label	n.a.	
10	**Amstel III/Bullewijk**	Hettenheuvelweg 37-39	1988	2463	**A**	**-0,7**	**NO**	in line with label	n.a.	
11	**Amstel III/Bullewijk**	Hettenheuvelweg 41-43	1988	2500	**A**	**-0,8**	**NO**	in line with label	n.a.	

Table 4.1. Final selection step on actual versus theoretical natural gas consumption

Table 4.1 on the previous page provides an overview of the last step in the selection of the case study properties. In the methodology chapter, four classifications were mentioned that would be suitable for conducting this research.

For the first stage non-compliance two building were selected, the Infinity Offices building and the Adam Smith Building. The Inifinity holds an energy label A while it performs a an energy label D. The Adam Smith Building also performs as an energy label D building but holds an energy label B. For the second stage non-compliance the Casuariestraat met the criteria for case 3, an energy label A building that performs as B. While the Beechavenue is suitable for case 4, an energy B label building that performs as C. This means that the four cases can be researched of which an overview can be found in table 4.2 below.

Table 4.2 The selection of case study properties matched with their classification

Case 1	Case 2	Case 3	Case 4
Infinity	Adam Smith Building	Casuariestraat	Beechavenue
			
Label A building that is non-complying in the first stage based on current gas consumption	Label B building that is non-complying in the first stage based on current gas consumption	Label A building that is non-complying in the second stage based on current gas consumption	Label B building that is non-complying in the second stage based on current gas consumption

4.2 Case Study Protocol

The case study protocol consists of two main parts, the collection of building characteristics and the conduction of interviews with the stakeholders of each case. For every case, the same protocol will be used to make comparisons between the cases. Each study report consists of the following subparagraphs

- Project analysis – an introduction to the case and the stakeholders
- Building characteristics – list of relevant data concerning the energy performance
- Interview with stakeholders – Topics discussed with different stakeholders
- Main finding – The most important findings in an overview

Step 1. Project information

General project information will be collected on the building and the involved stakeholders. The following point will be elaborated upon:

- Introduction to the case and its location
- Image of the case
- Introduction of investor
- Introduction of the property manager
- Introduction of tenant
- Stakeholders diagram

Step 2. Building characteristics

A list was created to gather the relevant information of the property before conducting the interviews with the stakeholders. A more detailed version of the list of building characteristics that will be collected can be found in table 2.7. Due to limited accessibility of the data on service costs over 2018 this line remains uncompleted. The list contains the following topics:

- General information
- Stakeholders
- Energy & Costs
- Use
- Adaptations

Step 3. Interview with stakeholders

For this step, a semi-structured interview protocol has been created. This interview protocol includes several topics extracted from the literature. The exact questions in the interview protocol can be found in figure 2.8. For this research, the three main stakeholders have been interviewed. The synthesis of the answers per topics will be given. The topics that will be discussed during the interviews are as follows:

- Insight into energy performance
- Structural adaptations
- Behavioural adaptations
- Drivers for adaptations towards sustainability
- Barriers for adaptations towards sustainability
- Stakeholders view on the current situation and future situation
- Preferred adaptations

Step 4. Main Findings

The main findings of the previous steps will be given in an overview. The most interesting facts from each of the steps will be gathered and summed up. By creating an overview per step, comparing the four case studies will be possible in an accurate way. This will conclude the individual case study reports.

Case 1
Infinity

Source: https://casperschwarz.com/portfolio-item/infinity-amsterdam/

4.3 Case 1 | Infinity

1. Project information

This first case study is conducted on the Infinity office building in Amsterdam. This rather iconic office building is better known by its nickname, *de schoen,* the shoe and is located along the A10 highway. Initially, this building has been built as the new headquarters for the Dutch ING Bank. However, due to the economic crisis, they decided to move out of this relatively expensive office building. This office building marks the end of the Zuidas, the financial business district of Amsterdam. Besides its shape, this building has a rather remarkable double glass façade which should enhance its energy efficiency. The building is very well accessible by car and public transport due to its location. Underneath the building, a parking lot is available for tenants and visitors. The construction has been completed in 2002 and was one of the most sustainable buildings at that time. Due to this high level of sustainability, it currently holds an energy label A while the actual performance is in line with an energy label D building. This would mean that when an EPG would be introduced it would possibly face legal non-compliance in the first stage.

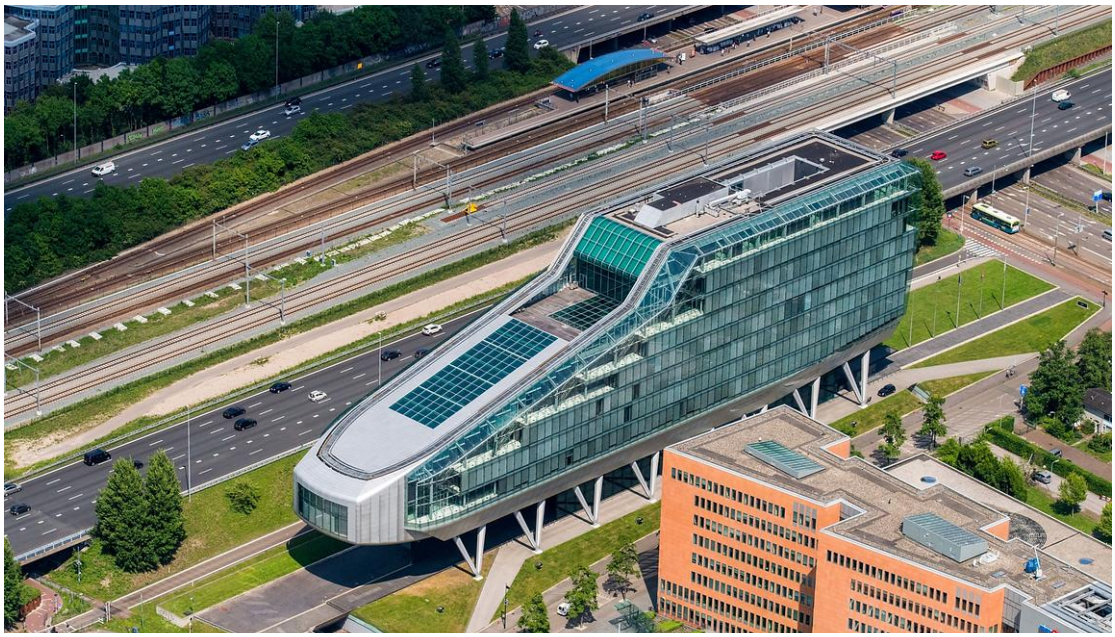

Figure 4.2. Aerial image of the Infinity office building
Source: http://www.hollandluchtfoto.nl/media/2dd4cebb-5055-45f9-a456-171cc9f6b177-amsterdam-luchtfoto-ing-house

Stakeholders

Investor - NN/CBRE Global Investors

The owner of this office building is NN investment, formally known as Nationale Nederlanden. This insurance company is part of the ING holding and collaborates with CBRE Global Investors in executing the investment management of this asset. This Infinity office building is part of a prominent Dutch office fund that strives for high levels of sustainability in their offices. The Interviewee (1) that has been consulted for this research

is the Technical Director Projects at CBRE Global Investors and is responsible for the technical asset management of this property. CBRE Global Investor is active in over 20 countries and is one of the three parties of the CBRE Holding. Interviewee 1 has been involved in this building for the last 3 years.

Property manager – CBRE Advisory & GWS

CBRE is the largest real estate related firm and acts on a global level. CBRE provides a wide range of services from investment management, development services, property management, strategic consulting to workplace solutions. In the Netherlands, CBRE is divided into three entities, CBRE Global Investors, CBRE Advisory and CBRE Global Workplace Solutions. Since this building is rather complex and demanding in its maintenance, one employee has been allocated on a full-time basis from Global Workplace Solutions. The Facility Coordinator has been consulted for this case study research who has been involved in this the management of this building from the moment of completion in 2002.

Tenant - IMC Trading

One of the tenants of this multi-tenant office building is IMC Trading which stands for International Marketmaker's Combination. This Dutch company was founded in 1989 and active in the business of trading stocks which is done primarily on the basis of data and algorithms. IMC Trading is one of the major tenants in this building and occupies approximately 5.000m2 of the total 18.240m2. There are about 250 workplaces available for the 210 employees it currently has. The interviewee (3) who has been consulted for this research is the Head of Facilities at IMC Trading and has been involved for over 11 years now. IMC trading moved into this property about two years ago.

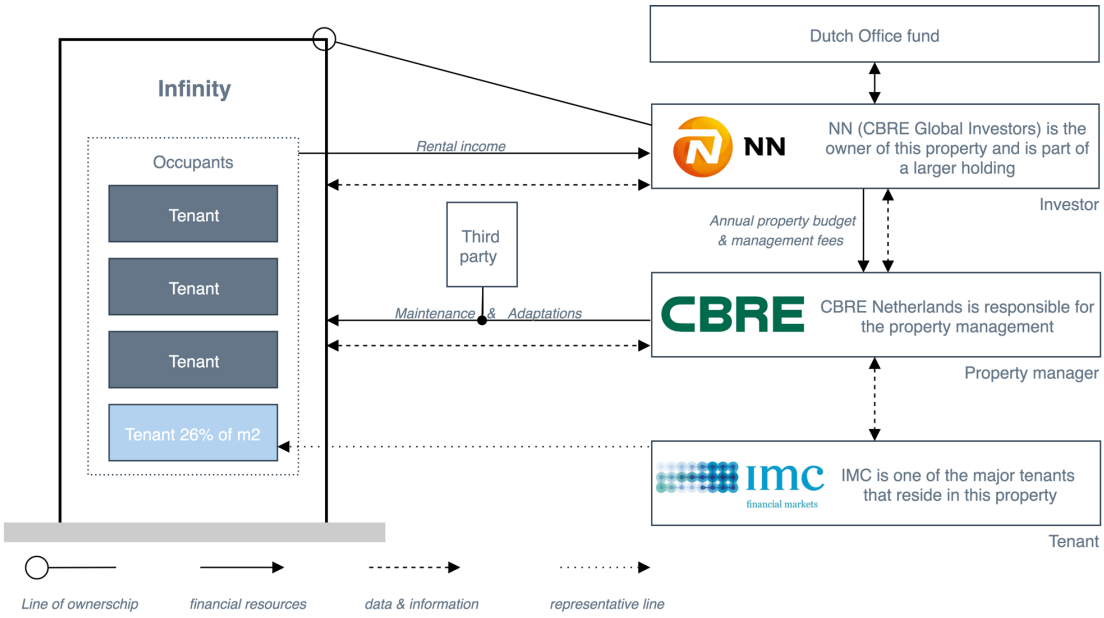

Figure 4.3. Stakeholders diagram Infinity

2. Building Characteristics – Infinity

Case Study number	**1**	
Period	**2018**	
Data Source	**CBRE B.V.**	
Classification	**A performs as D**	

Theme	no.	Topic	Answer
General	**1**	Property name	Infinity
		Address	Amstelveenseweg 500
		City	Amsterdam
		Total m2 of property	18240
		Year of construction	2002
		Rental price per m2 per year	€ 350,00
		Image	
Stakeholders	**2**	Tenant	IMC Trading
		Property Manager	CBRE B.V.
		Investor	NN (CBRE Global Investors)
Energy & Costs	**3**	Annual electricity consumption (kWh)	3042469
		Annual electricity consumption per m2 (kWh)	166,8
		Annual natural gas consumption (m3)	240319
		Annual natural gas consumption per m2 (m3)	13,2
		Total kWh per m2 per year	166,8
		Current EPC label	A
		Label valid till	2023
		Theoretical electricity consumption/m2/year (kWh)	39,3
		Theoretical gas consumption/m2/year (m3)	6,7
		Performance gap of electricity (%)	324,4%
		Absolute performance gap gas/year (m3)	118.111
		Absolute performance gap gas/m2/year (m3)	6,5
		Performance gap of natural gas (%)	96,65%
		EPC label based on actual gas consumption	D
		Service costs per m2 per year	unknown
		Costs electricity/year	€ 343.715,00
		Costs gas/year	€ 143.998,00
		Cost of gas performance gap/year	€ 70.771,55
		Costs of gas performance gap/m2/year	€ 3,88
		Total energy costs per m2 per year	€ 26,74
		% energy costs related to performance gap	14,51%
		% energy performance gap costs of rental price	1,11%
Use	**4**	Tenant's business activities	Financial services, trading, computer based working
		m2 in use by tenant	5000
		Average office opening hours a week	70
		Number of workplaces	250
		Number of employees	210
		m2 per employee	23,8
		Occupancy rate	unknown
		Type of HVAC	Through air and ceiling elements
		Business activities other tenants	Law firm, consultancy
Adaptations	**5**	Recent energy saving measures t	No recent energy saving measures
		Planned interventions	Replacing the thermal energy storage system and implementing a new building management system

Figure 4.4. The building characteristics of Infinity

3. Interviews with stakeholders

The interviewees for this case study are as follows:

Interview number	Function	Company
Interviewee 1	Technical Director Projects	CBRE GI
Interviewee 2	Facility Coordinator	CBRE GWS
Interviewee 3	Head of Facilities	IMC Trading

Insight into energy performance **I: ++ P: + T: +**

Insight into the energy performance is provided by a third party namely, Veolia. They share the energy consumption data every half year with the facility coordinator. Currently, the tenants do not demand further insight into the energy performance of this building according to interviewee 2 (2019). The tenant has a back-up powering system in order to continue business activities in case of a power blackout. The head of facilities has insight on the energy performance of everything that is connected to this back-up system. However, the back-up generation of energy is only connected to the components of their systems that are most vital. According to interviewee 3, further insights on the energy consumption per floor would favourable since heating demand is now settled as based on the tenant's floors space ratio. If the tenant is performing relatively well, this information could be used during negotiations (Interviewee 3, 2019). However, the Head of Facilities indicated that more insight would not be necessary at this moment since it not possible to steer on the consumption of the general installations. The investor is currently working on replacing the building management system due to its outdatedness. The new system will provide real-time monitoring on the energy performance which is made possible telemetric readers and sensors. The life-cycle replacement will be used to add more data collection points so that insight in a floor or tenant level can be obtained. In addition, this real-time monitoring is also demanded by the investing fund (Interviewee 1, 2019).

Structural adaptations **I: + P: +/- T: ++**

The different stakeholders mention that structural adaptations would could foster sustainability. However, all stakeholders mention that the building envelope with its double facade is already very energy efficient compared to traditional facades (Interviewees 1, 2 & 3, 2019). The potential of the double façade could be used in a more efficient way by collecting heath that is captured during cold days (Interviewee 2, 2019). While the tenant suggest that this double façade results in a higher cooling demand due to the malfunctioning of airshaft in summer (Interviewee 3, 2019). The label A status of this building is partly a result of the thermal energy storage system. However, for the last two years this system is not functioning as expected due to relatively high levels of salt water that causes erosion. Currently, this thermal energy storage cannot be used to its full potential which results in significant increase in natural gas consumption due to the heating demand. Therefore, all tenants suggest that getting this system up and running again would be the main challenge and best improvement from a structural point of view (Interviewee 1, 2 & 3, 2019). In addition, the implementation of the new building management system is also on the top of the agenda for the investor. The property manager mentioned that proposed structural adaptations are often granted by the

investor but in not suggesting major adaptations. When structural adaptations are being implemented, comfort and aesthetics are of high relevance for the tenant. When lighting was being replaced by the investor, the tenant found the proposed fixtures poorly from an aesthetical point of view. In collaboration with the investor they agreed to implement other fixtures that would meet the criteria of both stakeholders. Besides, high efficiency cooling was added to the ceilings. The extra costs for these interventions were partly borne by the tenant themselves (Interviewee 3, 2019).

Behavioural adaptations I: ++ P: +/- T: +/-

The tenant is not actively stimulating changes in behaviour since there is not the believe that this would result in major energy savings (Interviewee 3, 2019). According to the tenant, it would make more sense to seriously invest in a higher level of energy efficiency of devices such as computer screens. However, the devices need to be easily operational in order to prevent unnecessary energy consumption and stimulate proper use (Interviewee 3, 2019). The property manager mentioned that the tenant should be the party to initiate behavioural adaptations such as the adjustment of the office hours. Nowadays, the office is 24/7 accessible if needed. However, climate systems have been set up to only operate between 8 and 22 hours during working days as long as this is required by the presence of the tenant (Interviewee 2, 2019). The investor states that it is difficult to accomplish behavioural change of the tenant but believes that proper monitoring is essential for helping a tenant to perform more efficiently. Therefore, a highly specific building management system would be very helpful. Such a system could collect data on the tenant's presence, heating/cooling demand, space usage and level of lightning. This data could be assessed by algorithms to finetune the systems and optimise the tenant's behaviour in the end. According to the investor savings due to finetuning could be above 20%. The aim is to facilitate our tenants with this kind of information so that to enable them to steer upon space usage and behavioural adaptations (Interviewee 1, 2019). In addition, the investor is looking into providing benchmarking per tenant on their performance.

