Challenges for offices' implementation of energy saving PropTech

L.J.A. Buter

Challenges for offices' implementation of energy saving PropTech

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By

L.J.A. (Leon) Buter
4621611

Graduation committee:

Chair:	P. (Peter) Koorstra
First mentor:	Dr. I. (Ilir) Nase
Second mentor:	Dr. A. (Andrea) Mauri

TU Delft Delft University of Technology

"It is not the strongest of the species that survives, nor the most intelligent.
It is the one most adaptable to change."

Charles Darwin

Preface

Before you lies my thesis 'Challenges for offices' implementation of energy saving PropTech'. This thesis has been executed by researching the drivers and barriers between the involved stakeholders that currently lead to the (non)implementation of energy saving property technology. This thesis has been written as a final work for my master Management in the Built Environment at the Technical University of Delft, the Netherlands. From February 2019 until November 2019 I have been working on this research.

In 2012 I started my university career with studying 'Urban Planning' at the University of Amsterdam. Because I wanted to continue learning, was looking for a new challenge and developed more interest in real estate, I went to the TU Delft. I found the challenges I was looking for and in three years I have learned a staggering amount of information. During my years of study I have developed a strong interest in the world around us. In this thesis I was able to combine my curiosity for technology and innovation with research for a more sustainable world.

The design of this research was executed at the TU Delft, during the executing I have worked at Cushman & Wakefield at the department Real Estate Strategy & Innovation with great pleasure. I want to thank my initial first mentor Drs. Philip Koppels to help me set up this research and I want to thank my second first mentor Dr. Ilir Nase who showed me the way to finish this research. My second mentor Dr. Andrea Mauri was always there for me and from his own field of knowledge he has enriched the sharpness this research. At Cushman & Wakefield I want to thank the head of my department Elsbeth Quispel for giving me the chance to execute my research and work along on some very interesting projects. And thank you, Luc van de Boom for the help, guidance and explanations. Furthermore, I want to thank all the interviewees who helped me gather all the information needed to write this thesis.

Lastly I want to thank my family, girlfriend and friends who have always supported me throughout the years and gave me strengths to complete my years as a student.

Abstract

The goal of this research is to describe the drivers and barriers of stakeholders that result in the (non)implementation of NEST's (New Energy Saving Technologies) in Dutch office real estate. The energy consumption in offices is determined and what NEST's are available in the Netherlands. The fund manager, property manager, the tenant(s)/users and their relationships are researched resulting in an overview of their drivers and barriers. Next, the EFOPC's (Energy Focussed PropTech Companies) are analysed and how they work together with the different stakeholder at the demand. Finally flowcharts are presented for each stakeholder to ensure the implementation of NEST's. This explorative research makes use of twelve semi-structured interviews at the demand and supply side to acquire in-depth understanding of their drivers and barriers. Next to saving energy, NEST's provide MPB's (Multiple Project Benefits) for multiple stakeholders. These hard to quantify benefits provide the basis for the necessary collaboration between stakeholders to successfully implement NEST's.

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1.0 Introduction

This first chapter presents insight into the current problems concerning the energy consumption of Dutch offices and its role in the climate change. It provides a picture of the focus to lower this energy consumption and the position of technology to support endeavour. The research questions are structured on this basis and finally a methodology is presented showing the steps how this research was conducted.

1.1 Problem statement

Climate change is happening and one of the causes is a rising concentration of greenhouse gasses in the atmosphere. These greenhouse gasses have many sources, but one of the most important sources is the built environment. Worldwide, buildings uses 36% of all energy and is responsible for 39% of all energy related CO_2 emissions (UNEP, 2017). The Dutch built environment also uses 36% of the total energy use in the Netherlands with a large potential for energy savings (RVO, 2017). Global efforts to reduce the emission of CO_2 resulted in the 2015 'Paris Agreement'. This agreement calls for zero net anthropogenic greenhouse gas emissions to be reached during the second half of the 21st century to ensure global warming stays under 2 °C Celsius compared to pre-industrial levels (UNFFC, 2015).

To meet the 'Paris' agreement of 2015, the Dutch government is looking to transform the real estate stock to meet Dutch greenhouse gas targets. Currently they mainly focus on the physical elements of offices, by demanding that all buildings have an energy label. Based on the physical elements like insulation, window glass, lighting and the installations this office acquires an energy label (G - A++++). The idea is that better (energy) performing of these physical elements will lead to a lower energy use, and so an office gets a better energy label. The Dutch office stock is 'Paris proof' when all offices have a A++++ label (Van de Griendt & Timmers, 2018). The colourful energy labels are meant to make people aware, are easy to communicate, compare and to base regulations on. A Dutch regulation obliges offices to acquire an energy label of C (or better) before 2023. When not complying, they may not be used as offices anymore. At this moment, two-thirds of the offices does not comply (Westerveld, 2019). Figure 1 shows the impact of the 2023 target, a potential A-label for 2030 and the 'Paris' goal for 2050 on the total energy use of all the offices in the Netherlands. Under current and expected legislation the energy consumption will not decent fast enough.

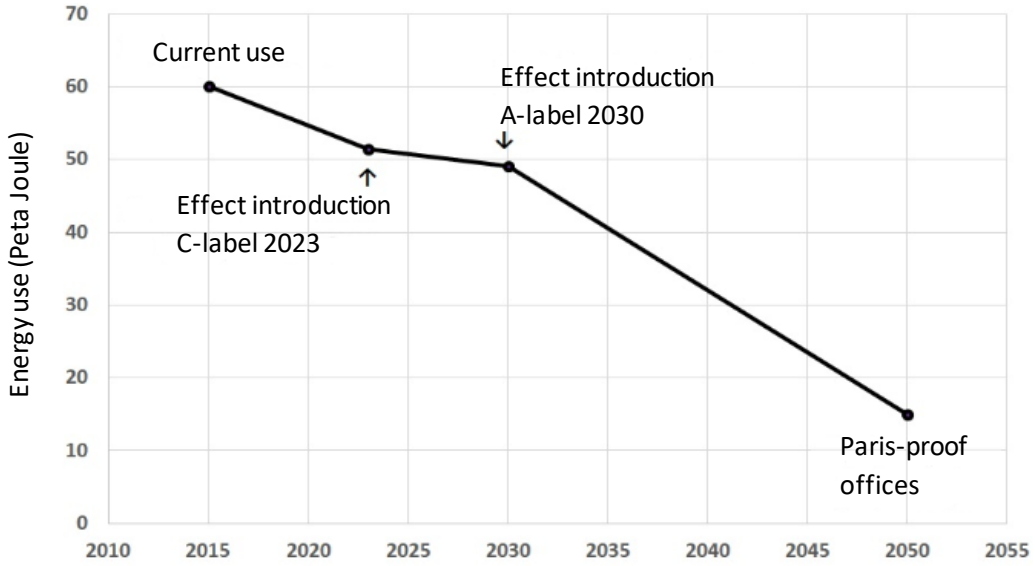

Figure 1: effects of legislation on the energy use of Dutch offices (own figure after Van de Griendt & Timmers, 2018).

One of the main critiques is that energy labels are not based on an office's actual energy use, or kWh's per square meter, but are mere assumptions. Research has shown that these assumptions do not stroke with reality and 'energy efficient' buildings use more energy than presumed. In 2014 Majcen & Itard found that Dutch social rental houses don't perform in gas and electricity use as their label suggest, and with that, emit more CO_2. It appeared that the way in which people use their energy (in)efficient house had a strong effect on the eventual energy use. Being aware of their energy (in)efficient house makes people nonchalant or careful with the heating and running appliances.

When looking at Dutch offices, research indicated that 65% performed worse than their energy label predicted. Here too, users are appointed as the culprits (Van Giersbergen, De Jong, Elkhuizen & Klaassen, 2017). So, even if all offices will have an A^{++++}label in 2050, the actual consumption of energy could still be too much if the users do not change as well. Both studies concluded that it would be better to base new legislation on the actual energy use of buildings, instead of the prognosed ones based on the designated energy label. Both examples make clear that buildings and its users do not understand each other.

Next to the physical elements and the users of an office who influence the energy consumption, there is a third factor: technology (Baum, 2017). The influence of physical elements and the role of the users have been subject of multiple studies, but the role, position and the way to implement technology has not. Property technology (or PropTech in short) refers to the tools, platforms, apps, websites and other digital solutions for the built environment (Block & Aarons, 2019). In this research, PropTech companies that focus on energy consumption are called EFOPC's (Energy Focussed PropTech Companies) and their technologies NEST's (New Energy Saving Technologies). The focus of this research is on technologies that try to lower the energy consumption in currently existing offices. This is because of two reasons: (1) 90% of the offices today will still be there in 2050, (2) newly built offices already use far less energy because of legislation.

The first goal of this research is to provide an overview of the NEST's that are available for Dutch offices. A second goal is to understand the different stakeholders involved with the implementation of NEST's including their relationships. A third goal is to understand their drivers and barriers that lead to the (non)implementation of NEST's in offices. Finally flowcharts are presented that supports the most important stakeholders on their road to the implementation of NEST's.

1.2 Main- and sub questions

We have to do things differently to combat climate change. EFOPC's and their NEST's are indispensable in this proces. Next to the physical solution, we have to look at PropTech and its innovations to make offices energy neutral. The problem statement in the previous paragraph leads to the main research question: *How can energy saving PropTech be implemented in Dutch office real estate?* The sub questions are:

1. *How is energy used in Dutch offices?*
This is the very basis of this research. It supports the NEST market research and provides the basis to pinpoint the stakeholders in sub question three.

2. *What are the capabilities of NEST's that are available for the Dutch market?*
The available NEST's and their characteristics provides an overview of benefits that could figurate as the starting point of stakeholder collaboration.

3. At *the demand side, which drivers and barriers do stakeholders experience in the (non)implementation of NEST's?*
Based on their characteristics and the available NEST's, their drivers and barriers to (not) implement NEST's are presented and discussed.

4. *What are the barriers to implement NEST's between demand and supply, and how can they be overcome?*
The real estate industry at the demand side and the EFOPC's at the supply side are of a different order, this chapter clarifies their differences and shows the drivers for cooperation.

5. *What can each stakeholders do to ensure the implementation of NEST's?*
Flowcharts are presented for the most important stakeholders with the steps that need to be taken to overcome the barriers from collaborating with other stakeholders.

1.3 Research strategy

Figure 2 provides a visual overview of the research design. The first part of this research consists of a literature review. The implementation of NEST's is seen from the demand and supply sides, this results in two starting points in the literature review. The top starting point is to understand the supply side. The theory behind the energy consumption in offices must be understood and how PropTech targets these energy consumptions. This provides the basis to understand how PropTech can save energy at offices. The lower starting point is to understand the demand side and its relationship with the supply side. The stakeholders involved with the energy consumption of an office including their relations should be clear. Their current drivers and barriers to make use of NEST's are the foundation for solutions to make sure they will make more use of NEST's.

The second part of this research is about data collection. The methodology to select the interviewees and acquire the data is explained first. In addition, a market research on available NEST's for Dutch offices is performed next to interviews with stakeholders on their drivers/barriers for working together with EFOPC's.

Then, the data analysis combines and connects the data from the interviews to answer the research sub questions. One sub question provides input for the next. Finally the findings are connected into flowcharts. All together the sub questions answer the main question of this research.

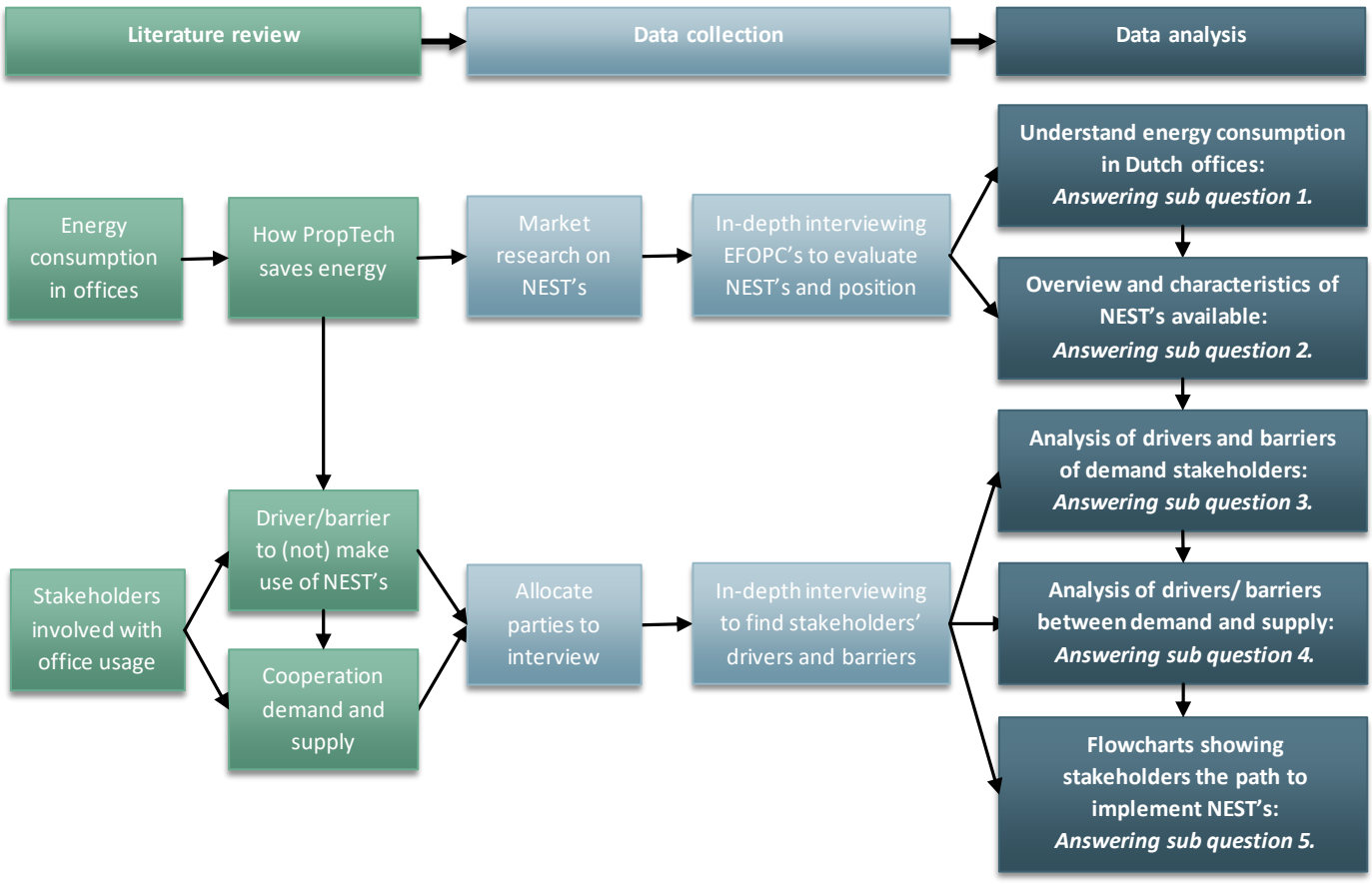

Figure 2: The research strategy applied in this research.

1.4 Relevance of this research

A wide body of knowledge on real estate and its energy consumption has already been built. In addition, there is a lot of research on how buildings can be transformed to be more energy efficient, including the business case behind it. However, most research has been focussing on the physical elements, such new insulation and installations or the influence of the behaviour of the user. This research adds new knowledge on how we can make offices use less energy via technology.

Investigating new ways of energy reduction and understanding the drivers and barriers of the stakeholders provides a new step in becoming 'Paris proof'. By cutting the energy consumption, and so CO_2 emissions, climate change is mitigated. As climate change is besieging our society, this research is also of societal relevance.

No matter what kind of office and energy label one has, using less energy means a reduction of the costs. A tenant or owner might be interested in the overview of energy saving solutions because it might show new ways in which energy (and costs) can be saved. Even if they are not paying the energy bill, it may encourage stakeholders to take up their social or environmental responsibilities. Furthermore, this research provides deep understanding of the interplay between stakeholders and how they can work together to implement PropTech. PropTech companies get a better understanding of how investors and other stakeholders act and what their drivers and barriers are.

2.0 Literature overview

In the previous introduction, several topics for a literature review have been identified. These topics are considered the foundation on which the new knowledge that this thesis produces rests. An introduction to some vital concepts together with in-depth core topics will make new insights meaningful. The literature overview starts with an introduction into the different sources of energy consumption in offices. This is followed by an introduction into PropTech and its ability to save energy at offices. Next is a review on stakeholder management and literature on the most important stakeholders. Finally, the institutional context is discussed.

2.1 Energy consumption in offices

It is clear that offices use a lot of energy. This first paragraph breaks down the processes and influences in an office that determines its total energy consumption. The processes and influences that make up most of an office's energy consumption are the most interesting subjects for PropTech to focus on because this is where most energy can be saved.

2.1.1 Physical elements

As visualised in figure 3, each building has a whole-life costs (WLC), wherein the life-cycle cost (LCC) consists of four phases: construction, operation, maintenance and end-of-life. Green (2009) argues that every phase in the life cycle comes with an environmental cost, including the emission of greenhouse gasses. This research focusses on the use of technology in the operation and maintenance phases (blue block in figure 3).

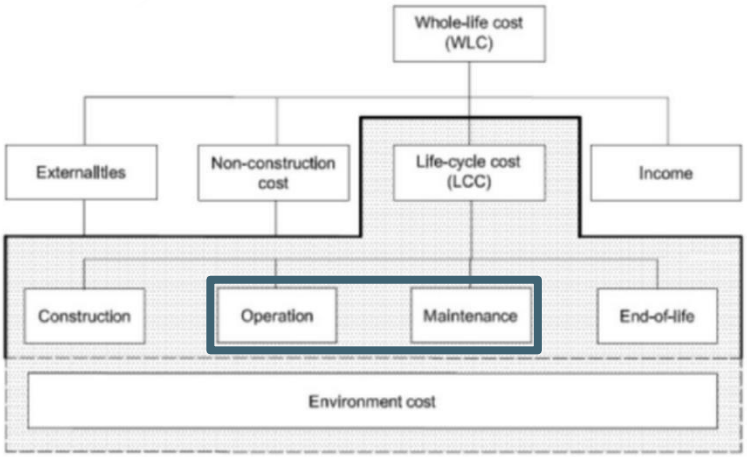

Figure 3: Environmental costs in the WLC (Green, 2009).

In 2003 Scheuer, Keoleian & Reppe calculated that the 75 year long operational phase of a new to build 7300m² university building will account for 96,5% of its total 135x10³ tonnes CO_2 LCC emission. Although the study has been performed several years ago, the operational phase still accounts for a huge part of the total CO_2 emission of the LCC nowadays (Cabeza et al., 2013 p. 402). Cabeza et al. (2013) defined the processes that make up the gross of the energy consumption in the operational phase of an office: HVAC (heating, ventilation and air conditioning), lighting, ICT (running appliances) and domestic hot water. Heating (40%) is responsible for the bulk of the energy used with lighting and ICT in second and third place (see figure 4). Because hot water is only accountable for 1% for an office's energy consumption, it will be left out of this research. When trying to save energy, focussing on these three energy consumptions will make most difference. How much energy the HVAC installations use depends on the insolation of the walls and windows. Eventually, the operational expenses depend on these characteristics, the use of the building plus the level of comfort required by the users (Ramesh, Prakash & Shukla, 2010).

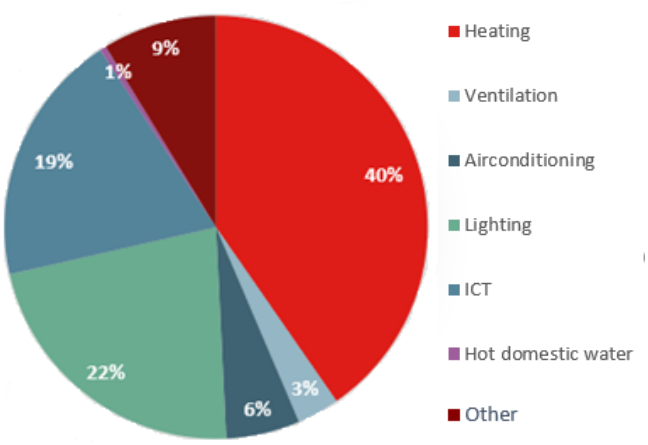

Figure 4: Energy balance in an average Dutch office (based on Meijer & Verweij 2009).

2.1.2 Users

When trying to save energy, at first the focus was to upgrade the physical elements of an office, like its insulation. Later on, the role of the users became clearer. A Finnish research performed by Karjalainen and Koistinen (2007) investigated how people in offices made use of their local temperature control. They found that almost half of the people they interviewed don't use the temperature control at all and the people who do use it experience a variety of problems with the control. User problems with thermal control lead to thermal dissatisfaction, but this also wastes energy. When an user does not understand the heating control or cannot find or reach it, he will open a window when he is hot, instead of turning down the temperature of the heating system.

With separate heating and cooling controls, an user is almost destined to heat and cool the room at the same time. Karjalainen (2007) found afterwards that designers often overestimate the knowledge users possess. This can easily lead to problems with the control and eventually to dissatisfaction with, or even disuse of, the climate system. A broader study on control devices of climate systems by Bordass et al. (2007) shows that controls which are found too complex simply are by-passed. They state that many control systems in buildings 'challenge rather than assist and confuse rather than inform'. Involving the end-user in the design process of control interfaces would end most troubles.

After making sure people know how to use the thermal control, the second step is to make sure the users utilize the systems in an energy efficient way. Providing feedback to energy users has long been regarded as a key mechanism in persuading individual end-users to voluntarily reduce their energy use (Orland et al., 2014). A wide variety of mechanisms from education about energy use to financial drivers and competitions have been used and described in a number of surveys of the field. Studies focusing on energy consumption in office settings report energy savings ranging from 4 to 10% (Carrico & Riemer, 2011; Metzger, Kandt & VanGeet, 2011; Weightman et al., 2012). Orland et al. (2014) identified an increasing emphasis on individual-level real-time and interactive feedback either explicitly or implicitly.

Early strategies comprised the use of explanatory billing and facility-level energy use dashboards. Without this feedback, this communication, the users do not know what processes are going on and how the office is performing. This provides no drivers for the users to utilize the building and the appliances in an energy efficient way. It also works the other way around; an office should know what its users want from it so it can perform optimally and energy efficient.

2.1.3 Summary

Most energy is used during the operational phase of an offices' life cycle, through the interplay between the physical elements and the users. Heating is the largest individual energy consumer, other large consumers are ventilation, air conditioning, lighting and ICT. The users do not know how their office performs, and have difficulties operating the controls for their comfort. This results in installations that are not working (energy) optimal. Providing well working individual-level real-time and interactive feedback to users results in energy efficiency and savings. But even with a focus on both the physical elements and the users of an office this does not mean they are attuned to each other. Figure 5 visualizes that there is still a suboptimal energy performance of that office. PropTech can be an way to optimize the energy performance of offices. The next paragraph describes how PropTech targets the physical elements, the users and their reciprocity (feedback).

