P5 REPORT

Energy transition in the retail sector

Revealing decision-making behaviours for Energy Efficiency Retrofits (EER) of shopping centres

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ABSTRACT

Despite the efforts made in the World and the Netherlands for the energy transition of the building stock, policies and research have been mainly focusing on housing, leaving the non-residential building stock lacking in keeping up an adequate pace and in need of additional efforts to catalyse its transition. The retail sector represents the highest share of the non-residential building stock, with shopping centres as the building typology with the highest energy retrofit potential. However, despite its potential, data gathered from previous research have demonstrated that the complex multi-stakeholder governance structure of these buildings makes the decision-making process for an EER difficult. Several barriers have already been identified in the literature about this issue. Yet, they are scattered and not identified within the decision-making process and the complex governance system of a shopping centre. Therefore, this research aimed to reveal stakeholders' behaviours during the EER within a process perspective, finding the interrelationships between the different parties involved during the different steps of the process, and giving light on the areas that need to be addressed in other to guarantee a smoother process. To achieve it, exploratory qualitative research was carried out for which the following main research question is proposed: *"How can retail owners support a better decision-making process to steer EERs of shopping centres?"*. The methodology included a mixed approach between literature study and qualitative empirical research from three case studies of shopping centres in the Netherlands. The results demonstrate shopping centre owners have a crucial role in optimizing the EER decision-making process and overcoming barriers. Key recommendations for achieving optimal and holistic solutions that enhance energy efficiency and sustainability in shopping centres include developing a cohesive and integrated sustainability strategy, optimizing its governance structure, investing in centralized building data systems, addressing tenant-related barriers in EERs, and fostering collaboration among internal and external stakeholders, among others.

Keywords: Energy transition, shopping centres, retail, energy efficiency retrofit, decision-making

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Maria
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List of abbreviations

SC – Shopping Centre

EE – Energy Efficiency

EER – Energy Efficient Retrofit

VVE – Owners association

DMP – Decision-making process

EPBD – Energy Performance of Buildings Directive

EED – Energy Efficiency Directive

RED – Renewable Energy Directive

GR – Governance Regulation

MEMO – Renovation Wave Strategy

EU – European Union

SFDR – Sustainable Finance Disclosure Regulation

CSRD – Corporate Sustainability Reporting Directive

ESG – Environmental, Social, Governance strategy

List of actors' terminology

Stakeholder*	**Abbreviation**
Owner organisation stakeholders	
Owner	OW
Owner – Single small real estate investor	OW-SS
Owner – Single large fund	OW-SL
Owner – Fragmented ownership	OW-F
Owner association	VVE
Director Board of Supervisors – Fragmented ownership	DBS
Fund manager	FM
Property management team	
Technical management	PM-TM
Commercial management	PM-CM
Tenants	
Tenant - Small	T-S
Tenant - Large	T-L
External project manager	EPM
Energy supplier	ES
Suppliers	S
Sustainability Advisor	SA
Contractor	C
Consumers	CS
Local authorities	LA
Government	GOV

* This list does not represent the complete stakeholders list. It compiles stakeholders interviewed or named by interviewees.

01 INTRODUCTION

CONTENT

1.1 The urgency of the energy transition

Buildings are currently responsible for 36% of the global energy consumption, from which 30% is accounted for the building's operation and the remaining 6% for other construction services (United Nations Environmental Programme, as cited in Santamouris & Vasilakopoulou, 2021). Similarly, buildings are also accountable for 27% of the total CO_2 emission, with an additional 6% of CO_2 emissions coming from the manufacturing of cement, steel and aluminium used for construction (IEA, 2022a). Although energy consumption and CO_2 emissions decreased during the 2020 Covid-19 pandemic, both standards have rebounded to 2019 values (Figure 1 & Figure 2) (IEA.2022). It is estimated that these values will continue to rise in the upcoming decades due to the increasing population growth, required floor area, rising demand for energy services, the economic growth of developing countries, and the limited improvements in energy efficiency (Santamouris & Vasilakopoulou, 2021). In fact, a study estimated that global energy consumption will triple by 2100 (Levesque et al., 2018), which will bring severe consequences to the global environment, healthcare, and economy (Liang et al., 2016).

In addition to the climate crisis, the current energy crisis has demonstrated that there is a profound need to address the energy transition of the building stock. After a significant rebound of the global economic recovery from the Covid-19 crisis, followed by the war between Russia and Ukraine in February 2022, high energy prices have led to elevated inflation rates, increasing poverty rate, deacceleration of economic growth and an increased likelihood of an economic recession in several countries around the world (IEA, 2022b).

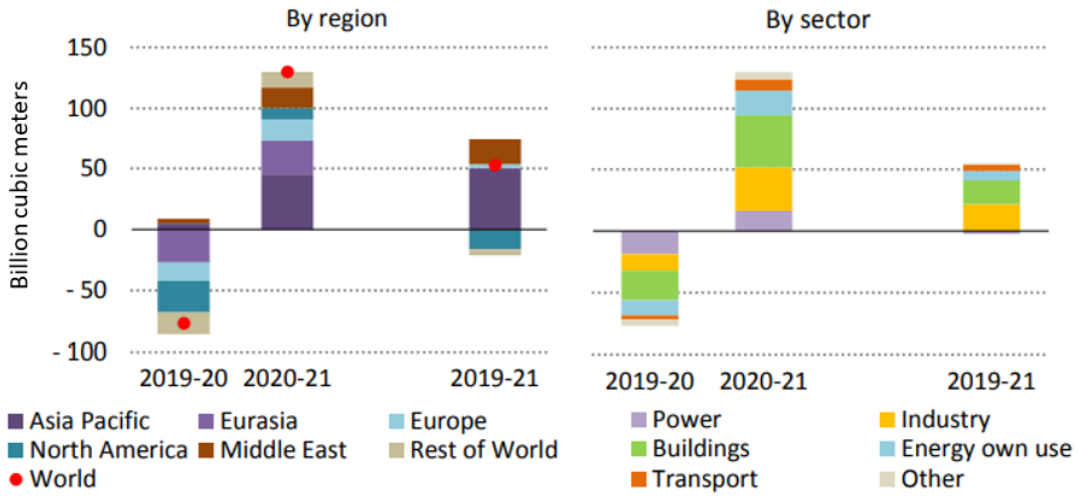


Figure 1. Natural gas demand growth by region and sector in billion cubic meters (bcm), 2019-2021. (IEA, 2021)

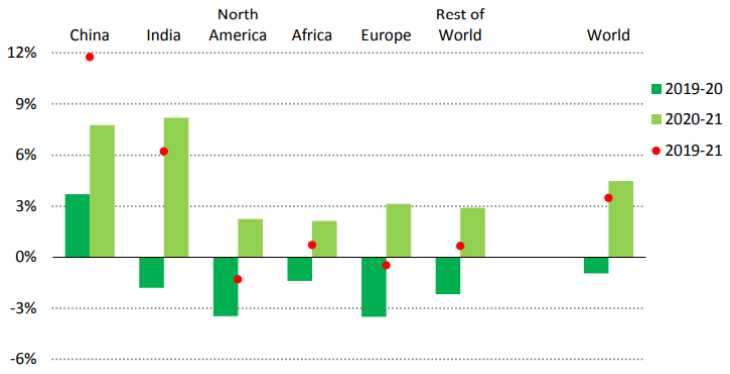


Figure 2. Change in electricity demand by region. (IEA, 2021)

World and European context

By 2023, 196 parties across the world have come together in the Paris Agreement to commit to the reduction of carbon emissions, limit the increase of global temperature to below 2° (ideally below 1.5°C) and reach climate neutrality before the middle of the century (United Nations, 2015). The agreement expects each country to submit a national action plan and expects them to increase their ambitions every 5 years (United Nations, 2015).

Several policies and initiatives have been developed at the European level to address energy efficiency in buildings. In 2015, the European Union established the Energy Union Strategy, aimed at providing secure, sustainable, competitive, and affordable energy to all EU citizens (BPIE, 2022). This strategy includes various initiatives, legislation, and policy packages with the 'Clean Energy Package' as the most important one. Adopted in 2018, this package consists of eight individual legislative papers that aim to accelerate the energy transition in Europe, with the Energy Performance of Buildings Directive (EPBD), the Energy Efficiency Directive (EED), the Renewable Energy Directive (RED), and the Governance Regulation (GR), as the most important ones (BPIE, 2020). Table 1 provides a general overview of these four directives.

Table 1. Clean Energy package. (BPIE, 2020, 2022; BPIE (Building Performance Institute Europe), 2021; EPB Centre, 2022)

EPBD	EED	RED	GR
2002, 2010 recast, 2018 amendment, 2021 revision proposal	2012 + 2018 amendment	2009, 2018 amendment, 2021 revision proposal	2018 amendment
2018 amendment (Energy Performance of Buildings and Directive (EPBD), 2018): - Legislation to transform and decarbonise the EU existing building sector by 2050. - Long term renovations strategies - Mobilisation of investment - Advisory tools **Revision proposal 2021** (*Revision of the Energy Performance of Buildings Directive (EPBD)*, 2021): - Double building's renovation rate (2030) - Foster deep retrofits - Improve information on building's energy performance and sustainability.	**2018 amendment** (Energy Efficiency Directive (EED)., 2018) : Sets the legal framework for energy efficiency policy in the EU 32.5% energy efficiency target by 2030 Energy savings obligation beyond 2020. (Art. 7)	**2018 amendment** (Renewable Energy Directive (RED), 2018): Target of at least 32% for renewable energy Policy for the production and promotion of energy from renewable sources in the EU to achieve 2030 renewable energy target.	**2018 amendment** (Governance of the Energy Union and Climate Action (GR), 2018): Cooperation framework to reach climate objectives of all EU member states on a national level. - National energy climate plans (NECP) - Long-term strategies (LTS) - Long-term renovation strategies (LTRS)

In addition to the Clean Energy Package, the European Commission introduced the **European Green Deal** in 2019 to achieve the Paris Agreement. The plan includes short and long-term goals such as a 55% reduction in greenhouse emissions from 1990 levels, a 32% share for renewable energy, a 32.5% improvement in energy efficiency across sectors by the year 2030, and net-zero greenhouse gas emission by 2050 (The European Green Deal, 2019). Considering that buildings in the EU are responsible for approximately 40% of the total energy consumption and 36% of the greenhouse gas emissions (European Commission, 2020), the building sector holds a big responsibility for the achievement of the 2030s and 2050s sustainability goals. Moreover, energy retrofit of the existing building stock in the EU represents a huge potential as 75% of the EU building stock is currently energy inefficient (European Commission, 2020). The European Commission (2020) estimates that energy retrofit of existing buildings could lead up to a total of 5-6% reduction in the EU's energy consumption and a 5% reduction in carbon emissions. However, the average retrofit rate of the existing building stock is less than 1% a year.

In order to meet the objectives of the European Green Deal, three policies and initiatives have been developed. These include the implementation of EU Taxonomy, the Sustainable Finance Disclosure Regulation (SFDR), and the Corporate Sustainability Reporting Directive (CSRD) (Jason Wiff, 2022).

EU Taxonomy: is a green classification system developed by the European Commission that allows to identify economic activities that substantially contribute to at least one of six EU environmental objectives, while not harming the other five (European Commission, 2022b).

SFDR – Sustainable Finance Disclosure Regulation: is part of the EU's Financing Sustainable Growth Action Plan and is focused to asset managers, investment firms, and other financial market participants to redirect capital towards sustainable finance and disclose ESG compliance within article 6, 8 or 9 (Sustainability-related Disclosures in the Financial Services Sector, 2019).

- Article 6: Funds that don't take sustainability into account.
- Article 8: (light green) Funds that take sustainability into account and promote some environmental or social sustainability characteristics.
- Article 9: (dark green) Funds that focus on sustainable investments as their objective.

CSRD – Corporate Sustainability Reporting Directive: EU regulation that requires large companies to disclose information on their sustainability policies and practices by 2024 (European Commission, 2022a). Although it is still under development and is subject to consultation and legislative approval, CSRD will require companies to report on energy consumption and CO_2 emissions in the entire supply chain. This includes Scope 3 emissions that account for emissions from employee commutes, leased assets and supply chain (CBRE, 2023).

The Dutch context

The building sector is responsible for 30% of the greenhouse emissions in the Netherlands (Colliers, 2021). In the efforts to integrate the Paris Climate Agreement and EU Commission goals, the Dutch Government developed the National Climate Agreement (House of Representatives of the Netherlands, 2019), and set specific goals for different sectors, including the built environment, with a 2030 and 2050 vision. In general, the agreement stipulates:

1. **A single goal of reaching 49% reduction** in national greenhouse emissions by 2030 compared to 1990 levels.
2. **The increase of the goal to 55%** due to the change of the European initial target that shifted from 40% to now 55% reduction.
3. **Monitoring principles** for which a cycle review and a report will be updated annually based on the country's current energy and climate status and other future forecasts.
4. **Governance** as citizens, businesses and public authorities will need to work together to achieve this goal.

The Built Environment chapter in the Climate Agreement specifies different goals for the sector in the 2030 and 2050 visions, which will be led by municipalities with a District-oriented approach. It has its main objective on housing, as it is the biggest segment of the building stock in the Netherlands (Economidou et al., 2011). However, it also considers non-residential buildings. An overview of the visions is:

Built environment vision 2050:

- Renovation of 7 million homes and 1 million buildings for energy efficiency, heated through renewable energy.

Built environment vision for 2030:

- Achieve a rhythm of 200,000 home renovations per year
- Achieve a 3.4MT reduction in the sector, for which 2.4MT will be achieved through the renovation of 1.5 million homes, and 1MT will come from cuts in non-residential buildings.
- It should count on the support of the districts as sustainable heating must be made available to reach it. The district-oriented approach includes heating grids or renovation projects organised at the district level.

In addition to the Dutch Climate Agreement, other measures to steer the transition in other sectors has been put in motion. These include:

- The requirement for all types of buildings to hold an energy label certificate when built, sold or rented by the Energy Agreement for Sustainable growth (Government information for entrepreneurs, 2022).
- A policy established in the 2012 Building Decree that demands office buildings to hold an energy label C or above by January 1st 2023 (Government information for entrepreneurs, 2022).
- Energy savings obligation which requires companies that use more than 500,00kWh of electricity or 25,000m^3 of gas to implement and report on recognised energy savings measures that can be recouped within 5 years (Netherlands Enterprise Agency (RVO), 2022).
- The establishment of maximum annual energy use levels per square meter for retail, with stores equipped with refrigeration systems limited to 150kWh/m2 and those without refrigeration limited to 80kWh/m^2 to reach Paris-Proof 2050's targets (Dutch Green Building Council (DGBC), n.d.).

1.2 The role of the retail sector in the transition

Despite worldwide and Dutch efforts towards the energy transition of the building stock, policy and research have primarily focused on the residential building stock, leading to non-residential buildings lagging behind and requiring additional efforts to accelerate the transition. This comes with no surprise, given that residential buildings make up 75% of the building stock in Europe (Economidou et al., 2011). However, the remaining 25%, representing non-residential buildings, remains a significant share that require attention. This is further supported by the fact that the non-residential sector consumes at least 40% more than the residential sector, with an average consumption of 280kWh/m^2 per year (Haavik et al., 2014).

Within the non-residential building stock segment, the wholesale & retail sector has the highest percentage of floor area in Europe, accounting for 28% (Figure 4) (Economidou et al., 2011)), and the highest share of non-residential energy consumption, amounting to 28% (Figure 3) (Haavik et al., 2014). However, despite this significant energy consumption and the need to transition to more sustainable practices, the adoption of energy-efficient measures in the Netherlands remains low in this sector. This is demonstrated by the low percentage of retail buildings that currently hold an energy label C or above. Out of 100,000 stores with approximately 27 million m^2 of retail space, only 26% currently comply with a level C or above, with an additional 17% estimated from non-labelled properties if it were to be demanded by the local authorities (Colliers, 2021). These figures highlight the significant challenges for energy transition that this sector entails.

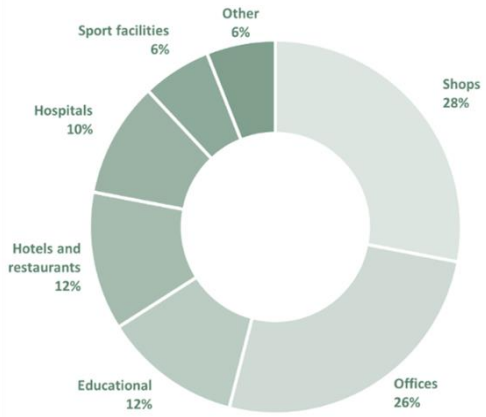


Figure 3. Energy consumption distribution of the non-residential sector in Europe. (Haavik et al., 2014)

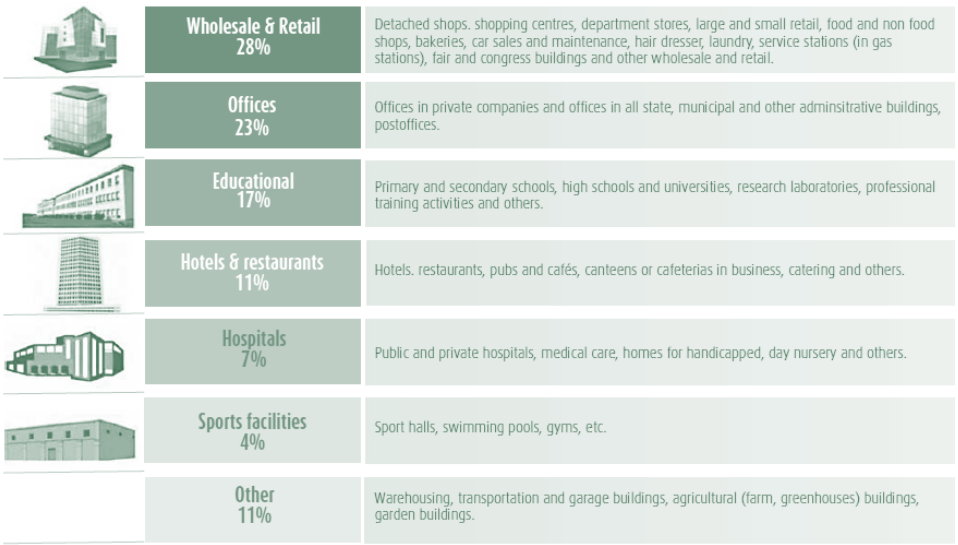


Figure 4. Percentage of floor area (m^2) per category of non-residential buildings in Europe. (Economidou et al., 2011)

Shopping centres

Shopping centres are hubs for social, economic, and commercial activity with a high structural complexity, because of all the activities they accommodate, and therefore are of great importance for cities and communities (Lollini et al., 2017). They are defined as one or more retail building(s) that contain individual commercial units (shops) and communal areas that are managed as a single entity (Bointer et al., 2014, as cited in, Haase & Ampenberger, 2017). To this definition, the International Council for Shopping Centres (ICSC) added that a shopping centre must have a minimum of 5,000m^2 of gross leasable area (GLA) to be classified as such (ICSC Europe et al., 2005).

Within the retail sector, shopping centres represent a relevant opportunity for energy efficiency improvement for two reasons. First, they require a high electrical and thermal load to operate (Barchi et al., 2018), having therefore a significant impact on the environment. In fact, they hold one of the highest specific energy demands for non-residential building stock (Lollini et al., 2017) with an average consumption of 200 kWh/m² a year in the Netherlands, 90% of which is obtained from electricity and gas sources (Figure 6). Second, most shopping centres in western Europe are already built, meaning that they are part of an already mature market with an existing old building stock that needs to be renovated in the upcoming years. Moreover, because of its continuous need to be updated to the latest trends, look stylish and reflect a modern lifestyle, this type of building already holds a high retrofitting rate of 4.4%, compared to 1-1.5% in housing (Bointner et al., 2014). Combined, all these characteristics offer a good potential for energy-efficiency retrofit and redevelopment (Lollini et al., 2017) of the building's technical systems, envelop, and monitoring systems (Haase, Woods, et al., 2015). Additionally, for the Netherlands, this segment is of particular interest because its Gross Leasable Area (GLA) is one of the highest in Europe with approximately 6.9 million m^2 (Figure 5), comprised of several relatively small shopping centres and a few 50,000m^2 or above properties (Cushman & Wakefield, 2019). This positions the country with one of the highest rates for shopping centres sqm per capita in Europe with 373m^2 per 1000 inhabitants (Cushman & Wakefield, 2019).