Drivers for adaptations towards sustainability I: ++ P: +/- T: ++

According to Interviewee 1 (2019), the investor and the fund behind it have a strong vision on sustainability. The aim of the fund is obtaining high scores on different sustainability assessing methods such as EPC, GRESB or BREEAM. In addition, their aim is to be pioneers in the Dutch office market. Therefore, the bar was raised to becoming completely carbon neutral by 2035 which is 15 years prior to the proposed national legislation (Interviewee 1, 2019). In order to reach this goal, only high-end building on premium locations will be acquired. Regarding this building, there are limited drivers for further adaptation towards more sustainability because this building is on paper relatively sustainable (Interviewee 2, 2019). Every adaptation should be financially feasible from the investor's perspective and therefore off-cycle adaptation are often not preferred. However, it remains possible to implement off-cycle adaptations on demand of the tenant by redirecting the part of the costs to the tenant. To counteract the split-incentive phenomenon, the service costs will be capped for a period of time so that the tenant is compensating the investor for the adaptations that have been made. After a certain

period of time when the investor is compensated, the tenant will also be enabled to benefit the lowered service costs (Interviewee 1, 2019). When there is good collaboration and relation between the tenant and owner it is possible to make extra steps according to the investor. Another important driver that was mentioned is the competitive advantage that can be obtained by delivering a relatively sustainable building. In addition, it also justifies higher rental premium and by that adds value to the property. In case of vacancy, possibilities arise to implement structural adaptation relatively efficient. However, for this building, the proposed EPG is not a driver in taking extra steps according to interviewee 1 (2019).

This tenant's main driver for adaptations is reducing their energy consumption as it is part of their CSR vision on the basis of principal of best effort. The interviewee (3) referred to it as, *if you are able to implement it, you should do it*. The costs were mentioned to be subordinate for adaptations due to their 10-year rental agreement. The most important factors to consider are the energy saving potential, the aesthetics and the improvements in comfort. In order to make adaptations justifiable, there should be clear benchmarking to monitor the actual reduction in energy consumption (Interviewee 3, 2019).

Barriers for adaptations towards sustainability **I: + P: +/- T: +**

The main barrier according to these three stakeholders is the division of the financial burden related to implementing sustainability measures. From a legislation point of view, there are no further demands due to the current national policies since this building is fully compliant. The lack of further guidelines or requirements by the government seems to withhold for further adaptations (Interviewee 2, 2019). In order to be able to implement off-cycle adaptations the tenant and investor will have to find consensus in the division of costs. This might be challenging and can be considered to be an important barrier (Interviewee 1, 2019). Implementing the logical adaptations for more sustainability have relatively favourable costs to benefit ratio. Therefore, the first step towards more sustainability is often relatively rewarding. However, the last stages in becoming energy neutral will demand rather large investments and would result in relatively little energy savings. So, finding the balance between these interests can be challenging (Interviewee 1, 2019).

The moment before moving into an office space is considered to be the favourable time to implement major adaptions. Once the tenant resides in the property, the costs will become too high compared to the energy and costs savings. In addition, the tenant might experience nuisance due to construction works (Interviewee 3, 2019). According to the tenant, it is of importance to guard the usability and user-friendliness of the systems that will be implemented. It might be that operating systems become too complicated to be used to its full potential.

Stakeholders view on current and future situation **I: ++ P: + T: +**

As mentioned, this investor has the aim to become carbon neutral by 2035 on a portfolio level. Whether 2035 is achievable depends on the development of technologies and innovations. In order to reach their own objectives structural and behavioural adaptations should be implemented and also be supported by the tenants. Therefore, it is of significant importance to align the tenant's and investor's interest. In order to stimulate

awareness, commitment and behavioural change of the tenant, accurate monitoring is important and should be provided by the investor, according to Interviewee 1 (2019). According to the investor, building owners should be more proactive in fostering sustainability and not wait for legislation to suddenly demands certain adaptations. Eventually, the government will aim for an energy neutral built environment which would take time and financial means to be realised. Therefore, investors should be incentivised, either by lowering prices of required installations or by subsidies. In addition, the current proposed EPG could not be considered to be fair for a well-willing investor in relation to a negligent tenant. Therefore, tenants should be forced by legislation to also actively contribute to lower energy consumptions (Interviewee 1, 2019). This building complies with the current energy labelling legislation. Therefore, the property manager is not proposing any further adaptations except for the replacement of the thermal energy storage system (Interviewee 2, 2019). According to the tenant, in general, investors are narrowly focused on the energy label due to higher selling prices. However, short-term adaptations are still of interest to all parties. The *Lijst erkende maatregelen,* will be of relevance for the coming regarding further adaptions in commercial real estate. Due to the relatively high standards of these buildings most of the remaining measures can be implemented soon. The tenant indicates that all measures that have a payback time of about 3 years should be obligatory to be implemented again (Interviewee 3, 2019)

Preferred adaptations I: + P: + T: ++

All stakeholder mention that the preferred adaptation would the repairing of the thermal energy storage system. Due to the malfunctioning of this system, the gas consumption has increased significantly (Interview 1, 2 & 3, 2019). Currently, the replacement is on the top of the agenda and it will be likely that new wells will be dug deeper to prevent the malfunction to happen again (Interviewee 1, 2019). In addition, the investor favours the adaptation of the building management system. Once installed, the benchmarking and monitoring could be realised as a conversation starter on behavioural adaptations. The tenant suggests that the building already obtained high efficiency characteristics and therefore no specific action is required. The big-win would be to keep all the installations working efficiently again which would also have a positive impact on lowering the service costs (Interviewee 3, 2019).

4. Main findings

The most important findings of this case study are as follows:

1. Project information

- This building is located along the highway A10 in Amsterdam where the market is relatively tight at the moment. The building marks the end of the financial business district of the Zuidas, a premium office location with high rental prices.
- The tenant resides in this property for about two years and occupies 5.000m2 of the total 18.240 m2. A Facility Coordinator manages this building on a full-time basis and has been involved since its completion. The building is part of one of the most sustainable office funds in the Netherlands.

2. Building characteristics

- This property holds an energy label A while it performs as D.
- The natural gas performance gap is 96,65%.
- The costs related to the performance gap results in a surcharge of approximately €3,88 per m2/year. That is 14,5% of the total energy costs and 1,11% compared to the rental price per m2.

3. Interview with stakeholders

Insight into energy performance I: ++ P: + T: +

- Insight is obtained through service costs and provide every 6 months.
- Tenant has insight into own back-up system, would like to have more insight.
- Extra data point will be added which makes real time monitoring possible, this is a demand from the fund.

Structural adaptations I: + P: +/- T: ++

- Structural adaptations to the façade would have little impact. The thermal energy storage system is malfunction which significantly increases gas demand.
- Adding data points and repairing the thermal energy storage is the main focus for fostering more sustainability.
- Tenant is committed to reaching high levels of sustainability and is willing to (partly) invest in higher aesthetics or more efficient adaptations.

Behavioural adaptations I: ++ P: +/- T: +/-

- This tenant rather invests in energy efficient devices and equipment that to steer on behavioural adaptations
- The current office hours exceed the regular office hours which has an impact on energy consumption.
- Behavioural adaptations should be initiated by the tenant. However, the investors realise that they play a key role in providing detailed monitoring to make such adaptations well-founded.

Drivers for adaptations towards sustainability I: ++ P: +/- T: ++

- Investor: Vision of fund to become carbon neutral by 2035, competitive advantages, increase of value, increase in rental premiums, drive to be pioneering and to be most sustainable fund.
- Property manager: no real drivers because for further adaptations, maintaining the current installations or improve them
- Tenant: Reduction of energy consumption is based on CSR and principal of best effort. In addition, enhance the level of comfort or aesthetic value.

Barriers for adaptations towards sustainability I: + P: + T: +

- Investor: coming to a consensus on the division of the financial burden, further improvements require larger investments,
- Property manager: measures should be cost effective and should contribute to reaching legislative demands
- Tenant: when tenant already occupies space, nuisance, low cost effectiveness, creating a too complicated system that will not be used to its full potential.

Stakeholders view on current and future situation I: ++ P: + T: +

- The investor is not concerned about the proposed EPG and founds the tenants should also be forced by legislation to actively contribute towards sustainability. Aside, the government should provide an incentive to reach energy neutrality.
- Whether the investor reach their own 2035 goals depends on innovations
- The tenant suggests that investors are too narrowly focussed on the label and not on actual performance. In addition, there should be an incentive to keep on improving, such as obligating adaptations with a return on investment within a 3-year period.

Preferred adaptations I: + P: + T: ++

- All the stakeholder agree that the main improvement would be to repair the thermal energy storage system.

Case 2
Adam Smith Building

Source: https://www.wecanteen.nl/2019/05/02/we-canteen-opent-food-court-in-het-adam-smith-building-in-riekerpolder/

4.4 Case 2 | Adam Smith Building

1. Project information

The second case study is conducted on the Adam Smith Building. This rather large office building is located in the area of Sloten en Riekenpolder and is part of the city of Amsterdam. The building is part of the Rieker Business Park close to the A4 highway which makes is well connected with other cities and accessible by car. However, public transport options are limited. The Adam Smith building consists of a low-rise and high-rise building which are connected by an atrium. The total office space measures 20.784m2 which is divided over 7 floors in the low-rise part and 13 floors in the high-rise building. The building has been constructed in 2002 and has recently undertaken renovation work mainly focussed on the aesthetics. The current energy label is B while the actual performance, related to gas consumption, is in line with a label D. Due this severe performance gap, this case has been selected for non-compliance in the first stage.

Figure 4.5. Image of Adam Smith Building
Source: https://www.1530.nl/nl/knab-huurt-in-adam-smith-building/

Stakeholders

Investor – Confidential
This investor is a globally operating investment manager with approximately $40 billion of assets under management. The assets are managed on behalf of institutional clients and private investors. The headquarters is based in the U.S.A. but has several offices around the world. The Dutch office acts as a private equity investor. The Adam Smith Building

has been acquired in October 2017 from Deka Immobilien. The aim of this investor is to generate a return on investment by upgrading the building and attract tenants. Once that is accomplished the building is likely to be sold again. However, strategies per asset might differentiate based on the possible business case. For this research, an interview has been conducted with the asset manager, Interviewee 4.

Property manager – CBRE Advisory

This property has been under CBRE's management since 2014. The current owner acquired this property in 2017 and transferred the property management along with it. CBRE was also involved in the acquiring stage by conducting a quick-scan on the potentials of this building for the investor. The interviewee has been involved since February 2018 and is the Technical Manager of this property.

Tenant – ACN Europe

One of the tenants that reside in this multi-tenant building for a long period of time is ACN Europe. The tenant used to occupy several floors. However, due to the reallocation abroad of several departments, they were able to decrease their footprint to about 1080m2. This multinational company provides multi-level network marketing mainly focussed on energy services and wellness. The company was founded in the U.S.A. while their Dutch offices have been housed in this building for around 20 years. The interview has been conducted with the Interim Director Facilities of ACN Europe, Interviewee 6.

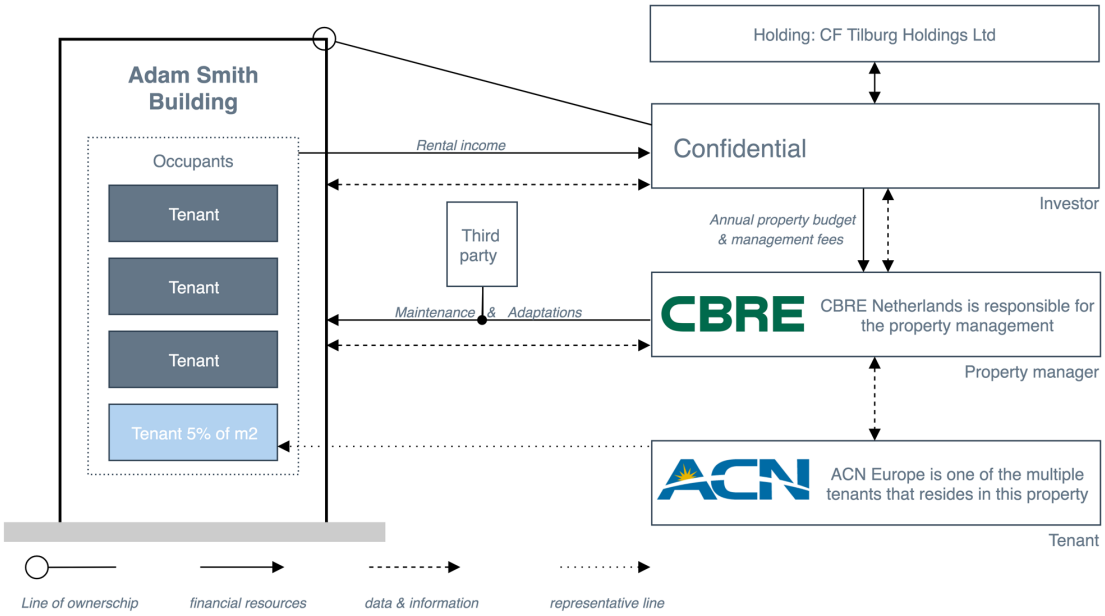

Figure 4.6. Stakeholders diagram Adam Smith Building

2. Building Characteristics – Adam Smith Building

Case Study number	**2**
Period	**2018**
Data Source	**CBRE B.V.**
Classification	**B performs as D**

Theme	no.	Topic	Answer
General	1	Property name	Adam Smith Building
		Address	Thomas R. Malthusstraat 1-3, 1066 JR
		City	Amsterdam
		Total m2 of property	20784
		Year of construction	2001
		Rental price per m2 per year	€ 224,17
		Image	
Stakeholders	2	Tenant	ACN Europe B.V.
		Property Manager	CBRE B.V.
		Investor	Confidential
Energy & Costs	3	Annual electricity consumption (kWh)	3036552
		Annual electricity consumption per m2 (kWh)	146,1
		Annual natural gas consumption (m3)	309864
		Annual natural gas consumption per m2 (m3)	14,9
		Total kWh per m2 per year	291,7
		Current EPC label	B
		Label valid till	2028
		Theoretical electricity consumption/m2/year (kWh)	42,2
		Theoretical gas consumption/m2/year (m3)	9,1
		Performance gap of electricity (%)	246,21%
		Absolute performance gap gas/year (m3)	120.730
		Absolute performance gap gas/m2/year (m3)	5,81
		Performance gap of natural gas (%)	63,83%
		EPC label based on actual gas consumption	D
		Service costs per m2 per year (2018)	unknown
		Costs electricity/year	€ 342.322,00
		Costs gas/year	€ 164.938,00
		Cost of gas performance gap/year	€ 64.263,35
		Costs of gas performance gap/m2/year	€ 3,09
		Total energy costs per m2 per year	€ 24,41
		% energy costs related to performance gap	12,67%
		% energy performance gap costs of rental price	1,38%
Use	4	Tenant's business activities	Finance, IT, direct sales
		m2 in use by tenant	1080
		Average office opening hours a week	65 hours (24/7 accessible)
		Number of workplaces	45
		Number of employees	45
		m2 per employee	24,0
		Occupancy rate	n.a. (80-90% estimation by tenant)
		Type of HVAC	Heated air system
		Business activities other tenants	Several financial service related companies
Adaptations	5	Recent energy-saving measures	no recent measures have been taken
		Planned interventions	air heating boilers will be replaced, the cooling system will become a heat pump system

Figure 4.7. The building characteristics of Adam Smith Building

3. Interviews with stakeholders

The interviewees for this case study are as follows:

Interview number	Function	Company
Interviewee 4	Asset Manager	Confidential
Interviewee 5	Technical Manager	CBRE Advisory
Interviewee 6	Interim Director Facilities	ACN Europe

Insight into energy performance I: + P: +/- T: ++

In this case, there is little insight in the energy consumption of the building. Insight on the actual energy performance could be obtained by looking into the annual service costs (Interviewee 4, 5 & 6, 2019). The tenant mentions that it would be favourable to have more insights on the actual consumption to be able to draw a link between the service costs and the actual consumption. If necessary, questions might be asked or adaptations could be justified (Interviewee 6, 2019). According to interviewee 5, there is not a demand for more detailed information of the energy consumption among the tenants. Currently, there is no active monitoring or possibility to easily access the energy consumption data and share this with the other stakeholders (Interviewee 5, 2019). The investor is aware of the underperforming in relation to its energy label. The settlement of the annual energy consumption lags behind approximately 6 months which is not stimulating energy efficient behaviour. Therefore, interviewee 4 suggest to introducing some kind of dashboard at the entrance to create awareness amongst the tenants on their energy consumption (2019).