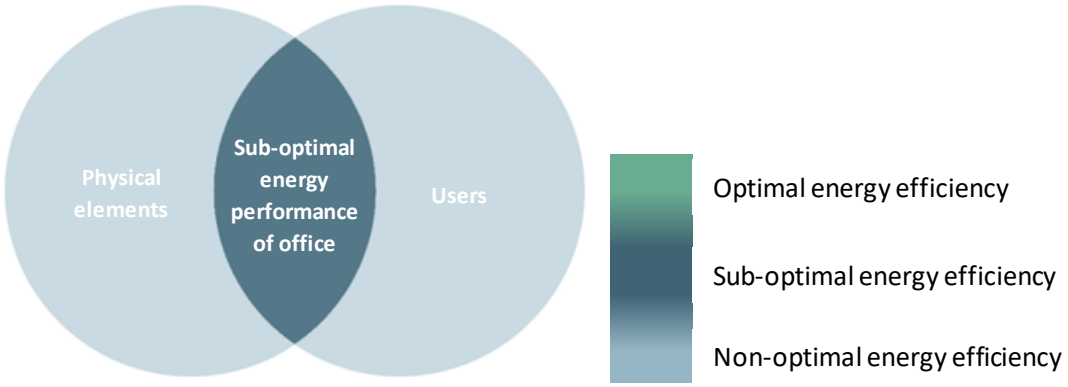

Figure 5: solely focus on physical elements and the users leads to a suboptimal energy performance of an office.

2.2 How PropTech saves energy

After having reviewed the role of physical elements and the users in an office, this paragraph will evaluate the role of technology. An introduction to PropTech is given and its position relative to the physical elements and the users is described. Next, two foundation technologies will be discussed which underlie PropTech with respect to their effect on offices' energy processes. Lastly, positive side effects that come with PropTech will be presented.

2.2.1 Introduction to PropTech

The real estate industry is seen as slowly moving and conservative, but there is a digital transformation going on (Baum, 2017). Technology to make real estate more efficient, effective and streamlined is called Property Technology, or PropTech for short. In the United States, the name CRE Tech (Corporate Real Estate Technology) is used more. PropTech is part of the wider digital transformation of the real estate industry. It describes a movement driving a mentality change within the real estate industry and its consumers regarding technology-driven innovation in the data assembly, transaction, and design of buildings and cities. PropTech refers to the tools, platforms, apps, websites and other digital solutions for the built environment (Block & Aarons, 2019). This technology realizes efficiencies and provides insight in the performance of the office for multiple parties. PropTech is gaining momentum and is expanding quickly. This is notable in different ways, books on the topic have been written, real estate conferences like MIPIM in Cannes and New York or the Provada in Amsterdam reserve an increasing amount of space for PropTech.

The real estate industry did not unleash its own technology potential but was initiated by the faster moving Financial Technology (FinTech) industry. The FinTech industry – in particular, online payment systems, crowdfunding equity and debt platforms and online exchanges – mainly provides the foundation for the PropTech revolution (Baum, 2017). This results in a large class of 'Real Estate FinTech', see figure 6. 'Smart real estate' and the 'shared economy' are the two other main PropTech categories.

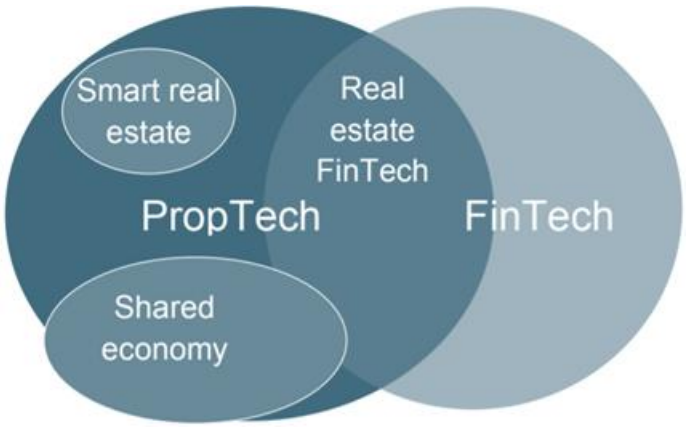

Figure 6: Positioning PropTech (Baum, 2017).

2.2.2 PropTech saving energy

Making buildings more energy efficient is part of 'smart real estate' (Baum, 2017). So, NEST's (new energy saving technologies) with its tools, platforms, apps and other digital solutions are part of the smart real estate category within PropTech. Figure 7 shows how 'smart building solutions' can make a building run even more efficient than the day it was constructed. This applies for the energy efficiency as well, enabled by energy saving technologies.

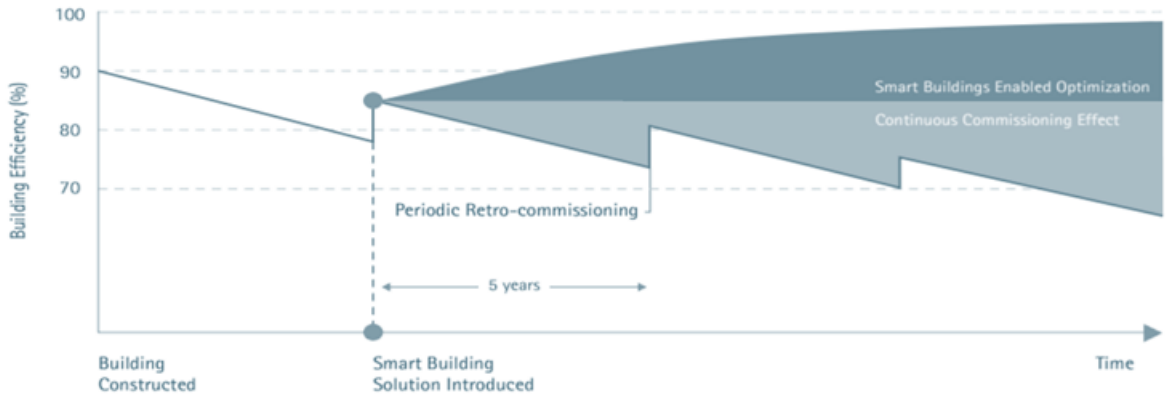

Figure 7: achieving better building efficiency through 'smart building solutions' (Accenture, 2011).

Figure 8 positions PropTech within the relation between the physical elements and the users of an office. To reach optimal energy efficiency for existing offices, the three elements must be energetically well performing on their own as well as within their interrelationships with each other. The physical elements of an office need users that are energy educated and aware of the processes (through PropTech) to be energy efficient. Users need energy well performing physical elements in their offices together with good management and feedback (through PropTech) to be energy efficient. And without good insulation and energy educated users, PropTech can not make that much of a difference in energy consumption. To meet 'Paris', the owner of an office should not focus on just one, two or all three parts, but also on their interplay.

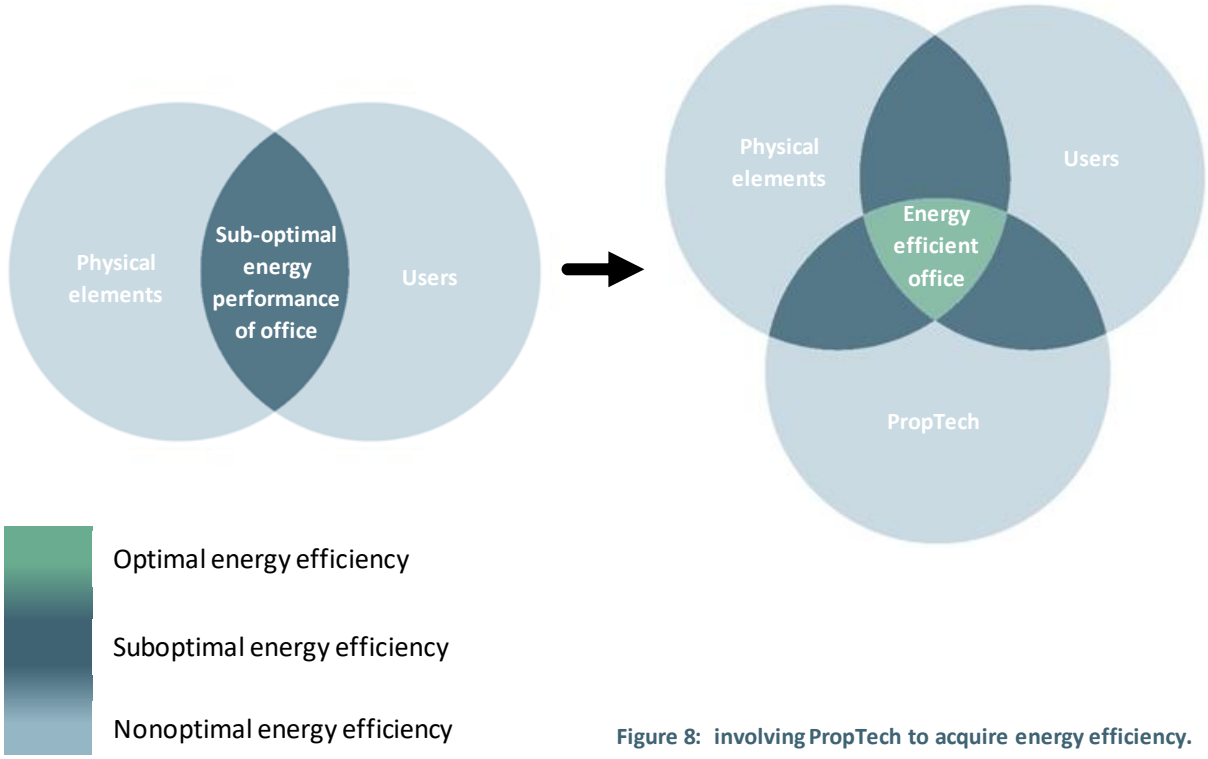

Figure 8: involving PropTech to acquire energy efficiency.

So, to make an existing office an energy efficient office, there should be investments into the physical elements, education & awareness among the users and the implementation of PropTech. Educating the users is mainly the job of the company that is leasing space in that office, but could be in consultation with the owner. The owner is more directly responsible for well performing physical elements and the implementation of PropTech. When a tenant rents space, the owner of that office can not renovate large physical elements as the façade or the installations for example. This intervenes with the contractual agreement of undisturbed renting. The owner has to wait for a so called 'natural moment' when there are no more tenants. Implementing PropTech is less of an intervention and can be installed at a so called 'independent moment', when there are tenants in the building. This is an advantage of NEST's over renovating physical elements. To get an understanding of how NEST's work, the next paragraph describes their fundamental technologies.

2.2.3 Fundaments of NEST's

In the Netherlands, all new offices are required to have a Building Management System (BMS) by law. Older or more basic BMS's only work with the basic processes, such as the HVAC installations and are often limited in functionalities and provide no feedback. This leaves room for inefficiencies and excessive energy consumption. NEST's can make better use of the current available information in the BMS and/or may require the addition of extra information. This information can be about the surrounding of an office, as the weather, or information on processes inside the office, like the amount of people or the temperature. Baum (2017) points out that NEST's make use of two basic technologies, 'Internet of Things' (IoT) and 'Big Data', to 'feel' and use this extra information.

IoT allows connection of everyday things to the internet and is often seen as an enabler for developing new intelligent applications and products. The IoT could be built on the pervasive deployment of a variety of sensors, actuators, mobile phones that are able to interact with each other and cooperate with other products to reach common goals (Atzori et al., 2010). IoT allows objects to be measured (information provision) but also sensed and/or controlled remotely across the existing network infrastructure, creating opportunities to adjust or turn systems on or off remotely. As an example, heating systems can be switched on remotely through a mobile phone app (Baum, 2017).

Big Data is the ability to process large amounts of data and to extract useful insights and products from it (Bilal, Oyedele, Qadir et al., 2016). There are various techniques to produce and spread these insights and products, for example, Artificial Intelligence (AI), Data Analytics (DA), Predictive analysis (PA) and Machine Learning (ML). Examples of applications include tools to support property management by quantifying a building's data (energy consumption, water consumption, etc.) and building inspection platforms (Baum, 2017).

IoT and Big Data are complementary trends, where the former generates large volumes of data via sensors and connectivity, the later stores and analyses this data (Bilal, Oyedele, Qadir et al., 2016). The other way around, an useful application of Big Data and its analytics would not exist without the feed of data from IoT. Wei & Li (2011) made a systematic scheme on how they perceive a Smart (they use the word Intelligent) Building works, see figure 9. At the 'perceptual level', the sensors (IoT) network provides data to the 'network layer' where it is connected with other data sources. Through the analysis and visualization in the 'application layer', interaction and feedback are available for multiple parties. Figure 9 provides an overview of all the systems that an intelligent building has, but reality buildings do not have all these systems. NEST's are products that add/replace missing or malfunctioning systems, in the perceptual, network and/or application layer to make a building smarter so it wastes less energy.

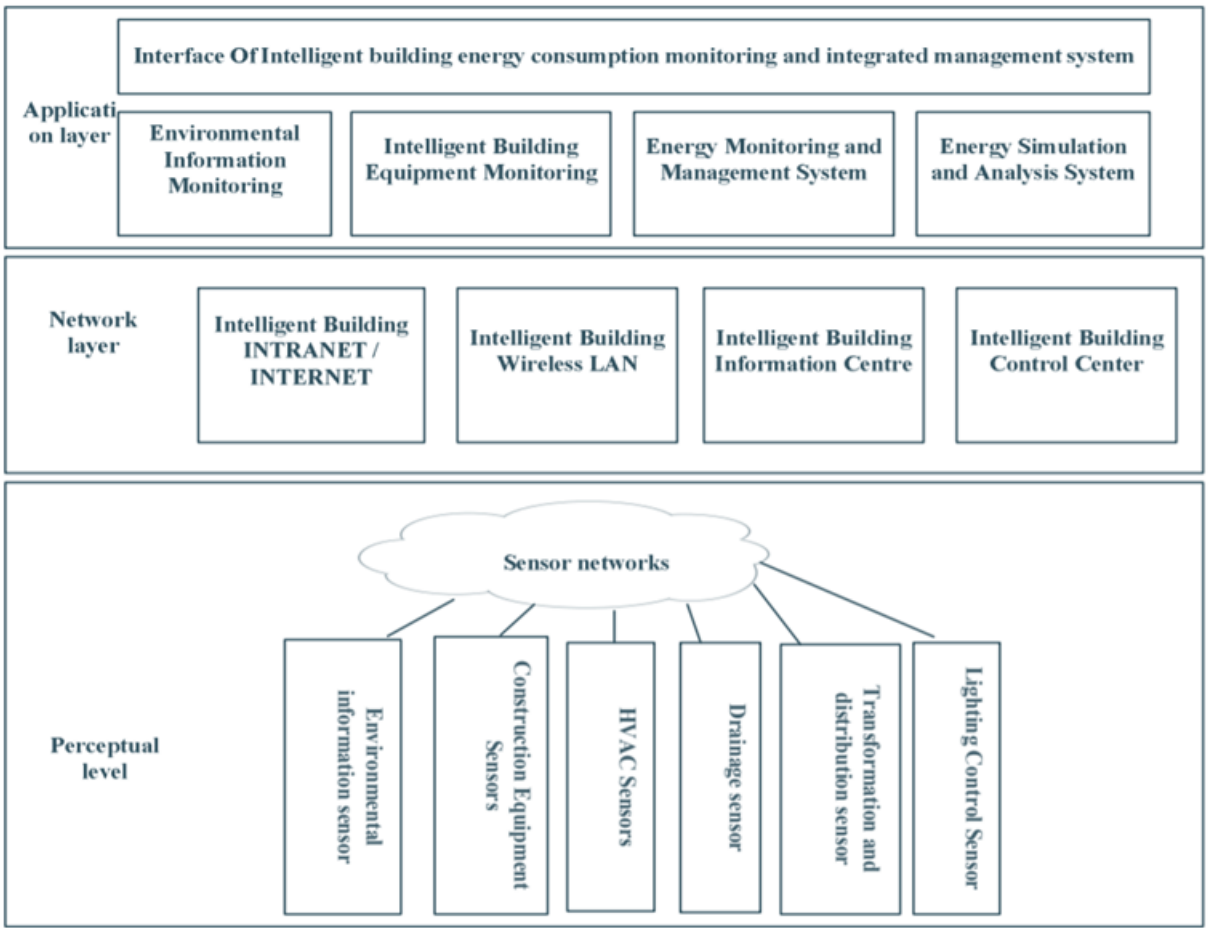

Figure 9: Framework for energy savings through IoT (Wei & Li, 2011).

As every office is different and consists of different systems, NEST's must be flexible so they can work with the systems (IoT) and Big Data that are already available. Connecting the right systems in the data road from sensor to interface is a complex matter. NEST's are not based on all systems but only on those that support their specific product. For example, an EFOPC's specialized in lighting will only use the 'Lighting Control Sensor' and do not even get to the 'Application layer' as it only works with the 'Intelligent Building Control Centre'. A NEST that wants to optimize the heating of an office could make use of (or has to install) HVAC sensors, 'Intelligent Building Information Centre', 'Intelligent Building Control Centre' and/or an 'Energy Simulation and Analysis System'.

The HVAC installations, lighting and ICT are responsible for the gross of the energy consumption in an office. NEST's can save most energy if they can make one or multiple of these perform better. The market research will provide an overview of the NEST's available for Dutch offices, on what technologies they are based and what energy consumptions in offices they target.

2.2.4 Multiple benefits

Blyel et al. (2019) demonstrated that renovating an older office to 'Paris Proof' is hard and goes beyond adding extra insulation. A Deep Energy Renovation (DER) might be needed where the office is stripped to its skeleton. It is technologically possible, but the business case isn't viable as the payback period is almost 25 years when only incorporating the energy savings are taken into consideration. They underwrite the importance to weigh the MPB's (Multiple Project Benefits) in the business model to make it attractive to owners. The PropTech industry in general, and NEST's in particular, aren't fully developed yet. It is hard to determine their yield, which makes it hard to form a (viable) business case. Just like with a DER, it is possible that cost savings by NEST's won't provide a viable business case either. Therefore, it is interesting to look at the MPB's of NEST's too. When the benefits are spread among different parties, it might appear that the party with the mandate to install and pay for it is not the party who enjoys the benefits. This 'split incentive' could block the implementation of PropTech, just as with the split incentive with investments for better energy performing physical elements.

2.2.5 Summary

PropTech is one small part of the wider digital transformation of the real estate industry. An Energy Focussed PropTech Company (EFOPC) with New Energy Saving Technology (NEST) works with IoT, Big Data and related technologies to achieve energy savings for offices. PropTech should focus on both the physical elements and the users in an office to achieve an energy efficient office. IoT at the perceptual level and Big Data at the network layer lay at the foundation for providing feedback to the users. The previous chapter stated that feedback is of great importance, Wei & Li (2011) illustrate that the road to feedback is multi-layered and could be multidimensional. Next to the costs saved on the energy bill, it is interesting to look at the Multiple Project Benefits (MPB's) to provide an adequate business model. The next paragraph describes to which stakeholders this business model applies.

2.3 Stakeholders and their interdependencies

Implementing PropTech firstly requires the cooperation of the multiple parties who are involved around the exploitation of an office. This paragraph introduces them based on their relationship with the operation of an office and their influence on the energy consumptions. Furthermore they are described based on their interest, power when implementing PropTech and their relation to other stakeholders. To make sure as many square meters of offices are targeted at every implementation this research focusses on offices managed by a real estate fund.

2.3.1 Stakeholders

In general, even with the most basic configuration, there are multiple parties involved when exploiting and maintaining an office. Figure 10 represents the most important stakeholders when operating an office. The black arrows indicate which parties contracts another party to provide them a service or asset in relation to the building. The red arrows indicate how problems at the office that are the responsibility of the owner are fixed.

A pension fund collects money from its members and manages it. They mostly don't invest themselves, but trust on (multiple) institutional investors to realize a return on their investment. These institutional investors invest in multiple assets like stocks, bonds and real estate to spread their risk.

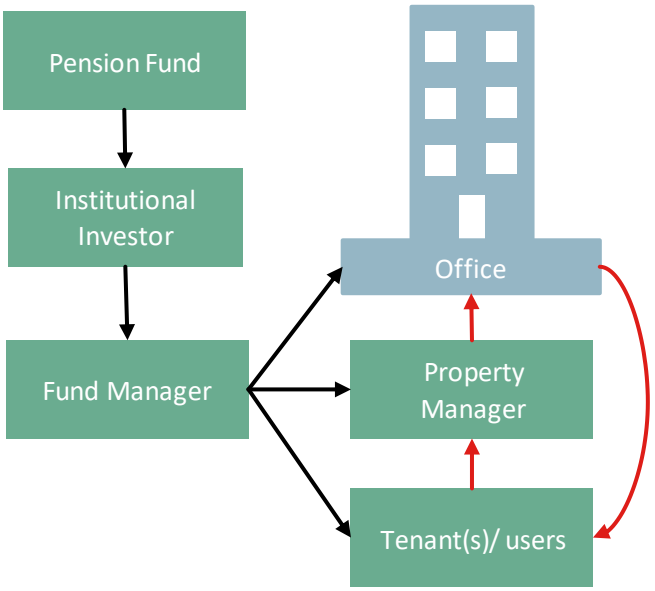

Figure 10: Stakeholders and contracts.

Within their real estate portfolio, institutional investors could have different fund managers focussing on different types of real estate to spread their risk even more. The institutional investor trusts on the expertise knowledge of the fund manager to realize a return on a specific real estate category, like offices for example. The fund manager contracts (a) tenant(s) and a property manager. The fund manager oversees it portfolio on a strategic level, realizing a long-term cash flow with the lowest possible risk (Geltner, Miller, Clayton and Eichholtz, 2003). The benefits of investing in sustainable offices are explained in the next paragraph.

The worst thing for a fund manager are offices without tenants or that they pay don't pay enough rent so his overall return isn't as expected. Companies have the freedom to rent any office space they like as long as it's available and within budget. They can negotiate about the conditions before a contract is signed. If there is much office space available a company can demand favourable conditions, when there is a shortage of office space available the fund manager can demand favourable conditions and prizes.

An office can be let by one or multiple tenants who have their own characteristics and may rent different amounts of space. A tenant rents a certain amount of space to execute its business. Based on the type of business and the identity of a tenant they might require 'suiting' office space. Greenpeace would require a sustainable and 'green' office for example. The most important criteria for renting office space are: flexibility, efficient use of space, energy efficiency/sustainability, comfort, architecture and price (DTZ Zadelhoff, 2011). The tenant and the fund manager have a contract to regulate the rent, taxes, damages and service costs, including the electricity and gas bill. The employees of the tenant are the users who are influencing the energy consumption of their office.

The property manager gets hired by the fund manager to make sure the office stays in operation. Their tasks can be of an administrative-, technical- and/or commercial nature. Their compensation is mostly a standard fee and a percentage of the service costs paid by the tenants. The property manager is in contact with the fund manager for strategic consultation and the tenant for the daily business.