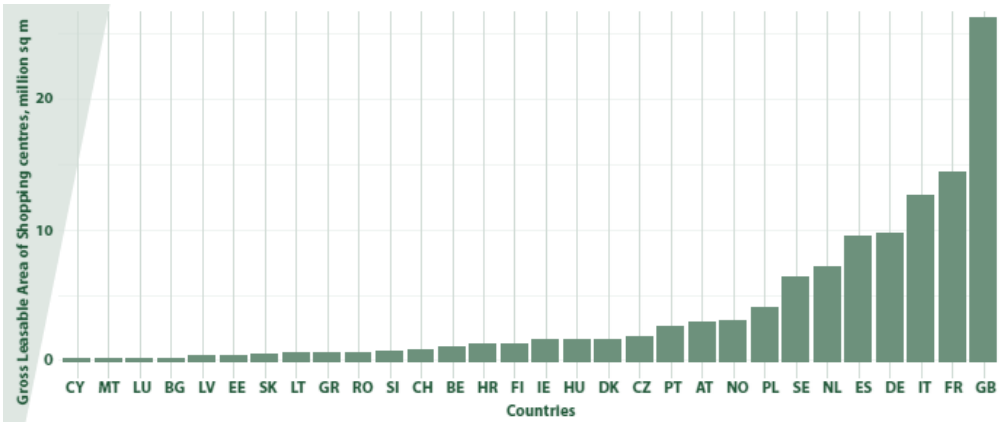


Figure 5. GLA for shopping centres larger than 5000m² in Europe. (Lollini et al., 2017)

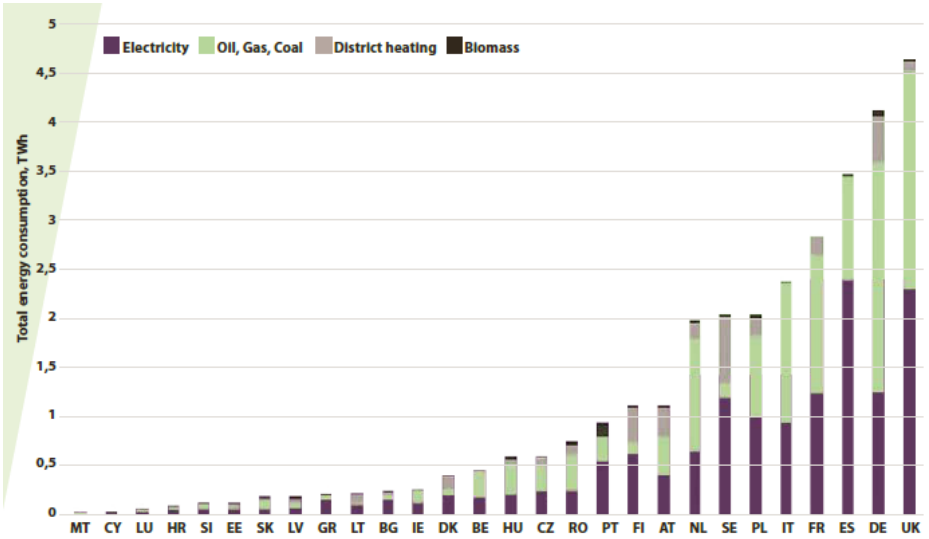


Figure 6. Total energy consumption of shopping centres in Europe subdivided by energy carrier.(Lollini et al., 2017)

1.3 The role of owners in the governance system of shopping centres

The gap between the previously mentioned shopping centre's high EER potential and the low-pace EER adoption of these buildings can be attributed to their multi-stakeholder governance structure, whose distinct behaviours have an influence over the positive or negative outcome of an EER decision-making process. This structure includes owners, asset managers, property management team, tenants, customers, and the community (Lollini et al., 2017), each with a different set of goals, drivers, and values.

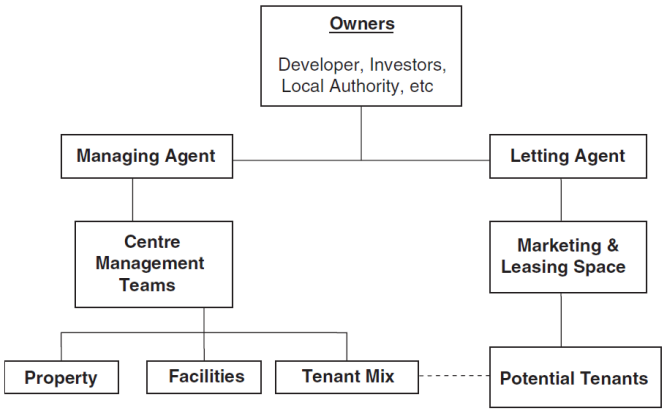


Figure 7. Shopping centre management system. (Pitt & Musa, 2009).

Particularly, owners and occupiers are considered key stakeholders in green retrofits decision-making (Liang et al., 2015) due to lease contracts that require owner-tenant cooperation (Miller & Buys, 2011). Although this relationship also exists in shopping centres, owners must additionally manage letting and management agents (Figure 7) to secure long-term income streams and achieve strategic objectives (Pitt & Musa, 2009). While letting agents are responsible for marketing the centre and leasing vacant space under the correct tenant mix, management agents set up the managing teams whose roles include decision-making development and managerial activities such as planning, organising, staffing, directing, and controlling SC functions (Pitt & Musa, 2009). Therefore, given owners' essential role in overseeing the multi-layered stakeholder structure, this research will focus on their perspective.

1.4 Problem Statement

Given that the building sector is responsible for 36% of the global energy consumption (United Nations Environmental Programme, as cited in Santamouris & Vasilakopoulou, 2021) and 27% of the global CO_2 emissions (IEA, 2022a), the energy transition of the building stock is one of the most important issues to tackle in the current climate and energy crisis. If unaddressed, these values will continue to rise in the upcoming decades due to the increasing population growth, required surface area, rising demand for energy services, and the economic growth of developing countries (Santamouris & Vasilakopoulou, 2021). Moreover, this situation is unsustainable as fossil fuels are limited and its supply revolves around complex and fragile geopolitical relationships (Murphy, 2016). Now more than ever, the building sector requires to detach from fossil-fuel dependency and accelerate the pace of the energy transition of the stock to reduce the socioeconomic impact that both crises have brought to the environment, health, economy, and social well-being of people around the world (IEA, 2022b; Liang et al., 2016).

To achieve it, many programmes and strategies have been developed at both international and national levels. Such as the Paris Agreement at the international level, the EED and EPBD Directives of the European level, the Dutch Climate Agreement, the Energy Agreement for Sustainable Growth, and a Building Decree adjustment at the national level. However, despite the efforts made in the World and the Netherlands for the energy transition of the building stock, policies and research have been mainly focused on housing, leaving the non-residential building stock lacking in keeping up an adequate pace and in need of additional efforts to catalyse its transition.

The non-residential sector represents 25% of the remaining global building stock, in which retail has the highest percentage of floor area in Europe, with 28% (Economidou et al., 2011), and the highest share of non-residential energy consumption (28%) (Haavik et al., 2014). Furthermore, within the retail sector, shopping centres are the building typology that represents the highest energy retrofit potential as they hold one of the highest specific energy demands for non-residential building stock and because, in western Europe, they are part of an already mature market with an existing old building stock that needs to be renovated in the upcoming years (Lollini et al., 2017). However, despite its potential, data gathered from previous research have demonstrated that the complex multi-stakeholder governance structure of these buildings makes the decision-making process for an EER difficult as it relies on the achievement of consensus within the parts (Ma et al., as cited in Liang et al., 2016). Several barriers that hinder the adoption of energy efficient measures in buildings have already been identified in the literature. These include barriers such as lack of knowledge, misplaced incentives, split incentives, asymmetric information, lack of regulations, among others. Yet, they are scattered and not identified within the decision-making process and the complex governance system of a shopping centre. Therefore, this research aims to reveal stakeholders' behaviours during the EER within a process perspective, finding the interrelationships between the different parties involved during the various steps of the process, and giving light on the areas that need to be addressed in other to guarantee a smoother process.

1.5 Societal and scientific relevance

The societal relevance of this research lies in supporting the acceleration of the energy transition of the retail building stock. This is not only relevant to support the efforts against climate change, but also highly relevant during the current energy crisis that has accentuated the need to reduce the energy consumption of the existing building stock and its transition into renewable energy sources. This research considers that by investigating decision-making behaviours of EERs of shopping centres, the retrofit of this type of building stock can be catalysed.

The scientific relevance of this research lies in addressing the gap found in the literature review about mapping stakeholders' behaviours for EERs in shopping centres within a process perspective that considers its complex governance structure. Analysing these behaviours will allow not only to map the process, but also to identify the specific drivers and barriers of each of the actors involved in the decision-making process, providing a valuable insight into which areas need to be addressed to mitigate these barriers. The results can be not only useful for SC owners to facilitate the energy transition of their buildings and portfolios, but also to policymakers as they may indicate which parts of the process and which stakeholders need to be addressed.

1.6 Research questions

Based on the aim of this research explained in section 1.3., the following research question is proposed:

"How can owners support a better decision-making process to steer EERs of shopping centres?"

To answer this research, the following research sub-questions are anticipated:

[SQ1]: What is the state-of-the-art of energy efficiency retrofit of shopping centres?

[SQ2]: How is the EERs' decision-making process of shopping centres taking place?

[SQ3]: What are the barriers encountered during the decision-making process of EERs of shopping centres?

02 THEORETICAL BACKGROUND

The theoretical background developed for this research has been divided in three areas. First, understanding the ***What***, namely reviewing the characteristics of shopping centres in the Netherlands and investigating the preferred retrofit measures. Second, identifying the ***Who***, meaning recognizing the stakeholders that are involved in a EER process. And third, identifying the ***How***, which refers to discover from literature how is the EER process of shopping centres taking place. While the *What* and *Who* allow to answer SQ2, about stablishing the state-of-the-art of shopping centres in the Netherlands, the *How* allows to develop the theoretical framework of the EER that will be tested in the empirical part of the research.

CONTENT

2.1 What

2.1.1 Shopping centres in the Netherlands

This section looks at the characteristics of shopping centres in the Netherlands and describes them in terms of ownership, size, form, function, and building year. Along this section each of these categories will be described and quantified using Strabo (2022) database of shopping centres in the Netherlands. This database registers characteristics from a total of 1044 shopping centres in the country.

Type of ownership

Different ownership types can be found in shopping centres in the Netherlands. Historically ownership of most shopping centres has been given to institutional investors, such as pension funds and insurance companies, and real estate investors (Pitt & Musa, 2009). In most cases, these buildings have a single owner that leases to different tenants (Strabo bv Amsterdam, 2022). However, shopping centres may hold a fragmented ownership style, which means that there is a shared ownership between two or more owners (Khoshbakht, 2015). The Dutch Shopping Centre registry indicates that the number of shopping centres with single ownership represent 84% of the shopping centre building stock in the country, whilst fragmented ownership represents 16% (Strabo bv Amsterdam, 2022).

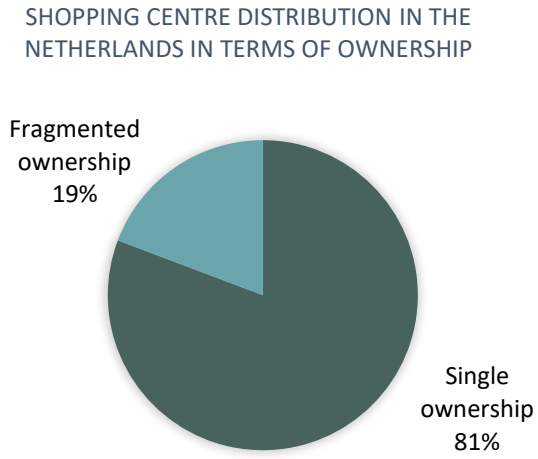


Figure 8. Dutch shopping centre distribution in terms of ownership. Own work based on database gathered from (Strabo, 2022).

Size

According to a categorisation made by the International Council of Shopping centres (ICSC), the European building stock can be divided into 4 categories: small (5,000-19,999m^2), medium (20,000-39,999m^2), large (40,000-79,999m^2, and very large (>80,000m^2) (Toleikyte & Bointner, 2016). However, data gathered from the Shopping Centre registry indicates that there is an additional group of shopping areas with a size range between 1,500m^2 and 4,999m^2. This research will classify

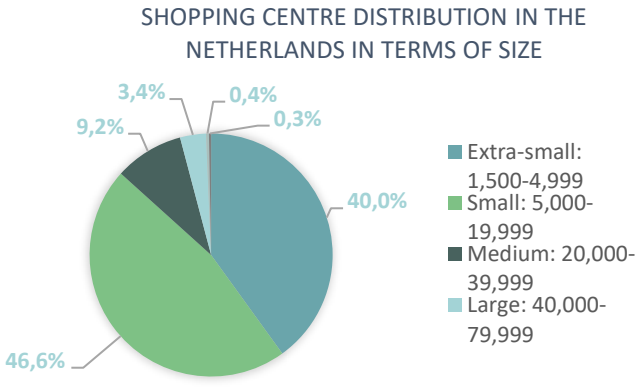


Figure 9. Dutch shopping centre distribution in terms of size. Own work based on database gathered from (Strabo, 2022).

this group as extra-small. As shown in Figure 9, most shopping centres in the Netherlands are within the small category, followed by extra-small, medium and large size (Strabo bv Amsterdam, 2022). This is not a surprise, as the Dutch retail structure is characterized by being within the fine-meshed category. This means that the Dutch retail landscape consists of multiple small shops and shopping areas in proximity to consumers in terms of distance and travel times (Evers et al., 2011), meaning that they are easily reached by foot or bike.

Building year

As mentioned before, the shopping centres building stock in western Europe is part of an already mature market (Bointner et al., 2014). Such is the case of the Netherlands, where more than half of the shopping centre building stock was built before 1989 (Figure 10). Apart from categorizing shopping centres by size, the International Council of Shopping centres (ICSC) categorizes them into three periods: Buildings built before 1990, 1991-2002, and 2003-2012 (Toleikyte et al., 2017). To safeguard this categorization, this research proposes a third building period that concerns the years 2013-2023.

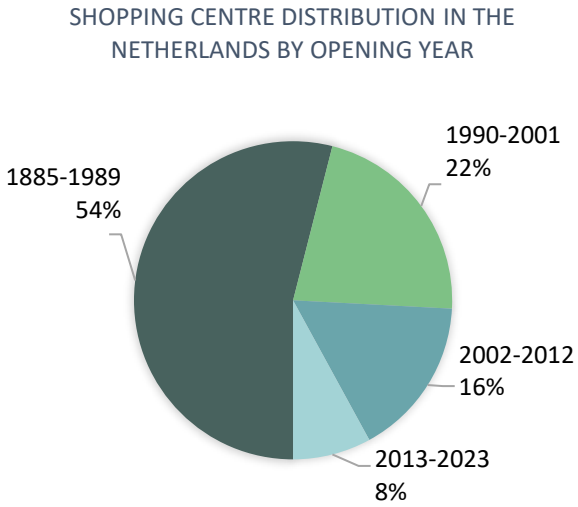


Figure 10. Dutch shopping centre distribution in terms of opening year. Own work based on database gathered from (Strabo, 2022).

Building form

The building form of the shopping centre plays an important role in the energy consumption of the shopping centre and possible energy efficiency interventions. According to Strabo (2022), a shopping centre can be classified by being a building structure covered, semi-covered or opened. Figure 11 displays the distribution of shopping centres in the Netherlands within these three categories.

- *Open shopping centres:* building structures that require the users to go outside to move from one unit to another. They can often be found in a row or as a U shape with an open courtyard (Bointner et al., 2014).

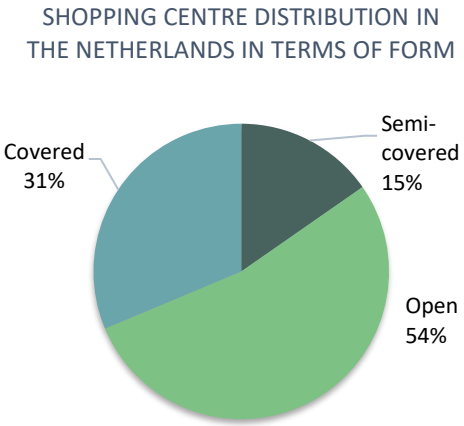


Figure 11. Dutch shopping centre distribution in terms of form. Own work based on database gathered from (Strabo, 2022).

- *Covered shopping centres:* As the name implies, these are structures with an enclosed environment that protect employees and customers from the outdoor conditions (Bointner et al., 2014).
- *Semi-covered shopping centres:* refer to building structures that have a combination of covered and open areas (Strabo bv Amsterdam, 2022).

Function

The function category of shopping centres is related to a combination of size, types of stores and location of the building within the urban fabric. Strabo (2022) classifies shopping centres according to eight (8) different types of function.

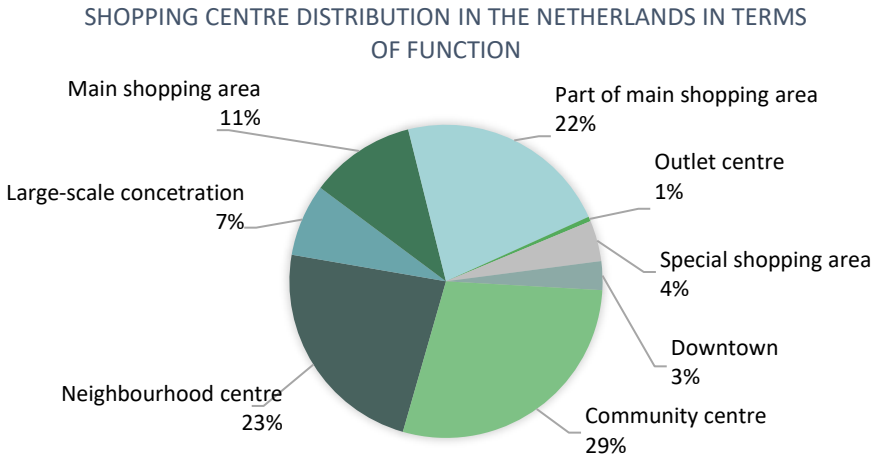


Figure 12. Dutch shopping centre distribution in terms of function. Own work based on database gathered from (Strabo bv Amsterdam, 2022)

These include:

- *Neighbourhood centre:* They are small local centres, close to people's homes where people can do daily shopping (Bointner et al., 2014). They have one supermarket.
- *Large-scale concentration:* are located in the periphery of a city and consist of large non-food shops (>1,000m^2), dedicated mainly to furniture and DIY stores.
- *Main Shopping area:* is located in a leading retail area or is the only shopping area. It can have either all food or non-food shops, or a combination of both.
- *Part of the main shopping area:* Is part of a larger shopping area with a leading location in the city but is not in the main anchor part of it. It can have either all food or non-food shops, or a combination of both.
- *Outlet centre:* Is a factory or outlet centre (Strabo bv Amsterdam, 2022).
- *Downtown:* a large centre(>15,000m^2) with a combination of food shops and a wide range of non-food shops.

- *Community centre:* larger than neighbourhood centres but smaller than 15,000m^2. They provide a greater variety of shops than in neighbourhood centres (Bointner et al., 2014), and have at least two (2) supermarkets.
- *Special shopping area:* none of the above, specialised shopping area. E.g. an isolated food centre in the middle of nowhere.

In the Netherlands, the largest share of shopping centres in terms of function are the ones classified as community and neighbourhood centres. These two categories account for 52% of the whole shopping centre building stock (Strabo bv Amsterdam, 2022).

2.1.2 Operation and services charges of shopping centres

The landlord-tenant structure of SC reflects on the way these buildings divide its operational costs, namely tenant and landlord services. Landlord services refer to the operational costs of common areas (e.g. staircases, storage areas, plant rooms, escalators, lifts, cleaning, among others) that are operated and maintained by centre management and paid by tenants through a service charge (Mangiarotti, 2006). Differently, tenant services refer to the operation, maintenance, and management of in-store connections, metering, and contracts with service companies by the tenants. This is because stores are leased on a shell-state that include the provision of water, electricity, drainage, telecoms, sprinklers, and, in certain types of shops, gas points within the leased area (Mangiarotti, 2006).

2.1.3 Preferred retrofit measures

Preferred interventions for energy efficiency of SC should be directed to the areas of major energy consumption and highest inefficiencies. These include lighting, HVAC, plug-loads, refrigeration (Haase, Skeie, et al., 2015; Toleikyte & Bointner, 2016), and architecture (Haase, Woods, et al., 2015) of both common and in-store areas. This can be tricky as shopping centre's managers only have control over the lighting of common areas, and a holistic retrofit requires the agreement between management and tenants (Haase, Woods, et al., 2015).

Areas of major energy consumption and inefficiencies

The total average annual energy demand for a SC in Europe is 272Kwh/m^2, and 200kwh/m^2 for a SC in the Netherlands specifically (Lollini et al., 2017). Although these numbers refer to existing SC, if compared to the current BENG Energy Performance requirement, they are particularly far from complying with the primary annual energy use f net-zero levels for new buildings (60kWh/m2) (Netherlands Enterprise Agency (RVO), 2020).

Lighting and refrigeration are the largest areas of energy demand for all shopping centres, followed by HVAC systems (Toleikyte & Bointner, 2016). This consumption is influenced by the type and size of the shops present in the building, where the energy demand of refrigeration, lighting, plug-loads, and HVAC systems have an impact over the building's energy gains & lose (Toleikyte & Bointner, 2016) s. Firstly, the type of shop has an impact on the share of specific power demand because

certain types of shops require more or less power in terms of lighting, appliances, refrigeration, and ventilation. For instance, as displayed in Figure 13, supermarkets require more specific power in refrigeration whilst retail in lighting (Retail forum for sustainability, 2009). Secondly, the size of the shopping centre is also relevant given that large shopping centres have the tendency of holding a lower specific energy demand/m^2. This is because, in general, they have a highest share of retail shops than of supermarkets, and lighting requires less energy than refrigeration (Toleikyte & Bointner, 2016).