Structural adaptations I: ++ P: + T: +/-

Several studies have been conducted by the property management company in order to give advice on possible energy saving measures. This was mainly driven by the desire to improve the energy label to A (Interviewee 4 & 5, 2019). Further adaptations to the façade regarding the level of insulation would not be feasible for this building since it already got improved recently and has not yet reached the end of the expected life-cycle. However, according to the interviewee 4 and 5, the technical installations for heating and cooling could be further optimised when taking the investments costs into consideration. No concrete numbers on potential energy saving could be given by any of the interviewees. The tenant is not taking the initiative to demand structural adaptations from the owner despite them experiencing some discomfort related to the indoor climate. However, their attitude towards structural energy saving measures is positive. The tenant sees potential in decentralising the climate system since they are not still operated on a building level (Interviewee 6, 2019). This intervention is currently being implemented by the investor since a new building management system will enable climate regulating per floor more precisely. This has great potential for better monitoring but also for tenants to adapt their behaviour (Interviewee 4, 2019).

Behavioural adaptations I: + P: +/- T: +

When considering energy reductive measures, behavioural adaptations were not at the top of these stakeholders' minds. The tenant has implemented some adaptations related to decreasing environmental impact as a company. They became a paperless office relatively early. However, at this stage, the tenant is lacking inspiration for further behavioural adaptions (Interviewee 6, 2019). Maybe, the investor could get more involved in this subject according to the property manager. Because when legislation will change from the EPC towards the EPG it will be the investor that should be steering on certain energy consumption. However, at this stage, the energy label is the most important topic related to sustainability (Interviewee 5, 2019). The investor acknowledges that stimulating behavioural change could be part of their scope to the level of providing insights with good monitoring and creating awareness. In practice, during tenant meetings, this topic is not on the top of the list to discuss but should maybe move up more with the possible EPG labelling in the near future (Interviewee 4, 2019). In addition, this building is not a typical nine to five building since the tenant has the possibility to enter it anytime.

Drivers for adaptations towards sustainability I: + P: + T: +

For this tenant, the indoor climate and a high level of comfort are of significant importance due to their history of experiencing discomfort by malfunctioning climate installations. Aside, reputational benefits are also considered but the main driver remains the reduction of service costs (Interviewee 6, 2019). On this last point, at the stakeholders agree, by decreasing service costs a competitive advantage can be realised which is of interest from a commercial perspective (Interviewee 4, 2019). Nowadays, corporate tenants demand higher levels of sustainability more frequently. Therefore, it is of importance to obtain a good energy label which will increase the chances of a property to be rented out. In order to increase this rentability, the building should not only be sustainable but should also be able to provide extra services and facilities (Interviewee 4, 2019). Apart from that, keeping tenants satisfied and attracting new tenants is also a driver for implementing more sustainability measures, according to the asset manager. However, the main driver for adaptations remains to obtain a certain energy label due to national energy policies (Interviewee 4 & 5, 2019).

Barriers for adaptations towards sustainability I: ++ P: +/- T: +

From the tenant's perspective, there is only one condition for implementing sustainability measures which is that the measure should be financially feasible (Interviewee 6, 2019). While the property manager and the investor claim that the main barrier is split-incentives. Interviewee 5 mentioned that sustainability investments that have been made are often not completely reflected in a higher value of the property (2019). Another barrier is that this is a multi-tenant office building which means that there are many different tenants with different business core values. Some of them have a strong sustainability agenda while others lack in having one. In order to impose certain adaptations to the building, all tenants will have to agree upon the way forward. Due to the lack of insight, it is not always clear what adaptation would have the desired impact (Interviewee 4, 2019). In addition, it is not very rewarding for a tenant to perform business activities in an energy efficient manner due to the relatively little impact on the overall energy consumption of the multi-

tenant building. In this case, there is also a rather large common space compared to the office space which exacerbates this effect. Lastly, it can be challenging to implement adaptations when the building is in use. Therefore, major renovations should preferably be done when the building is vacant in order to prevent nuisance for the tenants (Interviewee 4 & 5, 2019).

Stakeholders view on current and future situation I: + P: ++ T: +/-

Energy consumption is not often enough a topic of discussion since service costs are often too little of interest for a tenant, according to the investor. The location and the level of comfort are more important than the energy savings at this moment (Interviewee 4, 2019). Tenants are concerned about BREEAM and Label A buildings, but less concerned about their actual energy performance. For the investor their scope is between 4 and 7 years, therefore legal obligations for this period are inventoried. The EPG is not considered to be an issue due to its scope. The, *lijst erkende maatregelen,* entails a list of measures that have a positive payback time that has to be implemented which is a reasonable demand (Interviewee 4, 2019). The property manager addresses that the energy label is still a focal point for both tenant and investor. When the EPG would be in place, the property manager expects that the investor would want them to steer upon the tenant's behaviour in order to maintain a certain level of sustainability (Interviewee 5, 2019). In addition, the property manager mentions that steering for more energy efficient use by the tenants can only be done when the market is tight. There will be a moment when low service costs will give a competitive advance on the commercial real estate market in the future when the market is less tight (Interviewee 5, 2019).
The tenant expects that the owner takes care of energy and sustainability-related issues when signing an all-in rental contract (Interviewee 6, 2019).

Preferred adaptations I: +/- P: ++ T: +

Interviewee 4 claims that almost everything is up to good standards or is planned to be carried out. The building is complying with the current energy label policies. Therefore, no major new investments will be made on sustainability but are more likely to happen on increasing the rentability (Interviewee 4, 2019). According to the property manager, some quick-wins are replacing the heating and cooling installations or possibly steer on the behaviour. Another option would be to think on a larger scale and develop an area-based heating and cooling network which could make use of the large lake nearby (Interviewee 5, 2019). For the tenant, there is only one preferred adaptation and that would be solving the issues with the fresh air distribution (Interviewee 6, 2019).

4. Main findings

The most important findings of this case study are as follows:

1. Project information

- This building is located along the highway A4 in Amsterdam where the market is relatively tight at this moment. The buildings recently undertook major renovation works mostly related to the aesthetics to increase rentability.
- The tenant resides in this property for approximately 17 years and occupies 1080m2 of the total 20.874 m2. The investor acquired the property in 2017. This property has been property management since 2014.

2. Building characteristics

- This property holds an energy label B while it performs as D
- The natural gas performance gap is 63,83%.
- The costs related to the performance gap result in a surcharge of approximately €3,09 per m2/year. That is 12,67% of the total energy costs and 1,38% compared to the rental price per m2.

3. Interview with stakeholders

Insight into energy performance **I: + P: +/- T: ++**

- Insight on the energy consumption can only be obtained through the service costs that are settled 6 months after the previous calendar year.
- Tenant indicates that more insight would favourable while the property manager suggested that currently there is no demand for more insight.
- The investor is aware of the underperformance. Creating insight for tenant could be realised by introducing an energy performance dashboard at the entrance.

Structural adaptations **I: ++ P: + T: +/-**

- Structural adaptations to the façade are financially and technically out of scope.
- Adaptations to the installations are favoured by investor and property manager, partly driven by the potential to obtain label A.
- Soon the indoor climate can be monitored and regulated more precisely, this enables tenants to have more influence on their energy consumption.

Behavioural adaptations **I: + P: +/- T: +**

- Tenant is lacking inspiration and foundation on further behavioural adaptations.
- According to the asset and property manager, the investor has a role initiating in creating awareness by providing insights into the energy performances. In addition, this topic should be on the agenda more often during tenant meetings. Also, opening hours are extensive which increase energy consumption.

Drivers for adaptations towards sustainability I: + P: + T: +

- Investor: Legislation, adding value, increasing rentability due to tenants demanding higher levels of sustainability, a vision of the shareholders.
- Property manager: Preventing legal obsolescence, tenant satisfaction
- Tenants: Increasing comfort levels, reducing OPEX

Barriers for adaptations towards sustainability I: ++ P: +/- T: +

- For the investor: the main barriers are split-incentives, and the extra costs of making off-cycle adaptation. In addition, all tenants need to share the same vision.
- For the property manager: nuisance when adapting space that is occupied.
- Tenant: financially unrewarding.

Stakeholders view on current and future situation I: + P: ++ T: +/-

- Investor: There is demand for energy labelled building however actual performance is not often demanded. Their scope is 4 to 7 years and therefore they are not concerned about the possible EPG. The *lijst erkende maatregelen,* demand realistic interventions from the investor.
- Property manager: When the EPG would be enforced, the property manager expects that they will be demanded to steer on behavioural adaptations of the tenant. Steering on behaviour should be done when the market is tight.
- Tenant: Expects that issues related to sustainability are taken care of by the investor.

Preferred adaptations I: +/- P: + T: ++

- Investor: No major investments in sustainability required, only in rentability
- Property manager: Replacing the heating and cooling system or setting up an area-based heating and cooling network
- Tenant: Adaptations to the indoor ventilation system to enhance indoor comfort.

Case 3
Casuariestraat

Source: https://dgmrsoftware.nl/events/cursus-geluidwering-gevels/

4.5 Case 3 | Casuariestraat

1. Project information

The case study is on the office building at Casuariestraat 5-35. This somewhat traditional office building was built in 1972 in The Hague. In 2011, the building undertook a major renovation that contributed to energy A label it holds today. The façade, designed by Fokkema en Partners Architecten, was given a new look and has been energetically improved. The building is conveniently located between train station *Den Haag Centraal* and the historic city centre of The Hague which is known for the housing several government institutions. Due to its location accessibility by public transport is relatively high. The building also has its own parking lots which enable employees to travel by car as well. The building holds an A label but it is currently performing as a label B building. Therefore, this case has been chosen as the third case since it could possibly face non-compliance in the second stage.

Figure 4.8. Image of the Casuariestraat 5-35 office building.
Source: https://www.funda.nl/huur/verhuurd/den-haag/appartement-40093370-casuariestraat-35/

Stakeholders

Investor – Catella IM Benelux

Catella IM Benelux is an international property investment and fund manager that operates in over 15 countries in Europe and the U.S.A.. Their activities in the Netherlands are part of their Benelux (Belgium, Netherlands, Luxembourg) division. Catella claims to be a leader in the property sector, with a strong local presence which is possible because of their 600 employees. Within Catella there are four divisions, Corporate finance, Property investment management, Equity, hedge and fixed-income funds, and Banking.

Catella IM Benelux is investing for a German real state fund of SSP. This office building has been in their portfolio for seven years. The interviewee that was consulted for conducting the interview is the asset manager of this property.

Property management - CBRE Advisory

This property has been under CBRE's property management for four years. Within CBRE this property is serviced by one of the several teams from the property management department. The person within the managing team of CBRE who has the most knowledge on this building is the technical manager. The technical manager is involved with this building for one and half year and was the interviewee for conducting this case study research.

Tenant - DGMR

One of the tenants of this multi-tenant office building is DGMR. DGMR is a consulting and engineering company within the domain of real estate, infrastructure, mobility and environment. Due to their own business activities, there is a lot of inhouse-knowledge on the sustainability and energy related issues. This tenant resides in this property since the major renovation in 2011 and occupies approximately half of the office space that measures 1864 m2. Within this space, there are workplaces for 90 employees. For this research, a Senior Consultant of DGMR has been interviewed who was also involved during the renovations that took place in 2011.

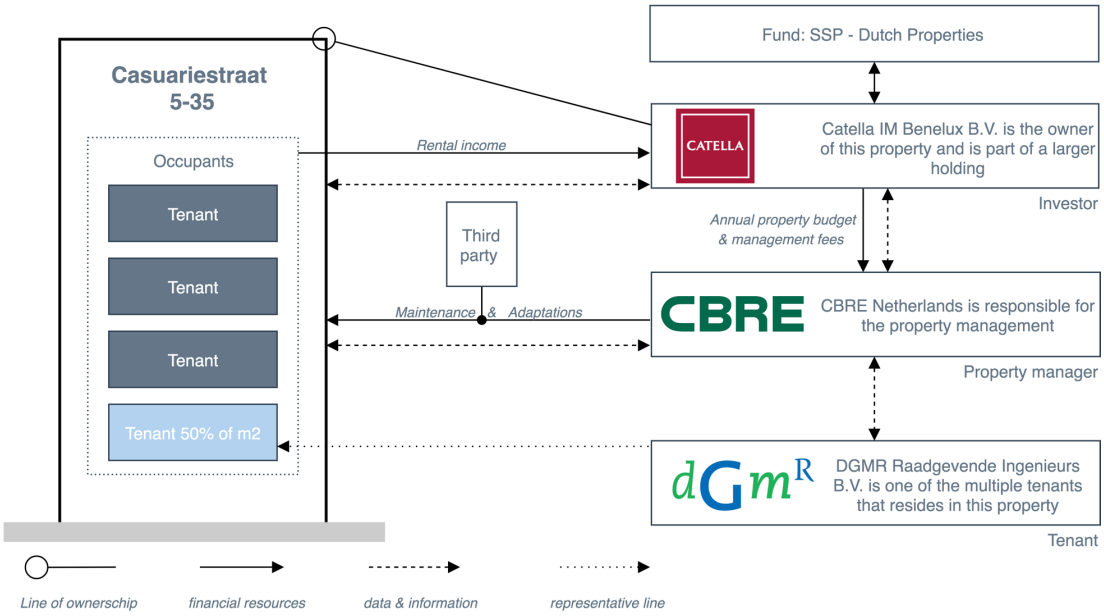

Figure 4.9. Stakeholders diagram Casuariestraat

2. Building Characteristics

Case Study number	**3**
Period	**2018**
Data Source	**CBRE B.V.**
Classification	**A performs as B**

Theme	no.	Topic	Answer
General	1	Property name	Casuariestraat 5-35
		Address	Casuariestraat 5-35
		City	Den Haag
		Total m2 of property	3500
		Year of construction	1972
		Rental price per m2 per year	€ 173,20
		Image	
Stakeholders	2	Tenant	DGMR Raadgevende Ingenieurs B.V.
		Property Manager	CBRE B.V.
		Investor	Catella
Energy & Costs	3	Annual electricity consumption (kWh)	265566
		Annual electricity consumption per m2 (kWh)	75,9
		Annual natural gas consumption (m3)	32531
		Annual natural gas consumption per m2 (m3)	9,3
		Total kWh per m2 per year	166,0
		Current EPC label	A
		Label valid till	2021
		Theoretical electricity consumption/m2/year (kWh)	39,3
		Theoretical gas consumption/m2/year (m3)	6,7
		Performance gap of electricity (%)	93,07%
		Absolute performance gap gas/year (m3)	9.081,00
		Absolute performance gap gas/m2/year (m3)	2,59
		Performance gap of natural gas (%)	38,72%
		EPC label based on actual gas consumption	B
		Service costs per m2 per year	unknown
		Costs electricity/year	€ 33.482,00
		Costs gas/year	€ 23.542,00
		Cost of gas performance gap/year	€ 6.571,73
		Costs of gas performance gap/m2/year	€ 1,88
		Total energy costs per m2 per year	€ 16,29
		% energy costs related to performance gap	11,52%
		% energy performance gap costs of rental price	1,08%
Use	4	Tenant's business activities	Consultancy, meeting rooms, computer based working
		m2 in use by tenant	1864
		Average office opening hours a week	50
		Number of workplaces	90
		Number of employees	90
		m2 per employee	20,7
		Occupancy rate	65%
		Type of HVAC	By air venitlation through ceiling and coventional (GF)
		Business activities other tenants	Medical, employment agency, consultancy
Adaptations	5	Recent energy-saving measures	no major adjustments after last renovation
		Planned interventions	Conventional lighting has been replaced for led and the boiler will be replaced by high efficiency boilers

Figure 4.10. The building characteristics of Casuariestraat

3. Interviews with stakeholders

The interviewees for this case study are as follows:

Interview number	Function	Company
Interviewee 7	Technical Asset Manager	Catella
Interviewee 8	Technical Manager	CBRE Advisory
Interviewee 9	Senior Consultant	DGMR

Insight into energy performance **I: +/- P: + T: ++**

All stakeholders indicated to have relatively little insight into the energy performance of this property. Interviewee 7 (2019), noted that from their perspective the actual consumption is not much of a focal point in their sustainability agenda. However, obtaining and maintaining a certain energy label is of high importance. The monitoring of the actual performance is handled by the property manager on an annual basis (Interviewee 7 & 8, 2019). The actual consumption is collected and submitted into a toolbox of the fund to guard the energy objectives of the investing fund (Interviewee 7, 2019). According to the tenant, sustainability is a broader concept than energy consumption alone and therefore they assess their own environmental footprint on a yearly basis (Interviewee 9, 2019). The property manager and tenant indicated that more precise monitoring and making this energy consumption data easily accessible has potential in justifying certain adaptation either structural or behavioural (Interviewee 8 & 9, 2019).