2.3.2 Stakeholders' influencing the energy consumption

In a standard rental agreement (ROZ, 2015) the owner is responsible for the HVAC and the tenant for the lighting if it is not already there. The tenant arranges his own ICT as well. As a result of this, the owner (fund manager) and the tenant can be appointed as the most important influencers of an office's energy consumption. This is visualized in figure 11. The fund manager influences the energy consumption of the HVAC system in three ways, he is responsible for the insulation, buys the HVAC installations and arranges an installer. The users can switch the installations on or off. The lighting may be already installed by the fund manager or the tenant has to install it himself. During the term of the rental contract, the tenant is responsible for the replacement of the lighting. Furthermore, the tenant is solely responsible for its consumption. The fund manager has no influence on the ICT that is brought in by the tenant and has no control on the usage of it.

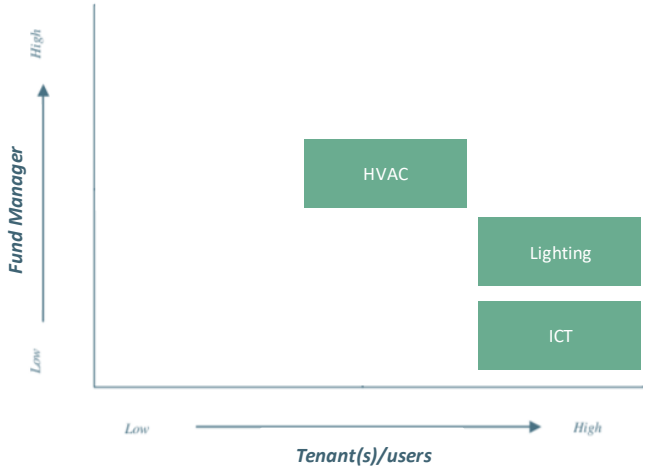

Figure 11: influence from stakeholders on energy consumptions.

2.3.3 Positioning stakeholders

As described, some parties have more power and interest than others to influence an office's energy consumption. This is also true for the implementation of PropTech. To provide a better overview of their interplay, all parties are placed in a power versus interest grid in figure 12. All stakeholders are positioned on their power and interest on the implementation of technology. As every office and situation is different, the interplay and position of stakeholders can differ. The interest of each stakeholder into PropTech is the sum of their multiple drivers.

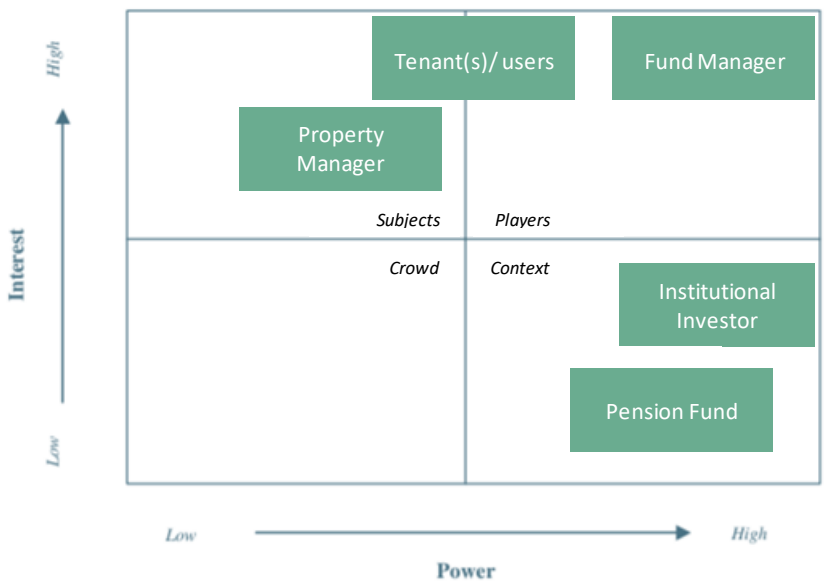

Figure 12: The perceived power and interest of stakeholders to implement NEST's (based on Eden & Ackerman, 1998).

Pension funds might experience pressure from its members to invest sustainably, but they do not exactly know where their institutional investors have invested. They are more interested in general CO_2 reduction than in the techniques used, but if they want PropTech to be used they have the power to demand it. The same applies to the institutional investor, who has a bit more interest and is closer to the PropTech implementation decision making. The fund manager is the most important stakeholder, he or she decides on investments and has interest into implement PropTech as it could influence the value of their office. Tenants also experience positive effects as the energy savings benefit their monthly cost of housing. But saving energy to ensure a lower energy bill or reduce their emission of CO_2 is not their main priority. The cost of housing is about ten percent of the total costs and their energy bill is only a small part of that. Furthermore, when something at the HVAC installations is altered, the tenant must ask the fund manager. Property managers have interests in PropTech as it can support their work, but also have to ask the fund manager to pay for it. The position of EFOPC's will be investigated throughout this research and is positioned at the end of the chapter with the findings.

2.3.4 Summary

There are multiple stakeholders involved in the exploitation and functioning of an office. The fund manager, tenant(s)/users and the property manager are most important. The tenant(s)/users have a lot of influence on the different energy consumptions (HVAC, lighting and ICT). The fund manager only has influence on the buying and servicing of the HVAC systems. Multiple stakeholders profit in different ways, but eventually the tenant or the fund manager pays for the implementation.

2.4 Real estate and sustainable investing

The previous paragraph described the stakeholders who are involved in the operation of an office. From the power versus interest grid it became clear that especially the investment side (institutional investors and fund managers) is important. That is why this paragraph tries to provide a better understanding of these investment parties. This paragraph will investigate the motives of investor and on which principles these are based.

2.4.1 Characteristics of real estate

To understand the motives of owners, the characteristics of real estate should be understood first. Owners base their actions on the specific characteristics of real estate (Baum, 2017). The value of real estate is to some extent linked to the performance of the economy, and like all assets its performance is linked to the capital markets. Generally, the impact of the real economy and the capital markets on the cash flow and value of real estate is distorted by several factors (Baum & Hartzell, 2012). The most important ones are: real estate is subject to depreciation, the supply side is highly price inelastic, property is highly illiquid and it's time consuming and expensive to manage.

2.4.2 Investor's criteria

Geltner et al. (2003) describe the major constraints and concerns that affect most investors focussed on the real estate market in their book *Commercial Real Estate Analysis and Investments.* They point out that risk, liquidity, time horizon, investor expertise and management burden, size and capital constraints are the major issues when investing in real estate. Compared to other asset investors, real estate investors prefer less risky investments, will pay more for assets that are more liquid, have a long-time horizon and have a need for costly specialized expertise plus management.

Based on the issues produced by the characteristics of real estate as an asset class, plus the investor's preferences, Van Gool, Jager, Theebe & Weisz (2013, p. 149) define several investing criteria:

- The desired return on the investment
- The timespan the investor is working with
- The intended liquidity of the investment
- The acceptable risk of the investment
- The potential use of debt with the investment
- The desired sustainability of the investment
- The desired results of the investments together with other responsibilities of the investor

When comparing the constraints and concerns raised by Geltner et al. (2003) and Van Gool et al. (2013), not that much has changed. Van Gool et al. (2003, p. 111) make notion of an increasing awareness amongst investors about the finitude of natural sources and the quality of the living environment. Van Gool et al. (2013) and also Kauko (2019), point out that the sustainability agenda has already become widely recognised in real estate analysis. Experimental buildings, like The Edge at the South Axis of Amsterdam, demonstrate what is possible and inspires others.

2.4.3 The benefits of sustainable investing

Efficient use of energy and sustainability are important for tenants, but although it is not their main focus they can profit from direct and indirect benefits from an office that is (increasingly) energy efficient and sustainable. In 2003, Kats summed up that tenants can profit in a direct way via energy and water savings, waste reduction and a more comfortable and more productive working environment. For most companies, the employees are their most costly asset. Indirect, a tenant profits via an improved image leading to more revenue and a higher profit (Kats, 2003).

As stated above, the awareness on sustainability is growing. But investors are not keen on losing money on their investment because of sustainability. Over the years, multiple researches from different perspectives have tried to pinpoint the extra value for a building created through a good energy label or a certain certificate like BREEAM or Green Star. Already in 2007, Nelson found that LEED certified A-class offices in the United States had 25% higher rental prices than non-certified A-class offices. Somewhat more recent research shows and quantifies the relationship between green features in offices and their higher rents and sale prices (Kok & Jennen, 2012; Kim, Lim & Kim, 2017; Oyedokun, 2017).

Also, in the Netherlands, sustainable offices are more wanted, generate more income, are regarded less risky, expect less vacancy and eventually lead to a higher market value (DTZ Zadelhoff, 2011). Less risk and more income do match a real estate investor's profile. Research by JLL (2010) shows that 86% of tenants indicate that they prepare plans, or take action, to accommodate themselves sustainably. On average, they want to realize this ambition between two and ten years. 51% of these tenants wants to make their current offices more sustainable. If there are clear benefits, the vast majority of tenants is prepared to pay a higher rent (between 1 and 5%). The research by JLL expects that this will mostly include energy savings as this is more accurate and reliable to predict than an improvement in comfort. An investor needs this extra income to cover his investments and secure his return. Split incentives occur when those responsible for paying energy bills (the tenant) are not the same entity as those making the capital investment decisions (owner). This 'split incentive' is an important barrier to invest in energy saving measures, like NEST's, and overcoming this would be an large step.

2.4.4 Demand and supply of NEST's

As the benefits of sustainable investing seem clear, most fund managers are reticent to physical renovations to make their offices more sustainable. But, most of the time they are not even able to perform a renovation as there are tenants in the office. With the implementation of NEST's there is no need for a physical alteration and the MPB's could benefit the fund manager, property manager and the tenant(s). Unfortunately there is no literature that exactly describes the process of parties in the real estate industry buy the products of PropTech companies. Block & Aarons (2019, p.99--135) do offer a description of drivers and barriers for the real estate industry and PropTech startups to collaborate or the former investing in the latter. Table 1 provides an overview of these drivers and barriers.

	 **Real Estate Industry NEST demand**	 **PropTech companies NEST supply**
Drivers for cooperation	Sustainability is a hot topic	Offers sustainable solutions
	Desires lower operational costs	Realizes lower operational costs
	Fund manager desires a higher revenue	Supports justification higher rents
	Competitive market	Latest technologies
	Data is considered valuable	Generates data and insights
	Desires to work with talent	Attracts best talent
	Costly/time consuming to develop product on their own	Already has created the product
Barriers for cooperation	Real estate language	Start-up language
	High profits, has 'no' problem	Tries to sell a solution
	Lacks digital strategy	A digital solution
	Wants one solution fits all	Specialized solution

Table 1: overview drivers and barriers for cooperation.

Table 1 combines the investor's basic criteria from paragraph 2.4.2 with the differences as described by Block & Aarons. This overview is applied to the process of buying a product, not investing in the PropTech company itself. This research will determine if these drivers and barriers for cooperation also specifically apply to the relation between fund managers and EFOPC's. When this is well understood, a flowchart to establish more cooperation and implementation of NEST's will be developed.

One of the main barriers is 'the different language' that the real estate industry and PropTech companies handle (Pyle, Grunewald & Wright, 2017). This is a term that is based on the differences of company size, agility, time horizon, level of specialized knowledge, acceptance of risk and return requirements between the two sides. These differences lead to misunderstanding and non-cooperation. Other 'language barriers are': the people making the decisions are not grown up with technology and are too proud to work together with a small PropTech company although they have a good solution. The specialized PropTech solutions are not their core business which leads to misunderstanding. Lastly, real estate companies think in KPI's (Key Performance Indicators) like price of m² and vacancy rates to assess PropTech, but innovative ideas can not always express themselves into those KPI's (Weir & Pyle, 2018; Block & Aarons, 2019).

Table 1 provides an overview of the drivers and barriers for the demand and supply sides to do business with one another. The drivers/barriers are not equally motivating or demotivating for the demand and supply side to meet the other and start. This results in a difference in power, resulting in one side should comply with the other, making the other in the lead and is more interesting to research. Drivers like sustainability being a hot topic, promising less costs and more revenue are drives for the demand side to do business with the supply side. But important barriers for the demand side are that they have 'high profits and do not experience that they have a problem' and the 'lack of a digital strategy'.

2.4.5 Summary

Real estate characteristics, like its illiquidity, force investors to be risk avert, value liquidity and have a long-time horizon. Although their business is based on the same principles, investors do have their own strategy. Within their strategy, sustainability is becoming increasingly important. Sustainable offices offer multiple benefits for an investor. For this reason it might be interesting for investors to start cooperating with EFOPC's. Nevertheless, it appears that there are also multiple obstacles for investors and EFOPC's to work together.

2.5 Real Estate Industry's Institutional Environment

There is a wide spectrum of policies on the topic of energy saving from a global scale (agreements of Kyoto and Paris) to a municipal level. Top-down, this research is embedded in global agreements, European Union legislation and Dutch central government legislation. Lower levels of government fit in their legislation to higher levels of government. Considering offices in the Netherlands, the legislation from the Dutch central government, based on European Union legislation, is the most important. This paragraph will explain the legislation and regulation that's important to Dutch offices.

2.5.1 European legislation on energy use

In Europe, the efforts to classify the energy performance of the real estate industry dates back to 1993. Article 2 of Directive 93/76/EEC had the purpose to limit carbon dioxide emissions. The implementation was non-mandatory. This changed when Directive 2002/91/EC on the energy performance of buildings directive was introduced in 2002. Article 7 of the Directive introduced the comparable Energy Performance Certificates (EPC's) across the European Union (Perez-Lombard et al., 2009). By dividing the EPC through the statutory obligation, the Energy Index (EI) is determined. This ratio determines within borders the energy label. Every country with in the European Union was free to formalize their own legislation that would fit their specific situation within the set boundaries.

Based on the goals in the Paris Agreement of 2015, the European Union set goals for 2020, 2030 and 2050 to reduce CO_2 emissions, energy savings and develop renewable energy. Member states are obliged to cut their CO_2 emissions yearly with 0.8%. In the long-term, the European Union should be climate neutral in 2050. The European legislation focusses specifically at the CO_2 emissions of the agriculture-, transport-, waste- and construction sector and buildings. Member states have the freedom to execute this legislation in their own way (EUR-Lex, 2019).

2.5.2 Dutch legislation on energy use

In the Netherlands an energy label was 'obligated' with every office transaction by 2008. But enforcement and sanctions began in 2015 when the 2002 EU directive finally was translated into Dutch legislation. The introduced EPC's were understandable, easy to use and for the government easy to produce legislation on. The energy labels are based on certain characteristics (not PropTech) of the building (the type of lighting for example) and only estimate the actual energy consumption. It can be done differently. In Germany buildings must have a theoretical energy label and an energy label that is based on the actual energy consumption. When an office uses more energy in practice than in theory the users and the owner know something is wrong (Van Eck, 2015). In 2013 forty parties in the Netherlands, among which the central government, singed an energy agreement. This agreement resulted in legislation that all offices must have at least a C-label in 2023 and the intention is that by 2030 all office building will have a A-label (EIB, 2016).

Through the 'activities decision' in 2015, the central government introduced an overview of energy saving measurements that pay themselves back in five years. This regulation obligates the owners whose offices uses more than 50.000 kWh or 25.000m^3 natural gas per year to take the introduced measures. One third of all utility buildings in the Netherlands is subject to this obligation, regardless their nature of use or energy label (EIB, 2017). To support companies in their energy savings, the central government and the RVO provide subsidies, knowledge, best practices, monitoring and organizing help with a split incentive for example. Research from JLL (2010) shows that 90% of the tenants wants the government to come up with legislation to stimulate sustainable housing.

2.6 Conceptual framework

Figure 13 visualizes the conceptual model that is derived from the theoretical framework. The outer plane represents the real estate industry's institutional environment. Legislation has influence on the decision making of stakeholders for example. The implementation of PropTech as new energy saving techniques (NEST's) is about supply and demand. The interaction between the fund manager, property manager and the tenant(s)/users at the demand side determines the drivers and barrier for these stakeholders to (not) desire NEST's. The drivers ensure a stakeholder will look for cooperation with an EFOPC to use its NEST. Although the user has most influence on the energy consumption, the fund manager is in the lead of the organization and payment.

On the other side there is the supply of NEST's by EFOPC's (Energy Focussed PropTech Companies). They target the physical elements of an office that use most energy: HVAC systems, lighting and ICT. On their own offices don't consume energy; the users do while interacting with the physical characteristics of the office. Therefore NEST's should understand the users of an office, how they interact with the physical elements of that office and how this results in energy consumption. These NEST's are furthermore based on the technologies of the Internet of Things (IoT) and Big Data. Next to the costs saved on the energy bill, it is interesting to look at the Multiple Project Benefits (MPB's) to provide an adequate business model. The costs can be split between different parties that enjoy different MPB's.

The stakeholders at the demand side firstly develop drivers and barriers as a result of their relationships with the other stakeholders. Whenever these are developed they relate these to the drivers and barriers of the supply side. The most important barriers come from the demand side as they do not perceive that they have a problem and they lack a digital strategy. Drivers supporting the cooperation are the increasing importance of sustainability and the increase of revenue for example. The implementation of NEST's will eventually depend on the common grounds at the drivers of both sides weigh up to the barriers. As the demand side has more power over the supply side they are in the lead to develop the conditions on the common ground that eventually will determine the implementation of NEST's or not. Therefore, this research mainly focus on the dynamics between the stakeholder at the demand side.

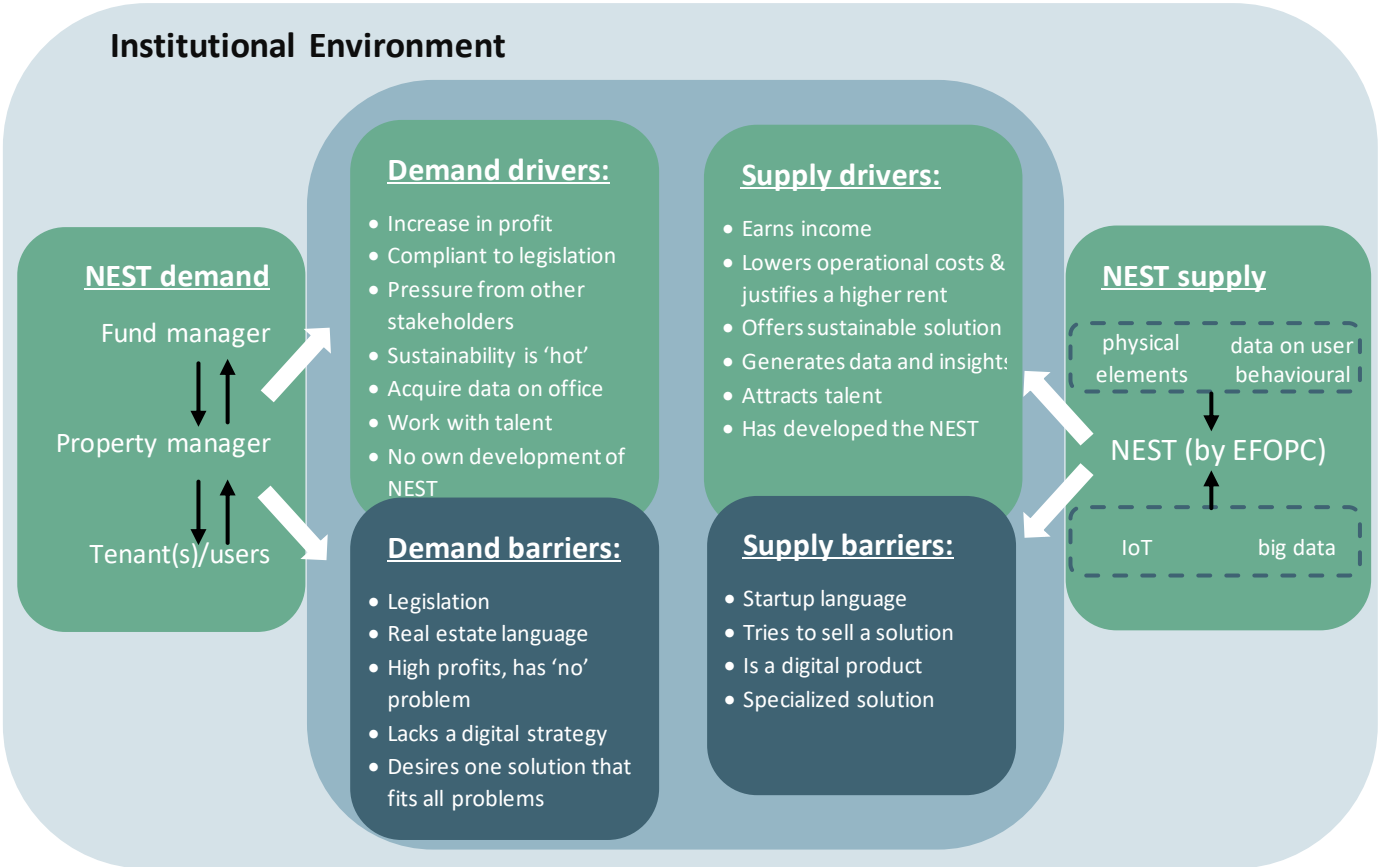

Figure 13: Conceptual Framework

3.0 Research design

This chapter describes the directive for the second part of this research, the data collection and analysis. First, the type of study is motivated together with the techniques used to execute this research. Thereafter, the process of selecting the PropTech companies and investors is described, followed by the techniques used to collect data from them. Finally, the method to analyse the acquired data is explained.

3.1 Explorative research

In this study, an explorative and inductive research strategy is used (Bryman, 2012; Glaser and Strauss, 1967). The lack of any prior scientific knowledge or research, which would provide some information or suggest theories about the multiple perspective on the implementation of PropTech, dictated the choice of an exploratory research. Theories from various scientific fields such as stakeholder theory and the implementation of general technology within one company are combined with findings from stakeholder interviews. Finally, flowcharts with steps for the most important stakeholders are presented. These framworks can be (partly) tested and refined in future (case study) research.

Understanding the stakeholders and their complex relationships and interdependencies requires a thorough analysis. Combining the qualitative research sources and methods as displayed in figure 14 provide such an analysis. The interviews are conducted among different groups of stakeholders who also cross-reference to each other, which provides a rich and multi-dimensional view on the topic. The second sub question to find out which NEST's are available for the Dutch market required desk research. The other sub questions were answered by conducting in-depth interviews with stakeholders involved in and around the implementation of NEST's to obtain a thorough understanding of its operation. This automatically leads to an epistemological position described as interpretivist. This research tries to understand (through conducting interviews) the social world wherein NEST's are implemented through an examination of the interpretation of that world by its participants. This contrasts with the adoption of a natural scientific model in quantitative research (Bryman, 2012).