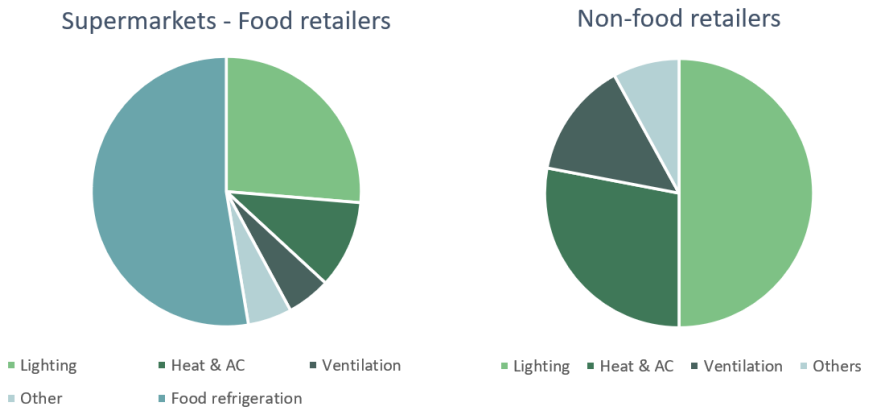


Figure 13. Share of energy demand in food and non-food retailers. Adapted from (Retail forum for sustainability, 2009)

Building categories	Shop types				
	SHP (Retail stores: clothing, hobby, home)	*CMA (Common area)*	*MDS (Medium stores, big size stores, super-markets)*	*RST (Restau-rant, cafes, food courts)*	*WRH (Other services: ware-house, service rooms etc.)*
Small	36%	25%	20%	8%	11%
Medium	42%	25%	15%	9%	9%
Large	50%	25%	9%	10%	6%
Very large	54%	25%	6%	12%	3%

Table 2. Shopping centre store composition according to building size. (Toleikyte & Bointner, 2016)

Lighting

Lighting annual energy demand ranges from 135 kWh/m^2 and 155kWh/m^2 depending on the size of SC (Toleikyte & Bointner, 2016). Considering that shopping centres often have a compact building shape, there is less available indoor natural daylight and thus require more artificial lighting to function (Haase & Ampenberger, 2017). In fact, excluding supermarkets, lighting holds the highest share of energy consumption in shops (Stensson, 2014). Lighting is important not only as a functional aspect for the use of space, but also for commercial purposes (Haase, Woods, et al., 2015). However, inefficiencies found in this area include lack of daylight possibilities, inefficient or outdated lighting sources, inefficient control and management systems, inefficient room or surface distribution, lack of maintenance or life-cycle performance, disproportionate use of accent lighting, no lighting design (Haase, Woods, et al., 2015). Therefore, energy efficiency retrofit interventions should be designed to address such inefficiencies.

HVAC

The average annual energy consumption for a SC ranges between 55kwh/m^2 and 65kwh/m^2 depending on the size of SC (Toleikyte & Bointner, 2016). HVAC stands for heating, ventilation and air-conditioning technical systems of a building. They compensate the heat deficit, heat surplus, and remove air pollutants to optimize indoor climate and thermal comfort (Stensson, 2014). These systems provide a constant renewal of fresh air in the building and require powerful electric motors to operate (Retail forum for sustainability, 2009). Inefficiencies in this area are related to outdated equipment, lack of detailed monitoring systems, implications of simultaneous heating and cooling activities, lack of control systems, and lack of exploitation of heat fluxes, thermal cascade, and its possible link with refrigeration systems (Haase, Woods, et al., 2015).

Food cooling and refrigeration

The average annual energy demand for refrigeration ranges is 50kwh/m^2 135kwh/m^2 depending on the size of SC (Toleikyte & Bointner, 2016). Refrigeration requires a high specific demand for supermarkets, market halls, convenience stores and in a lower extent, for restaurants (Toleikyte & Bointner, 2016). The energy demand of this system is supported by electricity and its inefficiencies are related to design and operation measures such as selecting storage temperatures and mechanisms to prevent cold losses (e.g. doors for freezers and refrigerators), cooling process inefficiencies, lack of control systems and proper monitoring processes, insufficient thermal storage and waste of resulting waste-heath (Haase, Woods, et al., 2015).

Architecture

Architecture represents a major area in the inefficiency off shopping centres because of the progressive retrofits that these buildings go through its lifecycle, where individual solutions are taken through time instead of integral ones (Haase, Woods, et al., 2015). Moreover, the architectural design of a shopping centre can have an energy impact on the overall energy consumption of the building. Therefore, energy efficient solutions should be considered as part of these integral renovations.

Connection to the grid

Overlooking shopping centre's potential to connect to the city's energy grid can be considered as a SC inefficiency. This is because, as high energy demand buildings with large available surfaces for renewable energy sources and energy storage integration, SC hold a high embedded energy demand flexibility potential (Barchi et al., 2018). Energy flexibility is defined by the ability of an energy system to adjust supply and demand to achieve energy balance in the grid (National Grid ESO, 2020). Therefore, by implementing adequate energy/retrofit measures, SC have the possibility to reduce its energy demand, generate its own renewable energy, store excess electricity, and use the surplus to provide additional energy services, use it during times of high peaks of energy demand or release it to the grid to restore the balance (Haase et al., 2016).

Retrofit measures

Considering that the previously mentioned areas of mayor energy consumption and inefficiencies are in lighting, refrigeration, and HVAC (Toleikyte & Bointner, 2016), retrofit measures should focus on addressing them. These are areas focused on the demand side of retrofit designs. Therefore, measures should be focused on decreasing the energy demand through the introduction of new technologies or passive technology systems (Ruggeri et al., 2020).

It is difficult to propose universal retrofit measures that fit all shopping centres as every building is unique and has specific needs and requirements. However, based on The U.S. Department of Energy guidelines for Energy Retrofit for Retail Buildings (2011) and the Advanced Energy Retrofit Guide for Grocery stores (2013), three general types of measures or packages can be implemented in shopping centres. First, a package with measures related to operation and maintenance called Existing Building Commissioning (EBCx) that targets up to 15% of energy savings with a minimal risk and capital investment requirement. It is focused on the control and performance optimization of existing equipment. Second, a standard retrofit package that targets 15-45% energy savings, if mixed with the first package, through measures that are cost-effective and that represent a low-risk investment for building owners. It includes measures that do not require a design process, do not entail changes to systems but rather component-level replacements to existing equipment, and do not represent any disruptions in the regular operation of the store. Third, a deep retrofit package that targets 45% or above energy savings, if mixed with the first package, with interventions that require a larger initial investment with a longer payback period compared to EBCx and standard retrofit measures. This package is directed to buildings in an advanced building lifecycle that require an integrated design rather than individual measures. It targets lighting, HVAC and building envelope retrofits that involve major interventions concerning interior layout and replacing equipment to downsize its capacity (Pacific Northwest National Laboratory & PECI, 2011). Although according to the BPIE (2021) objectives all building's renovations should be deep, and should hence target the deep retrofit package, these three packages will be used to identify the types of measures that SC are currently implementing in the country and if these retrofits are happening by stages.

Package 1 - Existing Building Commissioning (EBCx)

System	Description
Lighting	Calibrate exterior lighting photocells
Envelope	Reduce envelope leakage
	Replace worn out weather stripping at exterior doors
HVAC	Clean cooling and heating coils, and comb heat exchanger fins
	Revise air filtration system
	Add equipment lockouts based on outside air temperature
	Reprogramme HVAC timeclocks to minimize run time
	Optimize outdoor air damper control
	Repair airside economizer
	Increase deadband between heating and cooling setpoints
Refrigeration	Install night curtains on open refrigerated cases
	Verify/establish effective maintenance protocol for refrigeration system and cooking equipment in kitchen

Table 3. Existing Building Commissioning package. Adapted from (National Renewable Energy Laboratory, 2013; Pacific Northwest National Laboratory & PECI, 2011)

Package 2 – Standard retrofit

System	Description
Lighting	Add daylight harvesting
	Re circuit and schedule lighting system by end use
	Retrofit interior fixtures to reduce lighting power density by 13%
	Retrofit exterior fixtures to reduce lighting power density, and add exterior lighting control
HVAC	Remove heat from front entry
Refrigeration	Install doors on open refrigerated cases
	Install strip curtains and weather seal walk-in freezer doors

Table 4. Standard retrofit package. Adapted from (National Renewable Energy Laboratory, 2013; Pacific Northwest National Laboratory & PECI, 2011)

Package 3 – Deep retrofit

System	Description
Lighting	Add daylight harvesting
	Re circuit and schedule lighting system by end use
	Retrofit interior fixtures to reduce lighting power density by 58%
	Install skylights and daylight harvesting
	Retrofit exterior fixtures to reduce lighting power density, and add exterior lighting control
HVAC	Replace RTUs with higher efficiency units
	Replace HVAC system with a dedicated outdoor air system
	Remove heat from front entry
Building envelope	Replace/add wall and roof insulation
	Replace windows and frames
	Install high R-value Roll-up receiving doors
Refrigeration	Install high efficiency ECM evaporator fan motors
	Install doors on open refrigerated cases
	Install strip curtains and weather seal walk-in freezer doors

Table 5. Deep retrofit package. Adapted from (National Renewable Energy Laboratory, 2013; Pacific Northwest National Laboratory & PECI, 2011)

2.1.4 Conclusion

The *what* area of this literature review has helped to identify the current characteristics of the building stock in the Netherlands, providing a relevant input to answer SQ1 about the state-of-the-art of the energy efficiency of shopping centres. Firstly, it contributed to the confirmation that the age of the shopping centre building stock in the country is indeed mature and in need of an energy renovation. Secondly, the packages explained in sections 2.1.3, about the preferred retrofit measures and areas of major energy consumption, served to map the types and depth of the energy-related interventions that shopping centres are choosing, which may have an influence over the decision-making process of EER. Finally, other characteristics, such as form, size and ownership, contributed to identify the characteristics and relevance for the selection of the sample during the empirical part of this research. This will be further explained chapter 3.

2.2 Who

2.2.1 Stakeholders involved in the decision-making process for EERs

As mentioned before, shopping centres hold a complex governance structure because of the different stakeholders involved. It is fair to state that energy-efficient retrofit decisions happen not only within the organisation itself but also within a market structure, both of which are subject to government policies and regulations (Cagno et al., 2013). Barriers in the decision-making process of an EER may arise from either type of actor, therefore, the understanding of their role, drivers and barriers is a key aspect of this research. This section will focus hence on analysing the role of each actor in this process through stakeholder mapping.

Stakeholders are classified using Winch's (2010) classification system of internal and external stakeholders (Table 4). Internal stakeholders are actors that are in legal contract with the client or organisation, they can be classified as actors in the demand or supply side (Winch, 2010). In the case of shopping centres during a renovation process, owners, asset managers, centre managers, association of owners and tenants are placed on the demand side as they are within the organisation. Whereas designers, energy consultants, technology providers, manufacturers, contractors, energy suppliers and capital suppliers are placed on the supply side, as they supply the services and technologies needed for an energy efficiency measure. Differently, external stakeholders are actors that have a direct interest in the project but are not directly involved in the organisation (Winch, 2010), or in this case, in the shopping centre governance structure. They can be divided into private actors, such as costumers and local residents; and public actors, such as the government that enforces policies and regulations, and the local authorities.

Internal stakeholders		External stakeholders	
Demand side	**Supply side**	**Private**	**Public**
Owners-asset managers Property management Owners' association Tenants Employees	Designers/Architects/Energy consultant Technology/manufacturers Contractor / Project manager Capital suppliers Energy suppliers Distribution Net managers	Costumers	Government Local Authorities

Table 6. Internal and external stakeholders during EER of shopping centres. (Author).

Internal stakeholders:

- **Owners -managers:** this group is comprised by institutional investors, private investors, and asset managers. According to the literature, they are the group that is most interested in the energy efficiency of the buildings. However, their drivers for an EE investment rely on the return on investment (ROI), net present value (NPV), minimum holding period (Barchi et al., 2018; Salm et al., 2016), risks (Kuivjõgi et al., 2021) and pay-back time (Kuivjõgi et al., 2021; Liang et al., 2019) of the selected energy measures. Moreover, barriers presented by this actor involve the lack of benefits from undergoing an energy retrofit (Kuivjõgi et al., 2021; Seeley & Dhakal, 2022), a potential rent price increase that may lead to vacancy of the building, changes in occupancy from temporarily closed stores, and a lack of knowledge and control over the in-store energy use (Haase, Woods, et al., 2015).

- **Property management:** This stakeholder is responsible for organising and recruiting the management systems and **centre management teams** for a shopping centre on behalf of the owner in order to meet its goals and expectations. Their role involves the operation and management of the SC in terms of the property, facility, and tenant mix (Pitt & Musa, 2009).

  While the property and facility aspects allow to maintain and ensure the image and physical aspects of the property, the management of the tenant mix allows to optimise rent values, sales, service to the community and financiability of the shopping centre Kaylin (1973, as cited in Pitt & Musa, 2009). The composition of the team varies from centre to centre and can involve roles such as centre manager, marketing and publications manager, operations manager, information manager, event manager, customer service manager, etc (Pitt & Musa, 2009).

- **Owners' association:** Although this group was not found specifically for shopping centres in the literature, in the cases where fragmented ownership occurs, this actor becomes relevant to guarantee a collective decision-making and unified action among all owners (Johnston & Too, 2015). This actor requires consent from owners to operate and its role is to reconcile the interests of all owners in terms of the maintenance and operation of commonly owned areas, maintain the unity of the building, and enforce communal rules and regulations.

- **Tenants:** According to the literature, this group does not hold a special interest for energy efficiency (Haase, Skeie, et al., 2015). Their interest is focused on consumer satisfaction. Therefore, there is little interest from tenants to undergo EER unless consumers start to demand it (Lollini et al., 2017; Woods et al., 2015). However, this situation is attached to shopping centres that perform under a non-individual billing system (Woods et al., 2015) which may hinder the interest they hold towards consumption and a potential energy bill reduction. Shopping centres in which tenants hold an individual billing system might hold a different position towards it and it is subject of this research. Other concerns from this actor for an EER involve changes in rent prices (Haase, Woods, et al., 2015; Kuivjõgi et al., 2021) and sales decrease due to temporary closure of commercial activities during renovation (Kuivjõgi et al., 2021).

- **Designers/ architect / energy consultants:** This group involves the architects, engineers, and energy consultants that design the energy efficiency retrofit. Their role is to design and advise on adequate measures that are in line with the client's goals, budget, and energy requirements. Barriers related to these stakeholders are related to the proposal of high initial costs of the proposed technologies (Cagno et al., 2013).

- **Technology/manufacturers:** These are the actors that provide the technology, product and services that are needed during the renovation. Barriers attached to these actors involved providing inadequate technology for the intended use, providing solutions that required specialised training for its installation and operation, having scarce communication skills about the full capabilities of their technologies (Cagno et al., 2013) which may hinder the correct performance of the measures.

- **Contractor /project manager:** refers to the person or organization responsible for planning, managing, and executing projects aimed at improving the energy efficiency or aesthteic upgrade or renovation of the building.

- **Energy suppliers:** Their role is to supply energy in the form of electricity, gas or others to homes and businesses. Barriers from this actors involve not having good communication skills for consumers to identify the most suitable energy contract type; energy prices distortion where prices don't reflect the true price for energy suppliers to produce energy at different times of the day, or where the energy price does not stimulate the adoption of energy-efficient technologies; and a lack of interest on energy efficiency as it means less energy use by its customers and hence, less return on investment for the suppliers (Cagno et al., 2013). Moreover, energy suppliers can be more involved in the process if they were to offer integral building retrofit services. In this case, they will offer a single contact building retrofit service that will be based on energy performance guarantees, keeping a long-term relationship with costumer up to the operation and maintenance phase of the systems (Bertoldi et al., 2021).

- **Capital suppliers:** They refer to the financial institutions that provide loans for energy retrofit measures. Barriers coming from capital suppliers towards an EER are related to the high transaction costs that entail evaluating the debt carrying capability and the large amount of medium and small interventions; and to the difficulty in the evaluation of investments of innovative less-known interventions (Cagno et al., 2013).

- **Distribution net managers:** refers to the organisation that manages and operates the physical infrastructure of the distribution network, ensuring the reliable delivery of electricity or gas to end-users.

External stakeholders:

- **Customers:** While the energy wave has begun to influence purchase decisions of services or goods, it has not yet been transferred to the place of purchase (Haase, Woods, et al., 2015; Lollini et al., 2017). Therefore, there is a lack of knowledge from this actor towards EE (Haase, Woods, et al., 2015).

- **Government:** The role of this actor is to define energy efficiency standards through policies and regulations to comply with the country's and region's sustainability goals. They often provide subsidies or financial support for building owners to comply with energy-efficiency standards (Ma et al., 2012). The lack of clear standards represents a barrier for building owners to choosing the most adequate energy-efficient technology (Cagno et al., 2013). This is the case of the Dutch government where there are still no regulations in place that obliges the retail sector to comply with energy efficiency standards. Similarly, another barrier is the possibility of the distortion of fiscal policies which mean that the establishment of taxes, subsidies, or other regulations might lead costumers to be discouraged to adopt energy-efficient technologies as consumption becomes more or less expensive for them (Cagno et al., 2013).
- **Local Authorities:** This actor is relevant within a shopping centre renovation process because they not only provide the building permits for the renovation, but also because of the external effects that a SC redevelopment brings to the community such as helping combat neighbourhood deprivation (Zhang et al., 2020), job generation, improving community cohesion, etc.

2.2.2 Conclusion

The *Who* area of this literature review has aided in the understanding of the complex governance structure of shopping centres, and hence of the actors that are involved in an EER process. This was an important step as mapping their behaviours and interrelationships the object of research.

2.3 How

This section aims to examine the existing literature regarding the decision-making process involved in Energy Efficiency Retrofit (EER). To achieve this objective, the section begins by providing a clear definition of an EER retrofit. Subsequently, it delves into a comprehensive explanation of the EER process, highlighting the various decision-making steps that are essential for its successful implementation. Lastly, the section explores the barriers that have been identified in the literature, which pose challenges during the EER process.

2.3.1 What is an Energy Efficiency Retrofit?

An EER is a retrofit that seeks to improve the energy performance of existing aged or deteriorated buildings. It is considered one of the most cost-effective and realistic strategies to reduce greenhouse emissions and building energy consumption (International Chamber of Commerce (ICC), 2009; Ma et al., 2012). Ma et al. (2012) categorised six different key elements that an EER project relies on to be successful (Figure 14).

First, policies and regulations set standards and requirements for new and existing buildings. They also set incentives in terms of providing financial support and subsidies for property owners to motivate building retrofitting (Ma et al., 2012). Second, client resources and expectations determine the goals and influencing factors for an energy efficiency investment (Ma et al., 2012). This factor is

critical as it is here were the decision-making process for an EER initiates. Third, building specific information is also critical for the definition of the building solutions that fit best to each case. This considers information about the location, use, occupancy schedule, energy sources, building fabric, operation and maintenance, among others (Ma et al., 2012). Fourth, the correct selection of retrofitting technology also plays a role in the success of an EER. This is not only linked to the building specific information but also to the client resources and expectations as it should consider payback period (Liang et al., 2019), repercussions over rent prices (Kuivjõgi et al., 2021) and impact on the implementation of the measures (Ma et al., 2012), such as possible temporary closure of commercial activities (Kuivjõgi et al., 2021). Fifth, the human factor is key as the selected retrofit activities have an impact on the comfort requirements and may rely on occupancy, management and maintenance activities or control systems (Ma et al., 2012). An example of this factor was studied in the CommONEnergy project (Woods et al., 2015) when exploring shopping mall inefficiencies. They discovered that whilst there was a willingness from costumers to accept lower temperatures in the winter, tenants saw it problematic for their employees as they were the ones who would have to deal with lower temperatures and would have their thermal comfort affected for longer periods. Finally, the sixth factor for an EER success relies on other uncertainty factors such as lack of knowledge on energy savings estimations, energy consumption patterns, performance degradations, among others (Ma et al., 2012). Literature has found this factor as a relevant issue in EER of retail as there is a general lack of knowledge of energy consumption patterns between owners and occupiers (Haase, Woods, et al., 2015).

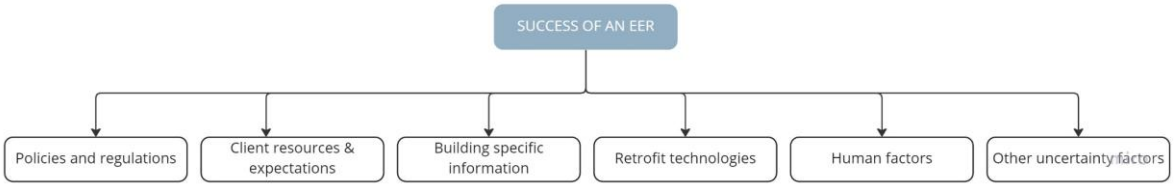


Figure 14. Success elements to achieve an EER. Adapted from (Ma et al., 2012)

2.3.2 The Energy Efficiency Retrofit process

An EER process is a five-stage process (Figure 15) that starts with the initial setup intention (Liang et al., 2016). Here, the owner and occupier propose the intentions to retrofit, define the objectives and expectations, and exchange different attitudes related to the retrofit. This is different from Ma et al. (2012), that state than an EER process starts with a pre-retrofit survey and project setup. The second stage is the pre-retrofit survey and energy performance assessment (Liang et al., 2016). At this point, a pre-retrofit survey, the data collection on energy performance assessment, and the goals and target establishment are performed. The third stage is related to the design (Liang et al., 2016). This includes, identifying and quantifying the retrofit measures (Liang et al., 2016; Ma et al., 2012), performing a cost-benefit analysis, developing action plans, client review, comments, and approval (Liang et al., 2016), and risk assessment (Ma et al., 2012). The fourth stage is the site implementation. This includes the commissioning and actual renovation (Liang et al., 2016; Ma et al., 2012). The fifth stage is the validation and verification of the measure (Liang et al., 2016; Ma et al., 2012). Here, a post-retrofit measurement and verification, and an occupier satisfaction

evaluation is performed. Finally, Liang et al (2016) names as a sixth stage the operation of the retrofit. It refers to the regular operation of the building (Ma et al., 2012), but should also consider the maintenance, the monitoring of the system, and an eventual future retrofit if required.