Structural adaptations **I: + P: + T: ++**

Structural adaptations are of interest when striving for less energy consumption. However, the technical lifespan of the façade and installations have a major impact on what is achievable within the financial scope of this building (Interviewee 7 & 9, 2019). This tenant strives for a high level of sustainability and had higher demands to the level of sustainability before moving in than was initiated by the investor (Interviewee 9, 2019). Due to the demands of the potential tenant, DGMR, the investor's aim for label C was adjusted to A during the major renovations in 2011, according to Interviewee 9 (2019). When implementing structural adaptations, the impact of the level of comfort is of high relevance for the tenant. The technical conditions of the façade and the installations are still up to the standards and therefore it would not make sense to demand further structural adaptations (Interviewee 9, 2019). This vision is shared by Interviewee 7, that indicated that only the end of the technical lifespan and legal obligations would stimulate structural adaptations. The tenant had an initiating role in the application of LED lighting and has a proactive attitude towards investor in suggesting structural adaptations due to their inhouse-knowledge. A structural adaption that the tenant would like to see implemented is the application of sensors have more insight on space use and steer towards more sustainable behaviour (Interviewee 9, 2019). This topic is currently on the table. The property manager mentioning that the replacement of the current heating boilers can have a rather big impact on gas consumption. Therefore, plans are developed to replace the current boilers by high efficiency boilers in a so-called cascade setting

which would increase the efficiency from 65% to 90%. In addition, a new indoor climate system enables the indoor climate to be regulated more automatically (Interviewee 8, 2019).

Behavioural adaptations I: +/- P: +/- T: ++

The investor is willing to think along to stimulate behavioural adaptations by the tenants in order to reduce the energy consumption and considers the property manager to be the stakeholder to steer on behavioural change (Interviewee 7, 2019). The potential of behavioural change is considered to be large by tenant and property manager. The main challenge would be the monitoring and stimulating the employees to adapt their behaviour in an energy efficient manner. Therefore, preferably on an individual employee level insight will be required to stimulate behavioural change and maybe even add a competitive element (Interviewee 9, 2019). In order to facilitate behavioural change, monitoring will be required on a more detailed level. Since this building is multi-tenant, it is unknown what share of the energy consumption is caused by which tenant (Interviewee 9, 2019)

Drivers for adaptations towards sustainability I: ++ P: +/- T: +

Both for the property manager and the investor, the main driver for taking sustainability measures is considered to be legislation. Currently, the *Informatie plicht*, pushes the level of sustainability of the Dutch office stock (Interviewee 7 & 8, 2019). Another important driver for the investor is the potential competitive advantage and thus commercial interest as a result of implementing sustainability measure. Because higher levels of sustainability positively influence the rental premiums. The third driver would be the CSI-vision of the fund behind the investment (Interviewee 7, 2019). For the property manager, apart from legislation, there is another driver. Namely, implementing newer and more sustainable installations often results in less work in maintaining the property (Interviewee 8, 2019). For the tenant, their main driver for sustainability is their CSR vision to set a good example of having a low carbon footprint. A yearly assessment is conducted to indicate how they could lower their environmental footprint. Remarkable, the costs are considered to be a factor in this process but are not a driver for adaptations (Interviewee 9, 2019).

Barriers for adaptations towards sustainability I: ++ P: + T: +

The division of costs is considered to be the main barrier in implementing adaptations towards more sustainability (Interviewee 7 & 8, 2019). Mainly the investor experiences the disadvantages of the split-incentive phenomenon. The division of the financial burden and the possibility of redirecting the costs to the tenant will need to be discussed and weighed carefully before making decisions. This is due to the dilemma that there are currently no incentives for the investor when a certain energy label has been obtained (Interviewee 7, 2019). Another challenge in redirecting the financial burden is the differences in the period of rental contracts for multi-tenant offices (Interviewee 8, 2019). The tenant of this property is pro-active in initiating adaptations due to their expertise. A challenge is to convince the owner of this process. However, a tenant should be reasonable in its demands because at a certain point rental premium will increase significantly which is a barrier (Interviewee 9, 2019)

Stakeholders view on current and future situation I: ++ P: + T: +

According to Interviewee 9 (2019), no major adaptations will need to be addressed regarding the current national legislation. Some improvements in terms of energy consumption could still be accomplished and will be elaborated upon in the next paragraph (Interviewee 9, 2019). For the property and asset manager, the *informatie plicht,* a national policy on taking energy reductive measures in commercial real estate, obliges them to map the current condition of the building and apply certain adaptations by next year. The tenants are not involved in these adaptations since they are relatively small and are obligatory. In general, the property and asset manager will normally discuss the feasibility of certain adaptations before tenants will be involved (Interviewee 8 & 9, 2019). The investor mentioned, that currently, supervision of the level of sustainability is still missing. Despite that, creating a more sustainable built environment is considered to be a good cause. The main challenge is finding a consensus on the measures and the division of the financial burden with the tenant (Interviewee 9, 2019).

Preferred adaptations I: +/- P: + T: ++

The investor is not planning in implementing further adaptations since the building meets the criteria from a legislation perspective. In addition, the property not experiencing any vacancy and therefore from a commercial perspective there are no drivers either (Interviewee 7, 2019). The property manager would recommend adapting the heating system by a high efficiency cascade setting which should result in an increase in efficiency of approximately 25% compared to the current boilers (Interviewee 8, 2019). The tenant is aware that the current technical conditions are relatively high. Therefore, the preferred adaptations would be a change in behaviour. As second option, introducing micro generation by installing solar panels. Lastly, the tenant suggests replacing the current installations (Interviewee 9, 2019).

4. Main findings

The most important findings of this case study are as follows:

1. Project Information

- This property is located in the city centre of The Hague and well accessible by public transport and car. The building undertook major renovations in 2011 which resulted in energy label A while it currently performs as B.
- The tenant occupies since 2011 approximately 1900m2 of the total 3500m2. The investor acquired this seven years ago and the property management company has been involved for four years.

2. Building characteristics

- This property holds an energy label A while it performs as B
- The natural gas performance gap is 39%.
- The costs related to the performance gap results in a surcharge of approximately €1,88 per year per m2. That is 11,5% of the total energy costs and 1,1% compared to the rental price per m2.

3. Interview with stakeholders

Insight into energy performance **I: +/- P: + T: ++**

- Annual insight in the energy performance through service costs settling.
- More insight is preferred by property manager and tenant to substantiate behavioural and/or structural adaptations.
- Investor is mostly concerned about energy label and less on actual consumption

Structural adaptations **I: + P: + T: ++**

- Structural adaptations are promising in theory. However, this building is up to standards from a technical perspective and holds an A label. Structural adaptations could find a way when at the life-cycle replacements or legally obliged.
- The tenant has a proactive attitude towards making structural adaptations and is involving investor in their initiatives such as applying sensors. The tenant is aware that the end of the technical lifespan of façade and installations has not been reached and therefore has no real leverage to demand more. When initiating structural adaptations, the impact on the level of comfort should be carefully considered by the tenant.
- Property manager looks into making life-cycle replacements as good as possible. Therefore, a high efficiency heating system is likely to be installed.

Behavioural adaptations I: +/- P: +/- T: ++

- Behavioural change is something the property manager should steer on, according to the investor
- The tenant is not actively steering on behavioural adaptations. This is due to a lack of insight into the actual performance. Therefore, the property manager might need to facilitate more real-time of firm-based monitoring so that a foundation for behavioural change can be given to stimulate the employees.

Drivers for adaptations towards sustainability I: ++ P: +/- T: +

- Investor: legal compliance, competitive advantage, vision of the fund
- Property manager: legal compliance, optimising or minimising maintenance
- Tenant: CSR, lower their carbon footprint of entire business operation

Barriers for adaptations towards sustainability I: ++ P: + T: +

- For the investor, the main barriers are financial split-incentives and the fact that there are no further legislative obligations
- The division of the financial burden becomes complicated due to varying periods of rental contracts
- For the tenant is challenging to get the investor on board and remain reasonable

Stakeholders view on current and future situation I: ++ P: + T: +

- National legislation, *informatie plicht,* is currently pushing for the implementation of some adaptations for which the tenant will not be involved
- The challenge is to find consensus on the adaptations and the division of costs
- All the stakeholders are unconcerned about the proposed EPG or not meeting other governmental requirements since the property holds an energy label A.

Preferred adaptations I: +/- P: + T: ++

- Investor: no adaptations are being proposed by the investor
- Property manager: Replacement of current boiler for high efficiency heating boiler.
- Tenant: Firstly, adapting their own behaviour. Secondly, add micro generation by solar panels. Thirdly, replace installations by more energy efficient versions.

Case 4
Beechavenue

Source: https://www.fundainbusiness.nl/kantoor/schiphol-rijk/object-40412060-beechavenue-102-120/

4.6 Case 4 | Beechavenue 102-120

1. Project information

This building in Schiphol-Rijk is situated several kilometres outside of the city of Amsterdam. This office building is near Schiphol Airport, the busiest international airport in the Netherlands. The area of Schiphol is therefore suitable for international companies due to the high level of international connectivity. The area is easily accessible by public transport and by car for which large subterranean parking is available. In the surroundings, several comparable office buildings are present that together form the business park of Schiphol-Rijk. This relatively ordinary looking office building has been built in 1999 and measures 2500m2. Currently, it holds an energy label A status but is performing label C building. Therefore, this building was selected as a case for non-compliance in the second stage.

Figure 4.11. Image of Beechavenue office building
Source: https://www.fundainbusiness.nl/kantoor/schiphol-rijk/object-40412060-beechavenue-102-120/

Stakeholders

Investor – Confidential
This property has been recently acquired by a fund that owns around 30 properties in the Netherlands. The properties within this fund are rather diverse in terms of typology and location. Some of the properties are held for a longer period of time while others are bought due to their development potential and will be sold quickly after. This is because the company behind this fund is medium-sized real estate developer in the Netherlands.

The interviewee that has been consulted for this research is the asset manager of the property who has been involved in since June, 2019 while the property was acquired in April 2019.

Property manager – CBRE Advisory
Property management has been performed by CBRE since 2017. Also, the previous owner of this property made use of the property management services of CBRE. CBRE has been involved in commercial and technical management. This property is within CBRE managed by one of the five office property management teams consisting of approximately 12 employees. Within the Netherlands, the property management department is own of the largest in commercial real estate mainly focussing on retail and offices. The interviewee for this research is the Technical Manager who has been involved since February 2018.

Tenant - Basefarm
Since this multi-tenant office building, one of the tenants was selected to conduct this research. In this case, the largest tenant in terms of rented space was interviewed. The interviewee is fulfilling a double role as Personal Assistant and Office Manager for over 10 years. Basefarm is a Scandinavian company founded in 2000 that provides services related to IT-consultancy and it resides in this property for 10 years. The company provides a workplace per employee which results in 35 workplaces that situated in their 1.000m2 office space divided over two floors.

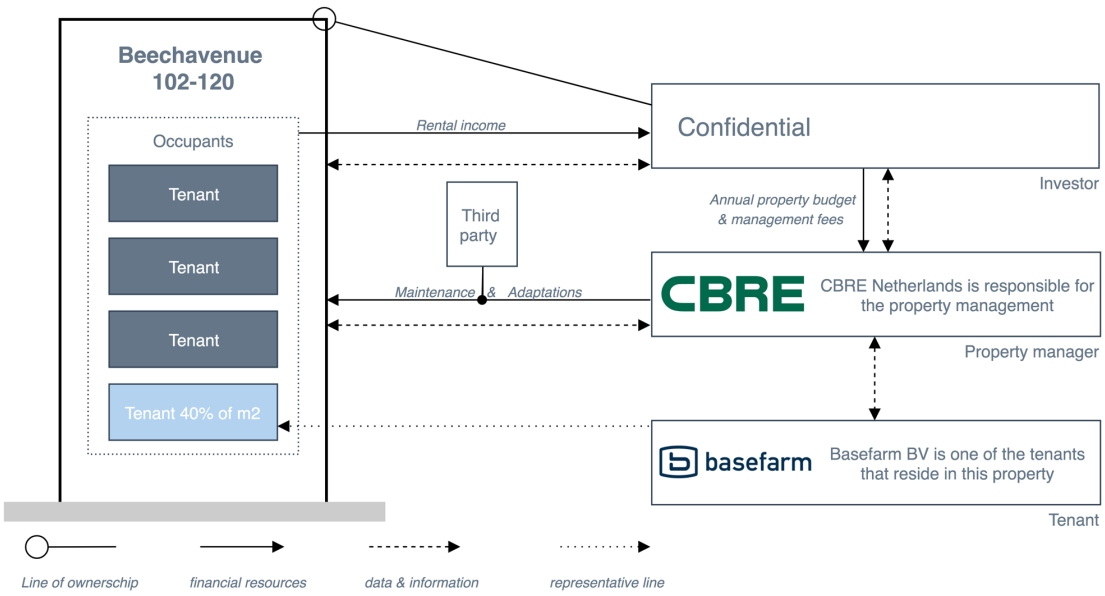

Figure 4.12 Stakeholders diagram Beechavenue

2. Building Characteristics - Beechavenue

Case Study number	**4**
Period	**2018**
Data Source	**CBRE B.V.**
Classification	**B performs as C**

Theme	no.	Topic	Answer
General	**1**	Property name	Beechavenue
		Address	Beechavenue 102-120
		City	Schiphol-Rijk
		Total m2 of property	2500
		Year of construction	1999
		Rental price per m2 per year	€ 130,00
		Image	
Stakeholders	**2**	Tenant	Basefarm BV
		Property Manager	CBRE B.V.
		Investor	Confidential
Energy & Costs	**3**	Annual electricity consumption (kWh)	289860
		Annual electricity consumption per m2 (kWh)	115,9
		Annual natual gas consumption (m3)	31678
		Annual natual gas consumption per m2 (m3)	12,7
		Total kWh per m2 per year	239,7
		Current EPC label	B
		Label valid till	2025
		Theoretical electicity consumption/m2/year (kWh)	42,2
		Theoretical gas consumption/m2/year (m3)	9,1
		Performance gap of electricity (%)	174,75%
		Absolute performance gap gas/year (m3)	8.928
		Absolute performance gap gas/m2/year (m3)	3,57
		Performance gap of natrual gas (%)	39,24%
		EPC label based on actual gas consumption	C
		Service costs per m2 per year	unknown
		Costs electricity/m2/year	€ 36.196,00
		Costs gas/m2/year	€ 22.927,00
		Cost of gas performance gap/year	€ 5.356,80
		Costs of gas performance gap/m2/year	€ 2,14
		Total energy costs per m2 per year	€ 23,65
		% energy costs related to performance gap	9,06%
		% energy performance gap costs of rental price	1,65%
Use	**4**	Tenant's business activities	IT-consultancy
		m2 in use by tenant	1000
		Average office opening hours a week	50
		Number of workplaces	40
		Number of employees	35
		m2 per employee	28,6
		Occupancy rate	80%
		Type of HVAC	Central heating, traditional boilers
		Business activities other tenants	Administrative and consulting
Adaptations	**5**	Recent energy saving measures	No recent measures have been taken
		Planned interventions	The switch from the current heating system to an area-based heating network

Figure 4.13. The building characteristics on Beechavenue 102-120

3. Interviews with stakeholders

The interviewees for this case study are as follows:

Interview number	Function	Company
Interviewee 10	Asset Manager	Confidential
Interviewee 11	Technical Manager	CBRE Advisory
Interviewee 12	PA & Office Manager	Basefarm

Insight into energy performance I: +/- P: + T: ++

All the interviewees agreed upon having very little insight into the energy performance at this moment. There is no real-time monitoring or a dashboard which makes accessing energy performance-related data possible. The only party that could request energy performance data is the Property Manager. However, the energy performance will only be checked yearly at the moment of settling the service costs which include the energy bills. The tenant was unaware of the energy performance gap and indicated that more insight should be provided by the Property Manager (Interviewee 12, 2019). Interviewee 10 (2019) noted that there is no reason for checking the energy performance and is also not interested into having more insight. In order to obtain more insight, interviewee 11 (2019) suggested to have an initiating role in adding more data points to measure energy performance more precisely.