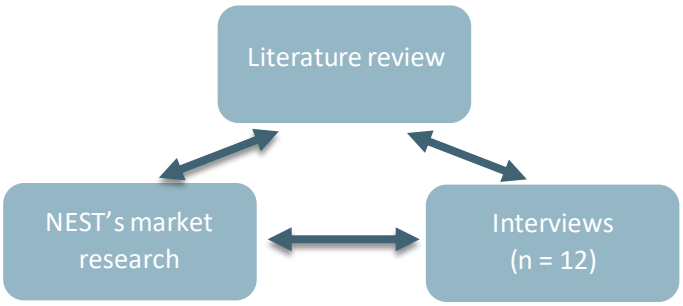

Figure 14: Sources of the qualitative data (own image, 2019).

Because of the interpretivist nature of qualitative research, Bryman (2012) and Yin (2014) call for quality control through four conditions: construct validity, internal validity, external validity and reliability. These quality conditions were intertwined throughout this research in the following ways:

1. *Construct validity*

Construct validity requires the accurate operationalization of the concept that is studied. To avoid subjective judgement, data from the empirical research together with the variables or attributes must be accurately defined (Yin, 2014). This research includes a literature review, NEST market research and interviews from multiple perspectives to support the development of the NEST implementation flowcharts.

2. *Internal validity*

Internal validity is the extent to which a study establishes a trustworthy cause-and-effect relationship between a treatment and an outcome (Yin, 2014). As this explorative research is mostly descriptive and doesn't try to assess the effects of an intervention, ensuring internal validity is not applicable.

3. *External validity*

External validity refers to the generalizability of the case study results beyond its own boundaries (Yin (2014). The explorative nature of this research makes it impossible to project the conclusions/flowcharts on other situations than the implementation of NEST's into Dutch offices.

4. *Reliability*

Reliability refers to the extent the study can be successfully replicated by another researcher using the same data collection procedure and achieving the same outcome (Yin, 2014). To be reliable, exploratory research should be conducted in a transparent, honest way and follow a set of guidelines to ensure its reliability (Reiter, 2017). Detailed methodologies will be written for the data collection and development of the flowcharts.

3.2 Research methods

This paragraph explains the selection procedure how NEST's are separated from other PropTech companies for the market research and how interviews provided a full view on the non-implementation of PropTech.

3.2.1 Relevant NEST's

To answer the second research sub question, EFOPC's were investigated through analysing their NEST's. Although PropTech itself is quite a new phenomenon, the real estate industry where it is based on is ancient. NEST's are developed in high frequency and the number EFOPC's is rising. Unissu is the leading PropTech platform that tracks, lists and analyses PropTech companies around the world. They have over 7000 PropTech companies in their library. The goal was to capture as many relevant NEST's as possible who are active in the Netherlands in a systematic way. Unissu was used because it has the most extended library of PropTech companies. It comes with a handy search engine to filter for relevant NEST's. The filters applied when searching were:

1. For sector: commercial
2. For sub industry: PropTech
3. For technology: Big Data & IoT

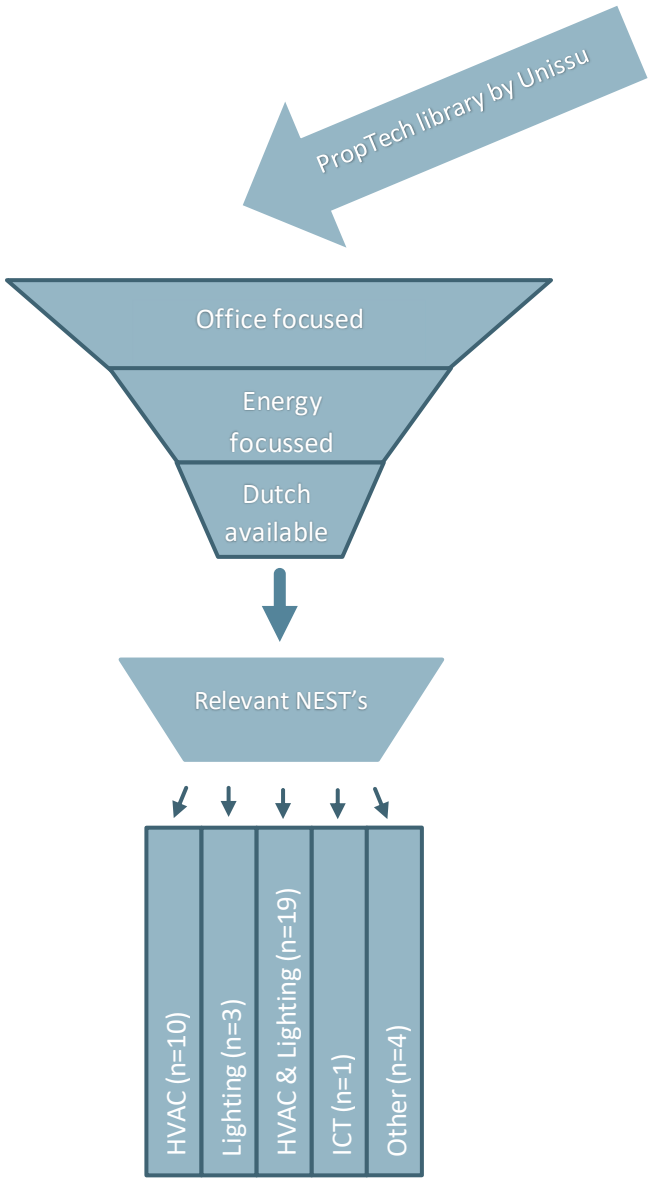

Figure 15: selection procedure NEST's.

Figure 15 illustrates the selection procedure. The NEST's in the list that was produced were checked if they were focussed on energy saving and if they delivered their product in the Netherlands. From the Unissu platform or the website from the EFOPC it was not always got clear if they have their products available in the Netherlands. At the first of July 2019 a first round of emails were send to all non-Dutch based EFOPC's wherein they were asked if they deliver their NEST's for Dutch offices. Two weeks later a second round of mailing were send to all non-responding EFOPC's as a reminder. Only the NEST's who responded before the first of August were included in the market analysis. These relevant NEST's for this research were then divided based on the specific energy consumption in an office they focus on: HVAC, lighting, HVAC and lighting, ICT and other.

Filtering the 7000 PropTech companies on their commercial application filtered it down to nearly 4000. From these, only 82 focussed on energy savings via IoT and/or Big Data on first sight. From the ones who were not based in the Netherlands, 22 did not emailed back and 28 did not provide products in the Netherlands, did not save energy at second sight or were not focussed on offices after all. This left 32 EFOPC's and their NEST's, 10 focussed solely on HVAC installations, 3 on lighting, 19 on both and 1 on ICT. One EFOPC can have multiple NEST's. Three out of the four NEST's in the category 'other' are part of EFOPC's whose other NEST targets HVAC & Lighting. The last NEST in the category 'other' is part of the EFOPC that targets the ICT. There was not a NEST that solely focussed on an 'other' way of energy saving.

3.2.2 Interview stakeholders

The second part of this research was firstly to identify which stakeholders have the power, interest and the drivers/barriers to (non)-implement PropTech into offices. After this, the drivers and barriers for the cooperation between the real estate industry and the EFOPC's was investigated. To get the full, detailed and conformed understanding of what currently (does not) happen when (non)-implementing NEST's, the perspective from the most important stakeholders should be interviewed. Figure 16 visualizes the research method wherein the overlapping perspectives provide a full view of what is going on. The literature review identified the stakeholders.

The fund manager, tenant(s)/users and the property manager were the most important stakeholders from the demand side. Next to them, the institutional investor is directly checking the performance of a fund manager and has the power to enforce the implementation of NEST's. Although he does not have a high level of interest, his role can be decisive and was therefore investigated. From the supply side there is a variety of EFOPC's with their own characteristics, several were interviewed. Lastly, there are parties that are not part of the demand or supply side but can offer a wider perspective.

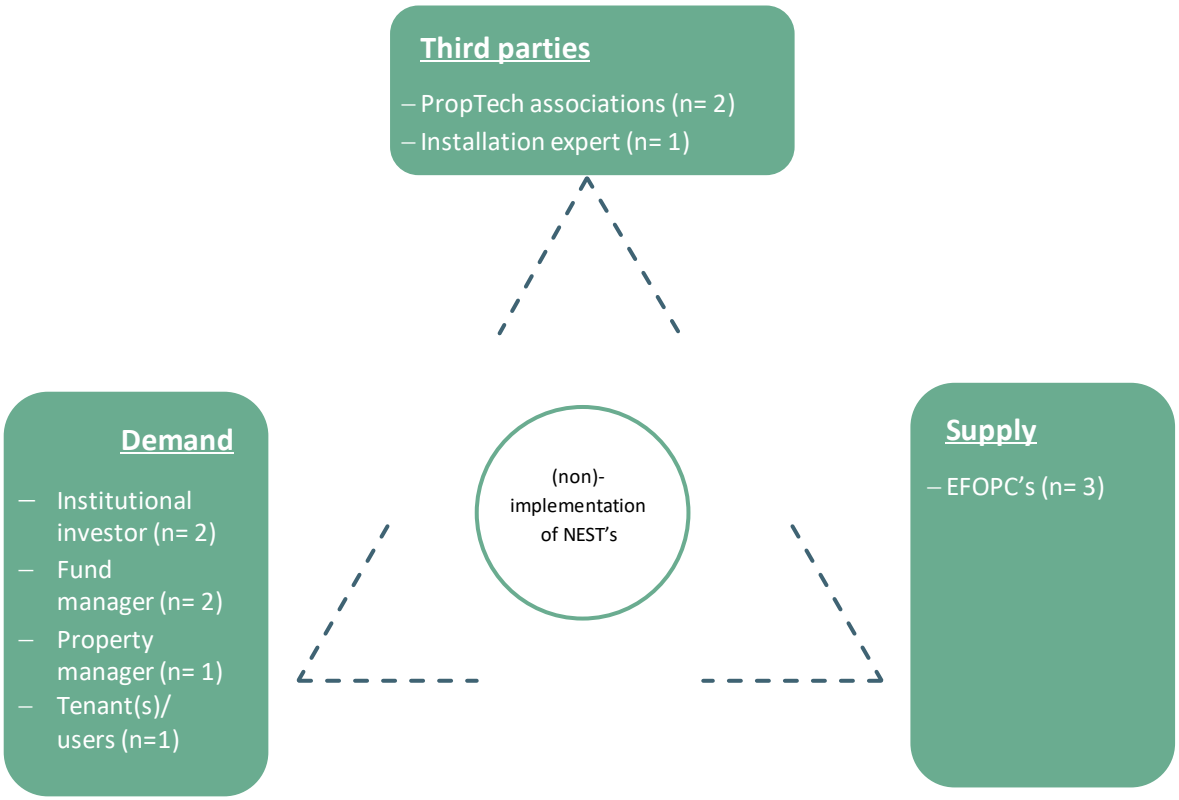

Figure 16: providing a holistic perspective.

3.3 Selecting NEST's and stakeholders to interview

Due to the limited time and resources of this research not all relevant NEST's could be interviewed. The same applies for the stakeholders that are involved in the demand side of the implementation of the NEST's. This paragraph explains the selection procedure that delivers an overview of EFOPC's and their NEST's that were interviewed. Also, the selection procedure for the other stakeholders is explained. As said, the interviewees should be chosen in such way that multiple perspectives provide a holistic coverage on all matters that lead to the (non)-implemented of NEST's. From the supply side, there were three people at EFOPC's interviewed, there were six interviews held among the different stakeholders on the demand side based on the stakeholder analysis of paragraph 2.3. Furthermore, three interviews were held among involved third-party companies that have an overview over all the supply and demand stakeholders.

3.3.1 EFOPC's

EFOPC's mostly focus on the HVAC installations via the Building Management System (BMS). These installations also use the most energy. Therefore, it should be well understood how these EFOPC's work and how they work together with other stakeholders. This is the same for EFOPC's that focus on lighting. To get a wide variety of insights, EFOPC's that focus on ICT and other NEST's should be interviewed too. A selection criterium was that, when about the same products were offered by multiple companies, a possible Dutch version would have the preference for an interview. This would provide the possibility for a face to face interview and eliminate misunderstanding because of a language barrier. Unfortunately, the EFOPC that focussed on ICT and other forms of energy savings is not located in the Netherlands and could not be interviewed.

This selection procedure decided that two EFOPC's were interviewed who had a different approach to energy saving via the HVAC installations. Four EFOPC's only focussed on HVAC installations were located in the Netherlands. From these, only one focussed on all installations (Simaxx). Hero Balancer was also interviewed because they have an odd approach to managing the HVAC and BMS system which produces another perspective. Energetika is an EFOPC that focusses on the lighting in offices, but via sensors in the fixtures they also work with the HVAC installations. All interviewees were of C-suite level.

3.3.2 Institutional investors, fund managers

Although investors in Dutch real estate are situated all over the world, for practical reasons this research focussed on Dutch based investors and fund managers. PropTech is still poorly used, mainly the early innovators (Rogers, 1957) with a prime focus on sustainability were expected to make use of these NEST's. These are the precursors in the field of sustainability, so these were the investors and fund managers to focus on.

Two institutional investors that were interviewed are PGGM and APG. Both institutional investors manage billions of euros from Dutch pension funds. Among others, they invest this in real estate funds. Both investors committed themselves to multiple sustainability goals and are internationally seen as precursors in sustainable investing. From the office funds which are active in the Netherlands, two large companies are selected, Bouwinvest (0,8 billion of office real estate in the Netherlands) and Cromwell (large portfolio of A class offices at prime locations in the Netherlands). Both funds are regarded as precursors in sustainable investing. All four interviewees were senior employees who are responsible for sustainability.

3.3.3 Tenant(s) and property manager

In figures 10 and 12 two other stakeholders were identified that have the power to implement PropTech, the property manager and the tenant. Tenant's come in all different types and sizes, some are more concerned with sustainability and energy saving than others. Due to time restrictions not all varieties could be investigated. Therefore a party was interviewed that advices all types of tenants on sustainability in general and the use of PropTech in specific. Such a party was found in the person of a senior sustainability consultant at Cushman & Wakefield.

There are multiple companies in the Netherlands that provide property management services. Asset Management Services from Cushman & Wakefield was chosen because of their view on sustainability. Furthermore, they have 'propositions on sustainability' as a service. Besides this, their seize and knowledge on smaller and larger office building with different sizes makes that they have a full-scale view.

3.3.4 Other stakeholders

Two other parties were interviewed with affiliation to the implementation of PropTech. PropTech associations are third parties who mediate between the new PropTech innovations and the real estate industry. Parties interviewed were Holland ConTech & PropTech and PropTechNL. And as installations are that important for EFOPC's to focus on, an installation expert was interviewed for a third-party perception. The interviewed party is De Installatieadviseur. All these interviewees were of C-suite level.

APG	Institutional investor	Interviewee 1
PGGM	Institutional investor	Interviewee 2
Bouwinvest	Fund manager	Interviewee 3
Cromwell	Fund manager	Interviewee 4
Cushman & Wakefield Asset Management	Property manager	Interviewee 5
Cushman & Wakefield Sustainability Consultant	Sustainability consultant	Interviewee 6
Simaxx	EFOPC	Interviewee 7
Energetika	EFOPC	Interviewee 8
Hero Balancer	EFOPC	Interviewee 9
Holland ConTech & PropTech	PropTech association	Interviewee 10
PropTechNL	PropTech association	Interviewee 11
De Installatieadviseur	Installation expert	Interviewee 12

Table 2: Company & interviewee number

Chapter four describes the findings from the interviews. These findings are supported by quotes from the interviewees. Table 2 connects the companies to an interviewee number.

3.4 Data collection

As mentioned, data was collected by performing interviews with the most important stakeholders involved in the implementation of NEST's. The interviews were conducted in Dutch and designed in such a way that they can be conducted within an hour. The semi-structured questions were pre-determined and based on the key concepts of the literature review that would determine the relationships between the stakeholders. The questions were designed in such a way that they were all open. The semi-structured design made follow-up questions on answers possible, ensuring deeper and richly data. The standard interview protocol can be found as appendix A. Additional questions were asked to the EFOPC's to support the market research. These extra questions can be found in appendix A too. Qualitative research in general and interviews in particular are subject to interpretivism. Therefore it was important to construct the questions in an unbiased matter. Furthermore, it is important that the interviewee is steered in the least amount possible to avoid that the interviewee gives an answer that the interviewer expects or wants to hear (Yin, 2014).

The goal of the interview questions was to test and elaborate on the different parts of the conceptual model. In this way an overview of all the stakeholders and their barriers/drivers were identified that produced parts of the flowcharts. First of all, permission for recording the interview was asked, followed by an introduction to this research and a clarification on the topics that would be asked. The first part focusses on the demand side, acquiring deep understanding of the relationships between the stakeholders responsible for the implementation of NEST's in offices and the barrier/drivers that are developed. The second part targets the supply side, the NEST's, to understand how they work with the physical elements of an office and the tenant(s)/users. The third part focusses on the drivers and barriers that the demand and supply side experience. As the interviewee might have thought about valuable information during the interview but this was not introduced for any reason, the interviewee was asked whether he or she had any final comments. After the interview the audio recording were transcribed. Due to sensible information, these are not included here, but can be requested from the researcher.

3.5 Data analysis

The goal of this research is to investigate how energy saving PropTech can be implemented into Dutch offices. The concepts from the literature review were captured in the conceptual model and this formed the basis for the interview design. The conceptual model also forms the foundation for the data analysis of the conducted interviews. Through combining and comparing the multiple perspectives for each topic the holistic view per topic was analysed and described. This must be done in an ordered and structured way to ensure the right conclusions are drawn. Glaser and Strauss (1967) developed a methodology to systematically structure and analyse qualitative data, grounded theory. This research made use of the 'iterative' approach wherein the data collection and the analysis of it are performed simultaneously, new insights provide input to collect new data until no new data was found anymore.

To keep the overview in the coding and analysis process, qualitative data analysis software was used, ATLAS.ti (version 8). Atlas.ti serves as a digital tool to mark the interviews with the codes deducted from the conceptual model and literature review. ATLAS.ti itself does not analyse data, but it serves as a supportive tool to structure the process of qualitative data analysis. It is an effective tool in retrieving, searching, structuring and integrating large amount of qualitative data in one place (Friese, 2014). Table 3 shows the codes deducted from the conceptual model and literature review.

Following the grounded theory, it prescribes three steps to code the transcribed interview data. These steps were followed while coding the interviews. Before starting to code, the codes of table 3 were listed as 'free codes'. The first step to execute was 'open coding'. All interviews were imported into Atlas.ti and from each interview all pieces of text were tried to match a code via 'list coding'. The codes in this 'list coding' consisted of the earlier defined codes of table 3. It often appeared that a quotation could be assigned to multiple codes, so most quotations were coded double or triple. After all interviews were assigned their coding, it was time for the second step: 'axial coding'. Axial coding is the breaking down of core themes within the collection of quotations within each code. Via the 'code manager' it is possible to obtain this list of quotations per code. Analysing the differences and similarities between the quotations provides understanding of the themes and provides structure. Here, it appeared that not all quotations were assigned right after all. The codes of quotations were adjusted until each code had the right quotations assigned to it. After this, a report of the list of quotations per code was produced. This overview enabled noticing the recurring themes in the quotations. The third and last step consists of 'selected coding' wherein the themes are formed towards new theory. Through constantly comparing, the consistency between codes was analysed. Furthermore, connections were made based on the frequency of reoccurring themes in the data. For example, if a stakeholder claims that he or she does not have that much power to implement NEST's, but others point out that this stakeholder is powerful, it is interesting to understand why and how this difference in perception occurred.

Code group	Codes	Dutch codes	Paragraph in literature review	Number of time mentioned
Demand	Drivers and barriers institutional investor	Drijfveren en barrières institutionele investeerder	2.3.1	13
	Drivers and barriers fund manager	Drijfveren en barrières fund manager	2.3.1 & 2.4.4	35
	Drivers and barriers of tenant(s)/users	Drijfveren en barrières huurder(s)/gebruikers	2.3.1 & 2.4.4	40
	Drivers and barriers of property manager	Drijfveren en barrières property manager	2.3.1	14
	Drivers and barriers of other stakeholders	Drijfveren en barrières overige stakeholders	2.3.1	14
	Stakeholder's influence on energy consumption	Invloed van stakeholder op het energiegebruik	2.3.2	23
	Requirements from NEST's	Benodigdheden NEST's	2.3.2	18
Supply	Incorporated technologies	Gegronde technologie	2.2.3	16
	Focus on physical elements	Focus op fysieke elementen	2.1.1	22
	Focus on office users	Focus op kantoorgebruiker	2.2.2	13
	Benefits fund manager (incl. MPB's)	Voordelen fund manager (incl. MPB's)	2.3.1	20
	Benefits tenant(s)/users (incl. MPB's)	Voordelen huurder/gebruiker (incl MPB's)	2.3.1	43
	Benefits property manager (incl. MPB's)	Voordelen property manager (incl. MPB's)	2.3.1	15
	Benefits other parties (incl. MPB's)	Voordelen overage partijen (incl. MPB's)	2.3.1	10
Legislation	Legislation supporting energy savings	Wetgeving dat energiebesparing supports	2.5.2	19
	Legislation that should change	Wetgeving die moet veranderen	2.5.2	17

Table 3: The deductive codes used during the coding process.

4.0 Findings

This chapter describes the findings from the conducted interviews and the market analysis. First the energy consumption/wastage in Dutch offices is discussed including the influences of the physical elements, the users, technology, their interconnectivity and the role of legislation. The second paragraph is the market analysis where all the relevant NEST's are categorized, the connectivity with the energy consumption is analysed and starting points for stakeholders are presented. Paragraph three maps the stakeholders, their relations and has an overview of their drivers and barriers. Furthermore it discusses solutions for these barriers including the starting points presented from the market analysis. Paragraph four presents an overview of the drivers and barriers between the supply and demand stakeholders on the implementation of NEST's. The aligned drivers and surmounted barriers eventually lead to the NEST implementation flowcharts in paragraph five.

4.1 Energy consumption/waste in Dutch offices

In general all interviewees agree that Dutch offices use too much energy and that something has to change. All interviewees were selected on their affinity with sustainability and they are all concerned about the excessive energy consumption and try to make a difference from their own field of expertise. As the stakeholders form the demand and supply side told stories from their perspective only, the PropTech associations and the installation expert provided a more holistic story. We even have to look beyond offices and start thinking and working on a higher level. Not only in terms of energy, but also with regard to the use of materials. It is complex and difficult in the beginning, but ultimately it benefits (interviewee 11). Saving energy is so versatile, people tend to do just a as little as possible (interviewee 9).