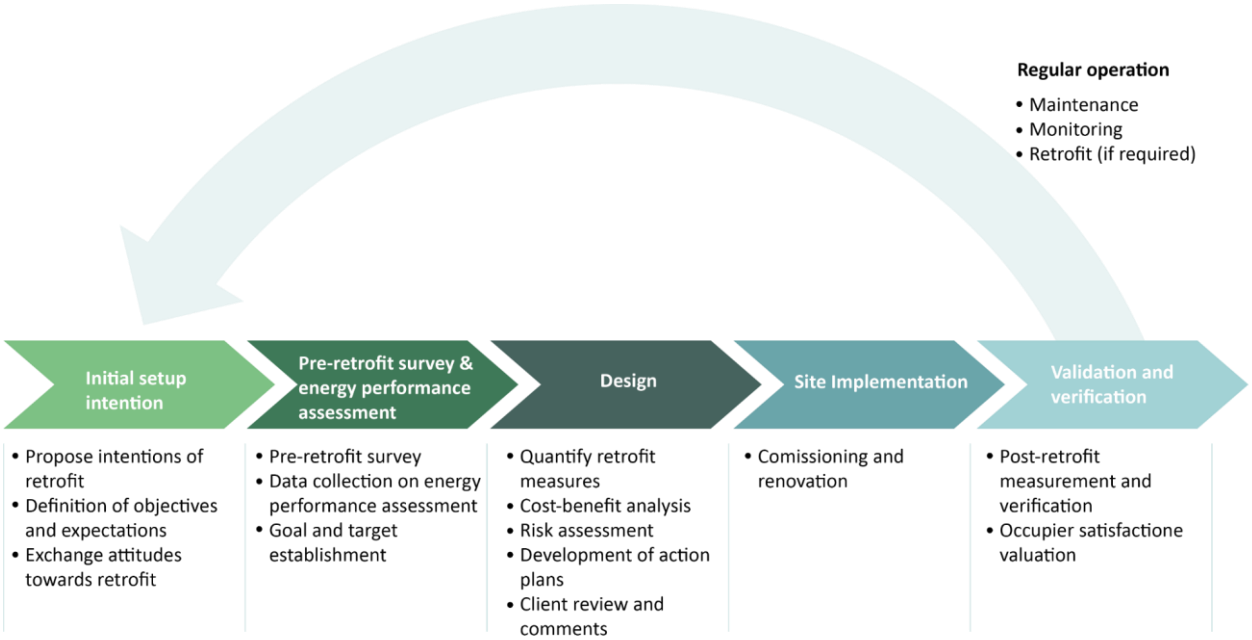


Figure 15. EER process. Compiled from (Liang et al., 2016; Ma et al., 2012)

2.3.3 The decision-making process of an EER

In order to effectively implement an energy-efficient retrofit (EER) process, it is crucial to have a comprehensive understanding of the decision-making process that guides the progression from one stage to another. Rogers' theory on the innovation-decision process offers valuable insights in this regard, suggesting that decision-making unfolds over time through distinct stages, whereby individuals or organizations decide whether to adopt an innovation into their existing practices (Rogers, 1983). Rogers (1983) proposes a five-stage process consisting of: (1) a knowledge stage, related to an awareness generation of the existence of an innovation; (2) a persuasion stage, related to the process by which an individual organisation discusses and forms a favourable attitude towards that innovation; (3) a decision stage, related to engaging in the actions needed to plan and evaluate its adoption or rejection; (4) Implementation, related to taking action and putting the innovation in use; and finally (5) confirmation, whereby reinforcement about the relevance and validity of that innovation were met and continuation is evaluated.

In line with Rogers' innovation-decision process, Mlecnik et al. (2018) explored the homeowner's renovation journey in adopting low-carbon technologies and identified five stages similar to Rogers' framework. However, they emphasized the significance of effective communication channels throughout each stage, providing essential information as a means of guidance to prevent potential adopters from discontinuing their adoption journey. This communication was further emphasized in the final stage of confirmation as pivotal, as it facilitates a transition from a linear decision-making process to a closed-loop one. In this stage, individuals who have already adopted the new

technologies can serve as sources of inspiration for new adopters, encouraging them to embark on their own adoption process (Mlecnik et al., 2018). This highlights the role of social influence and peer learning in fostering the adoption of low-carbon technologies.

2.3.4 Barriers taxonomy in an EER decision-making process

The study of barriers towards the adoption of energy efficiency technologies in different sectors has been documented by different sources of literature. This research has focused on Cagno et al. (2013) as they developed a barriers taxonomy for empirical research to help identify critical factors.

The taxonomy consists on seven different barriers categories, which include: *technology*-related barriers, concerning the availability and adequacy of energy-efficient technologies; *information barriers*, related to information exchange; *economic barriers*, related to the economic evaluation of the EER; *behavioural barriers*, concerning the behaviours of the decision-makers and operators; *organisational barriers*, related to barriers that arise from the interactions of different functions and roles within the organisation; *competences-related barriers*, concerning the specific competences that a firm needs to have identify inefficiencies and opportunities, and implement the interventions; and finally, *awareness barriers*, related to the knowledge on EE of decision-makers (Cagno et al., 2013).

2.4 Theoretical framework

This section provides a comprehensive synthesis of the literature review conducted in sections 2.1-2.3, resulting in the development of a theoretical framework that depicts the Energy Efficiency Retrofit (EER) decision-making process in shopping centres. This framework served as a valuable tool for guiding the data collection process during the empirical phase of the research, thereby enabling a systematic analysis and interpretation of the research findings.

The theoretical framework developed for this research is divided into two parts. The first part consists of the merger between the presented EER process and the EE decision-making. This was developed based on different literature sources, and specially from the work of Liang et al. (2016) who linked the retrofit phases to the stakeholders involved. The stakeholder classification was modified based on data gathered specifically for shopping centres, as presented in section 2.3.

Second, borrowing Cagno et al. (2013) taxonomy for empirical research about barriers in the decision-making process for the adoption of energy-efficient technologies, the research attempts to classify the barriers in the decision-making process for EER of shopping centres. This framework allows to map barriers already found in literature specific to shopping centres and make documented assumptions of others for each stakeholder involved.

2.4.1 EER decision-making process of shopping centres

Figure 16 portraits the compilation of an EER process with the previously discussed decision-making steps, resulting in a literature-base process of EER. The stages of this process can be described in the following way:

Stage 1 - Knowledge: This stage relates to the awareness about an interest or identified need by one or more stakeholder to improve the energy efficiency of the building from its status quo (Hasanbeigi et al., 2009). Although there is no specific stakeholder linked to this process, government policies might have an influence over the status quo, sparking the interest for an EER of some parties involved and steering the EER to move to the next step.

Stage 2 - Persuasion: This stage is divided in two phases. First, after that one or group of actors have become aware of an energy efficiency improvement opportunity, an initial intention set-up takes place (Cagno et al., 2013). This phase involves the initial proposal of the intentions of the retrofit, the definition of the objectives and expectations, and an exchange of attitudes between the different stakeholders towards the retrofit (Liang et al., 2016). Second, after the decision to launch the retrofit is made, knowledge on inefficiencies and opportunities must be gathered (Cagno et al., 2013; Liang et al., 2016). This will allow to establish the goals and targets and identify possible retrofit measures.

Overall, this stage is about reaching consensus about the objectives, expectations, and forming a common and favourable attitude to undergo a retrofit. Therefore, different to Liang et al. (2016), not only owner and occupier are involved, but also the owner association as consensus within a possible multi-owner structure needs to be achieved, the property manager and the energy consultant (Liang et al., 2016). Moreover, the influence of costumers over this decision-making step is a key aspect as customer satisfaction is central in shopping centre's success. If this stage is successful, then the EER process can move to the following step.

Stage 3 - Decision: this stage is about planning and proving the adequacy of the investment (Liang et al., 2016). Here, selected retrofit measures are quantified, and assessed in terms of cost-benefit and risks (Liang et al., 2016; Ma et al., 2012). Actors involved in this step include the designers, owner-asset manager, owner association, and facility manager. Moreover, stakeholders with a level of influence include financial institutions and energy service companies. The later because the benefits and risks of the energy contract type needs to be weighted (Cagno et al., 2013), as well as the possibility to contract with them integrated services, for which they will become key stakeholders throughout the project phases.

Stage 4 - Implementation: Once the design and investment are proven adequate, the site implementation and later validation of the measure(s) takes place (Cagno et al., 2013). This concerns undergoing the actual works, performing a post-retrofit survey to assess that goals and targets were met (Cagno et al., 2013; Liang et al., 2016). Stakeholders involved in these steps are the technology providers, manufactures, contractors, and energy consultants.

Stage 5 - Confirmation: This stage concerns the regular operation and monitoring of the measure within the building. Stakeholders involved in this process involve primarily the facility manager of the building. However, customers and employees act as influencing actors as their behaviours has an impact over the energy-saving potential of the measures (Cagno et al., 2013). These activities will continue on a regular basis until a new need is identified, steering the process to start over again.

EER decision-making process of shopping centres

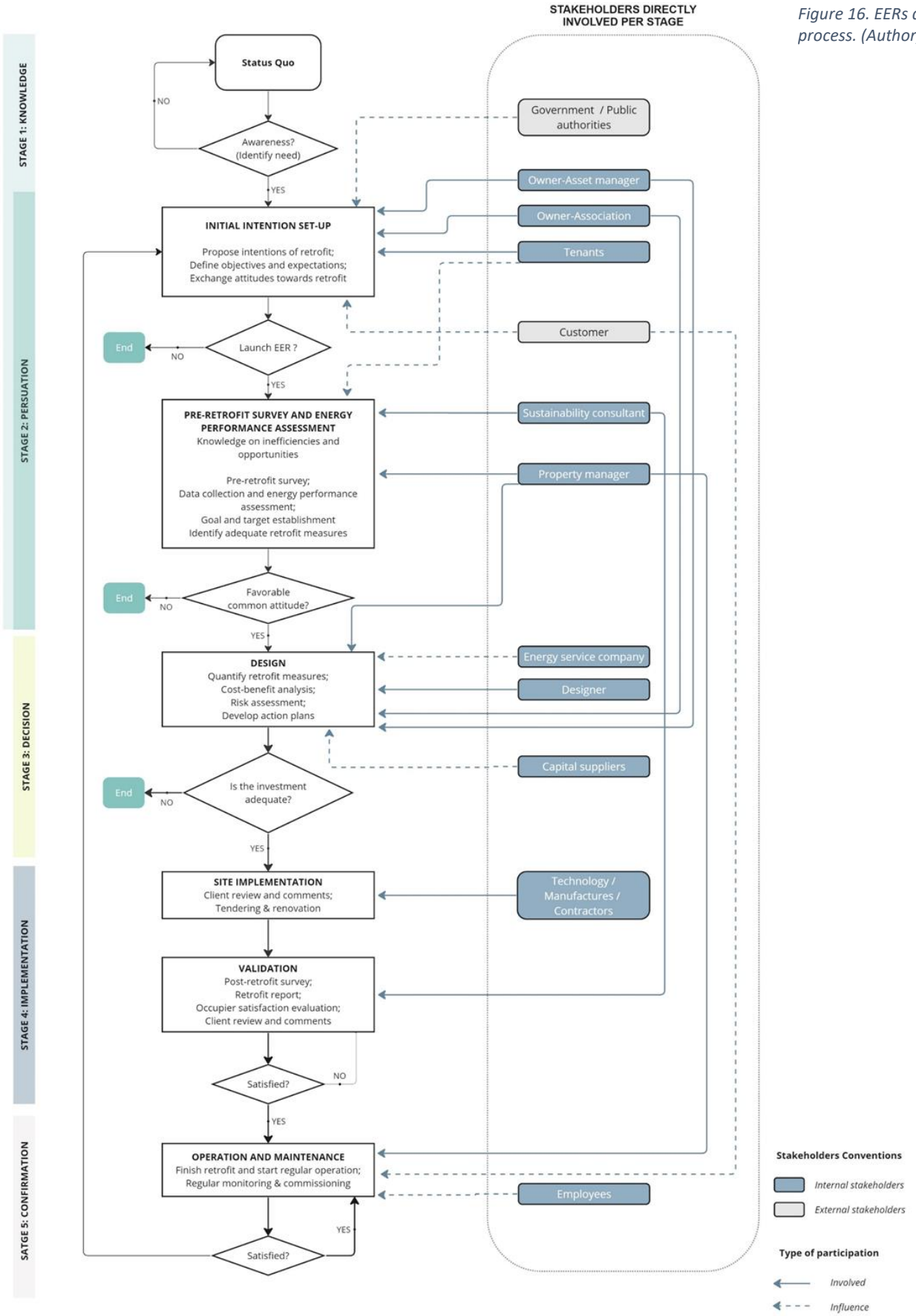


Figure 16. EERs decision-making process. (Author)

2.4.2 EER barrier's taxonomy

In Table 7 the barriers of an EER of shopping centres are classified using the taxonomy for empirical research of Cagno et al. (2013). This taxonomy was first adapted to match the EER decision-making process developed and explained in the previous section. And second, it was adapted to link each barrier to the specific stakeholder in the process, instead of the internal and external origin classification from Cagno et al.'s original work.

Scattered barriers found specifically for retail and shopping centres were mapped within these categories and identified within a decision-making step. Furthermore, documented assumptions on how other stakeholders might relate to each barrier were also made. The idea behind using this taxonomy was to serve as guidance during the empirical phase of the research. From this exercise, the framework suggested that most barriers were related to internal stakeholders. This was also documented by Cagno et al. (2013), that pointed out that external stakeholders reflect only on economic, information, and technology-related barriers. Whereas organisation, behavioural, and competence-related barriers are exclusive to internal stakeholders, except for the barrier about *lack of interest* from the behavioural category. Similarly, information barriers, except for the *lack of information on costs and benefits*, correspond mainly to external stakeholders.

Table 7. Barrier's taxonomy visualisation in the decision-making process. (Author. Compiled from multiple literature sources)

			Internal stakeholders											External stakeholders		
Barriers taxonomy	Barrier	Step	Owner / Asset manager	Property management	Owner association	Tenant	Employees	Designers/Architect/Energy consulta	Technology / Manufactures	Developer/Project manager	Capital suppliers	Energy suppliers	Distribution Net managers	Government	Local Authorities	Costumers
Technology	Technology not adequate	2, 4	X	X		X			△				X			
	Technology not available	2, 4						△	△							
Information	Lack of information on costs and benefits	3				X			△					△		
	Unclear information by technology suppliers	3							△					△		
	Trustworthiness of the information source	3							△							
	Information issues on energy contracts	3										△				
Economic	Low capital availability	2, 3, 4	X													
	Investment costs	4	X △						△							
	Hidden costs	3, 4	X △	X	X	X	△		△		△					X
	Intervention-related risks	4	△							△						
	External risks	2										△				
	Interventions not sufficiently profitable	4	X	X												
Behavioural	Lack of interest in energy-efficiency interventions	2				X			△							
	Other priorities	2	X	X		X										X
	Inertia (resistance to change)	2				X				X						
	Imperfect evaluation criteria	4	X △	△	△	△										
	Lack of sharing the objectives	4					△									△
Organisational	Low status of energy efficiency	3, 4		X												
	Split incentives	2	X													
	Complex decision-chain	3, 4	△	△	△	△										
	Lack of time	2, 4	△													
	Lack of internal control	4	X	X												
Competences	Identifying the inneficiencies	2, 3	△ X	△ X												
	Identifying the opportunities	2, 3	△													
	Implementing the interventions	2, 3	△							X						
	Difficulty in gathering external competences	3	△													
Awareness	Lack of awareness or ignorance	1				X										X

△ Assumptions from literature but not especifically related to retail
X Barriers found in retail-related literature

03 RESEARCH METHODOLOGY

In this chapter, the research methodology designed to answer the research questions is explained. It describes the research in terms of (1) the research design, (2) data collection, (3) data analysis, (4) data plan, (5) ethical considerations, (6) research output, and (7) personal study targets.

CONTENT

3.1 Research design

To answer the research questions, an **exploratory qualitive research** was selected. “Qualitative research supports the understanding of complex, dynamic, and multi-dimensional wholes” (Patton 1975, as cited in Sofaer, 1999). It allows to understand the context in which phenomena occur and identify and describe the patters and events in which actors are involved (Sofaer, 1999).

The research was designed in three phases, involving a theoretical study, an empirical research phase, and finally a synthesis and conclusion phase. Figure 17 displays the research methodology framework with these phases according to the P terms, the selected method, the data collection technique for each phase, the relationship with each research question, and the expected outcome.

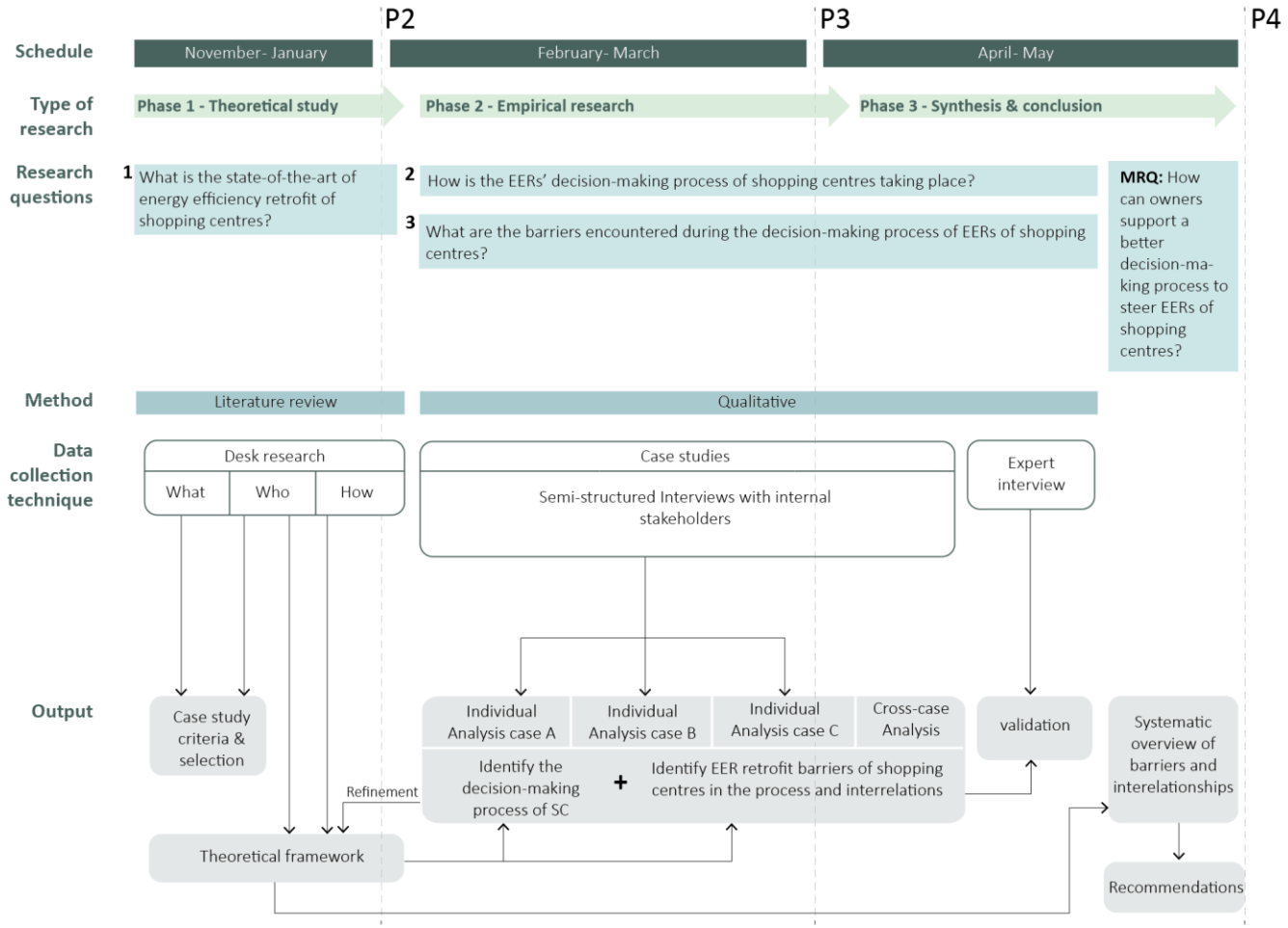


Figure 17. Research methodology framework. (Author)

Phase 1

The first phase concerned the theoretical study part of the research and focused on answering SQ1. Through a desk research method, the literature review was conducted. This phase, presented in the previous chapter of this document, allowed to develop a comprehensive understanding of the state-if-the-art of energy efficiency retrofits of shopping centres from around the world, setting the basis for the subsequent empirical part of the research. Specifically, it led to the establishment of the

selection criteria for the case studies and the development of a theoretical framework that provided the guidelines to gather and analyse empirical data.

Phase 2

The second phase concerned the empirical part of the research and focuses on answering SQ2 and SQ3. The methods used to answer this question were case studies of shopping centres in the Dutch context by means semi-structured interviews. The semi-structured interviews allowed to validate the decision-making process compiled from literature and identify the underlying factors and behaviours that influenced the decision-making process of EERs of shopping centres.

Phase 3

The third and final phase concerned the synthesis and conclusion of the findings. First, a cross-case study analysis allowed to compare, validate, and synthetise the findings. At the end of this phase, the research concluded with the two main outcomes: a systematic overview of stakeholders' behaviours, which allowed to identify the critical areas of improvement, and produce recommendations to improve current decision-making mechanisms for EERs of shopping centres, providing an answer to the main research question.

3.1.1 Case study design

As previously explained, part of the empirical component of the research was proposed as a case study method. This is because case studies attempt to give light about why, where, why, and with what result certain decisions were taken (Scharmm, 1971 as cited in Yin, 2009). For this purpose, a multi-case study design was selected as data gathered from different cases is more compelling than from a single source (Yin, 2009). As explained in Figure 18, the theoretical framework developed from the literature review replicated across cases. Yin (2009) explains that theory development is the first step in a case study design, followed by the selection of the case studies and the data collection protocol. The idea was that each case was studied and analysed individually, using a combined deductive and deductive approach, after which cross-case conclusions were drawn to modify and/or complete the initial theory, and from which the recommendations emerged.