Structural adaptations I: +/- P: + T: ++

The different parties all considered structural adaptation to be a logical intervention to foster the energy performance of the building. Interviewee 10 and 11 (2019) agreed that at this stage, upgrading the envelope would only be possible if the financial burden would be borne by the tenant. The end of the technical life-span and the threat for legal obsolescence would be the only reasons to implement structural adaptations, according to the asset manager. In addition, adaptations due to legal obsolescence will only be implemented 5 or fewer years in advance of the legal deadline. New investments into adaptations would probably be made to increase the aesthetics and the rentability (Interviewee 10, 2019). The tenant indicated that there is no in-house knowledge of installations. However, experience discomfort due to lacking airtightness of the façade. The tenant expects a proper functioning building from the moment of moving in and is currently not very satisfied with the technical conditions. Due to their intensions to leave this property next year they are not considering to demand structural adaptations to façade or installations (Interviewee 12, 2019). The property manager mentioned that the life-cycle replacement of the heating boilers will be used to connect to a new area-based heating network with an expected saving of 5%. The heating network would also contribute to obtaining an energy label A in the future (Interviewee 11, 2019).

Behavioural adaptations I: + P: +/- T: +

The potential of behavioural adaptations is clear for the stakeholders. However, the different stakeholders were not stimulating behavioural change to foster energy savings (Interviewee, 10, 11 & 12, 2019). Stimulating the tenant to adapt their behaviour could be

part of the investors' scope by creating awareness of the tenant's consumption. This could be established by investing in a monitoring system which stimulates the tenant's awareness and by that influences the behaviour (Interviewee 10, 2019). When the EPG method would be introduced, opportunities will arise to stimulate the tenant to become more energy efficient (Interviewee 11, 2019). However, at this moment there is no incentive to address this topic to the tenants (Interviewee 10 & 11, 2019). The tenant is slightly stimulating energy efficient behaviour. However, most systems are controlled on a building level so adapting your behaviour would not make an impact. Therefore, the challenge is to mitigate the installations as a barrier for behavioural adaptations (Interviewee 12, 2019)

Drivers for adaptations towards sustainability I: ++ P: +/- T: +

When a building is vacant and consumes relatively much energy, then it is of interest to make sustainable adaptations. Because high service costs have an impact on lowering the rental price and thus value and possible cash flow for the investor. In addition, a driver is the threat of legal obsolescence or when the building is underperforming compared to its specifications of the installations. If a company is interested in residing or prolonging the rental agreement, then there is commercial interest to adapt to be able to increase tenant interest or satisfaction (Interviewee 10, 2019). Delivering a more sustainability office could provide competitive advantage. However, a building on this location and given the scope of the investor there are no real drivers for a property manager to make adaptations. Therefore, according to Interviewee 11 (2019), the main driver would be legislation. If adaptations are required, implement state of the art replacements of the installations due to their higher efficiency and possible positive impact on the energy label (Interviewee 11, 2019). For the tenant, the main driver is to reduce OPEX since energy consumption is part of the service costs. The return on investment should be between 3 and 5 years due to the duration of rental contracts. Another recent driver became Corporate Social Responsibility since this tenant is setting up their own sustainability corporate policies. In addition, image and branding is gain tracking simultaneously (Interviewee 12, 2019)

Barriers for adaptations towards sustainability I: + P: +/- T: +/-

From the investor's point of view, structural adaptations to the building envelope are out of scope due to their payback period. Besides, tenants in this property are not demanding a higher level of energy efficiency. This has partly to do with the intentions of the tenant of moving out (Interviewee 10 & 12, 2019). Due to the location, rental prices are relatively low and the financial means are limited to make sustainable investments feasible (Interviewee 11, 2019). Also, replacing installations or renovating the façade before the end of their technical lifespan would not be viable from a financial perspective and not be sustainable from an environmental view. As long as the energy label is valid, there is zero incentive to make adaptation (Interviewee 10, 2019). The asset manager has a rather long-term scope while the tenant has a short-term scope. Lastly, this tenant lacks a sense of duty to implement changes because this is it not seen as their responsibility and the building should remain well-maintained (Interviewee 12, 2019)

Stakeholders view on the current and future situation I: + P: +/- T: +

The property manager should consider initiatives of opportunities addressed by tenants more seriously and convince the investor to invest in certain adaptations. In that sense, the property manager should have a more orchestrating role in keeping the tenants satisfied and prevent outdatedness, one of the tenant's reasons to move their business activities (Interviewee 12, 2019). However, Interviewee 11, noticed that the tenants of this property cannot be considered to be very demanding when it comes to sustainability related issues. In theory, each corporate tenant wants to reside in a sustainable-building but lacks a willing to pay for it (Interviewee 11, 2019). The investor wishes to retain the tenants and therefore, tenant satisfaction is of importance. The costs related to the energy performance gap in comparison to the total costs of housing will be too little to dissatisfy the tenants (Interviewee 10, 2019). In addition, without the EPG assessment method enforced, there are no real incentives to act upon this issue (Interviewee 10 & 11, 2019). If a system wherein total costs of occupancy is transparent would be introduced, the tenant's energy consumption could be benchmarked among others. In theory, an investor could ask higher rental premiums when service costs are lower due to the energy efficient behaviour by the tenant (Interviewee 10, 2019).

Preferred adaptations I: + P: + T: +/-

The different stakeholders had their own vision on what would be a suitable adaptation to reduce the energy demand. Interviewee 10 (2019) suggests that reducing the cooling demand could easily be accomplished by applying sun-blocking foil to the glass staircase or to introduce natural ventilation. While the property manager is in favour of the area-based heating network that is being developed. The tenant would rather see the façade being upgraded and renovated since some of the spaces remain poorly heated in winter (Interviewee 11 & 12, 2019)

4. Main findings

The most important findings of this case study are as follows:

1. Project information

- This property is located in a business park in Schiphol-Rijk close to Amsterdam. The area struggles with vacancy rates and rental premium are relatively low.
- Type of tenant resides for over 10 years in the property hand occupies two of the five floors. The investor acquired the property in April 2019. The property has been managed by the same company for over two years.

2. Building characteristics

- This building holds an energy label B while it performs as a label C building.
- The natural gas performance gap is 39%.
- The costs related to the performance gap results in a surcharge of approximately €2,14 per year per m2. That is 9,1% of the total energy costs and 1,65% compared to the rental price per m2.

3. Interview with stakeholders

Insight into energy performance **I: +/- P: + T: ++**

- Insight into the energy performance for all parties on an annual basis.
- The Investor in not very interested in actual energy performance.
- Tenant is in unaware and would like to have more insight. The property manager could facilitate insight by adding extra data points.

Structural adaptations **I: +/- P: + T: ++**

- Adaptations are not favoured by the investor as long as the end of the technical life-span is not reached. Adaptations will be implemented within 5 years from legal deadline due to investor's scope, and possible technological developments
- Tenant is not satisfied with indoor climate due to malfunctioning envelope, has little knowledge and experience on this domain and expects property manager to have an orchestrating role to deliver a proper function building.

Behavioural adaptations **I: + P: +/- T: +**

- Behavioural change is regarded as promising. However, at this moment incentives missing to adapt the tenant's behaviour.
- The current installations are unable to support the behavioural change in an efficient way. Creating insight and awareness should be facilitated by the investor.

Drivers for adaptations towards sustainability **I: ++ P: +/- T: +**

- Investor: threats of legal obsolescence, tenant satisfaction, competitive advantage, increase the rentability.
- Property manager: wants to deliver on the demands of the tenants and investor.
- Tenant: lowering OPEX, CSR vision, image and branding are most important drivers

Barriers for adaptations towards sustainability I: + P: +/- T: +/-

- Split-incentive is main barrier to overcome. Off-cycle adaptations are not financially feasible and have negative environmental impact
- Long-term versus short-term scope of investor and tenant
- Tenants finds it the investors responsibility to deliver a sustainable building.

Stakeholders view on the current and future situation I: + P: +/- T: +

- The property manager could have a more prominent role in creating a more sustainable building and transfer wishes of the tenant to the investor.
- The tenant should also be willing to at least partly pay for sustainability.
- The investor wants to retain tenants by satisfaction. However, the performance gap is no issue for a tenant and thus not for the investor.

Preferred adaptations I: + P: + T: +/-

- Reducing cooling demand by mitigating sun heat entering the building trough sun-blocking foil or natural ventilation
- Connecting to the area-based heating network which is more sustainable and mitigates 5% of the heat demand
- Upgrading the energetic standards and improve the airtightness of the façade

5 | Cross-case Analysis & Discussion

5 | Cross-case analysis & Discussion

In this chapter, the different case study objects will be compared with each other by conducting a cross-case analysis. The findings of the analysis will be categorised per topic, and an evaluation of the key findings will be given. After the cross-case analysis, the discussion section elaborates on the validity of the findings.

5.1 Cross-case analysis

This cross-case analysis might provide useful insights on a topic basis in answering the research questions. In order to be able to extract key findings that can contribute to the outcome of this research, the main findings per case will be evaluated and compared with the other cases. In order to increase the readability, separated tables per topic will be provided, followed by the evaluation per topic. In addition, an indication of the interest/relevance per stakeholder is given on each topic. More elaborate explaining on the findings per case study can be found in the individual case study reports in chapter Empirical Research.

Building Characteristics

First, the building characteristics of the different case study objects will be compared with each other. The most important figures have been distilled from the larger building characteristics lists that can be found in the case study report.

Table 5.1. Cross-case analysis of key building characteristics

Key figures	Case 1 Infinity A-D	Case 2 Adam Smith B-D	Case 3 Casuariestraat A-B	Case 4 Beechavenue B-C
Total m2	18240	20784	3500	2500
Rental price	€350	€224	€173	€130
Energy performance gap (Gas) %	96,7%	63,8%	38,1%	39,2%
Energy performance gap (Electricity) %	324,4%	246,2%	93,1%	174,8%
Costs epg gas m2/year	€3,88	€3,09	€1,88	€2,14
Percentage costs to tot. energy costs	14,4%	12,7%	11,5%	9,1%
Percentage costs to rent price	1,1%	1,4%	1,1%	1,65%
Office hours (weekly)	70	65	50	50
M2 per employee	23,8	24,0	20,7	28,6

Evaluation on building characteristics

As the cases are selected upon the presence of an energy performance gap related to gas consumption, it is logical that cases 1 and 2 show significantly larger discrepancies than cases 3 and 4. Cases 1 and 2 are categorised as non-compliant in the first stage (2023) and Case 3 and 4 as non-compliant in the second stage (2030). The building size and the typology of the buildings per stage show quite some similarities. Both buildings of the first stage are approximately 20.000m2 while the two buildings in the second stage measure about 3000m2. In addition, Case 1 and 2 have extended opening hours, and the offices are even available 24/7 if needed, this seems to have a significant impact on the energy consumption. Besides, both offices offer a shared entrance hall or atrium with

several facilities, which might have a severe impact on energy consumption as well. The rental prices show a rather significant differentiation wherein Case 1 is almost three times more expensive than Case 4. One could consider the rental prices to be a reflection of the local office market wherein Case 1 is situated in a premium office location and Case 4 in a relatively less attractive or demanded office location. Despite that, the costs related to the energy performance gap compared to the rental prices show a relatively little discrepancy as all the percentages are between 1,1% and 1,65% of the rental price which is remarkable considering that the almost three times higher rental premium for Case 1 in comparison to Case 4.

Interviews with stakeholders per topic

Per topic and stakeholder, the case study building will be analysed. The main findings per stakeholder are stated in keywords. In addition, their relative interest/relevance to this topic is given with the indication: ++ high, + medium, +/- low. Also, the evaluation per case and stakeholder is given, followed by a written general evaluation on the topic below each table.

Insight into energy performance

Table 5.2. Findings on insight into energy performance

Insight energy performance	Investor	Property manager	Tenant	Evaluation
Infinity section 4.3	++ Service costs, little insight Adding data points Vision fund	+ Through third party Update every 6 months	+ Favours more insight Own back-up system	All parties favour more insight into performance and implement real-time monitoring. On-cycle adaptations to add of more data point will be done soon.
Adam Smith Building section 4.4	+ Annual service costs Aware of underperformance Dashboard to stimulate	+/- Annual service costs Claims no demand for more insight	++ Annual service costs Favours more insight	Mainly the tenant is interested to obtain more insight due to potential costs savings. The PM and Investor mainly focus on the energy label.
Casuariestraat section 4.5	+/- Annual service costs Focus on energy label Keeps general overview for fund	+ Annual service costs Favours more insight	++ Annual service costs Favours more insight to make adaptations	All parties have little insight on an annual basis. The PM and tenant favour more insight to substantiate behavioural/ structural adaptations.
Beechavenue section 4.6	+/- Annual insight No further insight required Focus on energy label	+ Annual insight/demand More insight could be of potential value	++ Annual insight Unaware of performance Favours more insight	The investor is not concerned on the actual performance while the tenant is unaware and favours more insight. The PM is aware of the potential of more insight.
Evaluation	The vision of fund behind the asset has major impact on the interest, and investor is mainly concerned about the energy label	Property managers have little incentive to demand more insight. They are considered to be the party that could provide more insight by others.	All tenant favour more insight and are mainly driven by the potential costs savings and adaptations that could be substantiated.	*See general evaluation below*

General evaluation insight into energy performance gap

In all the cases, insight on the energy performance is limited. In general, insight into the energy performance is obtained once a year when the service costs are being settled with the tenant. None of the four cases studied had a possibility to obtain real-time insight into the energy consumption. All the tenants mentioned that they would like to have more

insight into their own performance than once a year. The property managers are normally the stakeholders that access the data on energy consumption and communicates to the tenants. The two investors of the second stage non-compliance cases are relatively unconcerned about the actual energy performance since the energy label is more important as a sustainability indicator because it is related to property value. The investor that would be non-compliant in the first stage were both interested in implementing real-time monitoring to foster energy-efficient behaviour of the tenants. In general, the level of insight is rather low due to the limited accessibility of the consumption data.

Structural adaptations

Table 5.3. Findings on structural adaptations

Structural Adaptations	Investor	Property manager	Tenant	Evaluation
Infinity section 4.3	+ Façade is high-end Adding data points Repairing thermal energy storage	+/- Building up to standards Only little improvements	++ Committed to energy efficiency Aesthetics and comfort Willing to invest	Remarkably this tenant is not very concerned about the costs but mainly focussed on sustainability, aesthetics and comfort. Repairing the thermal energy storage is a top priority. For the investor the addition of data points is a focal point.
Adam Smith Building section 4.4	++ To façade financially & technically out of scope Installations are the best option, quick-win Of interest when label step can be made	+ To Installations Label step No off-cycle adaptations	+/- Relatively unaware on the possibilities Expects this to be taken care of	This investor believes that the tenant should make the actual energy saving happen but that they should provide the right tools such as a dashboard and well adjustable indoor climate. The aim is on on-cycle adaptations the installations and not the buildings envelope.
Casuariestraat section 4.5	+ Technically up to standards Off-cycle adaptations are not preferred Wiling to think along with tenant	+ Strives for most energy efficient on-cycle replacements Focussed on installations	++ Very proactive in suggesting adaptations Cannot demand more or has to increase own housing budget Carefully consider impact on comfort Inhouse knowledge	This building has been improved by the wishes of the tenant who is in the sustainable building consultancy. All parties agree that the façade is up to standards and that life-cycle replacements should be an improvement. The tenant is proactive and takes comfort into consideration.
Beechavenue section 4.6	+/- Not favoured when off-cycle adaptations Loss of value Only within 5 years from legal deadline Scope & Innovations	+ Balance between tenant's and investor's demands Installations are favoured and planned Façade is out of scope	++ In favour of adaptations Not satisfied on airtightness of façade Increase comfort PM's business	The tenant expects the property manager to deliver a well-functioning building and would suggest adaptations to the façade while the PM and investor would only consider the replacement of installations and preferably as late as possible.
Evaluation	All the investors considered the façade to be out of scope for structural adaptions but do consider the replacement of installations.	Mainly concerned on fulfilling the wishes of the investor, in these cases improving the buildings installations. Have little incentive initiate structural adaptations	Most tenants are interested on structural improvements especially when its enhancing comfort of the users.	*See general evaluation below*

General evaluation on structural adaptations

None of the investors would consider structural adaptations to the façade to be realistic in order to mitigate the energy performance gap. The technical life-span has a major impact on implementing structural adaptations towards more sustainability. The facades of the studied objects are, according to investors and property managers, up to standards and have not yet reached their end of the lifespan. Therefore, implementing off-cycle adaptations to the façade would mean a loss of value. All the stakeholders consider structural adaptions, in general, to be efficient in reducing energy consumption. Mainly tenants are interested in structural adaptations since they could improve comfort or lower the OPEX or higher levels of comfort. The investors would only consider structural adaptations to the installations in order to foster sustainability. In case 1 and 2, the investor is currently implementing a new building management system with more data points which enables to monitor the energy performance more precisely and substantiate further adaptations if required.