There is a long list of energy faults in offices and their underlying faults. The main basic reasons are the fragmentation of the real estate industry and too little pressure from lenders and legislation. Most parties in all corners of the real estate industry keep on working as they always have done, do not see the benefits of thinking sustainable and they do not get penalised for it. Sustainable thinking and reducing energy use has still a long way to go (interviewee 10). Some errors could be solved today, but there are also necessary changes that will cost a lot of money, time and effort. Securing the return on investment is still by far the most important concern to office owners. Sustainability and saving energy come are subordinate, but are becoming more deeply anchored in policies and investments. Smaller and secondary offices have a smaller margin to make profit which makes it harder to invest in energy saving features and acquire that required return. Furthermore, as interviewee 4 states:

> '*existing offices can reach to 100 kWh/m2 with reasonable investments. With active management on energy savings and us working together with the tenant and latest technologies, we only get to 80 kWh/m²*'

4.1.1 Physical elements and energy consumption

> '*if you don't have proper insulation, don't even start thinking about energy saving installations, let alone incorporating technology. Well insulated offices require smaller and installations that use less energy*'

Interviewee 12 made it perfectly clear that insulation and refined installations are the starting point of the holistic view to realize energy savings in existing offices. But the absence of a vision on required activities results in extra costs. Here too, holistic and long-term thinking is necessary for a viable business case. Saving energy starts with proper insulation, preferably all offices become 'passive' which means no installations are needed. This is possible for new offices that are built from the ground up, it is much harder if not impossible for existing offices to become 'passive'. As interviewee 3**:**

'we are currently designing offices as speedboats, but we should design them as a sailing boat, making use of wind & soil energy'

So, insulation is key. Installations are required to produce the remainder required heating and cooling. These installations must be properly adjusted and work efficiently. The Building Management System (BMS) controls all HVAC installations, lighting and automated processes. All interviewees had several stories on (very costly) energy wastages because the BMS or HVAC installations had defaults. There are many types and versions of BMS systems that control a wide variety of HVAC installations, lighting and other processes. And the office it is standing in is always different which makes it even harder for an installer to build a perfect suiting BMS and installations. Older offices might not even have a BMS or it is very limited in its functionality. When the BMS is wrongly installed and adjusted this has major influence on the energy consumption of an office. Interviewee 8 outlines the size of the problem:

'the amount of BMS's that doesn't function properly is mind blowing, I believe that 80% doesn't function well. This costs huge amounts of energy'

The installations themselves are most of the time over dimensioned to make sure they can always keep up with demand. There is a gap between the installers and the owners of a building. The installer talks technical and the owner talks about strategy and returns. The installer does not know or does not care about the long-term strategy of the owner regarding the office and chooses to be on the save side. This results in over dimensioned, energy gulping, HVAC installations. This does not only apply to new offices, but also with replacements in existing offices. Furthermore, new and improved installations for existing offices have to work with the spacious characteristics of the office. Too little space for the right installation leads to sub-optimal performances. On a smaller level, it does not get any better. Technical property managers who replace smaller parts also tend to be careless (interviewee 5).

When looking at the lighting there is also a split between old and new offices. Older offices still have conventional lighting which is over dimensioned just like the installations. A tenant rents an office including the lighting, but when a light bulb stops working, he is responsible for the replacement. As long as it works, tenants(s)/users do not seem to care about the lighting (interviewee 6). When there is a possibility almost all offices switch to LED. Changing all lighting (instead of one bulb), to LED for example, is a different story. This is often not well documented in the lease contract, but a tenant always consults with the owner. The tenant is full responsible for the energy consumption of the ICT, the fund manager has nothing to say about this. Their energy consumption is dropping due to the fact that appliances become more energy efficient and increasingly more companies start working in the cloud which means a decrease in servers (interviewee 12).

4.1.2 Tenant(s)/users influencing the energy consumption

Next to the physical elements, it is the (lack of) human intervention that has huge influence on the energy consumption of an office. As interviewee 8 states:

'there was a parking dock underneath the office with a ramp. The first winter someone turned on the heating of the ramp so it wouldn't get slippery. But no one turned it off, so the ramp was heated for multiple summers and winters. They found out because they started measuring and monitoring their energy consumption'

Whenever the physical elements of an office are all functioning well, the users can still use them in the wrong way. It might be unconscious, the energy wastage might be big or small, but the users turn on HVAC installations, lights and ICT, but they do not always turn them off. Users require a certain level of comfort, they do not see or do not care how much energy this costs. The fund manager wants happy clients, it is hard to ask them to lower the temperature or put out the lights. As interviewee 5 states:

'law firms in a single tenant office aren't concerned with sustainability at all. They actually want the entire building to be enlightened at night because of their exposure'

Tenants come in all differences and sizes. Different activities of a tenant require different energy consumptions. A low-density office without heavy ICT requires less energy than a research and development (R&D) department. As a tenant you would like to conduct your core business over here, sustainability is subordinate. Such specialized tenants will not move that quick and make a good long-term return for a fund manager, he would rather not scare them away (interviewee 4). The fund manager or the property manager can inform the tenants about energy saving possibilities. For example, he can advise to set the cooling of the server to 22 degrees instead of 20. But if you hit old hands, the temperature will stay at 20. One tenant is more sensitive to taking measures than the other (interviewee 5).

There are three social ways to make sure tenant(s)/users use less energy: 1) they should lower their comfort requirements and make more use of the natural temperature fluctuations of the office (as interviewee 10 states it: '*try putting sweaters in every room'),* 2) they should be educated about the energy consumption in their office and act like it or, 3) they should have less control over the building and let (well installed) machines take over. The first two measures must be taken from the tenant and can be combined, the third measure must be initiated from the fund manager. But eventually buildings should think for its users, human steering capability should be decimalised so there is less room for energy wastage. The tenant/user is concerned about his core business, not how energy can be saved.

Tenant(s)/users have more power than they think. A tenant/user can also influence the energy consumption of offices through market forces. The user currently has too little voice to choose where he wants to sit and spend his money. As soon as this becomes more flexible and people can walk into any office within a certain area to work, we will see change. Then people start working in other offices, as an owner you will lose money when not focused on the energy performance of your office (interviewee 10).

4.1.3 The position and role of technology

Technology can have different rolls to save energy in offices. As said, it is not something to start with, but something to end with. It can work together with the physical elements, different stakeholders or both. When targeting both:

1. Technology can make one understand the other. The user learns how the office is functioning through feedback that's provided by technology. IoT tracks the performance of the different processes in the office and the big data gets analysed. The right information is then displayed to the users. An office can also learn to understand its users. IoT tracks the users and the processes, the analysis of big data unveils patterns. Actions can be made based on these patterns to support users in their consumption of the building. This better coordination leads to a more efficient and lower energy consumption.
2. A NEST can target energy consumption by the physical elements and focus on the energy consumption of the users without directly making a connection between them.

Although technology can take on different roles, it is clear that it is an essential part of the road to 'Paris'. One of the main concerns is the complexity that comes with the technology. Less technology is better. The complexity of technology is not coherent to its potential energy saving. Interviewee 10 questions himself:

'what is simple technology and what is PropTech? I have been inspired by a research on energy savings at places where people do not pay their own energy bill as in hotels and offices. The experiment installed little sensors in the water pipes that registered the water flow, this was linked to a display with a polar bear that fell from an ice floe. The energy consumption fell by 34% per person, that's some impact. By just visualizing their consumption and making them aware of a consequence, people consumed less energy'

The technology from this example was not costly to make an impact, but the same applies to physical or social interventions. Some advantages of implementing technology over physical elements is that it is way less disturbing for a tenant, results are revealed faster and the investments are lower. Downsides are the unfamiliarity with technology, less certain returns on investment and it is less proven to save energy.

4.1.4 Sustainable offices through legislation

All interviewees hope that no legislation is needed, and that all parties take their responsibility. Regulations are required when the market cannot produce a socially desired solution. Currently there are two laws in force to ensure more energy saving measures in offices. A C-label before 2023 and the energy consumption registration act. This fifteen year old energy consumption registration law says that real estate owners have to execute all energy-saving techniques with a payback period of five years or less. But there were no fines, it turned out market forces did not execute the imposition. But we know how office should perform in 2050 and where we are now. We won't get there without extra regulations. As interviewee 10 states:

> *'A fund manager looks at his long-term return. If the OPEX (operational expenditures) are too high to become more sustainable, he will not tackle his cash flow to actually make that investment unless he is forced by legislation. The legislation for 2023 helps with this and encourages many parties to take action. But even with a C-label an owner still has to take real steps.'*

In general, the less wealthy and less professional investors only start acting when it becomes mandatory. They only try to catch up. Fund managers need to have a long-term vision. If they do not investment now, then they will be confronted with it later when it becomes legislation. It takes a long time for investors to realize this, leading to bad investments that must be depreciated much faster than technical required. Actively sustainable managed portfolios are cost efficient and are worth more. And as interviewee 4 states:

> *'If other parties know that you primarily have energy efficient offices, they will come to you.'*

Many interviewees had one or more comments on the current Dutch legislation that should ensure Dutch office use less energy. The main critique was that energy labels are not focussed on the real energy consumption of an office, but on the theoretical use. An energy label of 'C' must be obtained by 2023, but a change in energy label is only based on physical adjustments to an office, not technological implementations.

Acquiring a C-label is not hard if done correctly, legislation should be more ambitious. The ultimate goal is to have a carbon neutral built environment in 2050, in reality, not on paper. So, (next to the theoretical energy label) there should be an energy label with the operational energy consumption. As they have in Germany for example. Furthermore, there is no adequate enforcement and things go wrong (interviewee 8). Properties that obviously cannot have an A-label do have it. This leads to two undesired consequences: 1) environmental thoughtful tenants aspire an A-label office but actually perform worse and 2) it allows companies to 'greenwash' their business. Greenwashing is making sure your office is compliant and 'green' on paper while the operational consumption is still bad.

It is unknown how non-compliant offices in 2023 will be punished. This leaves room for the 'laggards' to think that they can get away with it as it too cheap to be not compliant (interviewee 10). And with just a C-label were not even close to 'Paris', but there is no subsequent legislation. Although the leading sustainable fund managers have their own vision to reach 'Paris', the lack of legislation does not provide any guidance. On the other hand, gas is too cheap for a tenant at this moment for him to make a viable sustainability business case.

A lot of interviewees started talking about building sustainable certificates. Legislation motivates the laggards, building certificates motive the precursors. These certificates provide a guideline for institutional investors so they know how sustainable their investments are. Fund managers try to get their offices to a high score on a certain label so they are higher valuated. But it appears that some labels provide bariers to fund managers. To get to a higher score, they are going to focus on side matters that provide them with a higher score. This leads to circumstances wherein an office performs average on energy, but it still obtains the highest label. This too is a form of 'greenwashing'. But it is a first step in awareness, at least they now know what is going on in their office and provides them with a driver to act. As interviewee 1 states:

> *'we demand a BREEAM in-use certificate for all our investments in existing European real estate. It is not about the certification itself, but to acquire insight into the performance. Bad performing buildings can be certified too here'*

4.2 NEST market research

The previous paragraph addressed the physical, user and legislation influences on the energy consumption of offices. This paragraph starts a summary of the energy consumption sources from the last paragraph which are the starting point for NEST solutions. The NEST's available for Dutch offices are reviewed together with extra information from interviewed EFOPC's. Striking matters between the connection of NEST's and necessities from offices are discussed. This shows how mature the market for NEST's is and where it should work on. This paragraph finishes with an overview of NEST solutions including their MPB's. This will be the starting point for the next paragraph that analyses the stakeholders and who can benefit from the NEST's.

4.2.1 NEST's focus of the energy consumption

Before looking at the NEST's and what they do there is a concise list of points to focus on based on paragraph 4.1. First of all, addressing the energy consumption of an office includes lots of stakeholders, interests and processes which makes it difficult. NEST's should get along with all types of stakeholders. The HVAC installations do use most energy, so a NEST could achieve most savings here. But instead of focussing on one or multiple installations separately, a NEST should focus on the BMS to address them all. In this way it is easy to steer on the lighting and ICT. But there is a huge diversity in BMS's and HVAC installations that NEST's should consider. Depending on the NEST's focus there is also a difference in which stakeholder is responsible, who pays for it and who enjoys the benefits.

NEST's could eliminate the influence of the user if the energy consumptions in an offices would all be automated. The influence of the users on the energy consumption is large, if this can be eliminated, a huge reduction can be made. But side-lining the users shouldn't downgrade their comfort and satisfaction. NEST's should provide feedback to the users so they better understand how the office works and is performing. A NEST should also support the core business of a user.

When looking at legislation, NEST's should hook into the obligations for office owners. If a NEST can make sure he is installed on a BMS or new lighting system by default, it is installed more. There is a difference between the laggards and the precursors when adapting legislation, a NEST should focus on both. Lastly, NEST should hook into the requirements of certifications, precursors are willing to use the technology.

4.2.2 An overview of NEST's

After clarifying the subjects a NEST could focus on, this paragraph describes the actual focus of Dutch available NEST's. The 33 companies assessed can be found in appendix B. When analysing the EFOPC's and their NEST's it appeared that almost all (29) NEST's try to make the HVAC systems consume less energy. Most of them also work with the lighting (19). Three NEST's focus solely on the energy consumption of the lighting. There is only one NEST that tries to lower the energy consumption of the ICT. The reason for this underexposure is that the energy savings are built in the appliances themselves. External technology cannot make the appliances themselves use less energy. The single ICT NEST is only monitoring, provides insights to the tenant who has to take action himself. The three 'other energy saving services' next to the HVAC, lighting and ICT are 1) more efficient lift operation, 2) voltage optimization, 3) occupancy based cleaning.

The overview of NEST's was based on the energy processes of Cabeza et al. (2013 and the underlying technologies of energy saving PropTech by Baum (2017). NEST's are well captured by Cabeza et al., but it appears that all NEST's are based on more than just IoT and big data. Because IoT and big data are so coherent, they always come together, they could be seen as one for NEST's. The other technologies NEST's could score on were Artificial Intelligence (AI), Data Analytics (DA), Predictive analysis (PA), Machine Learning (ML) and Software as a Service (SaaS). Raw data on its own does not mean that much it must be analysed. This means that data analytics is also coherent to IoT and big data, but there is a huge difference in the level, thoroughness and output of that analysis. And this is the part the NEST's are starting to differentiate. More on this and other remarks are in the next paragraph.

4.2.3 Elaboration on NEST's

While putting the list together of NEST's, some interesting things came to light that influences the relationship with the demand side. Most of the EFOPC's analysed could be market as startup. This corresponds to Block & Aarons (2019) who talk about PropTech as if there are startups only. There is still room for new NEST's and the current once will mature into a next level product over time. As the market of sustainability and energy saving grow, niches will be found and filled up with new NEST's.

IoT, big data and data analysis are the basis of NEST's, but the level of analysis and the combination with other technologies makes the difference and functionality of a NEST. The prime functionality of NEST's is the monitoring of the energy consumption and the visualization of it. Based on suggestive actions a certain percentage of energy reduction can be realized. Monitoring can specified to the different HVAC installations, the lighting and remaining energy usage. Feedback to the users of an office is infrequent, the information is sent to the owner or the property manager. Some NEST's can steer the HVAC installations, other just the lighting and others both. But the level of autonomy and intelligence differs from one NEST to the other. As some require input from the users, others are almost autonomously and make use of the weather forecast and the agendas of the users. Active involvement of humans can be considered as an barrier for implementation as 1) interviewee 7 & 2) interviewee 5 state:

1) *'sometimes it happens that I cannot figure it out with a customer. He might think it is a great product, but he does not have someone who can fix our recommendations. Someone has to fix it, otherwise nothing happens and no energy is saved. And sometimes the technical people simply do not have the time/ knowledge to work with our product'*

2) *'I think it is a great product and it is helping me out, but if I do not put time and effort in it, nothing happens'*

Making people aware of their office's performance, failure and flaws make them start thinking and ask questions. This requires easy to understand and relatable information. Simaxx does not provide feedback to the users of the office because they think most gains can be achieved at the installations themselves, 1) interviewee 9 agrees**,** but 2) interviewee 8 thinks users can be involved:

1) *'I do not really believe in involving the user, he is busy with his core business and can only be adjusted to a certain limit'*

2) *'if you have a screen with slides, something has to move to draw the attention of the user. You can also pose a question: 'have you turned your monitor off?' A small stimulation works very well. Furthermore, no one gets it when you tells them how much kWh's is saved by the solar panels, you have to tell them how many households of electricity is saved'*

Interestingly, most NEST's are not just a piece of software, but they often come with some (small) hardware modifications too. NEST's that target the HVAC installations (via the BMS) often install a device that links the BMS to 'the cloud' for the analytics. This is not that radical, but the NEST's focussing on the lighting often require the installation of their (LED) lighting which requires adjustments to the ceiling. But much is possible to spare a tenant his core business, as interviewee 8 states:

> *'we can organize the implementation floor by floor and also in the evening, it will be somewhat more expensive though. But it can certainly be done on an 'independent' moment for an owner'*

It is clear that there is variety in NEST's, their capabilities and intelligence. Other difficulties are their variety of promises on the energy savings (somewhere between 20-70%), the costs and including MPB's. Saving energy is not always the main focus of a technology, which means the companies cannot be classified as an EFOPC. Companies may focus on security, the happiness of employees or space optimization, ordinating the saving of energy as a MPB. The EFOPC's energy all promise one or more MPB's. Some examples of these MPB's are:

1. Less maintenance on HVAC installations
2. Predictive maintenance analyse for the HVAC installations
3. Optimized use of the own local energy sources.
4. Optimal lighting conditions
5. Better indoor climate
6. Happier tenants (also as a result of better lighting and indoor climate)
7. Insights into the office occupancy
8. Higher workforce productivity (as a result of better lighting, indoor climate and occupancy insights)
9. Smoothing peak powers, lower energy bill for a bulk consumer (larger tenants)
10. Support reporting numbers to investors or certifications

Saving energy through interaction with the physical elements is well quantifiable although the MBP's are not. The energy savings through interaction with the users is well quantifiable, the MPB's are not. As stakeholders in the real estate industry are not used to invest in something that has a unknown return, the demand and supply side only keep talking about the energy savings (maybe some user happiness). Furthermore, MPB's are divided among serval parties and only one party pays for the NEST. The inexperience on the topic, the difficulty of quantification/distributing MPB's makes a fund manager holding back.

4.2.4 Points of improvement and future perspective

Although all three interviewed EFOPC's indicate that security is one of their top priorities, most stakeholders are sceptical. This is not specifically for NEST's, but for technology in general. The value of data is created by linking multiple data sources and systems. This interconnectivity can become a real problem when one of the links appears to be breached. Interviewee 11 has a solution for this:

> *'Technology is not visible and people are mostly unaware of it until they are hacked. Therefore you should show the users your technology, take them by the hand and let them experience it. A linkage with the users via a dashboard might be helpful for this'*

Such a dashboard might also help with the feedback/ communications of a business' sustainability efforts and performance. At this moment, the users are not aware of the energy consumption of their acting and their office in total although they might want to be. Providing feedback to the users might not be the core business or might not be seen as most important, the users of an office are responsible for the energy consumption and wastage. They must be included in another and better way to ensure their wrong habits and patterns change. As said, it is difficult, but at least it should be tried.

It is hard to say where the sector of energy saving technologies will be heading too. At this moment there are mostly static products that are not always working in harmony with the users. The tenant(s)/users of an office should be comfortable and willing to extend their least agreement. Technology that is proactive, autonomously and works together in perfect harmony with the user will eventually succeed. Another thing that might happen is the merger of companies to serve the customer with a total solution instead of partial solutions by several smaller PropTech companies (interviewee 11). Technology will get smarter, the analysis of data will get more complex and sophisticated. Comprehensive technology that support every specific need of a customer will be costly and will therefore not be implemented in every office. The high end offices will bear the investment, but secondary office will have a stripped version with less capabilities.

4.2.5 Starting points for stakeholders

This paragraph described the variety of NEST for Dutch offices, their differences and notable matters that stakeholders should keep in mind when buying a NEST. Before positioning and explaining the involved stakeholders, the starting points for them will be summarized.

Every stakeholder should think well about what he wants to do with the office in the sense of sustainability. Not only for now, but most important in the long run. Through holistic thinking some wrong and costly investments can be prohibited. Perhaps it might be better to invest a bit more at this moment to have more technological possibilities in the future. Also, by investing in a NEST now, a new heating installation in the future might be smaller and cheaper because less heating is needed. Less service costs for a tenant justifies a higher rent for the fund manager.

A proper strategy is needs because there is a variety of NEST's. They might primarily work with the BMS/ HVAC installations and lighting, but their functionalities differ. Not only the buyer of the product acquire benefits, but others too. NEST's often require attention and human work, the buyer should ask himself if he wants to spend his resources on this. Perhaps a somewhat more expensive, but more autonomous NEST might be better. Furthermore, for a tenant it might be interesting to investigate how a NEST might support the core business. More in general, every stakeholder should investigate how a NEST could solve other existing problems.

Next to saving energy a NEST could also have one or more MPB's which could resolve those other problems. But perhaps the buyer solves a problem for someone else or does it benefits in any other way. Stakeholders working closely together could look into a NEST together to split the benefits and costs equally. As for the main service, a tenant should look for a way in which a MPB is helping the core business. Last, but not least, NEST's could help to be compliant to legislation or acquire extra points for a sustainability assessment.

4.3 Demand side: drivers, barriers and solutions

This chapter describes the stakeholders involved in operating an office managed by a real estate fund and their relationship on the subject of the implementation of NEST's. The involved stakeholders are institutional investors, fund managers, property managers, tenant(s)/users and the EFOPC's themselves. Other parties were mentioned during interviews, but they didn't appear to have that much interest and/or power to be marked as a stakeholder.

Many stakeholders want to be more ambitious, but are stuck in a traditional role. People are inclined to do the minimum while much more is possible. Within real estate, operating or mutating a property requires the involvement of multiple parties. But if you add one stakeholder, the time to decide becomes exponentially much longer (interviewee 10 & 11). There are always too many stakeholders to make the right decision on sustainability right away. It is very difficult to change the repetitive standard processes, many parties do something because it was done last year. They run because something goes wrong, very reactive, not proactive.

4.3.1 Institutional investors

Investments don't stop by national borders, institutional investors operate worldwide. These are large companies that can (partly) own thousands of properties all over the world. Through their own persuasion on the importance of sustainability and imposition of their money lenders, institutional investors want and must steer on sustainable investments. From their own persuasion PGGM wants to be 'carbon neutral in 2035 for example, while the Paris agreement requests this to be done before 2050 (interviewee 1). Their future perspectives help them to control risks and realize a healthy return, but also enables them to easily incorporate sustainability.