The upcoming sections explain the case studies selection criteria, along with the selected data collection and analysis methods implemented.

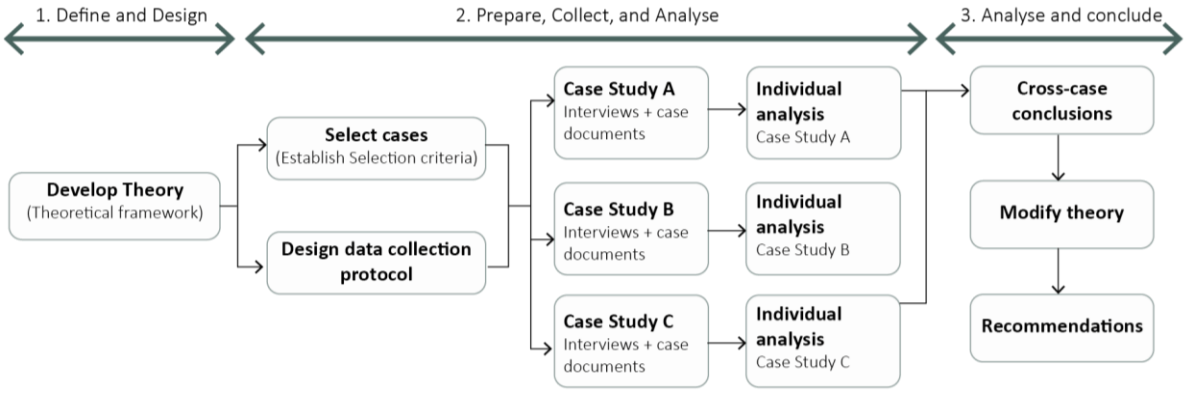


Figure 18. Case study method. Adapted from (Yin, 2009)

Case study selection criteria

The theoretical framework, developed in section 2.1, allowed to set up the case-study selection criteria. Data gathered in terms of size, form, opening year, types of shops, and type of ownership of the shopping centres in the Netherlands became valuable to stablish the most relevant criteria that will allow a greater degree of replicability of the findings. The criteria were divided in terms of *required* for all cases and *desirable*, where at least one of the cases must comply with (Table 8).

A maximum of three case studies were planned to be selected using these criteria because of two reasons. First, because more than one case study already constitutes a multi-case study design. This is required to ensure replicability as it is impossible to generalise with a single case (Sofaer, 1999). Second, because each case study entails multiple semi-structured interviews (Table 9). Consequently, there were time and resources constraints to conduct and analyse a larger sample.

	Criteria	Reason	Case A	Case B	Case C
Required	1. The shopping centre has undergone recently (5 years or prior) or is currently undergoing a deep EER process	Questions will be directed around how the EER process took or is taking place	✓	✓	✓
	2. Shopping centre GLA must be within the covered category	This way, energy consumption in common areas is also a relevant area of study	✓	✓	✓
	3. Shopping centre must be >5,000m^2	The purpose of this criteria is to add relevance to the complex governance system of shopping centres. A smaller SC will not have many shops or common areas	✓	✓	✓
	4. The opening year of the shopping centre is prior or close to 1990	This adopts the assumption that all buildings built before 1990 are the least energy efficient (BPIE, 2017)		✓	✓
	5. Shopping centre has at least 1 supermarket	Food and non-food retailers have different consumption habits. Therefore, the renovation measures and goals might differ between them	✓	✓	✓
Desirable	1. At least one of the shopping centres is in the small or medium size range	To ensure the relevance of the case studies as shopping centres in this category comprises 85% of the shopping centre building stock	✓		✓
	2. At least one of the shopping centres has a fragmented ownership type	Although this type of ownership is not the most representative, this adds complexity to the governance system, as more owners and an owner's association are involved. This is supported by (Flyvbjerg, 2006)who states that an atypical case often tends to reveal more information due to the presence of more actors and mechanisms.		✓	
	3. At least one shopping centre has a neighbourhood or community centre function	Together, these two categories represent more than half of the Dutch shopping centre building stock	✓		✓
	4. Select complementary cases that present different ranges of EE measures and EE drivers.	Literature review classified 3 different types of renovation packages. While some can be linked to aesthetic renovations, others are EE only. Studying different scales of EE measures could reveal different actors and barriers in the process.	✓	✓	✓

Table 8. First case study selection criteria. (Author)

Case studies introduction

Supported by the two-phase rounds of selection criteria, three case studies of shopping centres haven been selected. In this section a brief overview of the case studies is provided. However, a full case description can be found in the individual case analysis in chapter 4.

Case study A
De Tuinen shopping centre

Size	Small – 14,000 sqm
No. stores	50
Supermarkets	1
Type of ownership	Single – Pension fund
Building age	1998
Renovation date	(R1) 2022 – Ongoing (R2) 2023 - Ongoing
Degree EE driver	(R1) EE fortuitous (R2) Main driver
Renovation stage	(R1) Stage 4: Implementation (R2) Stage 2: Persuasion

Case study B
Zuidplein shopping centre

Size	Large – 70,000 sqm
No. stores	165
Supermarkets	2
Type of ownership	Fragmented – 60 owners
Building age	1972
Renovation date	(R1) 2018-2023 (R2) 2018-Ongoing
Degree EE driver	(R1) EE fortuitous (R2) Main driver
Renovation stage	(R1) Stage 4: Implementation (R2) Stage 4: Implementation

Case study C
Het Stroink shopping centre

Size	Small – 5,750 sqm
No. stores	17
Supermarkets	2
Type of ownership	Single - Investor
Building age	1978
Renovation date	2019-2020
Degree EE driver	Main driver
Renovation stage	Stage 5: Confirmation

3.1.2 Expert interview

Because qualitative research is more subjective than quantitative studies because findings may be interpreted different by different researchers (Burnard et al., 2008), an expert interview to a retail owner was conducted as a triangulation technique to increase the credibility of the findings and compensate for the shortcomings of the case study design. This way, the research design is a combination of desk research, case studies, and an expert interview. The interviewed is a retail fund manager from an institutional investor. This expert was selected because of the strong ESG organisation's strategy and experience in sustainable asset acquisitions and sustainable retrofitting of existing assets in their portfolio.

Figure 19. Triangulation of methods to improve credibility. (Author)

3.2 Data collection techniques

The data collection techniques of this research are a combination of desk research and semi structured interviews. While desk research supported the theoretical part of the research, semi-structured interviews were used to collect data on the decision-making process of EER and stakeholders' involvement and behaviours of each individual case study. The following sections indicate how each of these techniques took place.

3.2.1 Desk research

This data collection technique was used to develop the theoretical part of this research. Through a literature review that consisted of collecting data from different academic and scientific papers, books, grey literature, and Strabo's data base about data from shopping centres in the Netherlands. The outcome of the data gathered from this technique was the development of the selection criteria for the case studies, as well as the development of the theoretical framework that will be used to support the data collection and analysis of the empirical part of this research. Furthermore, the collection of the data was performed by means of different search engines such as Scopus, Google Scholar, TU Delft Repository, and Tu Delft library collection, using keywords such as decision-making, retrofit process, retail, energy renovation, energy transition, energy efficiency, and shopping centres.

Once the case studies were selected, desk research was also used to investigate about the case studies themselves. These included projects' brochures, projects' proposals to clients, infographic material about internal processes, client's presentations, decision-tools materials, and factsheets.

3.2.2 Semi-structured interviews

The semi-structured interviews were used as data collection technique. The subjects for each interview were selected first from a generic stakeholders list of common actors that participate in decision-making (Table 8). This list was later refined according to each case, as stakeholders varies from case to case.

INTERVIEWS– GENERIC ACTORS LIST

Interview	Role
1	Owner
2	Asset manager
3	Property management
5	Owner association manager
6	Retrofit project manager
7	Tenant (non-food retailer)
8	Tenant (Food retailer)

Table 9. Generic list of participants for semi-structured interviews. (Author)

3.2.3 Interviewee profiles per case study

The following tables identify the interview subjects selected and interviewed per case study. The selection of these subjects was based on the stakeholders mix needed to understand the full scope of every case study. Regarding stakeholders within the property management team, different profiles were found as not all stakeholders from this team exist across all case studies. At least one stakeholder of the property management team between account manager and commercial manager was interviewed to guarantee the perspective from a top management layer of this team.

No.	Case A	Case B	Case C
1	Asset manager – Owner organisation	Director Board of supervisors	Owner (During renovation)
2	Property management – Commercial manager	Property management - Technical management	Fund manager (from current owner)
3	Property management - Technical management	Retrofit project manager	Property management – Commercial management
4	Retrofit project manager	Owner association manager	Project manager ESG – Owner organisation
6		Tenant (non-food retailer)	Tenant (Supermarket)

Table 10. Interviewees profiles. (Author)

In addition to these interviews, other complementary documents from each case study were reviewed to have a general overview of the measures being taken in these shopping centres, as well as protocols and projects from certain actors.

3.3 Data analysis

Given that this was exploratory qualitative research, a qualitative data analysis needed to be undertaken for the case studies and expert interview. A narrative analysis method was used to analyse and interpret data for all case studies. This is because this method can provide significant value to unravelling the actor's actions, motivations, and behaviours, which are all aims of this research. For this purpose, ATLAS TI has been selected as data analysis tool.

As described in Figure 19, each case study was first analysed individually using a deductive data analysis approach. This is because used the predetermined theoretical framework to analyse the data (Burnard et al., 2008). Data was classified within the closed coding system of the framework. However, when required, new codes were created to modify the theory by means of an inductive approach. After the individual analyses were finalised, a cross-case analysis was undertaken as validation technique together with the expert interview findings. This allowed to compare all case-studies and to modify and complement the theory using a deductive approach.

3.4 Data plan

The data was collected, stored, and shared in accordance with the FAIR guiding principles of scientific data management, namely findability, accessibility, interoperability, and reusability (Wilkinson et al., 2016). First, in terms of the findability, the thesis report was uploaded in the TU Delft repository attached to key works to ease its findability. Moreover, data gathered from different sources within this research was properly referenced using APA 7th to facilitate the findability of the sources used. Second, in terms of accessibility, the thesis report has an open access through the repository. Third, the interoperability of the data used is guaranteed by using the formal English language, a language that is broadly applicable in scientific communities around the world. Finally, the reusability of the data is guaranteed by means of a CC-BY-NC license which means that you are allowed to share and produce derivative works as long as you provide adequate attribution to the authors and use it for non-commercial purposes. However, only processed data will have open access to the public. Raw data will remain confidential in accordance with the ethical considerations that concern protecting the identity of the participant parties involved.

3.5 Ethical considerations

Due to the involvement of human research subjects, the present study prioritized acknowledging and minimizing ethical risks for participants. This is especially crucial as the study aims to investigate the decision-making process from the perspective of multiple stakeholders, who may have conflicting interests and goals. Anonymity is a key consideration to ensure participants are protected from potential risks and can provide truthful responses without pressure to provide 'politically correct' statements. Additionally, the data collected was stored securely and was only accessible by

the research team. To ensure participants were fully informed and gave informed consent, a thorough interview protocol and consent form was developed (Appendix A and B), highlighting risks and planned mitigation measures. Clear and transparent communication with participants was essential, and it was vital that the study executed the agreed measures to prioritize the safety and well-being of participants.

3.6 Research output

3.6.1 Goals and objectives

This research aimed to reveal stakeholders' behaviours during the EER within a process perspective, finding the interrelationships between the different parties involved during the different steps of the process, and giving light on the areas that need to be addressed in other to guarantee a smoother process. Therefore, the research objectives included:

- Mapping of the EER decision-making process of shopping centres
- Creating a systematic overview of the stakeholders decision-making behaviours during EERs in shopping centres in the National and international context.
- Drawing lessons from cases studies and providing practical recommendations that can support owners in the process.

3.6.2 Deliverables

The deliverables of this research consist in the development of a systematic overview of stakeholders' behaviours in the EERs decision-making process of shopping centres, and a set of practical recommendations to improve current decision-making.

3.6.3 Dissemination and audiences

This research can be valuable not only to the main decision-makers for EERs of shopping centres, such as owners, asset managers, and tenants' associations, but also for real estate sustainable advisors to support them in the energy transition of the sector. Moreover, the findings of this research can also assist policymakers by highlighting the areas of the decision-making process where mitigation measures and incentives are mostly needed.

3.7 Personal study targets

Setting personal study targets is important to be critical of your own progress and work. Therefore, I have set up the following targets that would guide me through both, my academic and professional development:

- Learn to carry out proper research that is cohesive, coherent, and feasible.
- Stayed organised and be effective with time management.
- Interpret obstacles as challenges and opportunities for growth.
- Gain in-depth knowledge about energy transition and its implications in the retail real estate sector and deliver a result that is useful or valuable in practice.
- Put in practice and further develop critical and creative thinking skills.

04 FINDINGS

The current chapter outlines the collected empirical data. It is organised by first presenting the methods used to analyse the data. Second, it presents the analysis of each case study individually. This analysis encompasses various dimensions such as the general context of renovation, the governance structure, the energy-related measures, the specific EER decision-making process, the prevalent behaviours, and the existing solutions for identified barriers. Third, it presents the results of a cross-case analysis to validate the results. This cross-case analysis combines the individual case analyses with the findings from the expert interview. The findings are presented as a generalized version of the EER decision-making process, and the mapping of the behaviours exhibited by various stakeholders throughout the process.

CONTENT

4.1 Methods of analysis

4.1.1 Interview content and questions

Interviews where specifically tailored for each specific role. However, they all followed the same structure which comprised three main themes. The first theme concerned understanding the general context and background of each interviewee. Questions in this section involved understanding the role's responsibilities, place within the governance structure, and drivers and knowledge towards energy efficiency renovations.

The second theme involved an exploration of the decision-making process pertaining to energy efficiency (EE), as perceived by the interviewees. To ensure clarity and coherence, the participants were introduced to the established EE decision-making process derived from the theoretical framework. This process was explained to each participant with the intention of stimulating a constructive dialogue based on existing literature. The objective was to create a platform for the participants, wherein they could freely contribute by offering their insights, suggestions, amendments, or any supplementary remarks that could enhance the comprehension and mapping of the decision-making process.

The third theme involved understanding each stakeholder's behaviour within the decision-making process. To achieve this, the interviewees were initially prompted to identify perceived barriers in the process and discuss the solutions they had encountered to overcome them. This inquiry was intentionally conducted without providing any background explanation, in order to minimize potential bias and ensure unbiased responses. Once a preliminary understanding of the participants' perceptions was obtained, they were subsequently introduced to the theoretical framework comprising seven typologies of barriers. This additional information aimed to elicit further insights and facilitate a more comprehensive exploration of the stakeholders' experiences and perspectives.

The questions posed during the interviews can be reviewed in **APPENDIX A** of the present report.

4.1.2 Interviews coding and analysis

A total of 15 participants were interviewed, representing various roles across the three case studies. In this study, stakeholders are referenced using abbreviations provided in Table 11. Although external stakeholders were not directly interviewed, their activities and behaviours were examined through the perspectives of internal stakeholders. Thus, some of the cases encompassed insights into the activities and behaviours of these external stakeholders.

The interviews were transcribed and subjected to analysis using a two-fold approach: deductive and inductive. The deductive approach involved applying a close coding system derived from the theoretical framework to the transcribed data. Responses that did not fit within this coding system were analysed using an inductive approach, which entailed creating new codes as necessary.

During the coding process, each participant's responses were assigned two code groups. The first group of codes captured the activities and behaviours perceived by the participants in relation to each stage of the decision-making process as defined by the theoretical framework. These stages included Stage 1: Knowledge, Stage 2: Persuasion, Stage 3: Decision, Stage 4: Implementation, and Stage 5: Confirmation. The second group of codes assigned perceived barriers to the established

barrier taxonomy -Awareness, behavioural, technology, competences, economic, information, organisation, and technology-.

Table 11. List of abbreviations for roles encountered.

Role	Abbreviation used in findings	Additional explanation
Owner	OW	Refers to all types of owners in general
Owner – Single small real estate investor	OW-SS	Refers to small real estate redeveloper
Owner – Single large real estate investor	OW-SL	Refers to single ownership from large organisation
Owner – fragmented	OW-F	Refers to owner association (VVE)
Director Board of Supervisors	DBS	Chairperson of the board of the owner association
Technical manager	PM-TM	Part of the property management team
Commercial manager	PM-CM	Part of the property management team
Tenant	T	Refers to all tenants in general
Large tenant	T-L	Refers to large retail chains tenants
Small tenant	T-S	Refers to small family-owned shops
Fund manager	FM	Part of the owner's organisation
Project Manager EGS	PME	Part of the owner's organisation
External stakeholders (Not interviewed but analysed through internal stakeholders)		
External Project Manager	EPM	-
Contractor	C	-
Supplier	S	-
External advisor	AD	-
Government	GOV	-
Local Authorities	LA	-
Energy Supplier	ES	-
Consumers	CS	

Moreover, within the findings section of each case study analysis, tables presenting the identified process activities and stakeholders' behaviours for each stage are provided. These tables serve as a comprehensive summary of the interviews conducted for each respective case study, outlining the activities associated with each stage of the decision-making process and highlighting the perceived barriers reported by the relevant stakeholders. Additionally, the significance of each barrier is denoted based on the frequency of its mention across the stages and can be found indicated under the "Degree" column.

Finally, it is important to acknowledge that the actors identified in each case study and presented in each Energy Efficiency Renovation (EER) process do not encompass all stakeholders involved. Rather, they represent the individuals who were interviewed and mentioned by the interviewees, particularly those related to the supply side. As a result, certain cases may include additional stakeholders in the process compared to others.

4.2 Case Study A – De Tuinen

4.2.1 Context

De Tuinen is a shopping centre located in the centre of Naaldwijk. It is currently undergoing two separate renovation processes. The first renovation primarily focuses on enhancing the centre's aesthetics to ensure it remains in optimal condition, considering its construction 25 years ago. Although this renovation primarily emphasizes aesthetic improvements, certain energy-efficiency measures, particularly pertaining to lighting, are being incorporated. At the time of the planning of the first renovation, ESG measures were not on top of mind as there was no energy crisis. However, the evolving panorama has set in motion a second process exclusively dedicated to EER to align the centre with Paris-Proof requirements. This process is currently in an early stage (Stage 2: persuasion), which makes this centre an interesting case to study because of its shift in EER awareness.

Aesthetic renovation year: 2022-Ongoing
EER renovation year: 2023-Ongoing
Type of Owner: Single – Pension Fund
Size: 14,000m^2
Construction year: 1998

4.2.2 Governance structure

De Tuinen is a shopping centre owned by a Pension Fund. This means that the shopping centre is part of the fund's real estate portfolio and, therefore, must perform within the fund's long-term portfolio strategy. The Retail Fund Manager, together with the finance, technical and commercial manager, run and manage the portfolio on a strategic level. Moreover, due to the increasing need to implement ESG measures within the fund's portfolio, an in-house ESG manager position was created to support it. At the building level, the fund outsources a property management team to oversee the daily centre management operations, as well as the marketing, technical, and financial strategy of the centre. Recently, a sustainability advisor was added to the property management team to support the implementation of ESG goals from the tenant perspective.

For the renovation processes, external parties and advisors are appointed by the fund. These entities are selected and contracted directly by the fund, but they collaborate with the property management team to ensure optimal outcomes. In the case of the SC aesthetic renovation (1), the fund opted to hire an external project manager to oversee the entire renovation process. This decision was made to exercise control over expenditures and avoid overburdening the property management team, which is already dedicated to various tasks for each building in the portfolio. Through a Design-Bid-Build (DBB) contract, the external project manager assumed responsibility for the design, bidding, and construction of the project.

In the case of the ESG renovation (2), the fund enlisted the services of an external sustainability advisor to evaluate and rate the buildings in the portfolio. This advisor also provides guidance on the types of interventions that can be undertaken to enhance the buildings' sustainability performance. Based on this advice, the fund is formulating a long-term plan that prioritizes the upgrade of properties to align with Paris Agreement goals. The plan focuses initially on addressing the properties with the lowest energy performance and implementing measures that have the most significant impact on the portfolio. This long-term plan will undergo annual reviews and updates.

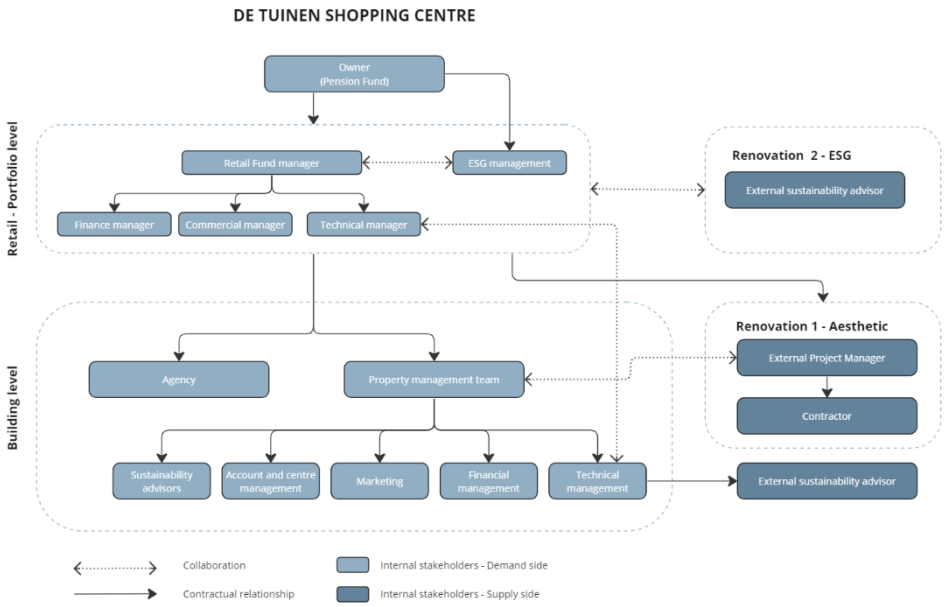


Figure 20. Case study A governance structure. (Author)

Furthermore, within the ESG framework, the technical management team of the centre is collaborating with an external sustainability advisor. This advisor provides recommendations on how to reduce energy costs and implement energy-saving measures at the individual building level.