Behavioural adaptations

Table 5.4. Findings on behavioural adaptations

Behavioural Adaptations	Investor	Property manager	Tenant	Evaluation
Infinity section 4.3	++ Difficult to accomplish Enabling tenant Monitoring	+/- Finds this a tenant's business	+/- Not actively steering Energy efficient devices	The investor acknowledges it has a duty to inform the tenant in order to accomplish savings. While the tenant is mainly focused on efficient devices.
Adam Smith Building section 4.4	+ Promising Not often on agenda Role in creating awareness	+/- Investor should provide more insight to tenants Extensive opening hours	+/- Lacking inspiration and foundation for behavoural adaptations	The is too little insight and awareness for the tenant to be able to steer. The investor can play a role in providing more insight and creating awareness.
Casuariestraat section 4.5	+/- PM's business mainly Promising	+/- Could be effective Collaboration with investor	++ Not actively steering No foundation Promising	The investor and the property manager have little incentives from their own roles. The tenants would need a real-time insight in order to motivate adaptions.
Beechavenue section 4.6	+ Regarded as promising Creating awareness	+/- Promising but not supported by current installations and no EPG	+ Interested No influence on systems	All the parties would consider this to be a good option. However, current systems are not supportive or easily adjustable.
Evaluation	Most investors find it a tenant's business while they feel a duty to create awareness by provide accurate monitoring	All the property managers recognise the potential but do not seem to feel responsible to steer upon behavioural adaptations.	Tenants are often lacking insight to motivate changes but is mostly willing to take more responsibility.	*See general evaluation below*

General evaluation on behavioural adaptations

Amongst the several stakeholders, the potential of energy savings through behavioural adaptations is known. However, in none of the cases, the tenant is yet steering upon behavioural change. All the tenants mentioned that the lack of insights is slacking the process to demand behavioural adaptations from their employees. In order to create awareness, real-time monitoring is required. The investors agree that behavioural adaptations should be initiated by the tenants themselves while the tenants mention that

they lack insights into their own performance. One of the tenants argues that larger savings can be accomplished by the use of highly energy-efficient devices and that therefore behavioural adaptations will not be required. The investor is mostly well-willing to provide more insights. While the property managers consider themselves not to be an important stakeholder in this process. Lastly, the current installations and systems are often able to provide or justify the need for behavioural changes by the tenant.

Drivers for adaptations towards sustainability

Table 5.5. Findings on drivers for adaptations towards sustainability

Drivers for adaptations	Investor	Property manager	Tenant	Evaluation
Infinity section 4.3	++ Vision fund 2035 carbon neutral Competitive advantage Increase value Increase rental prices Drive to be pioneering	+/- No real drivers Keeping everything running as smooth as possible	++ Sustainability CSR Best effort Comfort and aesthetics	The investor and tenant have a very clear vision on why they would implement certain measures. The property manager has less drivers. Remarkable for this tenant costs are not really an issue.
Adam Smith Building section 4.4	+ Legal compliance Increasing value & rentability Vision of shareholders	+ Legal compliance Tenant satisfaction	+ Increasing comfort Reducing OPEX	This case is somewhat typical meaning that the investor is mainly concerned about the legal and financial aspects while the tenant would like to benefit lower OPEX and more comfort.
Casuariestraat section 4.5	++ Legal compliance Competitive advantage Vision of fund	+/- Legal compliance Optimising maintenance	+ CSR Minimising footprint	This investor has been willing to think along with their tenants. While legal compliance remains very important for PM and investor. The tenant is mainly concerned about their CSR.
Beechavenue section 4.6	++ Legal compliance Tenant satisfaction Competitive advantage Rentability	+/- Deliver on demands of the tenants and the investor	+ Lower OPEX CSR Branding & Image	This tenant is mainly interested in the financial benefits while the investor is mainly concerned about legislations and tenant satisfaction. The PM is situated in between and wants to deliver on both demands.
Evaluation	By far, the most mentioned driver is legal compliance. All investors are interested in the benefits of more sustainability, mainly driven by the potential financial benefits it could have.	The property managers in all cases have medium to low interest in making adaptations, maybe because it would result in more works while they would not directly benefit from it.	Most tenants have several drivers for adaptations. CSR is often mentioned as a driver but also lowering the OPEX is of interest to some. Striking is that only one mentioned sustainability as a goal.	*See general evaluation below*

General evaluation on drivers for adaptations towards more sustainability

The drivers for adaptations mentioned in the different case studies were relatively similar per stakeholder. Except for case 1, wherein other drivers were mentioned. For case 1, the main driver for more sustainability from the investor's perspective was that the fund is aiming to become carbon neutral by 2035, which is 15 years prior to the current legislation. In addition, the tenant of case 1 and 3 mentioned that investing in energy savings measures is part of their CSR-vision and is not driven by cost reductions. Reasons for this tenant to make adaptations aside form energy reduction would be to

enhance the level of comfort and aesthetics. For the investors of case 2, 3 and 4, the main driver for adaptations would be legislation and the threat of legal obsolescence. Other drivers for investors are: adding value, increasing rentability, competitive advantage, tenant satisfaction, or the vision of the fund. All the property managers noted that the main drivers would be to keep tenants satisfied and to make sure that the building remains legally compliant. In addition, for the property manager, a driver is to minimise the required maintenance works. In case 2 and 4, the tenants mention that important drivers for implementing adaptations would be to lower their service costs. Concluding, most tenants are driven by their CSR-vision, to enhance comfort or by lower service costs. The tenants mainly act upon legislation and potential added value. While property managers seem to be driven by the tenant's satisfaction and the threat of legal obsolescence.

Barriers for adaptations towards sustainability

Table 5.6. Findings on barriers for adaptations towards sustainability

Barriers for adaptations	Investor	Property manager	Tenant	Evaluation
Infinity section 4.3	+ Division of costs Large improvements require large investments	+/- Low cost-effectiveness When not contributing to legislative demands	+ Nuisance Low cost-effectiveness Too complex system	Costs-effectiveness and the division of costs are very important to all stakeholders. Considering potential label steps and user friendliness is important when considering adaptations.
Adam Smith Building section 4.4	++ Split-incentives Off-cycle adaptations Visions of tenants	+/- Nuisance Occupied space	+ Financially unrewarding	The tenant and investor stress the financial aspects of adaptations while the property manager reflects on the practical side of the adaptations
Casuariestraat section 4.5	++ Split-incentives No legislative obligation	+ Division of financial burden in relation to rental contract of multiple tenants	+ Challenging to get investor on board Stay reasonable	The investor has no legislative incentives to make adaptations and the tenant finds it challenging to get the investor on board and to remain reasonable in their demands.
Beechavenue section 4.6	+ Split-incentives Off-cycle adaptations have negative environmental impact	+/- Long-term versus short-term scope of investor and tenant	+/- Investor's responsibility No knowledge on topic	The tenant finds adaptations something the investor should implement and has little knowledge on this topic. The investor is mainly concerned about the financial impact.
Evaluation	All investors experience split-incentives to be the main barrier to overcome. Aside, off-cycle adaptations mean a loss of value and negative environmental impact. However, the investor has a key role in implementing adaptations	The property managers are often the party in between which brings other challenges such as guarding the process, nuisance and aligning the scopes of the investors and tenants. However, this could be considered to be part of their job and thus they experience little barriers in general.	Most of the tenants were not willing to invest into their own sustainability and suggested this to be handled by the building's owner. Nuisance, and collaboration were also mentioned as a challenge to implement adaptations.	*See general evaluation below*

General evaluation on drivers for adaptations towards more sustainability

For all investors the phenomenon of financial split-incentives is still the main barrier to overcome when striving for higher levels of sustainability. In the current system, the adaptations to the property related to heating, cooling, ventilation, or the insulation should financially be borne by the investor. However, the increase in value due to a higher level of sustainability will not be enough to cover the costs of these adaptations. Therefore, these costs might partly be borne by the tenants in case of good collaboration. Another barrier is that implementing off-cycle adaptations to installations would mean that the previous investment will not be used to its full potential and therefore should be considered unfeasible. In addition, early replacements also can have a negative environmental impact due to the embodied energy. One investor mentioned that the absence of stricter legislation is withholding investors from making adaptation since new technologies will become more efficient and cheaper over time. Another barrier that was mentioned is the possible nuisance for the tenants when executing structural adaptations. Tenants found it a responsibility of the investor to deliver a sustainable building. Therefore, tenants are tending not to invest in the property that they are occupying. A challenge is to come to a consensus between the tenant and investor.

Stakeholders' view on current and future situation

Table 5.7. Findings on stakeholders view on current and future situation (Continues on next page)

Stakeholders' view situation	Investor	Property manager	Tenant	Evaluation
Infinity section 4.3	++ Not concerned on EPG Legislation for tenant Government should incentivise owners	+ Legislation is driving Replacement is focus now No specific view on situation	+ Investors too focussed on energy label Incentive to keep on improving a building Look at quick-wins	These different stakeholders are not concerned about a possible EPG. Legislation results in investors to be too narrowly focussed on energy labels. The government could provide incentive to keep on improving and involving the tenants.
Adam Smith Building section 4.4	+ Demand for energy labelled buildings Actual performance is not requested Not concerned on EPG Look at quick-wins	++ EPG would have result in a more steering role Steer on behaviour Only possible when market is tight	+/- Expects that issues related to sustainability and legislation are taken care of	The investor approaches the legislative demands from a financial angle. Looking for label steps to take and possible quick-wins. Actual performance is not demanded and the PM expects to have a steering role on behaviour when EPG is enforced
Casuariestraat section 4.5	++ National legislation is currently pushing The *informatie plicht* forces quick-wins Willing to think along Not concerned on EPG	+ No major challenges ahead First discussing with investor before informing tenants Not concerned on EPG	+ No major adaptations Property suffices Focussing on well-being Not concerned on EPG	All stakeholders are not concerned about the EPG legislation. They do not foresee major challenges. The *informatie plicht* states reasonable mandatory adaptations which will be implemented.
Beechavenue section 4.6	+ Tenant satisfaction is important Performance gap is no issue for tenant and thus not for investor Without EPG there would be no incentives	+/- Tenant is not very demanding related to sustainability In general tenants are unwilling to pay	+ PM should focus on keeping tenants satisfied	The tenants in this case is not very satisfied on the building and sees room for improvement. However, this is not specifically related to sustainability. There is no real driver from tenants to tackle the performance gap and also no legislative driver. Apart from that, the tenants might not be willing to financially contribute.
Evaluation	Legislation is of high importance and the *informatie plicht* was found to be reasonable by most. However, the EPG is not concerning so far and would be necessary to push for more action. Also, tenants might need to be included in new legislation.	In general, the property managers are not very concerned about the EPG. They would expect to have a more steering role. Currently, tenants are not very demanding and most adaptations are initiated by investor and PM. In general tenants are less concerned.	Tenants satisfaction is important to theme. The PM and investor should not only focus on the label but also on actual performance. They should unburden the tenants with issues of sustainability and increase their satisfaction.	*See general evaluation below*

General evaluation of stakeholders' view on current and future situation

Most of the interviewed stakeholders mentioned that they would probably not face any difficulties regarding the proposed EPG since the introduction of it has been postponed. The investors of case 2 and 4 noted that the sustainability demands of tenants is often based on the energy labels and is often less interested in the actual performance. Therefore, mitigating the energy performance gap is not an issue at this moment for these investors. In addition, the energy label they obtained will still be valid by the deadline of 2023. The investor of case 1 suggested that from a legislation perspective, the tenant

should also be forced to actively contribute to mitigating the energy consumption. All investors mentioned that the tenants should also be financially involved to speed up the pace of mitigating the energy performance gap and fostering a sustainable built environment. One of the property managers expects that when the EPG would be enforced, their role would become to also steer upon the behaviour and energy consumption of the tenants. While the other property managers are not foreseeing any major challenges regarding changes in legislation and possible shifts in responsibilities. The *Lijst erkende maatregelen* policy, is according to some stakeholders having the right impact. Both tenant and investor mentioned this. The policy obliges certain quick-wins to be implemented when the payback time is within 3 years. Concluding, most stakeholders do not foresee issues related to the EPG, and better collaboration between tenant and investor is required to move forward.

Preferred adaptations

Table 5.8. Findings on preferred adaptations (Continues on next page)

Preferred Adaptations	Investor	Property manager	Tenant	Evaluation
Infinity section 4.3	+ Repairing of thermal energy storage	+ Repairing of thermal energy storage	++ Repairing of thermal energy storage	All stakeholders agreed that the repairing of the thermal energy storage system is step one. Especially for the tenants since it will lower their OPEX
Adam Smith Building section 4.4	+/- No major adaptations Only in rentability	+ Placing heating and cooling system Implementing area-based H/C network	++ Adaptations to indoor ventilation to enhance comfort	The investor is preferring adaptations related to sustainability, except for the replacement of installations which is currently done. The tenant is mainly concerned about comfort while the PM focusses on possible larger-scale options.
Casuariestraat section 4.5	+/- No major adaptations	+ Replacement of boilers system for a high efficiency system	++ Adapting behaviour Micro generation Replace installations	This building is up to standards. Striking is that the tenant would first adapt their own behaviour in order to save energy. The PM mentioned the replacement of the boilers to be of interest.
Beechavenue section 4.6	+ Reducing cooling demand adding sun-blocking foil	+ Connecting to area-based heating network, this reduces 5%	+/- Upgrading energetic standards and airtightness of façade	The investor would like to minimise the cooling demand, while the tenant wants better insulation. At the same time the PM is working on connecting to a local heating network. The tenant will leave and has therefore low interest in further adaptations.
Evaluation	In general, the investors do not prefer major adaptations. Since they are mainly concerned about their energy labels, there is currently no real driver for extra adaptations	The property managers had very specific ideas on how what adaptations could be implemented to decrease the energy demand. Most of them are currently planned to be executed.	All tenants, expect for the moving tenant of case 4, had a clear vision on what should be improved. Probably because they would directly benefit either financially or in comfort	*See general evaluation below*

General evaluation on preferred adaptations

The last topic addressed during the interviews was the preferred adaptions in order to mitigate the energy performance gap. Since there are several stakeholders per building, the preferred adaptations could be considered to be divers except for the first case. All stakeholders of case 1 indicated that the most favoured and effective adaptation would be the replacement of the malfunctioning installations, in this case, the thermal energy storage system. This would mean that a new well will need to be dug in order to restore the full capacity of the system. The investors of case 2, 3 and 4 only were not planning on implementing any major energy-saving measures for their assets. The property managers all mentioned specific adaptations that could foster the mitigation of the energy performance gap, assumingly due to their technical knowledge on these possibilities. Three of the four tenants would prefer to implement structural adaptations mainly to the installations. While the tenant of case 3 considered behavioural adaptations to be the best starting point for mitigating the performance gap.

5.2 Synthesis | Step-by-step plan

Based on the findings of the empirical research and the cross-case analysis, a step-by-step plan was developed in order to provide a process framework for stakeholders to foster sustainable adaptations in the built environment. Firstly, the purpose for practice will be elaborated upon. Thereafter, the step-by-step plan will be provided as a guiding tool for practice stating the 'what' and the 'how'.

Elaboration on purpose for practice

As this research consisted of both a literature study and an empirical study, several people from practice were consulted to share their vision on the issues addressed in this research. The synthesis of this step-by-step plan might be of relevance to the several stakeholders that were involved during the interviewing and to policy makers.

The main stakeholders related to the existing stock were interviewed, and the findings were analysed. The synthesis of the input can be of useful for them in practice to foster a more sustainable office stock. The main barriers became clear in the process towards more sustainability, namely the division of costs and benefits. In order to achieve higher levels of sustainability, discussing the topic of actual energy consumption would be necessary. Often, only the energy labels are demanded by a tenant before moving in. Research shows that the energy label is not a guarantee for a low environmental footprint. Therefore, tenants can be more demanding when it comes to having insight into the actual performance of buildings and their own consumption.