They have much power to enforce their own sustainability goals when investing in (office) funds as they eventually (partly) pay for it. This can be demanded for new and existing offices. Institutional investors can also demand the certification of buildings or annual reporting of their performance by the fund managers. This too helps them to allocate risks and bring forward good investments. Investing in sustainability is not just good for the environment, it is also good from an investment point of view as interviewee 1 explains:

> *'we demand that a new development meets future regulations. Otherwise a future buyer will pay less for the building in the future as he demands a discount on the selling price because he has to execute all modifications'*

Chapter 4.2 reviewed the available NEST's for the Dutch market. No of them were specifically addressed to institutional investors. The only two indirect reasons why institutional investors would desire NEST's for their offices is that it would help them reach their sustainability goals and increase the value of their portfolio. Pension fund are even less related to implementing NEST's. Demanding NEST and checking this with the fund manager requires a certain amount of time and effort and is not considered effective as they are less direct involved with the office itself (interviewee 1). To keep it practical and manageable they rather steer on performance, how the fund manager executes the demands is up to him. But this doesn't mean that institutional investors will never demand the implementation of NEST's, interviewee 2:

> *'If some sustainable measure (like not using natural gas anymore for example) is possible in one country, it should be possible in another country too. I challenge parties to meet these possibilities'*

If they can demand parties to not make use of natural gas anymore, institutional investors could also demand the implication of NEST's if they wanted too. And because they operate worldwide they could spread NEST worldwide, increasing their impact. But NEST's should first get interesting for them, proof their effectiveness and impact before this will happen. Or the implementation of certain technologies should become compulsory through legislation. For now, institutional investors appoint the fund managers to make sure the right technologies are implemented in an office (interviewees 1 & 2).

4.3.2 Fund managers

Not only institutional investors appoint the fund manager as the prime stakeholder to implement NEST's, so do the property manager and tenant(s)/users. It appears that they have much power and interest to implement NEST's. Their drivers to invest in sustainability comes from their own persuasion, demand by their tenants and imposition of their money lenders (institutional investors and insurance companies). Although they collect (international) money that can be linked to various sustainable conditions, it differs where and from whom you collect the money. Collecting equity in the USA is more focused on compliance than on energy performance. When you raise equity with Dutch or Scandinavian pension funds, you are asked a lot more about sustainability (interviewee 4). Smaller fund and private investors never had this pressure from their money lender, but they are now force by legislation (interviewee 6).

When an office is empty, the fund manager can do whatever he wants with it. But when there is a tenant doing (physical) alterations becomes difficult because of restrictions in their contract. The tenant has much power to execute its core business without disturbance. With every extra tenant in the office negotiations about alterations become more difficult. This restricts the power of a fund manager. A fund manager can only ask his tenant(s) to make different use of the office to save energy, but he can't force them. Training the users is a task of the tenant (interviewee 4).

The fund manage does have power over the parties he contracts to operate the office. The supervision on the execution of the extra requirements in the contracts requires time and effort of the fund manager, so they choose in what they can ask as they can't do everything (interviewee 4). It is easier and less time consuming for fund managers to demand more general performance indications from the parties they contract instead of all details. Interviewee 3 & 4 hope that the property manager knows what is happening in the office and proposes energy saving measures, although this is not contracted. Realize sustainable measures through contracting is considered too time consuming and not varying effective as other parties have little experience in executing the demands.

The EFOPC's in paragraph 4.2.1 all see fund managers as their customer, although not always as their primary customer. Saving energy isn't their main focus though, the MPB's are often considered more valuable as the tenant pays the energy bill. When energy is saved through the implementation of a NEST the service costs of the tenants get less, justifying a higher rent for the fund manager. But a higher rent can only be agreed at the start of a new lease contract. Examples of MPB's that are interesting for a fund manager are the additional and real time insight into the performance and errors in his offices or an improved indoor climate resulting in happier users (and so, tenant(s)) that want to extend their lease contract. But these effects are hard to quantify, and as interviewee 3 remarks:

> *'a tenant might appreciate that all this technology is incorporated, but there is just that much it can do. But his experience of the user comes mainly from different things like his co-workers'*

From the fund manager's perspective, implementing NEST's mean that energy can be saved without large physical alterations that might infringe the lease contract with the tenant. Monitoring the office enables fund managers to make more accurate data driven decisions and investments, saving money in the long run. NEST's also enable a fund manager to serve environmental conscious companies looking to lease an energy efficient office (interviewee 4). But there are some considerable barriers too that makes a fund manager not willing to implement NEST's.

There are two needs for a fund manager, maximising profit and being compliant, if a NEST can help with this the fund manager is interested. He won't invest into something that doesn't support one of these two in the long run (interviewee 10). If the tenants want to pay for it, that would be great. A fund manager won't do it for nothing, as interviewees 1) 4 & 2) 10 remark:

> 1) *'if you buy a car, you can't go back to the dealer and demand some screens for the back seats. The same applies for alterations to the office'*

2) *'whenever an office is full, a fund manage tends to stop investing as the extra costs won't produce extra revenue'*

But the tenant doesn't own the building and is therefore less inclined to do the necessary investments as benefits will also fall to the fund manager. This 'split-incentive' is an important barrier to the implementation of NEST's. Both parties often don't know each other's sustainability ambitions and plans which leads to missed opportunities. Fund managers can't just advertise with MPB's, a tenant would demand performance agreements of these MPB's before he will pay for them (interviewee 3). Most of these MPB's are however hard to quantify which makes them hard to praise. Implementing NEST's in an office often requires the collaboration of the tenant(s). The cooperation in a single tenant office is easier than in a multi-tenant offices as there are less opinions and interests. Within each tenant there are multiple departments that want something to say about the matter too which frustrates the process (interviewee 3 & 4). A real estate fund consists of multiple departments too, internal interests frustrate innovation and the implementation of technology (interviewee 10).

Both interviewed fund managers prefer to use as less technology as possible. Buildings should operate as natural as possible and technology should be there for the monitoring. At this moment NEST's produces a lot of data and it takes time and effort to analyse it all and take affirmative action. There should be someone to work with the data otherwise it is worthless (interviewees 4,5 & 7) Furthermore, it is hard to determine the best NEST as there are many technologies who all work just a little bit different. And as every office is unique and has its own problems it is hard to find the perfect system (interviewee 4).

Lastly, legislation does not provides an driver for a fund manager to invest in NEST's. Compelling legislation mainly demand physical adjustments, not technological (interviewee 3). And in general, if the costs of not being sustainable are too low, then some owners think it's fine not to be compliant. Unless there is pressure from the government, then they need to act (interviewee 10). But still, when owners lose the economic function of their office in 2023 because they do not yet have a C label, the land is still worth something. The different certification do not always provide a driver either. This leads to the situation wherein fund manager rather 'greenwash' their offices than implement NEST's.

To overcome the barriers, there are several things a fund manager could do. First of all, fund managers should remember that tenants pay the rent and are worth investing in. NEST's come in a price range, the investment doesn't have to be high to have happier tenants. Performing research on the market of NEST's provides a chance of openly discuss the benefits and costs for both parties. This costs time and effort, but a tenant might want to pay a part of the bill. When both parties reasonably share the benefits and the bill, the 'split-incentive' might be overcome. Through a market analysis a fund manager also gets a feel for the amount of time and effort a certain NEST will cost him, paying a bit more for more automated actions might save him time and effort when analysing the data from the NEST.

If there are multiple tenants in an office it might get hard to implement NEST's that require the cooperation of tenants. To understand all tenants, the help of the property manager might be asked. A thorough plan with all the benefits and costs explained might convince some tenants to participate, but a viable business plan is unsure. To increase support for a desired NEST, a fund manager could start monitoring the energy consumption and display this in the entree of the office. Users will start asking questions if they think the energy usage is divergent and/or too high. This uncertainty in combination with the great effort for a fund manager does not make it an attractive option. A start could be to resolve any internal contradictions first and come up with a digital/technology strategy to implement NEST's first, interviewee 8 remarks that this is total lacking and that they don't know where to begin:

'we have to take an owner of an office by the hand and explain him how he can make use of the technology, how it can pay itself back and how he should explain it to other decision makers in the company. They have absolutely no clue at this moment'

Through a different set up of the lease contract between a fund manager and his tenant(s) the fund manager should be responsible and pay for the energy consumption in the office. This would provide the designated stakeholder to invest in energy saving solutions like NEST's a more direct driver. This would also open up the conversations between the fund manager and the tenant(s) on the energy consumption and how they can collaborate on this. Whenever stakeholders are familiar with these new kind of contracts, investments in energy saving solutions will go up. But interviewee 10 things that this is not necessary and that market forces will eventually provide the right drivers.

Market forces ensure that the return on sustainable investments will get larger over the years. This will provide an extra driver to immediately minimize all costs that you incur in terms of energy consumption in advance. Passing on the energy consumption to the tenant at a fictitious cost per kWh while generating the energy decentralized yourself, provides a financial driver to finance innovation from the operational expenditure (interviewee 10).

Interviewee 3 has an idea to force owners of offices to act more sustainable. Mandatory publicly available reporting on the performance of offices might force the owners to take action. Interviewee 8 thinks that parties who are working with sustainability should show this more. Fund managers should chance their contracts with their property managers if they desire more input on sustainability from them. Instead of tendering on price, contracts should be tendered on energy performance. Within a fixed sum of money property managers must show how much energy they can save during the contract. This encourages the property managers to start thinking about sustainable measures (interviewee 5), among which NEST's. Interviewees 1 & 2 understand that 'greenwashing' isn't helping anyone and demand that their investments are certified by the labels that represent the real performance best.

4.3.3 Property manager

The property manager knows best what is going on in an office, but does not have the mandate (and often budget) to alter more than repairs require because of his contract. He is often depending on the property manager. As the fund manager acts more on a higher and strategic level, a property manager works on an operational level. Property managers have saying in the multi-year maintenance plans, here they are on the same footing as the fund manager. Here, a property managers can come up with all kind of suggestions for work to execute in the future, including the implementation of NEST's. In addition, both parties also discuss investments to upgrade an office because it is vacant (interviewee 5). When questioned about their role to make offices use less energy interviewee 5 answers:

> *'there are a lot of property managers who work very traditionally, they are not into sustainability. But I think we have a duty to our client to incorporate this into our service'*

If something stops working, a property manager tries to do a repair himself first. If there are large component that fail, they have contact with the fund manager. The fund manager has maintenance parties contracted to fix this, the property manager monitors their work.

On a more daily basis, the property manager is the point of contact for the tenant(s) in an office and handles the administrative work like the billing of the service costs. One property manager can have as many as 25 properties to keep track of. They are spread out over the country and all have their own characteristics. (interviewee 5). To keep an overview of all properties and find and resolve issues quickly, NEST's like Simaxx exist. Saving energy is not the main objective though, quickly resolve complaints by a tenant saves time and the monitoring means less unexpected breakdowns (interviewee 7).

A property manager is obliged to ask the fund manager before he may implement a NEST in an office. This applies when making the multi-year maintenance plan as when halfway through the contract. He might not have the mandate, but it could be very attractive for a property manager to implement NEST's. As said, it provides him support in his activities, but he can also show that he is innovative. Just like any profession,

the activities of the property manager are changing, by adopting the latest technology he might keep up with the competition (interviewee 5). Because of all the contract extensions and reporting for certificates, it takes increasingly more time to report figures. The MPB's of NEST's can support the time consuming gathering of data from all portals as interviewee 8 states:

> *'it can take the people who have to report two to three days to gather all necessary information from all different portals. This costs a lot of time and money. We can built one portal for all his necessary data'*

But there are also barriers to make use of NEST's. NEST's require money, time and effort to implement and function well as they are not operating full autonomous. Some NEST's require more work than others. A property manager should ask himself what the added value is of a certain technology for a particular office. It might appear that the benefits do not weight up to the costs (interviewee 5).

Next to their standard earnings, property managers charge a percentage of the service costs as a compensation for the administrative work. These service cost include among other things the energy bill for the tenants. A property manager has an interest in using as much energy as possible because this leads to more service costs and thus to a higher administrative compensation for him. In addition to the driver to increase energy costs, they want to keep costs as low as possible by spending as little time as possible on sustainability. Interviewee 5 confirms that this is how other parties look at their role, but he himself is working on sustainability for his client. Because little happens, the office does not perform that well. This ensures property managers aren't eager to start showing the performance numbers to other parties if they do not have to. According to interviewee 10:

> *'it will often appear that the property manager doesn't have everything under control'*

Without information on the performance of the office, other parties are not encouraged to ask questions and start taking actions (interviewee 10).

Property managers are not paid to come to the board with an innovative idea like a NEST. There are also few agreements on sustainability and energy saving agreed in the contract. It has usually been agreed that the fund manager is compliant, but a property manager has no reason to do more than that (interviewee 8). If a property manager wants to implement a NEST that supports his work activities, the fund manager does not pay a pat. As the property manager does not have much budget, this is a barrier to implement NEST's. When asked which parties should work together to make the implementation of NEST's possible, interviewee 5 answers:

> *'everyone should be working on this. Everyone who is involved into real estate should do their part'*

Two solutions could solve most barriers for a property manager to not implement NEST's. The first solution is that the contracts with the fund manager should be tendered on energy performance as discussed above. Interviewee 5 thinks this might be a solution if it is designed well and works for all stakeholders. The second solution is that the property manager looks for collaboration with the tenants to implement NEST's and share the costs and benefits (interviewee 10). At least for now this is unlikely to happen as it these activities are distant from their current ones.

4.3.4 Tenant(s)/users

When there is much office space available and it is easy for a tenant to move he can demand favourable conditions when entering a new lease contract with the fund manager. During the contract the power of a tenant is controlled by the agreements in the contract. Here it says what they may expect from each other and what their obligations to each other are. New agreements can be made during negotiations on a new lease contract, but a fund manager is not obliged to grant extra alterations outside of the current contract. When a fund manager does not want to lose his tenant(s), he is willing to do a thing extra (interviewee 6).

Every tenants consists of different departments with their own requirements, it is difficult for a single tenant to carry out one sound. But, as a single tenant you can make a statement against the fund manager If you are in a building with other tenants, it will be more difficult. As the service costs are divided equally among the tenants, other tenants will benefit when one decides to save energy. In that case you have to mobilize other tenants if you want to get something done well (interviewee 8). Furthermore, as real estate is not the core business of a company, their real estate department is often too small to make up a comprehensive strategy (interviewee 6).

As said, within the current situation the financial benefits of energy saving are for the tenants which makes them positive towards energy saving interventions as long as it does not disturb their core business. The EFOPC's from paragraph 4.2 know this as well and most are focussing on them. Next to saving money on the energy bill, the MPB's provide a variety of support throughout the company. A more pleasant indoor climate via optimal lighting and air quality sound interesting for a tenant, but these are hard to quantify. Other MPB's like smoothening the peak powers in the energy consumption are better appreciable.

As the implementation of NEST's is not incorporated in standard lease contract a tenant cannot demand a fund manager to pay for it. And as the implementation of NEST's often work with the BMS, the HVAC installations and/or the replacement of lighting the tenant should always ask the fund manager for approval (interviewee 6). To make sure the fund manager pays for the NEST's, their implementation can be part of new lease contract negotiations. As a single tenant this is a different story than leasing in a multi-tenant office because you have more power. Furthermore, NEST's require a certain scale size to acquire an acceptable business case (interviewee 8), single tenants obtain more space than those in a multi-tenant office.

Real estate and saving energy is often not the core business of a tenant and it is certainly not its most expensive asset. Ninety percent of a tenant's operational expenditures (OPEX) are expenditures related to the employees, nine percent is the rent of the office and only one percent is reserved for other costs including the energy bill as part of the service costs. Saving one percent on their core business makes way more impact that saving twenty percent on their energy bill (interviewee 6). MPB's of NEST's that support the tenant's core business is the main driver, saving energy is secondary. But there can be a difference in what the company as a tenant and its employees find most interesting. The users could be more prone to saving energy than the MPB's.

Increasingly more companies want to do something for society in general. Following the 'Paris agreement' some companies have committed themselves to also become 'carbon neutral'. NEST's will not make a tenant immediately carbon neutral, but it might be a starting point. Another driver to implement NEST's is attracting talent to the company. Interviewee 6 remarks:

> *'that is why Deloitte is hiring the super sustainable office The Edge at the south-axis in Amsterdam, that helps them profiling that they are sustainable which is attractive to talent'*

If NEST's cannot demonstrate that their MPB's are of enough additional value, that might also be a barrier for a company to not make use of NEST's. As new technologies take time and effort to implement in the current business it must be of a certain added value because this time and effort could also be spend on other projects that improve the core business. As NEST's often come with a certain physical alteration, this should not negatively influence the core business of the tenant.

When asking the fund manager to do an investment on their behalf, the tenant is afraid that they will have to pay disproportionate more rent. The same applies when a fund manager proposes to invest in something that benefits the tenant, like a NEST.

To overcome the 'split-incentive', the solution is the same as from the situation from the fund manager. Try to create a win-win situation and openly discuss the benefits and the costs. This also reduces the fear that the fund manager will disproportionately increase the rent for the benefits enjoyed by the tenant. Furthermore, the increase in rent will (partly) be compensated by lower service costs (interviewee 6).

A tenant should inform a EFOPC about all the problems he is having in executing its business. This enables an EFOPC to demonstrate its total value to that company instead of just saving energy. But because this is very confidential information for a company, they will not do this immediately. By building a relationship so the company feels more at ease to share this information, and EFOPC's demonstrating all the capabilities of their NEST can bring them more together.

To acquire a viable scale to implement the desired NEST one tenant might need to convince the other tenants. They could unite in an association, this increases their power. Now they can not only ask for the implementation of NEST's, but also arrange other things more easily. A fund manager feels more pressure to take action, but he is also afraid that the dialogue will become unreasonable. But as this requires time, money and effort with an uncertain outcome for something that is not directly his core business, it is not an obvious situation (interviewee 6).

Other tenants might also be mobilized through activating the users. A screen with information on the poor energetic performance in a multi-tenant building can cause questions to be asked. Because what you get is that someone who is the last to go home sees that energy is still being used, and he is going to wonder why. But other people are also starting to wonder why a certain amount of energy is being consumed (interviewee 10). This can take a lot of time, or might not happen at all, but companies listening to their employees might provide the additional support needed for a viable NEST business case.

4.3.5 Stakeholders in a vicious circle

Figure 12 from the stakeholder paragraph in 2.3.3 is altered to figure 17 based on the findings in this the previous paragraphs. The three most important alterations are the pension fund is out, tenant(s)/users are split in multi and single and all stakeholders have changed position except the property manager. It appeared that pension fund are that distanced from implementing NEST's that they cannot even be considered as a 'context setter'. All interviewees made it clear that there is a huge difference between the power and interests of tenants who are in a single or multi-tenant office.

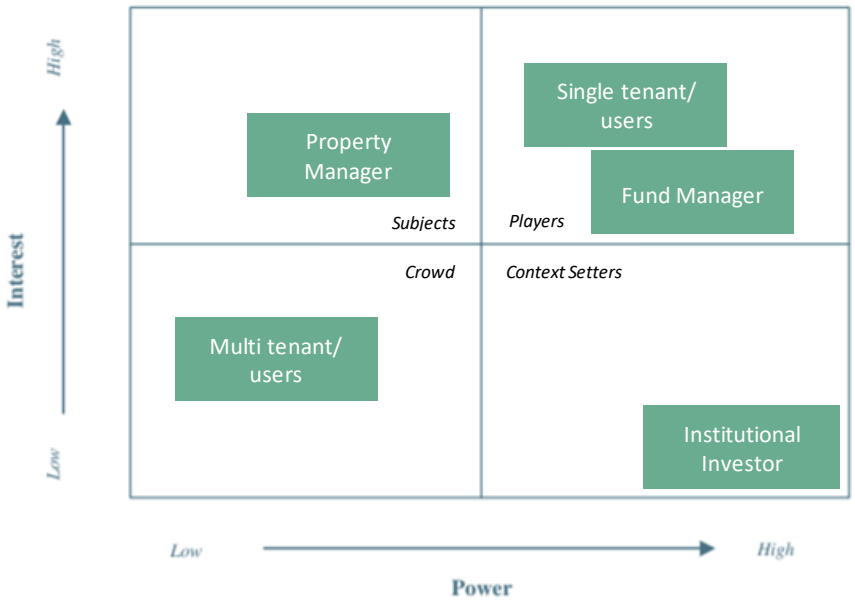

Figure 17: Power and interest from demanding stakeholders when implementing NEST's (based on Eden & Ackerman, 1998).

Institutional investors have maximum power over fund managers to demand certifications or certain technologies (like not using natural gas anymore), but NEST's appear to be too specific for them to steer on. It is up to the fund manager to make sure an office does not use too much energy. The fund manager enjoys some MPB's of the NEST which could help them make the tenant(s) happy, bind them longer and ask a higher rent because the service costs are lower. During the contract he is bind to the agreements with the tenant(s) and can't implement NEST's that require a (small) physical alteration.

The single tenant enjoys a lower energy bill and many MPB's (depending on the NEST). But it is not his office, so that makes him having somewhat less interest. If the MPB's were quantifiable in a better way his interest might be higher. Also when the costs upfront can be (equally) shared with the fund manager. A single tenant has leverage to ask the fund manager to implement NEST's, but he has somewhat less power than him because the BMS and the installations are still owned by the fund manager. It is depending on the number of other tenants, but a tenant in a multi-tenant office has less power and interest to implement NEST's as he has less leverage and the benefits well be divided among the other tenants in the office. This differentiates both as a single tenant being a 'player' and multi-tenants are part of the 'crowd'.

The property manager is mainly 'subject' to the desires of the fund manager and the tenants. He has power through shaping strategy- and maintenance plans together with the fund manager. But he cannot act on his own and needs permissions from the fund manager. The savings of energy are negatively influencing the compensation of the property manager, but the MPB's do support him with different facets of his work.

In 2000 Cadman developed a scheme called the vicious circle of blame, consisting of 4 stakeholders involved in the development of commercial real estate; end-user (tenant), designer, developer and investor (see figure 18). The interrelations and the motives and triggers indicate why is it difficult for each of these stakeholders to initiate the change and start demanding sustainable office buildings.

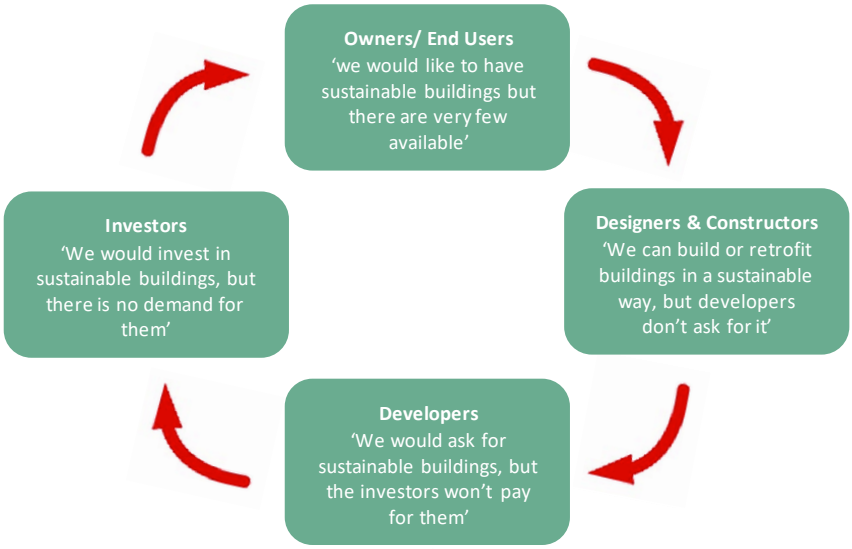

Figure 18: The vicious circle of blame (Cadman, 2000).