4.2.3 Energy-related measures

In this case study, energy-related measures were observed to be implemented either as part of the building's maintenance plan or within renovation projects. Specifically, measures associated with the Energy-Based Commissioning (EBCx) package were found to be already incorporated into the building's maintenance plan. This plan outlines the maintenance and operational activities for the building over the next 15 years, including an annual schedule and budget allocation for such activities. The responsibility for optimizing the building's existing systems, which aligns with the objectives of the EBCx package, falls under the purview of the technical management department within the property management team.

Furthermore, the other two packages were identified within two parallel energy efficiency renovation processes as follows:

Aesthetic renovation (R1)

The aesthetic renovation of this shopping centre focused only on updating the common areas. Several measures were planned with this purpose (Figure 21). These included the demolition and installation of new attractive entrance portals, the replacement of floor and wall finishes, a new lighting design, an improved indoor climate, raising the front of the stores in the main square to match ceiling heights, climatization of the interior terrace, and an improved indoor climate. Although this large renovation is mainly aesthetic, some EE measures resulted from it. These can be categorised within the deep retrofit package as they required a design process and represented the replacement of existing elements. These included:

- The redesign and improvement of the energy consumption of the lighting system with LED fixtures.
- New entrances were replaced with double glassing doors. Although this is not needed at the moment, as the passages are not climatised, the decision to upgrade them with higher energy performance standards was proposed and approved with a future-thinking perspective.

Figure 21. De Tuinen plan view of common area passages – Renovation focus.

ESG renovation (R2)

For this second renovation process, the exact EE renovation measures have not been defined yet. Currently the owner of the SC is working together with their in-house and external sustainability advisor to set up the plan to Paris-proof the building. Once the targets are set, the technical management of the building will include these measures in the long-term maintenance plan to implement them. Despite that the passage is not climatised, improvements in terms of the energy consumption of elevators, escalators, and other installations are needed as they are more than 25 years old.

4.2.4 EER decision-making process and behaviours

The EER decision-making process and stakeholders' behaviours of this case study is mapped per stage in Figure 22 and Table 12. Barriers indicated in Table 12 are mapped in terms of the stakeholder who perceived the barrier and the degree, meaning the frequency in which they were mentioned by stage.

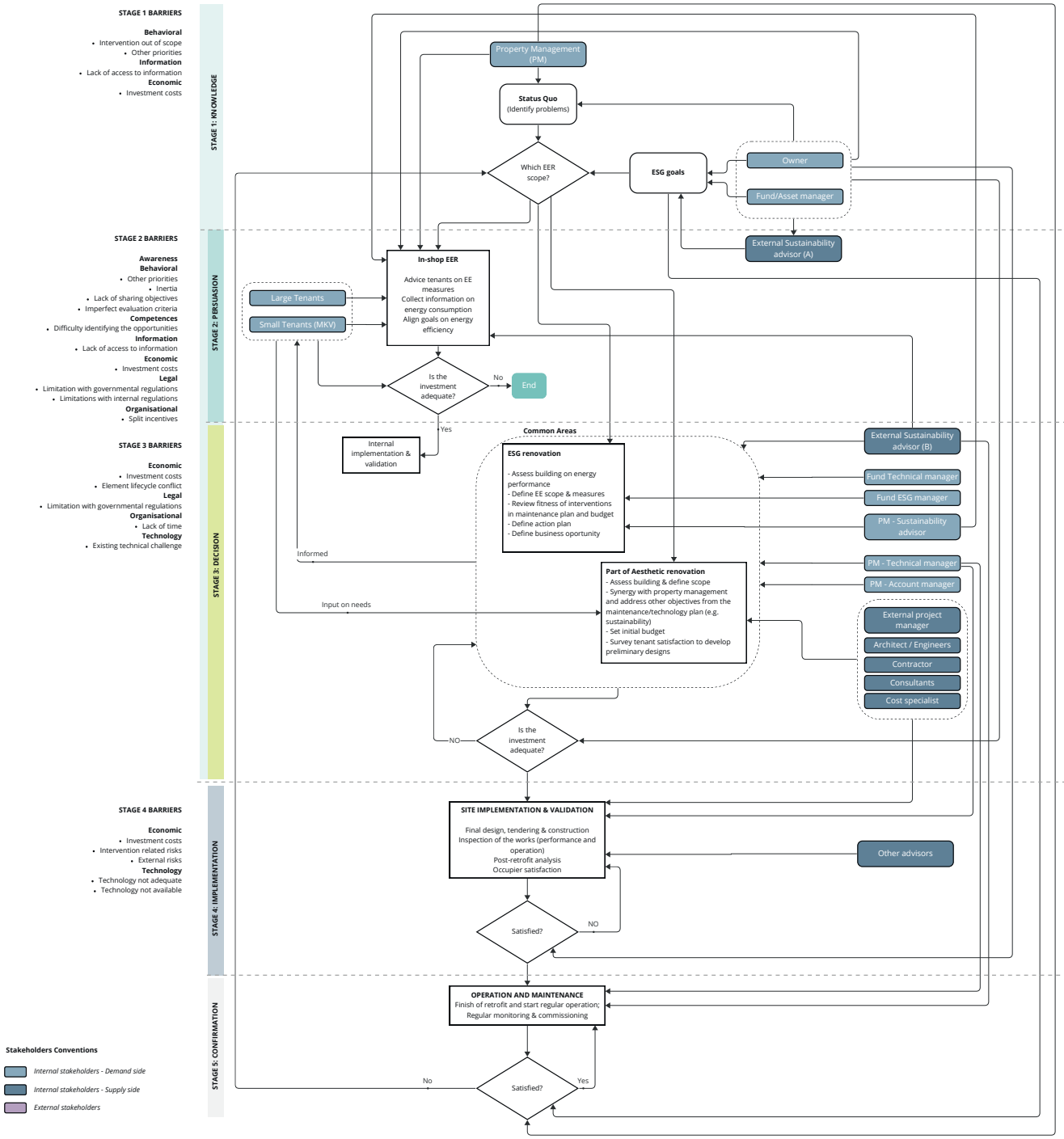


Figure 22. Case Study A – EER decision-making process. (Author)

Table 12. Case study A. identified process stakeholders' behaviours per stage. (Author)

Stage 1: Knowledge			
Description	**Barriers**	**Stakeholder**	**Degree**
- Awareness comes from: o Identifying a need/problem (Aesthetic renovation (R1)) o ESG portfolio-level strategy of Fund (EER renovation (R2)) - Awareness leads to an assignment. It is not a matter of *if* but of *what*, *how* and *when.* - Decision-node: Identify the scope of the intervention (common or in-shop intervention area).	Behavioural - Intervention out of scope	EPM, FM	3
	Behavioural – Other priorities	EPM, TM	2
	Information – Lack of access to information on costs and benefits	FM	1
	Economic – Investment costs	EPM, FM	3
Stage 2: Persuasion			
Description	**Barriers**	**Stakeholder**	**Degree**
Common areas: o No persuasion is needed as the intervention is an assignment. In-shop areas: o Shell-state lease: owners don't have control over the installations inside of the shops. o GHG protocol makes owners responsible for the CO_2 emissions and energy consumption of their entire value chain. o Recent conversation to persuade tenants to align tenants with this task. Current solution: o Project that provides free advice for tenants on how to upgrade their stores in terms of EC and CO_2 emissions. Includes: site visit, energy assessment, report with recommendations, 1 year coaching service, monitoring of engagement, implemented measures, energy savings and CO_2 reductions.	Awareness	T	2
	Behavioural - Other priorities	T	1
	Behavioural - Inertia	T	2
	Behavioural – Lack of sharing objectives	T, PM-CM, PM-TM, FM	3
	Behavioural – Imperfect evaluation criteria	T	1
	Competences – Difficulty in identifying the opportunities	T	1
	Information – Lack of access to information on energy consumption	T	3
	Economic – Investment costs	FM, T	1
	Legal – Limitation with governmental regulations	T, PM-CM, FM	1
	Legal – Limitations with internal regulations	T, PM-TM	1
	Organisational – Split incentives	T, FM, PM-CM	3
Stage 3: Decision			
Description	**Barriers**	**Stakeholder**	**Degree**
- Stage only applies for common areas. Two scopes: o ESG-only renovation plan: Technical management reviews how to implement ESG targets within the maintenance plan and budget. o Aesthetic large renovation→ secondary EE measures: Led by external EPM working in synergy with the property management team. They consolidate a team to develop preliminary design and budget to present to the fund. - Decision node: Defining adequacy of investment in terms of costs, time, and impact in the Fund's long-term strategy. Negative results lead to feedback to continue refining the plans.	Economic – Investment costs	PM-TM, FM, EPM	6
	Economic – Element lifecycle conflict	FM, PM-TM, RPM, PM-CM	7
	Legal – Limitation with governmental regulations	FM	1
	Organisational – Lack of time	PM-CM , PM-TM	1
	Technology – Existing technical challenge	PM-TM, EPM	6
Stage 4: Implementation			
Description	**Barriers**	**Stakeholder**	**Degree**
For both scopes: - Final design, tendering and construction. - Inform tenants about the works and develop action plans to avoid disruptions in daily operation. - Validate and inspect works. - Technical advisors could be needed depending on the selected measures	Economic – Investment costs	C	1
	Economic – Intervention related risks	EPM, T	1
	Economic – External risks	FM	1
	Technology – Not adequate	ES	1
	Technology – Not available	C	1
Stage 5: Confirmation			
Description	**Barriers**	**Stakeholder**	**Degree**
- Neither renovation scope has reached this stage - Led by property management team. - Monitor and ensure the building keeps on track with maintenance plan and Fund's strategy	Not Applicable to case	-	0

External project manager: EPM | Fund manager: FM | Tenant: T
Commercial manager: PM-CM | Technical manager: PM-TM | C: Contractor

Stakeholders' behaviours

This case study led to the identification of new barriers that were not included in the theoretical framework. These include a new type of barrier that is relevant for this building typology, the *legal barrier*, and four others that were added to the *technology*, *information*, *behavioural*, and *economic* barrier.

Legal barriers. This type of barrier was identified in this building typology as shopping centres have their own governance system with its own internal regulations, as well as have other limitations on regulations on a national level. Two types of barriers were identified in this category.

- *Legal - Limitation with internal regulations:* Tenants require permission from the property management system to implement measures that need to be placed on common areas. For example, if a tenant would like to place PV on the roof, it requires the permission of the owner to do so.
- *Legal – limitation with governmental regulations:* These were highlighted by the Fund manager and have an impact in two areas. First, there are no regulations that oblige tenants to share their energy consumption with the owners. Therefore, it is difficult to assess energy consumption inside the shops. Second, owners are not allowed to become energy providers. Therefore, there is a limitation for the implementation of solar panels in the SC roof as it is less likely to benefit tenants.

Technology - Existing technical challenge: the building's existing characteristics can increase the difficulty in implementing certain measures. For example, they can manifest as a challenge to find space for new installations or may require improving other additional systems or building structures not accounted for. This may require larger retrofits processes that are often too lengthy or expensive.

Information - Lack of access to information on energy consumption: This refers to the lack of information about energy consumption on the overall building level, both in common areas and inside of the shops.

Economic: Element lifecycle conflict: refers to the difficulty to implement a measure that requires to replace elements of the building that have not reached yet their life-cycle. This is not only not sustainable, as elements are still in good state, but also plays against the reduction of its Capex capturing period. Shortening this period may require of extra costs in the building's maintenance plan.

Behavioural - Intervention out of scope: this occurs when the opportunity is identified but implementing an EE measure falls out of the scope of the assignment given by the owner and for which no budget was assigned.

Besides these new barrier types, the degree in which barriers were named by the different interview subjects demonstrate that most barriers in this shopping centre are found in Stage 2 and 3. While stage 2 presents mostly behavioural barriers in direct relationship with the tenants, stage 3 behaviours demonstrate a larger concern for economic barriers. This last one concerns barriers regarding investment costs, element lifecycle conflict, and a related existing technical challenge that

might increase costs, as interventions need to be aligned within the existing maintenance plan and asset budget. Finally, stage 1 also demonstrates the importance of including EE measures within the scope of the assignment. Despite that the RPM might have the knowledge to implement further energy related measures, these are not considered as they fall out of the scope and budget set in this stage.

4.2.5 Existing solutions for known barriers

During the interviews some solutions were mentioned by different stakeholders. Overall, owners and property managers have focused on addressing tenant-related barriers such as *Intervention out of scope*, *Lack of sharing the objectives*, *Lack of access to information on energy consumption*, and *Lack of information on costs and benefits*. These are being tackled by promoting green leases and a tenant advisory programme, launched by the property management team and the owner, to support EE measures inside the stores. Regarding the economic barriers, owners are solving this issue by having a future thinking perspective by aiming for higher element specifications for any element touched in a renovation. This way, elements can fulfil their expected lifecycle and still comply with future more strict regulations. Moreover, when investments are too high, they also spread the costs in a longer capex value capturing period, so it fits better within the asset's maintenance plan and budget. Regarding organisational barriers, owners have tackled this by organising ESG specific roles within the organisation to reduce the *Lack of time* barrier. Further, *Lack of access to information on energy consumption* has been tackled by contracting external advisory services to perform building assessments and gather knowledge on inefficiencies and opportunities.

Table 13. Case study A. Found solutions for known barriers. (Author)

Barriers found in Case A		**Existing solution**	**Description**
Awareness	Awareness		
Behavioural	Imperfect evaluation criteria		
	Inertia		
	Intervention out of scope	**x**	- Advise programme for tenants - Provide energy/heating directly (mentioned only as idea, like in offices) - Green leases
	Lack of sharing the objectives	**x**	- Advise programme for tenants
	Other priorities		
Competences	Identifying the opportunities		
Economic	Element lifecycle conflict	**x**	- Future planning for higher specifications even if not required
	External risks		
	Intervention-related risks		
	Investment costs	**x**	- Extend capex value capturing period
Information	Lack of access to information of energy consumption	**x**	- Green leases - Contract advisors for building assessments
	Lack of information on costs and benefits	**x**	- Advise programme for tenants
Legal	Limitation with governmental regulations		
	Limitation with internal regulations		
Organisational	Lack of time	**x**	- ESG specific function inside the organisation
	Split incentives	**x**	- Tenants pay but get their service costs reduced - Split costs. One pays for equipment, the other for maintenance
Technology	Existing technical challenge		
	Technology not adequate		
	Technology not available		

4.2.6 Case A conclusion

The conclusion for the individual case A analysis will be given in terms of the three sub-questions of this research.

[SQ1]: *What is the state-of-the-art of energy efficiency retrofit of shopping centres?*

This case study brought to light how EERs are being implemented in shopping centres and highlights a change in awareness towards energy efficiency. Before, EE measures were implemented by chance rather than by intention. This was evidenced by the ongoing aesthetic renovation of the centre, where the lighting was upgraded because of an aesthetic need to update the lighting design of the common areas rather than by the intention to improve the energy consumption of the building. However, with the increasing global and European awareness towards bringing buildings to Net Zero values, EE measures are gaining more track. Therefore, it was revealing that when the owner has clear ESG targets, the decision-making process (DMP) becomes a process to identify how these targets are going to be implemented rather than if they are going to be implemented or not. Hence, the DMP skips the persuasion stage in most scopes as the attitudes of the different stakeholders do not need to be aligned.

In terms of the governance of the decision-making, the assignment nature from the owner allows to reflect on the hierarchical governance structure of the centre by which decisions were taken in a centralised way. From what was observed in this research, this centralised decision-making overlooked the opportunity to fully leverage the specialised and collective knowledge of the different stakeholders involved. This was evident during the initial renovation phase when the owner opted to relieve the property management team, the stakeholder group with on-site expertise and close tenant connections, from additional responsibilities. Instead, an external project manager was appointed to oversee the renovation process.

[SQ2]: *How is the EERs' decision-making process of shopping centres taking place?*

This case led to identifying that the EER decision-making process in practice, compared to the original theoretical framework, presents fewer moments in which a negative decision might lead the process to an end. The single moment in which this might occur is when the scope of the retrofit tackles EE improvements inside of the shops. Here, despite the efforts from the owner and the sustainability advisor from the property management team, it is up to the tenant if they implement the measures or not. However, despite this limitation, the general perception is that tenants are becoming more aware an interested in carrying out these renovations due the current high energy prices.

Different from the key role that tenants usually play in the decision-making of EER of the residential stock, in shopping centres is different as tenants do not play a key role because of two reasons. First, there is a distinction between the energy consumption between common areas and private interior shop areas. When the renovation concerns the common areas, tenants are only informed and not involved in decision-making. And second, although tenants are becoming more involved now when SC owners seek to reduce the energy consumption and carbon emissions of their leased space, this discussion is rather new, and results are yet to be identified.

[SQ3]: *What are the barriers encountered during the decision-making process of EERs of shopping centres?*

Different barriers stand out per decision stage. The following key findings were identified within this theme:

- At Stage 1, where the renovation assignment originates from the owner, stakeholders' behaviours are influenced by these requests. Consequently, barriers such as "Intervention out of scope" and "Other priorities" were identified. This indicates that stakeholders are limited in proposing energy efficiency measures beyond the scope specified by the owner, due to a lack of explicit objectives pertaining to energy efficiency.

- Stage 3 exhibited the highest frequency of barriers, particularly concerning investment costs, conflicts with the lifecycle of elements, and existing technical challenges. Although these barriers can be attributed to the technical and economic aspects of the renovation, their presence may also stem from a lack of clearly defined sustainability and energy savings targets within the assignment. In the absence of a compelling need to adopt these measures, the costs and challenges associated with implementing them become more prominent.

[MQ]: *"How can owners support a better decision-making process to steer EERs of shopping centres?"*

This case study led to reflect in two main areas that may drive owners to support a better decision-making process for EER.

Firstly, given that EERs were found to be typically assignment-driven, it is crucial for owners to establish a clear sustainability strategy that incorporates specific energy efficiency (EE) targets. This strategic approach enables the formulation of well-defined assignments, ensuring that all stakeholders involved are aligned with the overarching objectives of the EER. By setting out explicit sustainability goals, owners provide a framework that guides decision-making and facilitates a more focused and purposeful approach to EER initiatives.

Secondly, these assignments would greatly benefit from a decentralized decision-making approach that actively incorporates the perspectives and specialized knowledge of various stakeholders. Owners can consider implementing participatory mechanisms that allow stakeholders, such as the property management team or renovation project manager, to transition from being task-driven actors to becoming active participants in the decision-making process. This shift toward participatory entities enables the inclusion of diverse viewpoints, expertise, and insights, thereby enriching the overall decision-making process and enhancing the likelihood of successful EER outcomes.

4.3 Case Study B – Zuidplein

4.3.1 Context

Zuidplein shopping centre is one of the largest covered shopping centres in the Netherlands. It was built in 1972 and has gone through different renovations processes through time. The most recent one took place in 2018-2023 as part of the Hart van Zuid area redevelopment project in Rotterdam.

The project consisted in improving the quality, experience, and residential value of the shopping centre. This included the improvement of common areas, such as the atrium, entrances, and halls and passages; the replacement of shop fronts; a 7,000m^2 expansion for new retail space; additional parking spaces and the connection to the bus and metro station; the replacement of shop fronts (Sven de Graaf, 2023); the replacement of all common areas ceiling and lighting systems among other measures. In terms of energy efficiency, the centre also implemented a second EER process that involved a combination of energy efficiency measures to make the building self-sufficient in terms of energy and cooling, that will be later detailed in 4.2.3.

Moreover, this shopping centre represents an interesting mix for this multi-case study research as it also holds a fragmented ownership type, with 60 different owners that range between institutional investors and private investors of different sizes. Large private investors account for more than half of the VvE and they share their power with smaller investors and owners. This is valuable as it adds an additional layer of stakeholders in the decision-making.

Aesthetic renovation year: 2016-2023
EER renovation year: 2018-Ongoing
Type of Owner: Fragmented – 60 owners
Size: 70,000m^2
Construction year: 1998

4.3.2 Governance structure

The fragmented ownership of this case study makes its governance structure different (Figure 23). This is because by law, the shopping centre is automatically unified under an owner's association or Vereiniging Eigenaars (VvE) in Dutch. This VvE functions under a legal deed that specifies the different regulations, procedures, and obligations to guarantee the correct and optimal operation of the shopping centre. Furthermore, all decision-making takes place within an owner's association meeting (ALV) that meets with the frequency stipulated in the deeds, often once or twice a year for general matters or more if requested by more than 10% of the owners. Given the size of Zuidplein's VvE, the deed also stablishes that the SC must hold a Board of supervisors (RVC) to oversee and manage all general building-related affairs with a Supervisory Board Chairman at its head.

As stablished before, the highest decision-making organ is the ALV meeting. During these meetings, all owners are updated and decide on yearly maintenance, budget, annual accounts, and other affairs. Each decision is subject to voting, and depending on its nature, different voting ratios apply as stated on the deeds. For high-impact decisions, a qualified majority applies. This means that an increased quorum and increased majority applies. In this case study qualified majority implies a quorum of 2/3 and 65% approval rate. Each owner represents a different coefficient in decision-making, and this varies depending on the position of their shop in the centre and the amount of own area.