Investors have a very prominent role in the built environment. Due to their ownership of the buildings, they will always have the last say in any measure that will be taken. Investors could be more initiating in suggesting adaptations, also when it is not required by law. By starting conversations with the tenants, consensus can be found in how to approach a certain wish for more sustainability. Getting the tenants around the table will increase their awareness of this topic and could also lead to investment from their side. In addition, other wishes of the tenants, such as improving the indoor climate, may be possible to tackle in one adaptation. Therefore, it is of high relevance to discuss sustainability-related

issues more often and on a more serious note when the aim is actually to deliver a sustainable building.
The property manager is often functioning as a filter between tenant and investor. This can lead to miscommunication on demands or wishes from both parties. Property managers often obtain significant knowledge on the building, its technical state, and the adaptation possibilities. This research suggests, that the property manager could have a more initiating role in fostering collaboration between investor and tenant. A step-by-step plan has been developed which can be used as a guide for this process, see figure 5.1.

Even though this research is mainly focussed on the stakeholders in the operational phase of a building, the findings will also be of relevance to policy makers. The current EPC labelling is known to be not very representative for measuring sustainability. The proposed EPG labelling could have a serious impact on the energy consumption of real estate. However, so far, the legislation has always been focussed on the building characteristics and not on the user of space. The buildings that have been researched show a discrepancy in energy performance compared to their energy label. Even though it is possible that space is being used very efficiently. Therefore, it would be useful to divide the labelling into two parts, the building characteristics (passive consumption) and the user (active consumption). This might stimulate energy-efficient behaviour by the tenants. If the national policy makers aim to lower the environmental impact of the built environment, they should also be more demanding towards the users of space since they cause the actual consumption.

Step-by-step plan

What	How
Step 1 | Mapping The first step is to carefully map the current situation on the building characteristics, the stakeholders, and legislation. Collecting data can be done through monitoring. The findings of the current situation should be shared with the stakeholders.	Energy consumption needs to monitored closely with a high level of detail. Smart meters or other building management system/tools can provide accurate insight into the energy performance. The PM should initiate the application of such devices and the gathering of relevant information on the use of the building.
Step 2 | Awareness Once the current situation has been mapped. The involved stakeholders would need to become aware of the findings on their energy consumption and the possibilities for energy savings adaptations.	During the regular tenant consulting or meetings, the findings on the energy performance should be shared with all stakeholders. The different stakeholders can reflect on their level of awareness and current performance. Also, visions per stakeholder on how to move forward should be shared during the tenant meetings so that everyone is aware of the attitude related to this topic. This might be led by the asset or property manager.
Step 3 | Discuss & Aim This step entails the collective aim for a proposed solution to mitigate the energy performance gap. The interest of the different stakeholders should be aligned to come to a consensus on which adaptations are required.	In the follow-up meetings with all stakeholders, the aim of the adaptations can be discussed. In an open, collaborative session, all stakeholders can share their vision on the proposed adaptations by the property manager or specialised third party. The energy savings objectives will need to be aligned to be able to move forward.
Step 4 | Division of costs The fourth step entails the division of costs. The challenge is to come to a consensus on the division of the financial burden related to the adaptations. Consider the risks that are taken and the added value to tenants' satisfaction, to the asset or commercial value for the investor, and the impact of the required works needed by the property manager or a third party. In addition, discuss what-if scenarios related to a lower ROI than expected for different stakeholders.	The division of costs is a rather sensitive topic as all parties would like to have as little costs as possible while receiving the benefits. Therefore, any appearance of a conflict of interest must be prevented. This can be achieved by the involvement of an independent party with no further financial interest in the building. Such a party could advise on the fair division of costs, considering the different horizons of each stakeholder. This step is likely to be time-consuming, and therefore extra meetings should be scheduled.
Step 5 | Implement The next step is to implement the adaptations which were proposed in good collaboration. Consider the possible nuisance due to the adaptations. The property manager should check upon the right implementation or installation of the adaptations. *(continues on next page)*	A third party should execute the actual process of implementation. It depends on the type of adaptations, whether it would be necessary to have a selection process of the third party before the implementation. The PM should be involved in the procurement and executing phase to guard the process made. While the tenant's wishes related to nuisance might have an impact on the planning. *(continues on next page)*

Step 6 | Check Through the year, the benefits of the adaptations can vary due to seasonal differences. The different stakeholders should check for a longer period of time whether the adaptions perform according to plan. If not, further adjustments need to be made.	Once the adaptations have been implemented. It could be the PM's task to check whether the adaptions made are received as expected by the tenants. Any obstacles related to adaptations can be addressed during periodic visits. Besides, the PM should check on the correct installation and use of the made adaptation. Any problems found should be reported and shared with the stakeholder in order to be transparent and obtain more knowledge.
Step 7 | Benchmark Real-time monitoring might be used to indicate the impact of the adaptations. After a year, one could give a profound meaning to the results in benchmarking the energy savings with data from other projects with similar adaptations or by benchmarking the before and the after stage.	A year after the implementation, the effectiveness of the adaptions should be discussed during a regular meeting. By benchmarking the results with the results of several different properties that undertook the same adaptations, meaning can be given to the effectiveness of the adaptation. Especially large property management firms might be able to benchmark performances and achieved savings with other properties. The results could ultimately be shared to foster transparency within the RE sector.
Step 8 | Steer – Maintain On the basis of the benchmarking and the consideration of possible other influencing factors, the actual results can be compared with the expected results. If the performances are in line with the expected savings, stakeholders should put effort to maintain this level of efficiency. If certain adaptations are found to be inefficient, the property manager should steer and assist the involved stakeholder in reaching the objectives.	Depending on the results of the previous step, the different stakeholders could agree to steer or maintain the current situation. When the expected results have not been achieved, the PM could initiate a plan of action to the tenant when it is related to behavioural adaptations, and to the investor when it is related to structural adaptations. By having a discussing on the discrepancy between the actual and expected results, the stakeholders might go back to step 3. If the expected results are achieved, it is the PM task to make sure the adaptations remain effective over the years.

Figure 5.1. Step-by-step process plan to enhance achieving sustainability objectives

5.3 Discussion

In this sub-section, the research findings and the research design will be discussed. Thereafter, the limitation of this research will be given.

Discussions on research findings

Drivers

Several drivers were derived from literature to be of importance for fostering sustainability in the built environment. Different drivers could be distinguished per stakeholder due to the conduction of the case studies. Overall the drivers per stakeholder were found to be relatively similar, which was also expected due to potential interest in certain topics. The potential interest was derived from the general objectives per stakeholder combined with findings in literature. The main driver for investors mitigates the energy performance gap would to meet legislation objectives. For tenants, the main drivers are general lowering the OPEX, increase comfort, or to meet their CSR vision.

Barriers

Due to the ownership of the investor, their role is most powerful when initiating adaptions. As literature also suggested, the split-incentive phenomenon is the most disrupting factor towards energy neutrality. Because of the high costs related to structural adaptations in general, off-cycle adaptions are not preferred by the investor. This is due to the loss of value of their investment because of not using the façade or installations to its full potential. Tenants are often not interested in investing in the property they occupy, which can be considered to be logical because of the rent that is being paid to the investor. In addition, tenants have a shorter commitment to the building due to the period of their rental contracts. Lastly, tenants expect to reside in a properly functioning building.

Adaptations

Structural adaptations to the façade or building envelope are not preferred by the investors due to the high costs. The favoured adaptions would be to upgrade building installations or to implement better monitoring. Better monitoring could create awareness amongst the tenants, which could foster behavioural change. More insight was requested by all tenants.

Legislation

All the building owners were relatively unconcerned about the proposed EPG labelling which in theory could result in their asset to lose value. The property managers mentioned that when an EPG assessment would be in place, they might become the person to steer upon behavioural change when a property is underperforming. Between the two groups of non-compliance in the first or second stage, no significant different vision was shared on the issues regarding a change in legislation. However, some investors suggested that in future legislation, the tenants should also be forced to actively contribute to mitigating energy demands.

Discussion on research design

Literature Review

The conducted literature review provided a solid foundation for conducting this research. Since this topic is closely related to sustainability, large quantities of literature were available. Due to the conduction of this literature review, the most relevant topics were distinguished. By abstracting the essence of literature, eventually, a theoretical framework was developed which was used for conducting the semi-structured interviews, which was found to be relevant and useful.

Case study

In order to conduct this qualitative research, a case study approach was chosen to research buildings that were selected through critical case sampling. The cross-case analysis method of Yin (2017) has been used in order to abstract the most essential findings of a topic basis. The findings can be found at the beginning of this chapter. It was not always possible to draw general conclusions per topic since the answers were

diverse. However, this method provides well-structured guidelines to evaluate large quantities of qualitative data.
In order to obtain more insight on a building level, several building characteristics were collected. The gathering of these characteristics mainly provided a better understanding of the energy performance of the building. Based on the number of cases and the heterogeneous character of each building, no general conclusions could be drawn based on this analysis.
The interviews that were conducted provided substantial quantities of useful information for this thesis. Since most of the interviewees were experts in the domain of real estate, the conversation could go in-depth. A lot of interesting information was provided. However, not all of it would be of relevance to this research. Also, the conducting of the interviews enabled visits to each of the case study objects.

Limitations

As stated before, the nature of this study is qualitative. As a result of this qualitative character of the research, a research method was selected that would enable the collection of qualitative data. In order to obtain a better understanding of the phenomenon, a of case study method was selected.
Due to data availability, only a part of the Dutch office stock could be analysed in order to find suitable case study objects. This means that a part of the Dutch office stock has not been taken into consideration, which could possibly have resulted in different findings.
The conducted interviews were all based on the semi-structured interview proforma that has been developed. As a result of this type of interviewing, different follow-up questions have been asked as a reaction to the interviewee's answers. This could have resulted in the omitting of relevant information. The interviews themselves were held in Dutch, which might result in information being lost in translation. In addition, the processing of the provided data has been conducted with the greatest possible care but could still have resulted in an incorrect conversion.
The research has been conducted with different stakeholders from different companies. An exception to that is that all the property managers that were interviewed were working for CBRE. Preferably this should have been avoided to minimise the risks of advertising, incentivising, and avoidance of bias.
When this research was initiated, the EPG was scheduled to be introduced in 2020. However, along the process of this research, the EPG has been postponed for an unknown period of time. This could have had a major impact on the answers provided by the stakeholders, especially since the postponement mitigates the urgency and relevance of this topic.
Lastly, the service costs were not available at the moment of collecting the data on the building characteristics. Therefore, no complete indication could be given on the total costs of occupancy.

6 | Conclusions & Recommendations

6 | Conclusions & Recommendations

The aim of this chapter is to provide conclusions and further recommendations derived from the conducted research. The first part consists of the main conclusions that can be drawn from the literature study, empirical research, and analysis. The second part provides recommendations for further research.

6.1 Conclusions

The aim of this research was to obtain more insight into the actual energy performance in relation to the granted energy label of office buildings in the Dutch stock. Previous research indicated the presence of an energy performance gap for energy label A and B buildings related to their actual gas consumption. In order to achieve the objectives of national and international climate agreements, it is of importance to research the sustainability levels in the existing stock. Therefore, the current report is focussed on how adaptations to the existing stock might have an impact on the level of sustainability and what the role different stakeholders play in mitigating the energy performance gap. The methods used in the current report consisted of a literature study, empirical research (i.e. four case studies of buildings), and a cross-case analysis. The case study office buildings were: Infinity, Adam Smith Building, Casuariestraat 5-35 and Beechavenue 102-120. Below, an in-depth discussion of the main conclusions is presented.

One of the objectives of this research was to deliver a framework or a step-by-step plan that enables stakeholders during the process of fostering the energy performance of their office building. The proposed step-by-step plan can be considered to be one of the key deliverables of this thesis, which can be found in sub-section 5.2. The step-by-step plan clearly indicates the 'what' and 'how' of the collaborative process of aiming for higher levels of sustainability within the existing office stock. The eight steps to be taken derived from this research are as follows:

- Step 1: Mapping the current situation
- Step 2: Create awareness amongst all the stakeholders on the performance
- Step 3: Discuss & aim collectively for a certain level of energy reduction
- Step 4: Division of costs amongst the different parties
- Step 5: Implement the suggested adaptations
- Step 6: Check whether the adaptations performing as expected
- Step 7: Benchmark the year result with comparable projects
- Step 8: Steer or Maintain

For this research, the main drivers for implementing adaptations towards more sustainability were mapped for the investor, property manager, and tenant. Striking was that only one of the twelve interviewees, the tenant of case 1, mentioned energy savings on its own as a driver while the other interviewees often referred to the financial benefits in terms of increase of rentability, asset value, competitive advantage, and lower OPEX. In addition, national legislation has a major impact on the investor's and property manager's attitude towards implementing measures. The threat of legal obsolescence

can be considered to be the main driver for them, while tenants mostly mentioned their CSR-vision and higher levels of comfort as an essential driver.
The main barrier to implementing structural adaptations is the divisions of costs amongst the different stakeholders. Typically, the investor would need to invest in structural adaptations, which will only partly reflect in the asset value while the tenant benefits from the lower OPEX. The lack of legislative demands and the split-incentives can be considered as main barriers for investors to implement structural adaptations. The role of the tenants is of significant importance since they are the only group to execute behavioural adaptations. However, all tenants are only provided with a yearly overview of their energy consumption through the service costs. In order to steer upon behavioural adaptations, real-time monitoring was mentioned to be essential by all tenants. The investors acknowledged that they are the ones that should provide this more detailed insight into the energy performance, which therefore seems to be a logical next step to take in the process of mitigating the energy performance gap.

In order to obtain more insight on a building level, several building characteristics were collected and analysed per case. In the analysed cases, the gas performance gap accounted for 1,1% to 1,65% in relation to the rental costs, which is remarkable since the rental prices varied between €130 and €350 per m2 per year. Based on the interviewed tenants, one might conclude that the energy performance gap costs of 1,65% in relation to the rental price is negligible for tenants to be actively demanding or steering towards more sustainability. Another conclusion from the studied objects is that there seems to be a correlation between the size of the performance gap and the opening hours, amenities, and size for the office building. The first and second stage non-compliance cases groups showed several similarities in size, facilities, and office hours. Wherein, more extended than 'regular' office hours resulted in a discrepancy of approximately 65-95% while the regular office hours cases showed an approximately 39% discrepancy compared to the energy label.

From the literature review, several drivers and barriers were distinguished related to making sustainable adaptations to the existing stock. Most of the drivers and barriers were also found during the empirical part of this research related to the mitigating the energy performance gap. The most crucial driver for the investor and the property manager is considered to be the threat of legal obsolescence since this would negatively impact the value and cash flow from the building. In addition, increasing the tenant satisfaction, rentability, commercial value, and the vision of the investing fund were found to be important drivers for the investors. The most mentioned barrier is the split-incentive phenomenon, which can be challenging to overcome. According to some investors, in good collaboration with the tenants, it is possible to redirect some of the costs to the tenant in order to make off-cycle adaptations. For tenants, the most mentioned drivers were lowering their OPEX, CSR, and enhancing the level of comfort. Therefore, the main challenge would be to find adaptations that are favoured by both parties so that the financial burden can be shared.

Nowadays, aligning the visions of different stakeholders remains challenging and especially when trying to break the vicious circle of blame. Most tenants are driven from their CSR-vision and the reduction of OPEX to invest in sustainable adaptations that could result in less energy consumption. The savings through behavioural adaptations and finetuning the current systems and/or installation could potentially result in savings of over 20% (Interviewee 1, 2019). However, to be able to steer on behaviour and to be able to finetune the current system, accurate insight on usage and performance is missing to justify actions from any stakeholder. All tenants would like to have transparency on their OPEX by obtaining more insight into their actual energy performance. Once this insight can be obtained, the tenant could become more aware of its own consumption and possibly implement adaptations. There is a significant role for the investor to provide more insight into the energy consumption, which is becoming easier to facilitate due to technological developments. Even though the investors currently miss a financial incentive to lower their actual consumption, they were all found to be aware of the saving potential of behavioural change and their duty to provide a higher level of insight. Since property managers aim to satisfy both tenant and investors in reaching their objectives, they could take a more initiating role in making sure the demanded level of insight can be obtained and provided to the tenant.

Regarding the structural adaptations, mostly adaptations to the installations, such as heating and cooling systems, were found to be favourable from the investor's perspective. According to two of the four investors, their tenants do not explicitly demand higher levels of sustainability, but they do demand higher levels of comfort. Due to the absence of a demand for more sustainability by these tenants, the investors found themselves unable to implement structural adaptations since the tenants are not likely to pay a part of the investments even though the tenants would benefit the lower OPEX. However, there seems to be potential in getting these types of tenants on board to partly invest when higher levels of comfort and sustainability can be obtained through the same structural adaptions that would be implemented. All investors mentioned that off-cycle adaptations are not preferred since it results in loss of value. If partly redirecting the costs to the tenants would be possible, in general, the investors were found to be willing to think along on further improvements to the building's installations or the façade. Regarding the structural adaptions, the property manager could have a more orchestrating role in collecting the specific demands from the tenants and redirect them to the investor, followed by a proposal on the preferred structural adaptations.