When analysing the situation around the implementation of NEST's in offices, the same principle happens as described by Cadman. The three involved stakeholders (fund managers, property manager and tenant(s)/users) are working from their own island and point to other parties to be in the lead (see figure 19). All stakeholders have their drivers to implement NEST's, but they also have their barriers. As it takes effort to settle their barriers and the status quo is working, stakeholders point fingers to other stakeholders. Pressure from the institutional investor or legislation could breach these barriers, but their intervention is unlikely due to the specificness of NEST's.

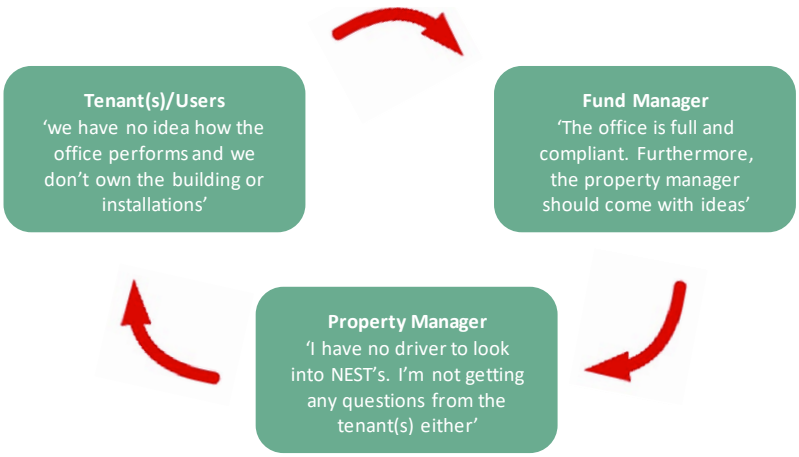

Figure 19: The vicious circle of blame when implementing NEST's (Based on: Cadman, 2000).

4.4 Drivers and barriers between demand and supply

The previous paragraphs provided an overview of the characteristics, position, drivers and barriers of the stakeholders to (not) implement NEST's in an office. Block & Aarons (2019) explain that there are certain differences between PropTech companies and the established real estate sector. These paragraphs show the common ground and the friction between the demand and supply stakeholders when implementing NEST's. When all barriers are solved, the starting point for a solution can be pinpointed.

4.4.1 Demand side experiencing collaboration with supply side

In general the experiences are good, but cooperation is not naturally. The main difference between EFOPC's and real estate companies is that the first is mission driven and the latter profit driven. There are a few real estate companies that are mission driven too who invest in the smaller EFOPC's, but this is very limited (interviewee 10). Most real estate companies start with a small test or even a POC (proof of concept) even when the technology has already proven itself. Whenever the customers have found a NEST they like, they value the contact with the EFOPC. But up front real estate companies remain very reservedly.

It appears hard to find the right EFOPC, for monitoring the BMS there are just too many. Interviewee 4 remarks:

> *'after a while you're just done with the requests. I don't even invite them over anymore'*

Interviewee 3 endorses this problem. There is a lot of choice in a lot of NEST's who do the same thing just a bit different. It's up to the fund manager to make a selection into this. This matching between both parties is difficult. And they truly are different, different decision making, way of working and expectations. Interviewee 3 continues:

> *'if you don't speak their 'language' it can get real difficult. Starting a pilot is doable, but I am wondering if companies exactly know what they want. Their problem might ask the cooperation with a startup, but it could also be the case that they need to cooperate with a Microsoft'*

And it is important to make a good choice, after you have chosen you're stuck to a certain technology. After a while it might appear that a NEST has some downsides, it is costly and time consuming to transfer to a different technology. That is why interviewee 4 always works with an open source technology. At least they use the data from the technology themselves instead that it is out of their reach. This also enables them to easily report numbers.

As a real estate company you cannot just do the cooperation with a EFOPC on the side, it is a close relationship that needs to be maintained. They should listen to each other instead of just hearing what the other says. Understanding EFOPC's takes time. Time is valuable, especially to an EFOPC, there must be a policy on this. Furthermore there must be an open relationship that enables both parties to really know each other. There is a difficult balance between matters that should be arranged properly (security, privacy, ownership of data) and flexibility. More than two pages of contract is demanding too much management of the small EFOPC (interviewee 11).

In general the property manager and the EFOPC work together great, the small EFOPC is really trying to help and think along with the work activities. Interviewee 6 endorses the difference in 'language' between the tenant and the EFOPC as the tenant is considered with totally other belongings than the EFOPC:

> *'at the end of the day I'm judged on my core business, not the amount of energy I saved'*

To surmount the barriers that the demand side experiences, the demand side should develop a general strategy on how to work with technology and what technologies would be applicable for this specific office. The stakeholders at the demand side also tend to work independent of each other instead of trying to unite benefits and divide costs. By tendering their needs and wishes, demanding parties are taking measures into their own hands and can make a better choice in available NEST's.

4.4.2 Supply side experiencing collaboration with demand side

On the one hand, EFOPC's have many parties to focus on (fund manager, property manager and tenant), all of whom gain an advantage. This means that pressure to implement their NEST can be exerted to multiple sides. On the other hand, they might have to go through all those departments at every company. But it may also be that a director says "let's do it" and then it can go quickly (interviewee 8). A NEST itself must really solve a problem or save a lot of money for a party if it is to be implemented since it does not help to be compliant at this moment. But technology often comes with a physical intervention that can make a stakeholder compliant with legislation (2023 and/or DEE), installing LED lighting for example. This provides EFOPC's with a starting point to implement their NEST. Other powers are the short payback times and being able to pre-finance the NEST. There is a lot of competition, for example there are many EFOPC's that focus on HVAC installations. This creates a fragmented landscape and they work against each other. At the end of this paragraph the EFOPC's are positioned in a derivative of figure 17 based on their power and interest.

First the things that go well according to the EFOPC's. Interviewee 9 experiences a high level of interest from the different parties they are speaking to. Their interest varies depending on the particular party they are speaking to. Therefore, it is key to understand the customer and adapt your story on the benefits they will be most interested in. Even when the payback time for a NEST is short, the decision period often take long. But sometimes the right person approves the implementation and it can go real quick (interviewee 8).

Interviewee 9 explains that he feels he is on the same level with his customers and fully understand their motivations and considerations. Interviewees 7 & 8 agree on this, they do understand the considerations of their customers, but have the opinion that these aren't always reasonable. The EFOPC's are flexible in the services they offer to convince the customer, special dashboards can be made or the installation of the LED lighting can be done at night.

When questioned about what is going wrong, interviewees 7, 8 & 9 come with many topics and examples. To start with, many customers don't know about the possibilities. When there is a problem in an office, they go to the parties they have always worked with and caused the problems in the first place. Whenever something functions no one asks himself if it can run better, there is no ambition. Something has to break down or the tenant(s) complain first, second the timing of the EFOPC should be right to implement the NEST fast.

The processes before a NEST is implicated often takes quite long. The decisive party is divided and all relevant departments should be convinced first. The wrong people with wrong incentives and no mandate lead to long decision making at the customer. Talking to the right person is very important (interviewee 7,8 & 9). When the customer is dealt with, the other involved parties should work along too. Interviewee 7 tells the story for a large office building in The Hague:

> *'The fund manager says: it is our building, we would like to manage it better, we want Simaxx. The property manager says: I would like to pay for it, but as the energy delivering company is mostly making use of it, they have to pay a part as well. Whenever all parties are in agreement, the energy delivery company says: contact the service provider of the BMS, we have that subcontracted. When we call them it takes two weeks for the rights answers. This is the challenge we're facing, more difficult than the technology. We're now organizing 'kick-offs' to make sure everyone is aligned'*

EFOPC's should really think about the easiest way to realize the implementation of their NEST. The tenant(s) might be their main focus and are the ones who lay first contact, but the fund manager might be a better contact point as he eventually decides on the implementation. Less parties involved speeds up the decision making.

Other objections from fund managers that EFOPC's must deal with are management of the payback periods and who should be paying. Fund managers don't dare to look beyond the current lease period and are of the opinion that the tenant(s) should pay for it. Interviewee 8 explains that they therefore actively think along with the fund manager how they can convince the tenant(s) and how it can be financed internally. It is hard for fund managers to go beyond a budget, even though the payback period is that low. He further explains:

> *'as the payback periods are that good and we can finance everything ourselves upfront the customer sometimes thinks that there is a catch'*

EFOPC's see their products as something that is easy to install and handle. But the larger customers experience the implementation as a project because multiple people from multiple departments are involved. The shortage of the right manpower to make use of the NEST is also a reason for difficult negotiations or even the reason why the implementation doesn't proceeds (interviewee 7). All those different departments all have their own questions and desires. EFOPC's should choose which requests they incorporate as it is undesirable that their NEST gets fully adapted to every new customer.

Whenever the demand and supply parties are negotiating, there is a difference in language. Interviewee 11 & 12 underline that both are some completely different 'worlds' with different cultures, making incomprehension widespread. They might understand each-others motives and needs, but when it comes to the elaboration of a pilot, the differences as contract formation and further expectations become clear. These differences must be dealt with, the pilots are helping with this (interviewee 11). Building a relationship and creating trust is key for good collaboration and mutual success. EFOPC's shouldn't look at the business development from the technical perspective, but from the relationship perspective (interviewee 10).

4.4.3 Positioning EFOPC's

After repositioning the stakeholders from the demand side in figure 17, the position of EFOPC's on the supply side can be determined too. EFOPC's are fully dependent on the willingness of their customers to implement their NEST as there is no pressure from legislation or other stakeholders. Furthermore, it appeared that they have great trouble to convince other parties, they have no leverage to force the implementation. On the other hand they have maximum interest in the implementation of their NEST as they consider it their mission to ensure the built environment consume less energy and they earn their money with it. Therefore, figure 20 places them in the top left corner as 'subjects'.

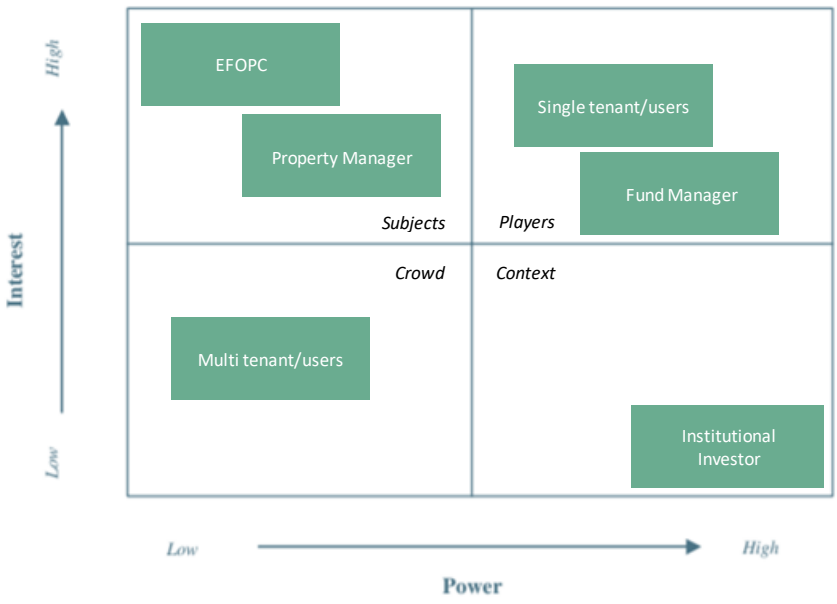

Figure 20: Power and interest of demand and supply when implementing NEST's (based on Eden & Ackerman, 1998).

4.4.4 Surmounting barriers

The demand side has no needs to adapt to the EFOPC's. They are concerned with their own business and don't feel any pressure yet to work together with an EFOPC. The EFOPC's on the other hand are fully depended on their customers and are fully focussed on their problems, needs, wishes and way of working. Fund managers, property managers and the tenant do not mention any shortcomings from the EFOPC's when it comes to their collaboration. Their critiques is focussed on the shortcoming of the NEST's themselves. Interviewees 10 & 11 do mention their shortcomings in 'language' that obstructs their collaboration. Here too, their one way relationship comes forward. All interviewees expect that EFOPC's understand the motives of their customers, but no one expects the fund manager, property manage or tenant to try to relate to the EFOPC's. With more demand for NEST's, EFOPC's will feel encouraged to produce that perfect NEST that is the solution to (nearly) all the customer's problems. But currently there mostly the supply of NEST's, with a low demand. And this is exactly the problem at this moment to take the market for NEST's to the next level, a lack of demand (interviewee 10).

EFOPC's criticize the cautious way of working of their customers. Every stakeholder is working on its own, there is a lack of cooperation. And cooperation is need to implement NEST's. EFOPC's understand that their customers cannot just invest in anything they come across, but the internal division and lack of policy at their customer frustrates them. Fund managers, property managers and tenant(s) should develop policies on innovations wherein the critical departments are united. This speeds up the negotiation process. These policies could also regulate which requests will automatically be offered a pilot. To fund these innovations all stakeholders should erect a fund to finance the pilots (interviewee 9 & 10). Clear regulations will create clarity for all parties. Also other parties at the demand side can now hook into this, resulting in more collaboration. As said, open conversations and working together could make the demand side work more together and act as one party.

4.5 Flowcharts 'route to implementing NEST's'

Paragraph 4.3 described the stakeholders at the demand side and paragraph 4.4 described how they work together with the supply side. Paragraph 4.3 provided solutions to the barriers that the demand stakeholders experienced. Paragraph 4.4 provided solutions to the barriers between the cooperation between the demand and supply side.

As figure 19 visualizes, there is no stakeholder who initiates the implementation of NEST's, they are all pointing towards each other. Only when the benefits of NEST's go up and/or the barriers go down it will become more appealing to implement NEST's. After a stakeholder decides that they want to implement a NEST, they have to go through some effort to settle the barriers based on their interdependencies with other stakeholders. Based on their severity, there is a certain order to settle these barriers. Based on the exact situations, there are different routes to follow to implement a NEST. This route is different for the fund manager, tenant and property manager as they all work from a different perspective and differ in power and interests. Because EFOPC's are so dependent on the power and interests of their customers, they never have a route to implement NEST's solely. Therefore, they do not have their own flowchart.

All flowcharts consist of three parts. The first part consists of a list of actions for that particular stakeholder to arrange before starting to interact with other stakeholders. This list is based on the outcomes of paragraph 4.3. The middle part of the flowcharts consist of the concatenation of steps to take for each stakeholder, showing their options in routes to come to the (non)implementation of NEST's. The third part shows the steps to take for each stakeholder before they should start contacting and work together with an EFOPC. These are the same for each stakeholder as this is universal and does not depend on the specific characteristics of a stakeholder. The first and third parts are described here, the flowcharts themselves can be found in appendix C, D & E.

Before discussing the subject with the tenant, a fund manager should take the following steps:

1. Built a technology/digital strategy;
2. Analyse applicability of a NEST for offices and develop energy saving goals;
3. Consult with property manager and anchor goals in the multi-year maintenance plan;
4. Determine a fund for innovations (incl. NEST's);
5. Make an inventory of tenants' energy/ business desires and problems;
6. Explore market of NEST's.

Before discussing the subject with the fund manager, a tenant should take the following steps:

1. Built a technology/digital strategy;
2. Develop goals (based on future and scenarios);
3. Make an inventory of the energy/core business desires and problems;
4. Determine fund for a innovations (incl. NEST's);
5. Explore market of NEST's.

Before discussing with the fund manager or tenant, a property manager should take the following steps:

1. Develop energy saving goals and anchor them in the multi-year maintenance plans;
2. Determine the role of NEST's;
3. Allocate funds at fund manager for implementation;
4. Make an inventory of tenants' energy/ business desires and problems;
5. Explore market of NEST's.

Before making a good decision on which NEST to implement, a fund manager or tenant must think about how this fits into the overarching (technology/digital) company strategy. It is important to think about things such as ownership of the data and the security for example before it turns out the NEST does not fit the company after all. The fund at step four is a jar of money destined for (energy) innovations. This is money the fund manager or tenant can miss and does not require a solid business model from the start of a negotiation. Requiring an acceptable business case at the end of negotiations provides space to try innovations more easily.

Going through the flowchart can take months, or years, or might never be finalized at all if the stakeholder decides to stop the procedure. It might also turn out that in certain circumstances, no NEST can be implemented at all, due to contractual constrictions for example. The third part is only activated when the second part leads up to 'implementation of a NEST'. This third part is the same for the fund manager and tenants, a property manager lacks the first step as his decision making does not consist out of multiple departments as he works alone in every office.

After going through the flowchart, but before cooperating with a EFOPC, the fund manager and tenants should think of:

1. Align internal departments;
2. Identify EFOPC('s) and NEST that suit you and the problems;
3. Determine goals and objectives together with EFOPC;
4. Determine drivers and obstacles for cooperation together with EFOPC;
5. Define plan to realize long-term relationship together with EFOPC.

After going through the flowchart, but before cooperating with a EFOPC, the property manager should think of:

1. Identify EFOPC('s) and NEST that suit you and the problems;
2. Determine goals and objectives together with EFOPC;
3. Determine drivers and obstacles for cooperation together with EFOPC;
4. Define plan to realize long-term relationship together.

5.0 Conclusion and recommendations

In this thesis, research has been done on how energy saving property technology (PropTech) can be implemented into Dutch offices from a stakeholder perspective. In this research, these technologies are called NEST's (New Energy Saving Technologies) which are developed by EFOPC's (Energy Focussed PropTech Companies). Based on the findings of the previous chapters conclusions are now drawn. Answering the five sub questions leads up to answering the main question: *How can energy saving PropTech be implemented in Dutch office real estate?* These conclusions result in recommendations for all stakeholders, followed by a discussion.

5.1 Conclusion

The goal of this research was to investigate how energy saving PropTech operate and can be implemented into Dutch offices. Enabling offices to consume less energy results in less CO_2 emissions and eventually a lesser contribution to climate change. The values of the NEST's available for the Dutch market has been described and connected to stakeholders that profit from these NEST's. The dynamics between these stakeholders provided an overview of drivers and barriers to (not) implement NEST's, and how to resolve these barriers. Lastly the relationship between the different stakeholders at the demand and supply side of NEST's has been investigated to discover their drivers, barriers and how these barriers can be resolved.

The main barrier why NEST's are not implemented into Dutch offices is that the stakeholders at the demand side (fund manager, tenant and property manager) do not experience enough urgency to do so. Fund managers are in the lead to implement NEST's. The main objectives of a fund manager are being compliant and realise his prognosed return on investments. Current legislation to ensure offices consume less energy is not compelling to them and the direct financial benefits of NEST's are for their tenants. Fund managers desire input from their property managers to be advised on sustainability measures. But property managers do not experience this as part of their job, are not paid for this and have many other things to do. Property managers do not have the mandate or budget to implement NEST's on their own. Single tenants do have the power to demand the implementation of NEST's from the owner. However, they do not ask for NEST's as they are focussed on their core business, do not know about the possibilities and believe they are not in the lead. Altogether, the lack of urgency, unawareness and finger pointing leads to a low demand for NEST's.

As mentioned, it appears that the current NEST's do not provide enough added value to overcome the barriers the demand side experiences. NEST's address the right energy consuming processes (HVAC & lighting) in an office and effectively save energy, but this is where it often stops. They often do not focus on the users of that office. These users have a large impact on the energy consumption. It would be ideal to eliminate their interference, but NEST's are not capable of running fully autonomous yet. With the implementation of current NEST's the users are still in control. They often do not receive the proper feedback to make energy thoughtful decisions. To make their NEST's more appealing, EFOPC's should better quantify the MPB's (Multiple Project Benefits). And instead of selling their NEST as a way to save energy, they should frame it as a way to support their customer's core business or to score on sustainability performance assessments. This supports the negotiations on costs and benefits for an acceptable business case between stakeholders at the demand side.

Implementing NEST's in an office is almost never the matter of one single stakeholder. Depending on the situation and NEST, a fund manager, tenant, property manager and several sub-contracted companies can be involved. The decision-making trajectory often takes a long time as all these parties need to be aligned. They all tend to work on their own, decide their own (sustainability/innovation) strategy and only consult other stakeholders in a late stadium. Instead of trying to save energy on their own, fund managers and tenants should better listen to each other to understand one another's desires and problems on energy savings and their core business. The next step are open conversation on the costs, energy savings and MPB's of NEST's that build on those desires and problem. This is key to build the necessary multi-stakeholder support for NEST implementation. The decision-making trajectory to implement NEST's must become dramatically shorter and less complex.

EFOPC's are subjects in their relationship with stakeholders at the demand side as the demand for their NEST's is low. The perception on this relationship differs between them. EFOPC's have the idea that they understand their customers, but the fund managers believe their pains and desires are not heard. After the decision is made to implement a NEST, relationship management between demand and an EFOPC should become as important as the NEST itself. The approach of the collaboration, the terms of condition and the expectations differ between EFOPC's and fund managers. Instead of implementing their product as fast as possible, EFOPC's must better understand the desires, restraints and expectations of their customers.

How can energy saving PropTech be implemented in Dutch office real estate?
NEST's should focus on the HVAC installations and lighting via the BMS to ensure most energy is saved. Appealing feedback to the users is key to activate them, ensure more energy conscious decision making in general and starts further energy saving measures (including more NEST's). Stakeholders at the demand side are focussed on their core business and ignorant on the existence and possibilities of NEST's. Furthermore, they do not experience enough financial or legislative pressure to start working with NEST's. Fund managers and tenants should better listen to each other to understand one another's desires and wishes on energy savings and the core business. Open conversations on the costs, energy savings and MPB's of NEST's are key to build the necessary multi-stakeholder support for NEST implementation. Regardless if an EFOPC is already involved in such conversations or not, the decision making trajectory to implement NEST's must become dramatically shorter and less complex. Whenever the decision is made to implement a NEST, the relationship management should become as important as the NEST itself to create long term collaboration and corresponding expectations. As demand is weak, EFOCP's should continue their efforts to settle the established real estate industry barriers. To make their NEST's more appealing they should better quantify the MPB's to support the negotiations between stakeholders at the demand side on costs and benefits. Furthermore, instead of selling their NEST as a way to save energy, they should frame it as a way to support their customer's core business or to score on sustainability performance assessments.

5.2 Discussion

In this section the limitations of the research will be emphasized. Lastly a personal reflection on the thesis process is given.

5.2.1 Connection theory and findings

It was expected that the stakeholders at the demand side did not experience enough urgency to start working with NEST's because the benefits were too low. Legislation that should encourage fund managers to ensure their offices consume less energy do not help at all. The level of unfamiliarity is somewhat surprising though. Whenever they are familiar with NEST's, they have the opinion that NEST's offer to little to tackle all their problems. Meanwhile, NEST's do tackle the right energy processes. Instead of focussing directly on the HVAC installations or lighting, NEST's work via the BMS. Furthermore, it appeared that NEST's work with more technologies that IoT and big data alone, these are really just the basics. As expected, the MBP's are important to implement more NEST's. But they were not conceived to be of such importance that NEST's could better be framed to support the client's core business.