Regarding the operation of the building during the renovation, the centre had a property management team in place that oversaw the day-to-day operation of the building and maintenance planning. However, recently the VvE selected a company to assist with property management, client management, research, agency, and design and development activities as part of a 3 years strategic and performance plan of the centre. However, it is important to highlight that this company only became active during the last stages of the DMP (Late stage 4 implementation), which is why in the following sections explain two different DMP. The first one (Figure 24), identifies how the renovations occurred in practice, whereas the second one identifies the new DMP under the new property management team (Figure 25).

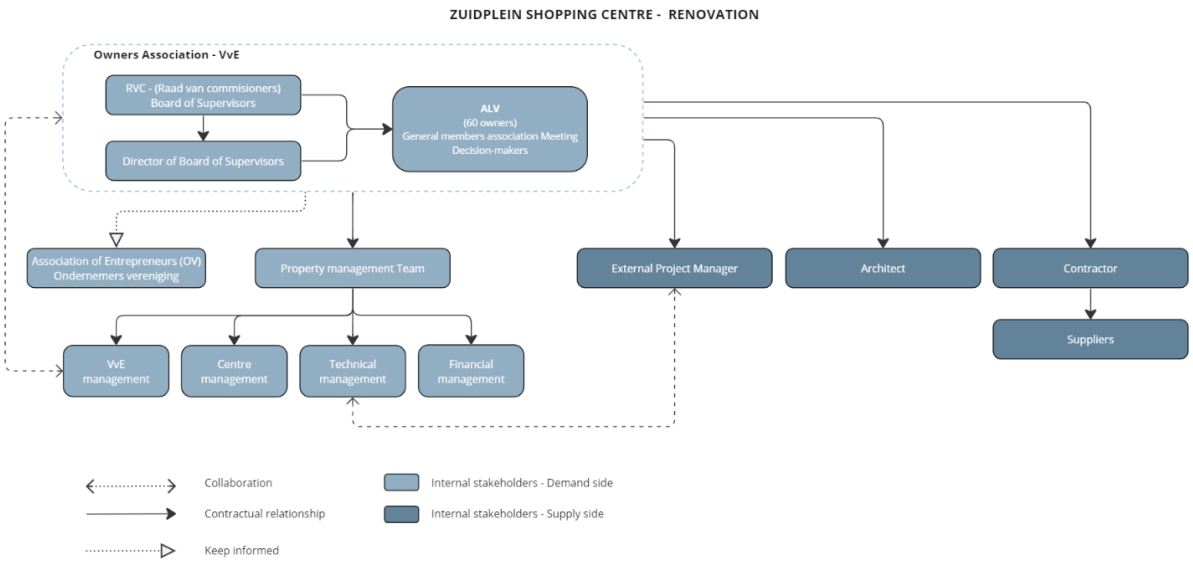


Figure 23. Case study B governance structure during the renovation. (Author)

4.3.3 Energy-related measures

Similar to case study A, energy-related measures in this centre are divided between measures taken within the aesthetic renovation and those taken at a later stage within an energy-efficiency retrofit only process.

Aesthetic renovation (R1)

Although energy-related measures were not necessarily intended within the original planning of the aesthetic renovation of the building, some measures had an impact over the overall building's energy consumption. As these measures represented the replacement of wholes systems, they can be classified as measures within the deep retrofit package. These included:

- Update of lighting systems to LED
- Addition/replacement of new escalators and lifts with lower energy consumption

EE renovation (R2)

The second renovation process was initiated at a later stage and was not initially allocated within the budget of the centre's aesthetic refurbishment. This process primarily focused on the installation of solar panels on the roof of the shopping centre. Additionally, other energy-efficient measures were considered as part of the technical management team's efforts to optimize the building's energy consumption within the established maintenance plan. Measures within this process can be considered a combination of the EBCx and the standard package. These measures include:

- 1800 solar panels which are anticipated to generate an energy surplus beyond the operational requirements of the shopping centre's **common areas and systems**. Currently, any excess energy is fed back into the grid.
- Replacement of lighting fix to LED in common and service areas
- Switching program for lighting fixtures
- Activation detection of emergency lighting when building is not occupied
- Smart meters for energy monitoring from the new property management team

4.3.4 EER decision-making process

As portraited in (Figure 24) through data gathered from the different interviewees the DMP of both renovations at the shopping centre was mapped. It is important to acknowledge that neither of the renovations contemplated energy efficiency measures on the inside of the shops. Therefore, tenants are not a key stakeholder in this process. Moreover, renewable energy sources were found to be only intended for energy consumption of common areas and there are currently no plans to involve the scope of energy consumption inside the shops in the future. The process is depicted in Figure 24 and explained in

Table 14. Overall, what was found most representative of DMP in this case is the merger between the persuasion and decision stage. From taking the decision to do a feasibility study to taking the actual decision to renovate, all decisions are put through the same process: an ALV consultation meeting. Decisions are hence taken in a gradual step-by-step process.

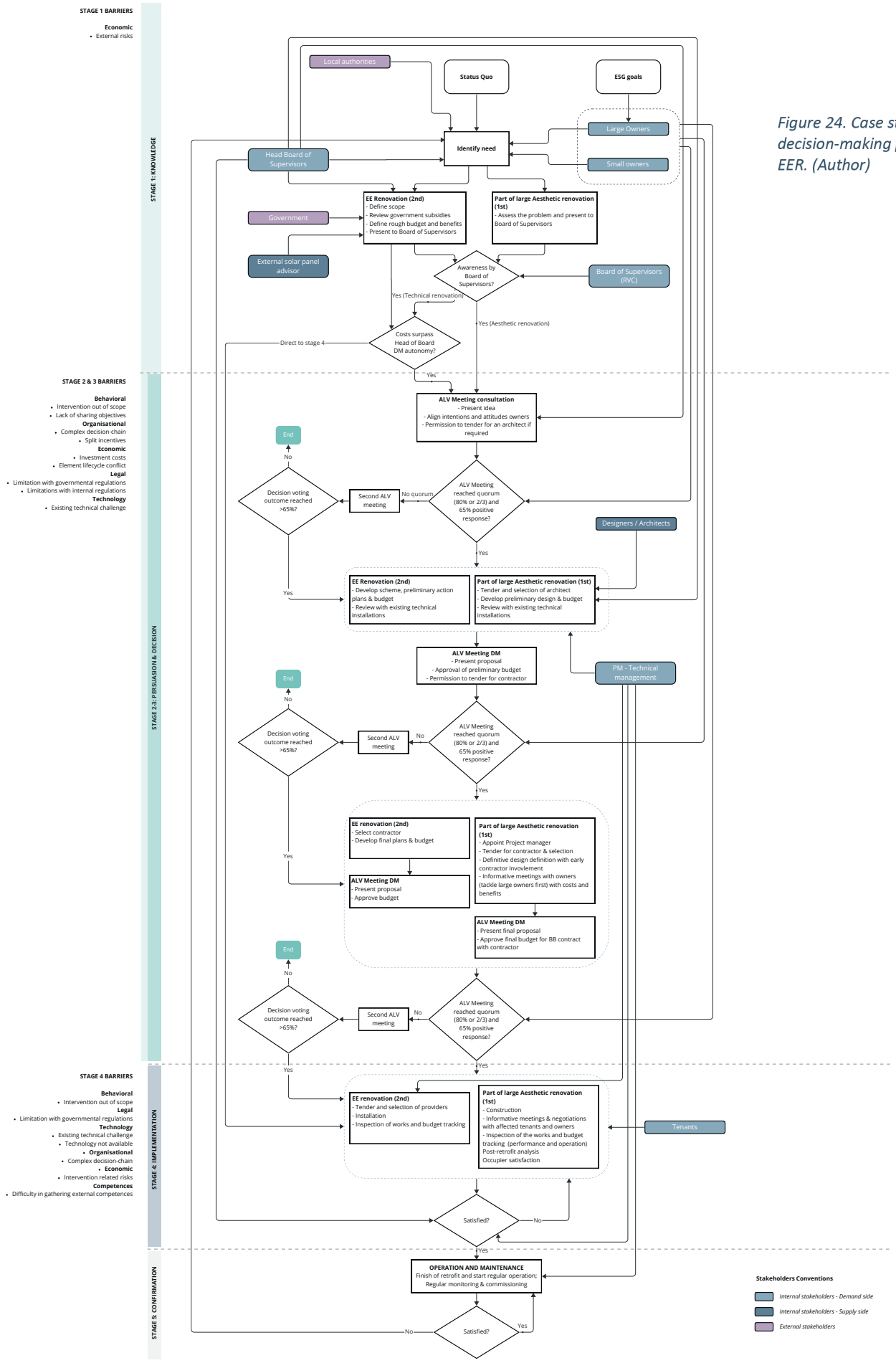


Figure 24. Case study B decision-making process of EER. (Author)

Table 14. Case study B. Identified stakeholders' behaviours per stage. (Author)

Stage 1: Knowledge			
Description	**Barriers**	**Stakeholder**	**Degree**
- Decision node: This stage in fragmented ownership is about raising awareness to the Board of Supervisors as they prepare a consult and summon an owners' association meeting (ALV). - Awareness can come from multiple stakeholders that identify a need and present a plan with rough estimations to the board - For small interventions, if costs of the plan don't surpass the autonomy costs of the Director of the Board of Supervisors, the process skips directly to stage 4.	Economic – External risks	DBS	1
Stage 2-3: Persuasion & Decision			
Description	**Barriers**	**Stakeholder**	**Degree**
- In fragmented ownership of SC this is the primary stage for decision-making. - Persuasion goes together with the decision stage, whereby decisions go through a step-by-step process to ensure that all owners are aligned and that no unnecessary resources are wasted. - Aligning attitudes and gaining knowledge on inefficiencies and opportunities are taken at the same time as plans are being drawn up, cost and benefits are being analysed, and the budget is being defined and approved. - Final decision node: Reaching quorum and required approval rate	Behavioural – Intervention out of scope	VVE	1
	Behavioural – Lack of sharing objectives	VVE, S	5
	Organisational – Complex decision-making chain	VVE	3
	Organisational – Split incentives	VVE, T	1
	Economic – Investment costs	VVE	2
	Economic – Element lifecycle conflict	VVE	3
	Legal – Limitation with governmental regulations	VVE, PM-TM	1
	Legal – Limitations with internal regulations	VVE, PM-TM	3
	Technology – Existing technical challenge	PM-TM	2
Stage 4: Implementation			
Description	**Barriers**	**Stakeholder**	**Degree**
- Depending on the type of renovation, the project leader has permission to tender and select providers - Negotiations with tenants and owners of affected stores take place to ensure that they are informed of the schedule, works or other affairs to ensure that they can operate as usual. - Similar to the theoretical framework, this stage also includes inspecting the works, validating that goals and targets are met and performing a post-retrofit analysis and satisfaction survey. - Decision node: Satisfaction of inspection and validation of measures	Behavioural – Intervention out of scope	C, S	2
	Legal – Limitation with governmental regulations	PM-TM	1
	Technology – Existing technical challenge	PM-TM	2
	Technology – Not available	PM-TM	2
	Organisational – Complex decision-making chain	VVE	1
	Economic – Intervention related risks	PM-TM, EPM	1
	Competences – Difficulty gathering external competences	PM-TM	1
Stage 5: Confirmation			
Description	**Barriers**	**Stakeholder**	**Degree**
- Both renovations in the SC have not reached this step fully as some validations are still in progress. - In the future, the technical management team will perform the regular operation and maintenance of the building, monitoring the energy efficiency of the installations until a new renovation process is required.	Not Applicable to case	-	0

Director Board of Supervisors: DBS
Tenant: T
Technical manager: TM
Contractor: C
Owner Association: VVE
External Project Manager: EPM
Suppliers: S

EER decision-making process with new property management team

Although the current property management team did not participate in either of the two DMP, data gathered on how this process would take place for future interventions led to valuable findings. First, Figure 25 confirms that the gradual step-by-step persuasion and decision stage remain a strong differential in decision-making in SC with fragmented ownership. This not only guarantees all stakeholders' alignment but also allows for better time and resources management of the new property management company assigned to this SC.

Before moving forward to further steps and presenting a proposal in an ALV meeting, the property management team answers three key questions:

1. Is the measure technically viable? This means if it fits within the existing technical systems of the centre.

2. Is it legally possible? This question highlights the importance of reviewing if the proposed intervention fits within the VvE deeds' and other governmental legal constraints.

3. Is it cost-wise? Of course, EERs have a strong environmental focus. However, decisions in these buildings usually have a high economic driver.

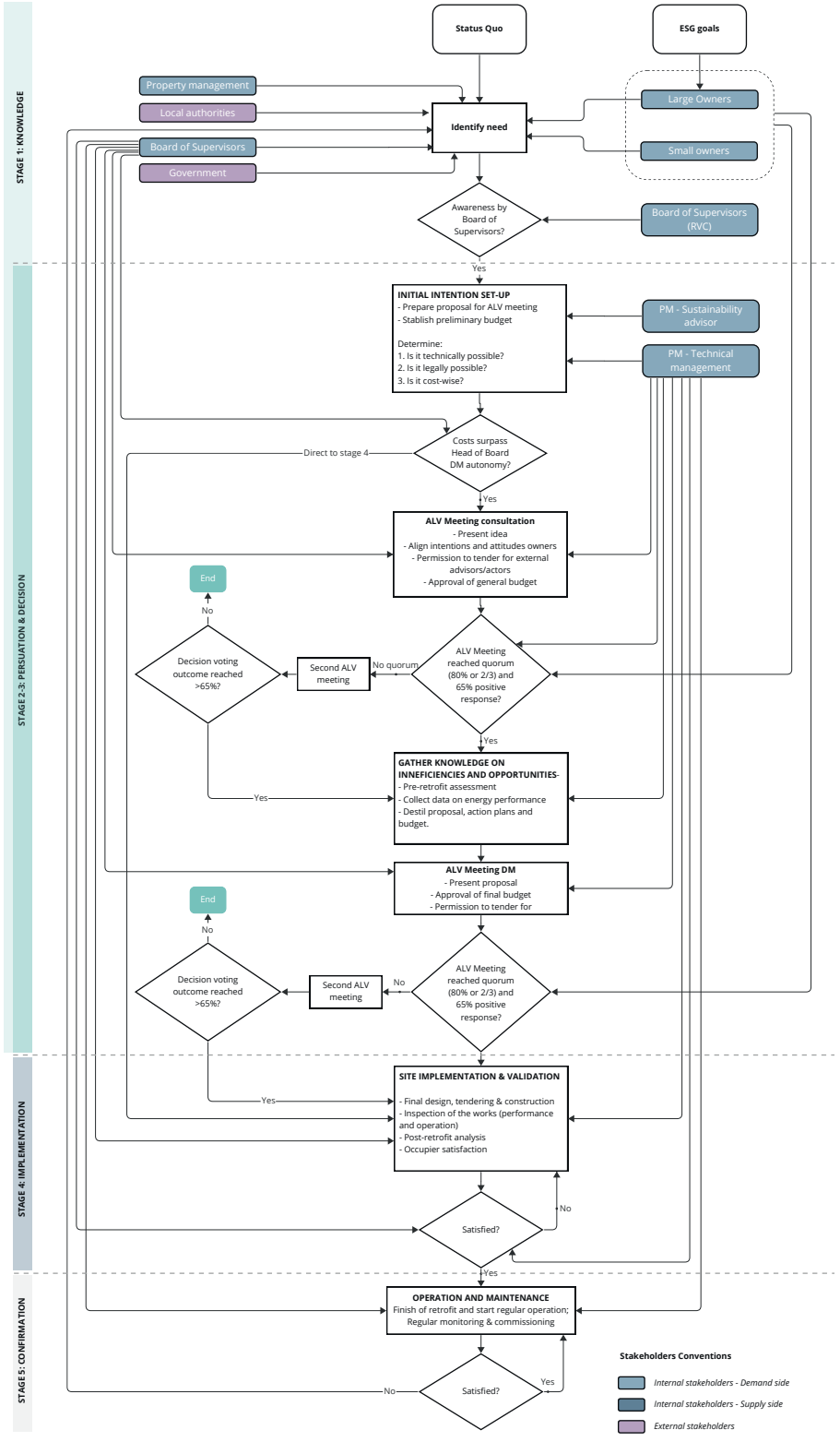


Figure 25. Case B EER decision-making process with new property management team. (Author)

Stakeholders' behaviours

This case study ratifies barriers found in the previous case, such as the *legal barriers*, *element lifecycle conflict*, *existing technical challenge*, and *intervention out of scope*.

The degree by which barriers were named by different interview subject demonstrate that in this case study, most barriers are found in the stage 2 & 3, and usually concern the owners' association (VVE) and the owners' association meeting (ALV). The most concurring barrier is *Behaviour-lack of sharing the objectives* as the most concurring one, which is in line with the exhaustive decision-making process because of the large number of owners that need to be persuaded in the ALV meetings. However, the findings also led to a differentiation between large private investors and small owner-operated shops. Given that decisions are based on quorum and owner's area coefficient in the centre, large owners are more influential than smaller ones, which leads to a general perception that small owners do not come to the meetings as they feel their vote is not representative in the pool. Moreover, large owners are also perceived as easier to persuade because they are professionals and have a better understanding of dense data.

"When there are owners that have 35% or 20% of the votes, they have a big role in decision-making. And then what you see is that sometimes small owners don't come to the meetings because they feel they don't have much to say there (…)"
(VVE Manager)

Another barrier that also stands out across stage 2 & 3 is *Organisational: complex decision-chain*. This barrier applies not only within the shopping centre's general governance structure in which decision-making is made though a gradual step-by-step process, but also because of internal governance of every individual owner. For instance, it is perceived that larger owners take longer to take decisions as they are more corporate, and decisions need to go through different management layers before reaching a positive outcome. Differently, smaller owners, although they may need to consult with family members, take shorter and more direct decisions. Overall, the VVE and Board of supervisors has managed to overcome these barriers by guaranteeing a continuous communication among all owners.

Finally, although not mentioned by a large number of stakeholders, it was found that tenants currently face two types of barriers to benefit from renewable energy projects. First, if they were to steer their own renewable energy project (e.g. solar panels), they will encounter a legal barrier related to *Limitations with internal regulations* as they are not allowed to make use of roof area for individual purposes. Second, if it was up to the owner to supply this benefit to the tenants, they will also encounter another legal barrier but, this time, related to *Limitation with governmental regulations*. This is because owners are not allowed to act as energy suppliers.

4.3.5 Existing solutions for known barriers

During the interviews some solutions were already mentioned by different stakeholders. Overall, these solutions are focused on addressing behavioural, economic, and organisational barriers such as *Lack of sharing the objectives*, *Intervention-related risks*, and *complex decision-chain*. Solutions in this case study involved sustaining open a constant communication with different stakeholders

throughout the whole process. This is in line with the EER decision-making process for this case as the fragment ownership type requires a gradual process in which owners are aligned and plans are developed and approved step-by-step. Further, this communication is also extended to tenants to ensure that they are informed of the plans and can cooperate accordingly to deliver the works.

Table 15. Case study B. Found solutions for known barriers. (Author)

Barriers found in case study B		**Existing solution**	**Description**
Behavioural	Intervention out of scope		
	Lack of sharing the objectives	**x**	- Open and constant communication with owners
Competences	Difficulty in gathering external competences		
Economic	Element lifecycle conflict		
	External risks		
	Intervention-related risks	**x**	- Open and constant communication with tenants
	Investment costs		
Legal	Limitation with governmental regulations		
	Limitation with internal regulations		
Organisational	Complex decision-chain	**x**	- Open and constant communication with stakeholders in decision-chain
	Split incentives		
Technology	Existing technical challenge		
	Technology not available		

4.3.6 Case B conclusion

The conclusion for the individual case C analysis will be given in terms of the three sub-questions of this research.

***[SQ1]:** What is the state-of-the-art of energy efficiency retrofit of shopping centres?*

Similar to Case Study A, this particular case sheds light on the shifting awareness concerning energy efficiency and the influence of governmental incentives, such as subsidies for solar panels, in driving the adoption of renewable energy systems in buildings. However, it is important to note that this awareness predominantly focuses on renewable energy sources and does not encompass energy-efficient installations. Furthermore, these initiatives primarily target the common and service areas of the shopping centre rather than addressing energy consumption within individual shops. As most owners do not possess clearly defined Environmental, Social, and Governance (ESG) goals and are not obligated to report on CO2 emissions generated by the interior of the stores, tenants are not actively involved in the decision-making process.

***[SQ2]:** How is the EERs' decision-making process of shopping centres taking place?*

This case also brought light to a lack of distinction between stage 2, persuasion, and stage 3, decision, as the fragmented ownership requires a gradual step-by-step decision-making. This is because the process does require a stakeholder alignment as decisions need to be reached by achieving a voting threshold among all owners. Therefore, negative decisions might be reached within the ALV meetings, meaning that there are various decision moments in which the process might lead to an end.

[SQ3]: *What are the barriers encountered during the decision-making process of EERs of shopping centres?*

In terms of barriers encountered, this case study revealed that the presence of a fragmented ownership structure in a shopping centre, characterized by a lengthier decision-making process and the presence of a larger number of owners that need to be persuaded, led to the emergence of notable behavioural barriers. However, it is noteworthy that despite these challenges, the attainment of consensus and favourable decisions was not compromised. The process involved additional meetings to facilitate the sharing of plans and project updates, and effective communication played a fundamental role in overcoming these barriers and maintaining progress.

Furthermore, this case also led identify that the in-store EER scope face additional challenges, especially when considering the use of renewable energy sources inside the stores. Tenants are currently in a disadvantageous position to benefit from such sources because of legal barriers on both an internal level to the centre and national level from governmental constraints.