All the investors mentioned that the possibility of legal obsolescence of their assets is considered to be the main driver for implementing adaptations to reduce the energy demand. Regarding the proposed EPG, none of the investors were concerned that this new method of assessing would lead to the threat of legal obsolescence, either because of their short-term scope and selling intentions, their planned replacements maintenance, the still long-lasting validity of their label or by the fact that their stage of non-compliance would be too far in the future. Apart from that, in the current labelling system, the full responsibility of mitigating carbon emissions in the built environment is transferred to the investors. They considered this to be unfair since they have to invest in the CAPEX but

will not benefit the results in lower OPEX. Besides, they consider themselves to have minimal steering possibilities in influencing the tenant's behaviour and consumption. At the same time, tenants often lack awareness of their performance and have little knowledge of real estate related issues such as sustainability and possible adaptations.

In order to give meaning to the value of specific adaptations, it would be of high relevance to benchmark the accomplished savings of this specific adaptation to test its effectiveness. Even though buildings are unique objects and differ in their characteristics, it could be of use to have clear benchmarking on saving potential to convince tenants and investors to contribute or to stimulate behavioural and structural adaptions. Despite the potential of creating a more transparent real estate sector, one should be aware of the possible constraints regarding sharing information on energy performance due to privacy-related matters. As mentioned earlier, there is a demand for more transparency on the energy consumption by the tenants, so a logical step would be to facilitate this.

Summarising, as every building in each case study is unique and depends on a variety of factors such as location, type of tenancy, and architectural design, it can be challenging to draw general conclusions on the building characteristics. However, the findings clearly hint on a correlation between long office hours, amenities, size, and the level of discrepancy between the actual and theoretical consumption. The national legislation has a relatively great impact on the pace of transferring towards a more sustainable office stock in the Netherlands. At this stage, the proposed EPG is not concerning for the investors or tenants since the enforcement has been postponed. However, the main drivers for implementing adaptions towards sustainability remain legal obsolescence, rentability, tenant satisfaction, lowering OPEX, adding value to the asset, CSR-vision, and comfort. While the division of CAPEX and OPEX is considered as the main barrier. In general, structural adaptations are considered to be promising by all stakeholders. However, often, the end of the technical lifespan has not been reached yet, which withholds investors from implementing certain adaptions. In theory, behavioural adaptations are promising, according to most stakeholders interviewed for this research. The challenge is to provide transparency and insight into the actual energy performance of the buildings. Implementing real-time monitoring would help to create awareness, to steer on behavioural adaptations. In general, the investors were found to be well-willing to invest in better monitoring to stimulate behavioural adaptations. Besides, property managers could have a more informing or consulting role in order to stimulate collaboration between tenants and investors in creating a more sustainable office stock.

6.2 Recommendations for further research

Based on the findings derived from this research, further research might be conducted on several themes and topics. These topics will briefly be explained.

The current report provides insight into the current energy performance of the Dutch office stock in relation to the current and proposed legislation. However, the exact assessment method of the proposed EPG remains still unknown. Therefore, further research should be conducted to the precise content of the new assessment methods on how this would differ from the current legislation and the effects on the labelling.

Another trend is to eliminate the use of gas in the built environment. This development is likely to have a major impact on the energy consumption of the existing stock. In addition, major structural adaptations will need to be implemented in order to facilitate the switch to electric heating. Further research on this topic in relation to the energy demand and the performance gap will be useful.

Behavioural adaptations were often mentioned to be promising when insight on the energy performance can be obtained by the tenant. Further research could focus on what specific insight would be required to fulfil the tenant's needs.

This research focussed on the Randstad area in the Netherlands. Researching this topic on a national or even international scale might provide new insights. These insights could also be of use for policy makers to be able to set up a more accurate assessment method.

In order to be able to mitigate the performance gap, possible adaptations and their savings will need to be researched more precisely. When more insight is obtained on potential savings and costs, stakeholders can more carefully weigh the pros and cons of the adaptions.

Reflection, References & Appendices

Reflection

In this chapter, a critical reflection is given on the conducted research and the process. This reflection will provide more insight into the challenges that were faced during the research. Besides, this reflection elaborates on the research topic, the used methodology, and the outcomes of this thesis.

Topic selection

The reason for researching the mitigation of the energy performance gap in offices was that I would go in-depth on the topic of sustainability in combination with the challenges of adapting the existing stock. Personally, I am very interested in the energy transition that is going on and the role that real estate could play in contributing to the achievement of the stated climate agreement objectives. So far, I was mostly interested in the development of new technologies that would make new buildings even more energy efficient. However, considering the slow replacement rate of buildings, I became very interested in contributing to the body of knowledge on how to create a more sustainable office stock. Initially, I was considering combined research on the possibilities of smart tools in fostering energy efficiency since this was also a topic of interest to me. However, regarding the scope of this research this was found to be too extensive which has been a good decision when looking back. Also, I liked to research a topic that could be of relevance for practice and possibly could be combined with gaining experience in practice. When looking back, I might have consulted people from practice at an earlier stage to discuss the relevance of the proposed topic as I found out that most companies were more interested in the research to BREEAM certifications. Also, the unforeseen postponement of the EPG labelling made this topic less relevant for now, which is unfortunately insurmountable.

Research Aim

In general, this research aimed to contribute to the body of knowledge and to have applications possibilities for practice. One of the initial deliverables was to set up a framework based on the level of underperformance, which would suggest what adaptation would be most realistic in a certain situation. Along the way, I found out that the adaptations possibilities are limitless and that there is very little insight into the actual effectiveness due to the uniqueness of each building. Also, it would require a lot of quantitative data to be able to develop a reliable model for practice, which is not openly available or easily accessible. Therefore, the aim has been adjusted to a more qualitative and managerial research. The new aim was to map the different stakeholders' attitudes towards behavioural and structural adaptations concerning legislation and their role in the built environment. This resulted in a switch to a qualitative research methodology, namely the conduction of case studies. When looking back, I think the adjustment of the research aim was wisely, and better fits this master track. Even though I found it a pity not to be able to map the actual saving potentials of the adaptations. Due to the adjustment in the aim, the deliverables from this research have a more managerial tone than initially planned.

Research methodology

As mentioned, the research aim and the expected deliverables have slightly changed over time due to the scope of this research. The initial adaptation framework would have required more quantitative input to provide general solutions to certain levels of underperformance. However, since the aim and deliverables have been changed, a different methodology would better find this research, namely a literature study and the conduction of case studies.

The literature study is an inevitable first step for every academic research. As I was struggling a bit in pinning down the exact scope of this research, the initial literature study was extensive. I had the idea that I to obtain much knowledge that might be considered background knowledge in the first place. Therefore, it took quite some time to start writing my theoretical underpinnings since I always like to have a clear overview before I start typing. There was plenty of interesting literature on the topic of sustainability, but it was sometimes hard to evaluate whether literature could be of use in a later stage. When redoing the literature study, I would more precisely keep track of all the consulted literature as I was struggling to get an overview. Also, having a more specific scope of the research would have made the literature study more efficient.
The case study method of Yin (2014) was chosen for conducting this research and was found to be very useful to capture the essence of the answers provided by the interviewees. The collection of building characteristics helped to obtain a better understanding of the building, which was of use during the interviews. The collection of this data was rather time-consuming but very important for mapping the energy performance gaps. Even though it was challenging to arrange all the 12 interviews in time, the input from the interviews has been an invaluable source of information. Thereafter, the cases were cross-case analysed, which eventually enabled me to translate the essence of the input into the findings, develop the step-by-step plan, and draw conclusions.
The semi-structured interview protocol has been developed based on the topics derived from literature. When looking back, the interview protocol has been handy for obtaining the required insights. However, most tenants were not really informed on the issues related to this research, which is logical since it is not their daily business. If I could redo the conduction of the interviews with the tenants, I would have informed the tenants more extensively on the research so that they could prepare themselves better and formulate opinions upfront. However, the conduction of the study has led to invaluable information on the stakeholders' attitudes towards the researched topics. In general, I would certainly recommend this method for conducting case studies, and I would use it again if applicable since this method enables us to make very complex information insightful.

Research results
The research results derived from the theoretical and empirical research could be of value for both academics and practice. The results of the research provide more insight into the preferred adaptions of the different stakeholders. I would have liked to get more specific on the actual adaptations that could be implemented per case study object since this could be of value for these buildings in practice. However, collecting information on certain adaptations, the costs, its effectiveness was out of scope for this research. Therefore, the results are more focussed on the stakeholder's attitude towards certain types of adaptations and their driver and barriers to improving the energy efficiency of the existing stock. It was a pity to receive the message the introduction of the EPG assessment method per 2020 had been postponed. The introduction would have increased the relevance of the research and by that its outcomes. Due to this postponement, it became a rather theoretical research on the possible impact on the situation in case of this legislative change. However, a different labelling method will replace the current one soon. Therefore, this research and its results might be still beneficial to policymakers and other stakeholders. The step-by-step plan could help stakeholders in addressing the issues related to the energy performance gap. Even though I hoped my research could have more added value, I think this research is of value regarding some interesting results and provides useful recommendations for practice and further and possible further research.

Research process & collaboration

The research process went with ups and downs. I found some difficulties in pinning down the exact research questions. Therefore, the literature study was initially too broad, which stagnated my writing progress. At my P2 presentation, I had a more precise plan, but my methodology was still lagging behind and I was not yet ready to conduct the research. Also, I had some difficulties finding a company that could help me providing me with the required data on the actual energy performance, which was concerning me at that time. After some weeks, I was able to reach an agreement with CBRE on the collaboration for this research combined with a job as a working student for two days a week. This job, in combination with the obligations of a committee, I was a member of resulted in only little time to spend on my thesis. When looking back, I should have minimised my time related to these activities as my thesis would need full attention. At the first P3 moment, we decided that it would be wise to postpone the P4 moment with one quarter as my planning would be too tight to deliver a proper qualitative thesis. As I continued working on my thesis, I was able to make quite some progress during the summer. The collection of data was time-consuming since many different employees within CBRE had to be consulted. Also, getting permission to interview tenants was stagnating the conduction of interviews. Since nobody was assigned within CBRE to assist me with my research, finding the right person was sometimes difficult. When looking back, I would not do this the same way since I would recommend a higher level of involvement from the company itself.

At the second P3 moment, I only conducted one-third of the interviews, which was worrying considering the planning. Since then, I decided to 'cut the middle man' in setting interviews, and I directly approached the interviewees since I was determined to get a 'Go' at the upcoming P4 assessment. Luckily, all remaining interviewees were able to meet in the short-term, which enabled me to conduct all the required interviews in time. This stimulated me to work extra hard to get everything ready for the p4 assessment and, ultimately, this final report. When critically reflecting on my process, I should have been stricter to myself in setting deadlines for planning interviews or finishing certain chapters. This would enable me to get feedback earlier and improve my work even more. Despite the postponed and the less specific outcomes I initially thought this research would have, I am delighted with the final report and the findings. The feedback during this trajectory has helped me to improve my work and to push for a bit more. Even though I aimed to deliver a more specific framework on particular adaptations and their impact on the energy consumption, I hope that the conclusions and step-by-step plan of this research can benefit the different stakeholders in mitigating the energy performance gap.

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Images

Cover image retrieved from: https://www.dearchitect.nl/projecten/arc18-blaak-16-dzap

List of Interviewees

Interviewee number	Function	Company	Type
Case 1 – Infinity			
Interviewee 1	Direct Projects	CBRE GI	Personal
Interviewee 2	Facility Coordinator	CBRE GWS	Personal
Interviewee 3	Head of Facilities	IMC Trading	Personal
Case 2 - Adam Smith Building			
Interviewee 4	Asset Manager	Confidential	Personal
Interviewee 5	Technical Manager	CBRE Advisory	Personal
Interviewee 6	Interim Director Facilities	ACN Europe	Personal
Case 3 – Casuariestraat			
Interviewee 7	Technical Asset Manager	Catella	Personal
Interviewee 8	Technical Manager	CBRE Advisory	Personal
Interviewee 9	Senior Consultant	DGMR	Personal
Case 4 - Beechavenue			
Interviewee 10	Asset Manager	Confidential	Personal
Interviewee 11	Technical Manager	CBRE Advisory	Personal
Interviewee 12	PA & Office Manager	Basefarm	Personal *

*Expect for this interview, all interviews have been recorded

Appendix A: Buildings Characteristics

Part 1. Building Characteristics - 'name property'

Case Study number	**#**
Date	**07-2019**
Data Source	**CBRE B.V.**
Classification	**# performs as #**

Theme	no.	Topic	Answer
General	1	Property name	
		Address	
		City	
		Total m2 of property	
		Year of construction	
		Rental price per m2 per year	
		Image	
Stakeholders	2	Tenant	
		Property Manager	
		Investor	
Energy & Costs	3	Annual electricity consumption (kWh)	
		Annual electricity consumption per m2 (kWh)	
		Annual natual gas consumption (m3)	
		Annual natual gas consumption per m2 (m3)	
		Total kWh per m2 per year	
		Current EPC label	
		Label valid till	
		Theoretical electicity consumption/m2/year (kWh)	
		Theoretical gas consumption/m2/year (m3)	
		Performance gap of electricity (%)	
		Absolute performance gap gas/year (m3)	
		Absolute performance gap gas/m2/year (m3)	
		Performance gap of natrual gas (%)	
		EPC label based on actual gas consumption	
		Service costs per m2 per year	
		Costs electricity/year	
		Costs gas/year	
		Cost of gas performance gap/year	
		Costs of gas performance gap/m2/year	
		Total energy costs per m2 per year	
		Percentage energy costs of service costs	
Use	4	Tenant's business activities	
		m2 in use by tenant	
		Average office opening hours a week	
		Number of workplaces	
		Number of employees	
		m2 per employee	
		Occupancy rate	
		Type of HVAC	
		Business activities other tenants	
Adaptations	5	Recent energy saving measures	
		Planned interventions	
		Possibilities for energy reduction	

Appendix B: Interview Proforma

Introduction of interviewer

First of all, welcome to this interview. I would like to thank you for participating in this research.

I will shortly introduce myself. My name is Otte van der Pluijm and I am a graduate researcher at the TU Delft at the department of Real Estate Management. I am conducting a research to the energy performance of office building in the Netherlands. The purpose of this research is to obtain a better understanding on what can be done to mitigate the discrepancy between actual and theoretical energy consumption of an office building.

You are invited to take part in this research because of your experience in one of the case studies I am using for this research.

Before I start with this interview, I would ask your permission for this interview to be audio recorded. The recording will be used for transcription purposes and gathering the core information from the answers provided. The recordings collected of the interview are strictly confidential and will not be distributed to other parties. Also, all the answers will be presented anonymous in the final report.

At the end of the interview you have the opportunity to leave comments and questions regarding the interview and research.

Thank you very much for your collaboration and effort!

Kind regards,

Otte van der Pluijm
Contact: o.vdpluijm@gmail.com

Semi-structured Interview proforma	
Name Interviewee	***
Function	***
Name Interviewer	***
Date Interview	***

(Name case study building)- Case #

Question	no.	Theme
		General
question	**0**	Can you please introduce yourself and can you explain your relation to this property?
answer		
		Insight into energy performance
question	**1**	Who and how do you have insight into the energy performance of this property?
answer		
		Structural adaptations
question	**2a**	How do you think structural adaptations, to the facade or installations of this building, can enhance the energy efficiency of this building?
answer		
		Structural adaptations
question	**2b**	What would be your preferred structural adaptations and why has this not been implemented yet? What would be the expected energy saving (in the percentage of overall energy saving)?
answer		
		Behavioural adaptations
question	**3**	What role can behavioural adaptations play in order to enhance the energy efficiency of this property from your perspective?
answer		
		Drivers for adaptations towards sustainability
question	**4a**	Why would you take energy savings measures and what kind of measures would be preferred?
answer		
		Drivers for adaptations towards sustainability
question	**4b**	To what extent does a sustainability measure need to be financially feasible and how should the financial burden be divided among stakeholders?
answer		
		Barriers for adaptations towards sustainability
question	**5**	What would you consider to be the most important barrier in investing/stimulating sustainability measures?
answer		
		Stakeholders view on current and future situation
question	**6a**	How do you think national energy policies will influence the energy performance of utility buildings at this moment and in the future?
answer		
		Stakeholders view on current and future situation
question	**6b**	Is enhancing the energy performance a priority to you and where do you see room for improvement in mitigating the energy performance gap and how would the process look like?
answer		
		Preferred adaptations
question	**7**	What would be your preferred/suggested adaptation for this office building and what is required in order the implement this to get the energy performance in-line with the energy label?
answer