From theory it was already expected that the different stakeholders needed each other to implement NEST's. This appeared to be correct, but due to the lack of urgency they have no reason to put energy in working together, and in the end nothing happens. It is notable that tenants were presented as one type. It appeared that there is a large difference between the interest and power of single- or multi-tenants to implement NEST's.

The drivers and barriers appeared to be completely different than those from the theoretical framework. There were more drivers than barriers, but one barrier is more important than all those drivers: the stakeholders have the idea that they do not have a problem. Furthermore, the drivers from the theoretical framework seem to be more appropriate in a deeper cooperation between the demand side and EFOC's than just implementing the NEST's.

5.2.2 Research approach limitations

Choosing for an exploratory research provides flexibility which is supportive in a research wherein current available knowledge does not provide fitting delimitation and a changing context is expected. However, the ever-changing context can entail that the research itself changes over time and it can become less relevant. For example, the drivers from the stakeholders at the demand side appeared to be too formal, although the knowledge on the status level of implementation of NEST's valuable information.

The imperfect knowledge and delimitation of exploratory research can also mean that the focus of the research is not the main problem. This research started with a focus on the tuning between the energy consuming sources in an office and the connection to the available NEST's. However, it became apparent that the main problem was not the tuning of NEST's with the energy consumption, but the relationships between the stakeholders around this. Time was lost duo this switch of focus, hence a more thorough research was not possible.

Furthermore, as this research is explorative, it is hard to find relevant stakeholders to interview that have experience with a variety of EFOPC's. Their knowledge on EFOPC's and NEST's is limited and is incomplete to provide a holistic answer. To compensate for this, the experiences of the multiple stakeholders at the demand side is combined.

5.2.3 Research method limitations

The twelve experts and stakeholders interviewed for this research were selected to provide a holistic view from the demand and supply side involved around the implementation of NEST's. Up front is was expected that the institutional investor would have more influence and the tenant(s)/users had less interest. Instead of interviewing two institutional investors and one representative for the tenant(s)/users, this could better have been switched.

The semi-structured interviews provided the necessary ratio between structure and space to deviant from the initial questions. However, the lack of delimitation meant difficulty to bring focus while conducting the first interviews. The explorative nature of the first interviews is compensated by conducting multiple interviews with this type of stakeholder. Furthermore, the demand and supply side both have high stakes and are biased. Because demand and supply are such opposites it was supportive to add some neutral voices in the sense of interviewees 10, 11 & 12.

5.2.4 Language limitations

This research is focussed on Dutch offices and Dutch stakeholders are interviewed. The results are based on the concurrence of Dutch stakeholders and are therefore very limited in usefulness for other countries. As English is not the mother tongue of the researcher, wrong translations and interpretations could influence the exact accent of critical findings. English concepts have been translated to Dutch and later on Dutch findings have been translated to English, leaving room for inaccuracies.

5.3 Recommendations

The findings and conclusion demonstrated what the drivers and barriers are for the stakeholders to implement NEST's. This paragraph provides recommendations to settle barriers and encourage drivers. Furthermore, suggestions for further research are mentioned.

5.3.1 Recommendations for stakeholders

PropTech is not the one and only solution, but it is a part of the total solution to make less energy is consumed in offices. All stakeholders should think more holistic when addressing their energy consumption. Stakeholders should look into the future and determine how they can make sustainable investments that also deliver a good return. Staying in front of legislation makes better investments in the long run. Real estate companies must determine an internal sustainability strategy with all relevant departments. Whenever there is a chance to save energy, there is no need for long internal consultation as all disputes are already settled.

At this moment the market is only based on supply. To brings NEST's to the next level and make them better fit to every specific office and its users, there needs to be more demand. At this moment there is a vicious circle that needs to be broken to make sure more NEST's are implemented. This can be realised bottom-up via mobilising the users or top-down via pressure from the institutional investors or legislation. To mobilize users they should be provided with feedback about the performance of their office so they will start asking questions if it is not understandable. Instead of doing all the work themselves, institutional investors could ask their fund manager to come up with a roadmap for all offices to meet 'Paris' in 2050 or a list of energy saving measures (including NEST's), so they can make a selection. As legislation is now fixed on the physical elements of an office to make sure it uses less energy, it should to a focus on the actual energy consumption.

The stakeholders at the demand side must organize their collaboration and interdependencies differently. They generate no drivers to think about sustainability, but barriers. Fund managers have the possibility to anchor sustainability into the contracting of tenants and the property manager as interviewees 3 & 4 were trying. It is essential that the regulations are workable and reasonable for both parties. Fund managers may insert an 'effort obligation' in the lease contract with their tenant(s) so they are obliged to cooperate when the fund manager wants to do implement NEST's. The tender with the property manager shouldn't be about the lowest price, but which sustainable measures the property manager can do for a fixed price. An extra driver might be the adding of bonuses.

EFOPC's should ensure their NEST's become as automated as possible, the interaction with people is a bottleneck. This requires less time and effort of their customers and make them more willing to make use of them. EFOPC's should better quantify the MPB's of their NEST's to clarify the benefits for multiple stakeholders. Fund managers and the tenant(s) should then have an open discussion about the benefits and costs trying to overcome their 'split incentive'.

5.3.2 Further research

Further research should investigate:

- how the real estate industry should realize more implementation of innovations in general. The current relationships between stakeholders should be changed from the root.
- how legislation should change to ensure more implementation of NEST's
- how the involved stakeholders should change their behaviour so they are more open to implement innovations including NEST's
- how the relationships between the stakeholders should change so they have more drivers to implement NEST's
- which legislations and (internal) drivers exist or should be changed to breach the vicious circle at the implementation of NEST's.

5.3.3 Personal reflection

I have always been a practical social individual with a high interest into technological progressiveness. This research enabled me to combine this all together. The interesting people and technologies gave me the motivation to dive into this research for the last six months. Doing research in a fairly new subject was challenging and had me struggling to provide focus. The explorative nature of this research made me permanently investigate of a new lead was supporting his research. These side investigations and wrong tracks have provided me with a new pool of knowledge that goes way beyond this research.

When starting this research I was in doubt about the best research method. It was obvious to do qualitative research because I was trying to acquire in-depth understanding of stakeholders and their interdependencies. But it was hard to find the correct research approach. At first I tried to frame the stakeholders around the implementation of NEST's as a community and perform a case study on this community. Seeing the group of stakeholders around the implementation of NEST's in an office as a community was too far-fetched and In consultation with my mentor I decided to chance to an explorative research. The explorative nature of this research provided me the possibility to first get a grip on the actual problem and showed me the insights to correctly change my research perspective.

As qualitative research is not backed by statistical analysis it is hard to make claims. An explorative research also comes with a certain amount of disclaimers on the results. To not end up with meaningless sum ups of conditions I decided to map them into flowcharts to make them more real and this would place them into a better relationship to each other.

As I was constantly struggling to focus my research, allocate the exact problem and the route to answer the main question, the help of both my mentors was indispensable. Sometimes it was hard to accept that something I wrote was a side path and wouldn't help me to answer the main question. This meant that hours of work would be left out. After a meeting with my mentors I tried to take a step back and place all the critiques and remarks into the bigger picture. For example, my mentors made it clear that qualitative research is vague by default and that it takes a clear methodology to compensate for this. This made me reconsider the thoroughness of this and that is why I have elaborated more on this.

As a MBE student we are taught to understand the stakeholders and the properties that make up the built environment. In every course there has been a focus on sustainability too. One of my favourite courses was REM, Real Estate Management. Combined with my prelove for technology I soon ended up with PropTech. I believe my thesis provided me more insights into office real estate is managed and what the considerations are behind it. Further

The excessive energy consumption and the emission of greenhouse gasses is a societal problem. This research provides ways to implement more NEST's. As NEST's have the possibility to make the built environment use less energy, this research contributes to less emission of greenhouse gasses and soften this societal problem. Although there is a wide body of knowledge to make the built environment use less energy, this thesis adds understanding to the collaboration between different stakeholders to implement

energy saving technologies in offices. The results of this research could be transferable to other asset classes although the composition of stakeholders might differ. The considerations because of money, time, effort and the return will largely be the same. The flowcharts must also be adapted to other situations.

I'm grateful for all the learnings and knowledge that I have gained throughout this research. Hopefully, this research will help others understand the problems they are facing.

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Appendix A: interview protocol & questions for market research

Opening statement
Sir/madam, thank you for having me. Because of the right elaboration of this interview I would like to ask you for your permission to record this interview. For your knowledge, only the researchers of this thesis (me and my professor) will hear these records. These records will be fully erased after I've finished my thesis. (When I have permission I will now start recording).

This interview is designed in such a way that I won't take longer than a hour. Within this hour different themes on PropTech will surpass. For this research it is of equal importance that all themes will be assessed, it might occur that I have to stop you somewhere and we have to move on to the next topic. I highly value your time.

The topics of today's interview:	**goal**
A: Introduction (interviewee & company)	providing an introduction
B: Vision on offices and energy use	what do they think is important for saving energy in offices
C: Own drivers/barriers	discover the drivers and barriers of the interviewee
D: Relationship with EFOPC	discover their relationship with EFOPC's and NEST's

The interviews with EFOPC's did not consist of the topics C & D, but had these instead:	
E: market research NEST's	what is their product, what value to which stakeholder
F: Relationships with customers	understanding drivers and barriers

A. introduction to the PropTech company

1. Hello (name) what is your professional background?
2. What is your position over here? What are your responsibilities?
3. How would you describe the company to me?

B. vision on offices and energy use

1. Energy wise, what do you think about the current state of the Dutch office stock?
2. What do you think of the current legislation ensuring that offices consume less energy?
3. What is your role to ensure offices consume less energy?
4. What is the role of PropTech according to you?

C. own drivers/barriers

1. With which parties do you work together to ensure office consume less energy?
2. What is your position (power) in this?
3. Do you experience drivers to work with innovative technologies to save energy in offices?

-----: what are these? MPB's?

4. Do you experience barriers to work with innovative technologies to save energy in offices?

---: what are these?

5. What should change to ensure you experience more drivers to implement this kind of technologies?

----: and to lower barriers?

6. If not you, who is in the lead to implement these kind of technologies?

----: and why?

D. relationship with EFOPC

For this research I make use of the PropTech description by Block & Aarons, they refer to PropTech in offices as 'tools, platforms, apps, websites and other digital solutions.'

1. Within this description, or closely attached: have you ever came across, or worked with, a PropTech company?
   If **no**, why not? Would you like to?

   If **yes**, what kind? How did this occurred?

2. How would you describe this working together?

----: What went well and/or what went wrong?

E. the company's product (NEST's market research)

1. What kind of product do you offer to make sure offices consume less energy?

2. What energy consuming processes does it target?

3. To whom does it provide value? Any MPB (Multi Project Benefits)?

F. relationship with customers

1. How do you perceive your contact/relationship with your customers?
   Examples?

2. What goes well in the cooperation with your customers?

3. Do you perceive any difficulties (barriers) for cooperation?
   If yes: how so? And are these surmountable?

End of this interview

Dear sir/madam, I really want to thank you for this interview and your time, I really appreciate it. Do you have any remaining remarks or questions?

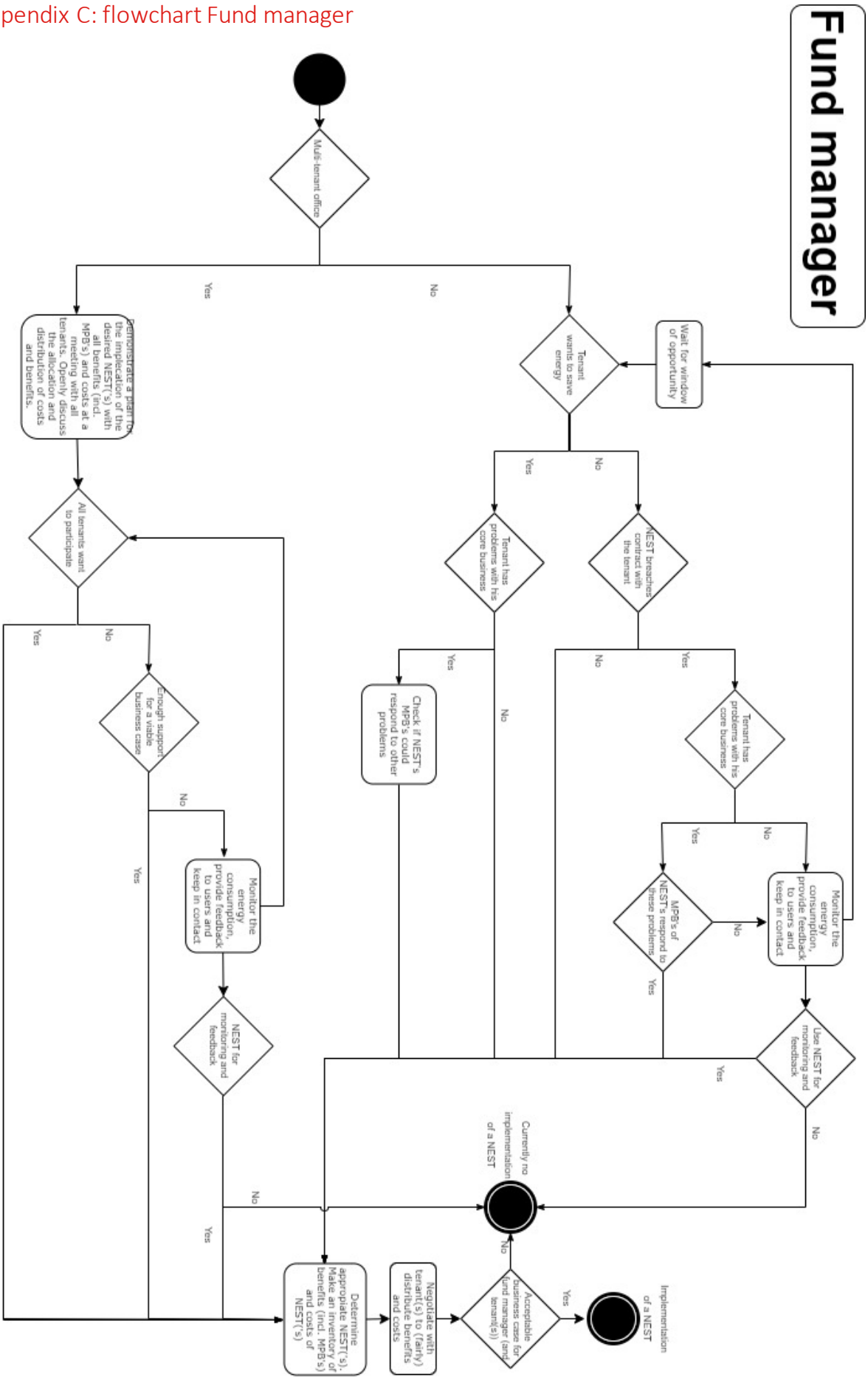
If not, then I would like to end this interview. Once again, thank you very much for your time.

Appendix B: list of companies assessed for market research.

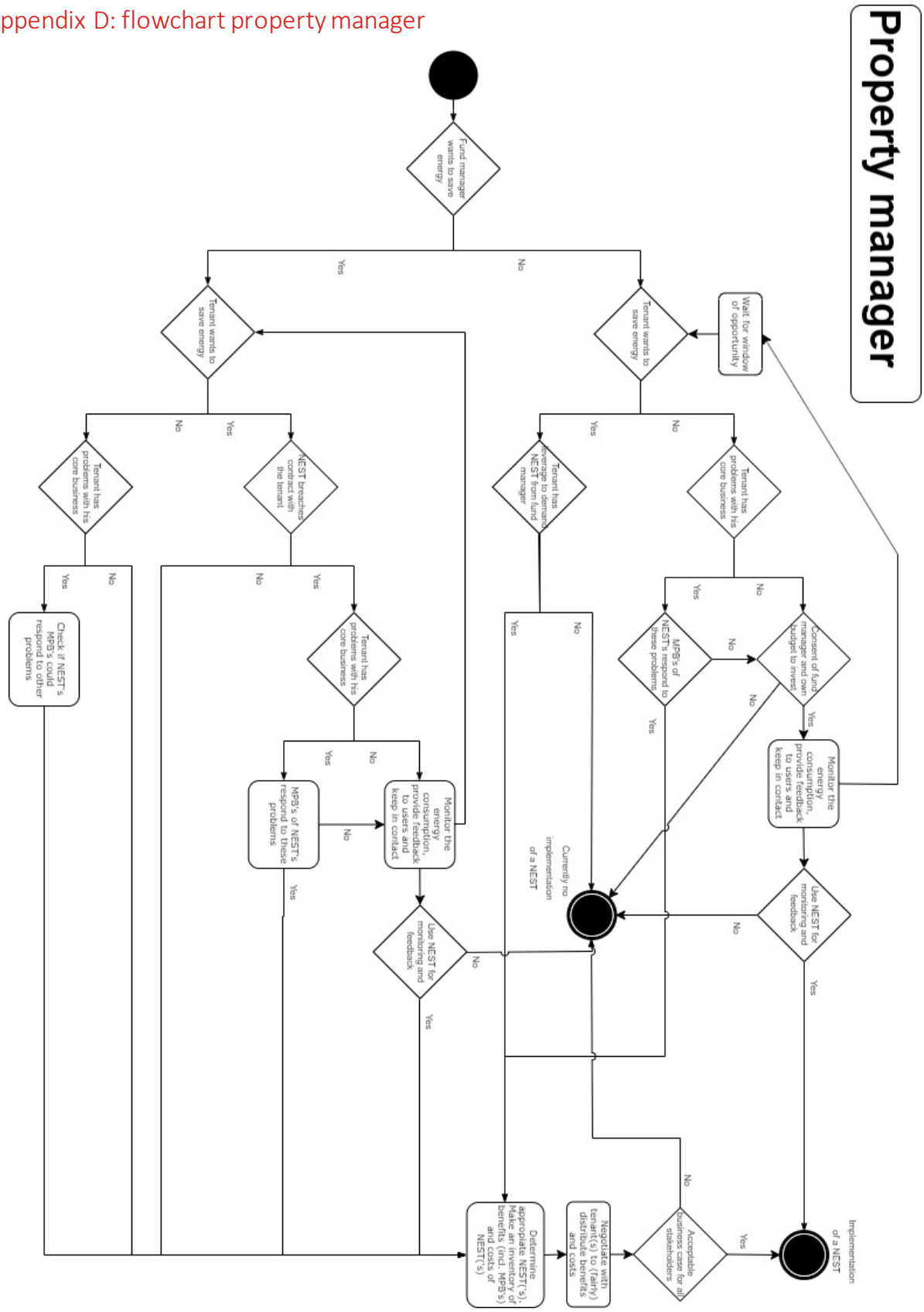
EFOPC's name	Country	Technology it is based on	Remarkables
Office vitae	Netherlands	IoT, BD, DA	
	HVAC & lighting		
Iconics	UK	IoT, BD, DA, PA, CB	Occupants foc, empty rooms, lifts
	HVAC, it doesn't work in rooms that aren't occupied. Lifts!		
NUUKA	Fin, SE, NL	IoT, BD, DA, CB	Edge, GRESB,
	HVAC & lighting. It optimizes these processes		
Lone Rooftop	Netherlands	IoT, BD, DA, PA,	Wifi, occup, detect, HVAC, open pl
	HVAC & lighting.		
Smart Plants	Norway, NL	IoT, BD, DA, PA, CB, ML	Weather forecast
	HVAC		
Verdigris Technologies	USA	IoT, BD, DA, AI, PA, ML	
	HVAC & lighting		
Ledsgogreener (lumilink)	Netherlands	IoT, BD, DA	Provide LED (built netwerk)
	Lighting		
Qbus building intelligence	Belgium	IoT, BD, DA	HVAC, sec, light, beeld, audio
	HVAC & lighting. But also blinds & security		
Sustainable Buildings	Netherlands	IoT, BD, DA, CB, AI, ML	Feedback to users
	HVAC, lighting. Choose to: only be informed, hand use the appliances or full auto		
Tridium (Niagara)	Canada	IoT, BD, DA, SaaS	
	HVAC & lighting. Lifts?		
Energetika	Netherlands	IoT, BD, DA, PA	
	HVAC & lighting		
SWYCS	Netherlands	IoT, BD, DA, PA	
	HVAC (but only monitors!)		
Twingz	Austria	IoT, BD, DA, AI, ML, SaaS	predict & prevent
	(HVAC & lighting?) ICT (appliance detection, only monitor)		
Global Green Buildings	Netherlands	IoT, BD, DA, ML	measures BMS>specific roadmap
	HVAC, lighting & 'voltage optimisation'		
Bgrid	Netherlands	IoT, BD, DA	
	HVAC, lighting. Smart cleaning, Senses air quality		
Chess wise	Netherlands	IoT, BD, DA	MyriaMesh Building Light Control
	lighting		
Herobalancer	Netherlands	DA, PA	feedback (insight into heatingsys)
	HVAC		
Ingy	Netherlands	IoT, BD, DA	lighting, sens in lumin, nav, occupa
	Lighting (steer), HVAC (monitor)		
Ionair	NL, Swiss	IoT, BD, DA	
	HVAC		
CIM Enviro	Australia	IoT, BD, DA, PA, ML, CB	
	HVAC (only monitoring)		
Skyfoundry	USA	IoT, BD, DA	weather, calculates costs!
	HVAC, lighting. Also insights in costs of consumption.		
Wtec	Germany	IoT, BD, DA	occupancy & app
	Lighting		
Simaxx	Netherlands	IoT, BD, DA, PA, ML	
	HVAC		
Wattabit	Spain	IoT, AI, DA, PA, CB, ML, SaaS	
	Energy in general (HVAC & light included?)		
Envio	Germany	IoT, BD, AI, DA, PA, CB	weather, occupancy, air
	HVAC & lighting		
Qualisteo	France	website under work	

	Energy in general (HVAC & light included?)		
Demand logic	UK	IoT, BD, DA	
	HVAC		
Buildpulse (coppertreeanaly.	Canada	IoT, BD, AI, DA, PA, CB, ML, SaaS	focus on PM
	HVAC		
Smart Locus	USA	IoT, BD, DA, AI, PA, CB, ML, SaaS	weather
	HVAC		
Lucid	USA	IoT, BD, DA, AI, CB, Saas	feedback to colleagues, occupants
and the public	Energy in general (HVAC & light included?)		
Fourdeg	Finland	IoT, BD, DA, ML, CB	weather, wifi thermostats
	HVAC		
Comfy	USA	CB, SaaS	
	HVAC & lighting (also desk searching (occupancy) & amenities search)		

Appendix C: flowchart Fund manager



Appendix D: flowchart property manager



Appendix E: flowchart tenant