[MQ]: *"How can owners support a better decision-making process to steer EERs of shopping centres?"*

Owners can support a more effective decision-making process for energy efficiency retrofits in shopping centres by initially establishing a well-defined sustainability roadmap that outlines how the centre will align with the sustainability goals set for 2030 and 2050. The inclusion of a dedicated sustainability advisor in the decision-making process can provide significant advantages, especially considering that no such advisor was identified in this particular case study. Collaborating with the property management team to develop and execute this strategy can also prove beneficial.

4.4 Case study C – Het Stroink

4.4.1 Context

Het Stroink is a convenience shopping centre located in the municipality of Enschede. It was acquired by a real estate redeveloper in 2016 with the objective to enhance the centre's sustainability, expand its facilities, and ultimately attract a real estate investor for future sale. The improvements in this plan encompassed various aspects, such as the enlargement of the building to accommodate a discount supermarket on the opposite side to improve visibility for smaller retailers. Additionally, aesthetic enhancements were introduced, incorporating natural materials, enhancing façade transparency, and restoring entrances to create a more welcoming ambiance. The entire centre underwent a comprehensive modernization to improve its overall look and feel. Furthermore, the parking capacity was expanded, public areas were redesigned, the roof was upgraded with new insulation, natural ventilation and lighting were enhanced, and charging points for electric vehicles were installed. Notably, this case study stands out due to its strong emphasis on energy efficiency, distinguishing it from the other two cases. Furthermore, it is currently positioned in the final stage of the decision-making process, namely confirmation.

Renovation year: 2019-2020
Type of Owner: Single – Small private investor (during renovation)
Size: 5,750m^2
Construction year: 1978

4.4.2 Governance structure

This case study has two different governance structures as the renovation was led by a Real Estate redeveloper (Figure 26), from stages 1 to 4, and it was later sold to a larger real estate investor (Figure 27), where it is now at its latest EER stage 5, confirmation.

The governance structure during the renovation was simple as the SC was bought by a small Real Estate Redevelopment firm with only two partners. These two partners convinced a small group of close and familiar investors to fund the project and organised a small retrofit team to implement it. This team consisted of an architect, a contractor, and different external advisors.

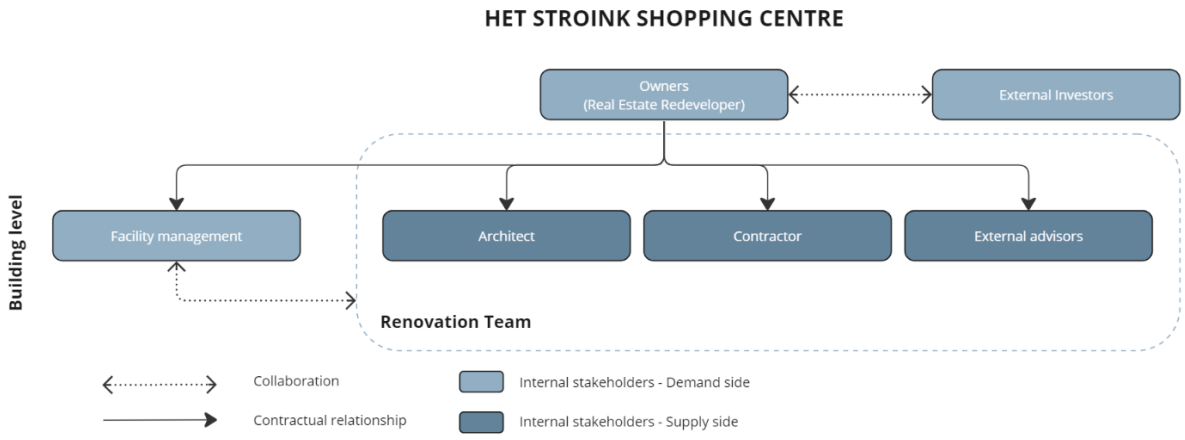


Figure 26. Governance structure until implementation stage. (Author)

Once the renovation was finalised, a large real estate investor proposed to buy the shopping centre and made it part of their retail real estate portfolio. Therefore, the second governance structure (Figure 27) functions within two levels, a portfolio and a building level. First, the retail fund manager must make sure the retail fund complies with the company's ESG strategy framework. This framework stablishes the roadmap to become Paris Proof in the upcoming years, considering financial and nonfinancial targets, and is developed on a strategic level with the shareholders. On a building level the fund, together with the property management team, translate these targets into the SC maintenance plan. The property management team is composed by a commercial manager, as team leader, and a technical management team that oversee the building's daily operation. When required, the commercial manager may bring an in-house sustainability advisor, and the fund manager will directly appoint a contractor if new measures are defined.

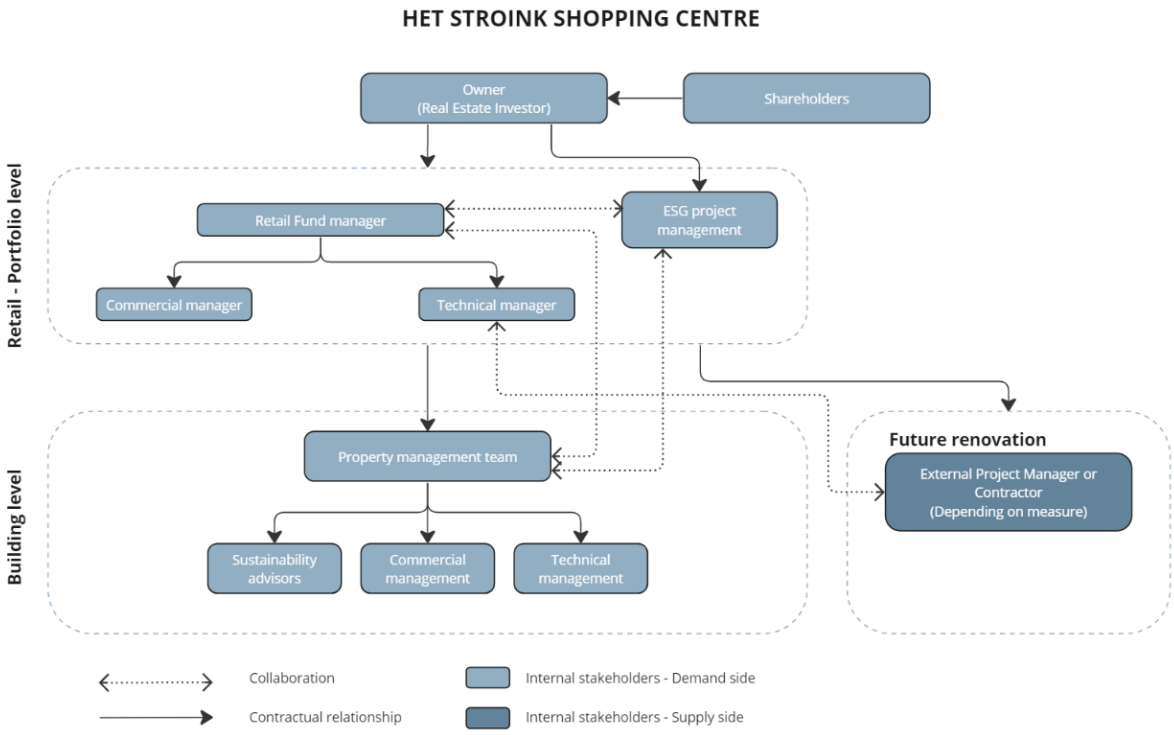


Figure 27. Governance structure after implementation stage. (Author)

4.4.3 Energy-related measures

Implementing environmental sustainability measures was a key driver in this shopping centre's retrofit. The owners believed that this would create an added value and would increase the sale value of the shopping centre. The measures that were implemented in terms of energy savings were the following:

- Renewal of roof with optimal insulation
- Roof partly equipped with solar panels
- New roof design that allows natural ventilation and lighting
- New lighting design with LED fixtures

4.4.4 EER decision-making process

The EER (Energy Efficiency Retrofit) renovation process of this shopping centre progressed smoothly and efficiently, owing to the small-scale ownership structure and minimal management layers within the owning company. Decision-making primarily involved two partners, streamlining the process. It is important to note that the renovation was focused solely on the common and service areas, aligning with the stages outlined in the theoretical framework. Currently, the renovation has advanced to stage 5 under the supervision of a new owner, a prominent real estate investor, who acquired the centre as part of a large retail real estate portfolio. To gain insights into the EER decision-making process and understand stakeholder behaviours at each stage, refer to Figure 28 and Table 16.

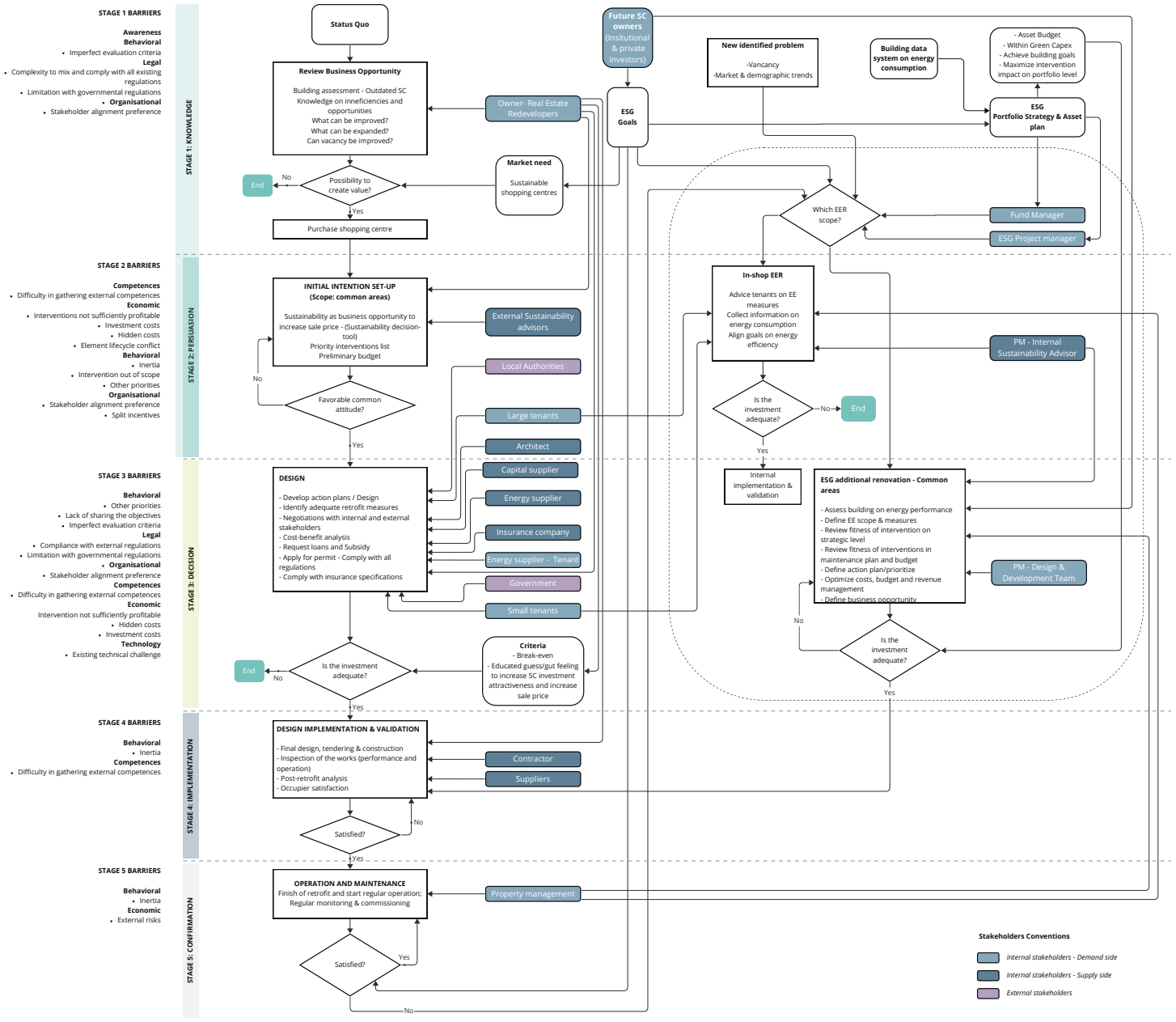


Figure 28. Case C - EER process. (Author)

Table 16. Case study C. Identified stakeholders' behaviours per stage. (Author)

Stage 1: Knowledge			
Description	**Barriers**	**Stakeholder**	**Deg.**
- Awareness comes from a business opportunity to tackle a market need of sustainable real estate assets. - Knowledge on inefficiencies and opportunities gathered before buying the shopping centre - Decision node: Determines the asset's purchase	Awareness	OW-SS, OW-SL	1
	Behavioural – Imperfect evaluation criteria	OW-SL	1
	Legal – Complexity to mix and comply with all existing regulations	OW-SL	2
	Legal – Limitation with governmental regulations	OW-SS	1
	Organisational – Stakeholder alignment preference	T, OW-SL	2
Stage 2: Persuasion			
Description	**Barriers**	**Stakeholder**	
- Short persuasion stage: o Small number of stakeholders had to be aligned to have a favourable attitude towards the retrofit. (4 between partners and small investors) o Decision-makers already had knowledge on the inefficiencies and opportunities of the centre from the previous step. - Use of Sustainability decision-tool to rank different possible interventions in the centre and agree on a priority interventions' list among decision-makers → Set roadmap for renovation including goals and preliminary budget - Future renovations: will be focused on tenant's persuasion on EE renovations inside of the shops.	Competences – Difficulty in gathering external competences	OW-SS, SA	3
	Economic – Interventions not sufficiently profitable	OW-SS	1
	Economic – Investment costs	OW-SS	1
	Economic – Hidden costs	OW-SS	1
	Economic – Element lifecycle conflict	T	1
	Behavioural – Inertia	T	3
	Behavioural – Intervention out of scope	T, OW-SS , OW-SL	3
	Behavioural – Other priorities	T	1
	Organisational – Stakeholder alignment preference	T, OW-SL, PM-CM	1
	Organisational – Split incentives	CM, T, OW-SS	2
Stage 3: Decision			
Description	**Barriers**	**Stakeholder**	**Deg.**
- Developing actions plans - Identifying adequate retrofit measures - Negotiations with stakeholders: o Local authorities to collaborate in upgrading surrounding areas o Energy suppliers to identify grid capacity for PV o Energy supplier to lease roof area and operate PV o Capital suppliers for financing o Government for subsidies request o Insurance company for construction policies - Decision node: Adequacy of investment based on professional experience, educated guesses, and gut feelings so that measures will indeed increase the SC attractiveness and sell for a higher value.	Behavioural – Other priorities	OW-SL	2
	Behavioural – Lack of sharing the objectives	LA, OW-SS	2
	Behavioural – Imperfect evaluation criteria	OW-SS	1
	Legal – Compliance with external parties regulations	OW-SL	1
	Legal – Limitation with governmental regulations	PME, OW-SL , OW-SL	3
	Organisational – Stakeholder alignment preference	OW-SS, GOV	2
	Organisational – Lack of time	PM-TM	2
	Competences – Difficulty in gathering external competences	OW-SL, EC	1
	Economic – Intervention not sufficiently profitable	OW-SS	1
	Economic – Hidden costs	OW-SS	1
	Economic – Investment costs	LA	2
	Technology – Existing technical challenge	OW-SS , ES, PM-CM	2
Stage 4: Implementation			
Description	**Barriers**	**Stakeholder**	**Deg.**
- Taking action: finalising the designs, tendering for a contractor, undergoing construction works, validating and inspecting the works, and performing a post-retrofit analysis	Behavioural – Inertia	C, S	2
	Competences – Difficulty gathering external competences	OW-SS , C	1
	Technology-Not available	C	1
Stage 5: Confirmation			
Description	**Barriers**	**Stakeholder**	**Deg.**
- Change of ownership: Large real estate investor - Ownership determines a different DM process depending on the scope of the new renovation - Owner's ESG portfolio targets translated into a building's specific asset plan (Green Capex) - Adequacy of the new investment will be determined based on Green Capex criteria.	Behavioural – Inertia	T	1
	Behavioural – Intervention out of scope	T, PM-CM	1

Owner-Single small real estate investor: OW-SS
Owner-Single large real estate investor: OW-SL
Contractor: C
Technical management: PM-TM
Commercial manager: PM-CM
Tenant: T
Energy supplier: ES
Government: GOV
Project manager ESG:PME
Local Authorities: L
Sustainability Advisor: SA

Stakeholders' behaviours

This case study ratifies barriers found in the previous cases, such as the *legal barriers*, *existing technical challenge*, and *intervention out of scope*. Moreover, it also brought to light three new barriers within the Legal and Organisational types:

- *Legal – Complexity to mix and comply with all existing regulations:* there are several regulations for sustainability that organisations are currently preparing for. Although some are similar to each other, each one has specific goals and often require a lot of resources from the owners to comply with (OW-SL, PME).
- *Legal – Compliance with external parties regulations:* refers to regulations set by external stakeholders such as capital suppliers or insurance companies (OW-SL, PME) to acquire a service from them. For example, insurance companies have a list of at least 80 requirements of building's specifications that need to be met before issuing an insurance policy on a building. Complying with all building requirements require a lot of time (OW-SL, PME).
- *Organisational – Stakeholder alignment preference:* the tendency to put more focus on EER of supermarkets hinders smaller tenants to benefit from EE interventions. This was found to apply to different stakeholders. For example, subsidies from the government for solar panels were perceived to only be available for large energy consumers such as supermarkets (OW-SS); the energy supplier leasing the roof has a preference to supply energy for a few large supermarkets than to several individual stores because the later will require a larger amount of connections and transaction costs (PM-CM); owners give a little more focus on tackling supermarkets as reaching energy consumption targets in these buildings is more challenging without renewable energy sources, and they also have the potential to become influential actors for smaller tenants (OW-SL, PME).

The degree by which barriers were named by different interview subjects demonstrate that most barriers are found in stages 2 and 3. In stage 2, although persuasion was a rather short process, most barriers were found on the behavioural category regarding tenants' future alignment for in-store EE measures. This is a conversation that is yet to happen. However, regarding what the small real estate redeveloper went through during the renovation process, the greatest barrier in this stage was *Difficulty in gathering external competences*. This was because this stakeholder reported difficulty in finding more experienced and reliable advisors.

Stage 3 was the stage that presented most barriers in this case study. *Behavioural*, *legal*, *organisational*, *economic*, and *competencies* related barriers were all found in this stage. They come from a wide range of stakeholders, as this stage in this case study focuses on negotiating and collaborating with external stakeholders to implement the measures. For instance, here the barrier *difficulty in gathering external competences* was found as advisory services are saturated in the market, and there are long waiting periods if a service is required (OW-SL, PME). Moreover, behavioural barriers such as *other priorities* or *lack of sharing the objectives* were also found. The former mainly from the new

"we have strong ambitions, but we also are dependent on the capacity of contractors and advisors. So, for example, if I want to have a new building certificate, you really have to wait months for it in the current market".
(REI, PME)

owner of the SC that has other priorities such as bringing the whole portfolio to a higher sustainable standard, rather than focusing on smaller building specific measures that have a lower impact on a larger scale. And the later because the previous owner of the centre perceived that although sustainability is named by local authorities in their programmes, in practice they are not proactive in addressing it (OW-SS). This perception was also extended into stage 4 were *inertia* (change aversion) from contractors and suppliers was also indicated when referring to the Dutch construction industry as old-fashioned and slow to adapt to sustainability (OW-SS).

"other stakeholders are not doing. They are not proactive, they are a reactive. (…). Municipalities think they must implement sustainability in their programmes, but in practice they don't because it's too expensive". (OW-SS)

"the construction business in the Netherlands is it's an old fashioned industry. So they are working on old fashioned manner, so they're not changing into sustainability (…)." (OW-SS)

This case study was interesting as it was the only one that is currently at stage 5, confirmation. Barriers found in this stage are closely related to *inertia* and *intervention out of scope*, both related to tenants and consumers behaviours. For example, refusing to operate with the doors closed indicates an aversion to change and has an impact on EE (PME). Similarly, the inability to monitor energy consumption inside the stores is related to activities that are out of the scope for owners and property managers (PM-CM).

Finally, although it was not documented as a barrier, another interesting finding in this stage was that the owner is currently investing on building data systems, so they don't become too dependent on property managers from each asset to track building data to track and take decisions on a wider portfolio level. This was interesting as monitoring the energy efficiency and consumption of the system is usually a task that is the responsibility of the technical management team.

4.4.5 Existing solutions for known barriers

Solutions found in this case study were also addressed to tackle tenant collaboration in EE improvements inside the stores such as the tenants advisory programme, green leases, and considering implementing central systems for heating, cooling, and electricity as it occurs in the office stock. This last one was not implemented, but was an idea mentioned by the owner during the renovation. Another mentioned solution was having open and constant communication among all stakeholders as a way of tackling the *Lack of sharing the objectives barrier*. Further, collaborating with external stakeholders was used as a solution to address hidden costs from an increase in transaction costs that rise from investing too much time in addressing sustainability-related tasks. Finally, to tackle the legal barrier of the *Complexity to mix and comply with all existing regulations*, the current owner is implementing future planning on a broader portfolio level to define intervention priorities.

Table 17. Case study C. Found solutions for known barriers. (Author)

Barrier found in case study C		Existing solution	Description
Awareness	Awareness		
Behavioural	Imperfect evaluation criteria		
	Inertia		
	Intervention out of scope	**x**	- Advise programme to tenants - Green leases - Implement central system for heating, cooling and electricity (not implemented, owner's idea)
	Lack of sharing the objectives	**x**	- Open and constant communication with all stakeholders
	Other priorities		
Competence	Difficulty in gathering external competences		
Economic	Element lifecycle conflict		
	Hidden costs	**x**	- Delegate and collaborate with external advisors - Green leases
	Intervention not sufficiently profitable		
	Investment costs		
Legal	Complexity to mix and comply with all existing regulations	**x**	- Future planning on a broader portfolio level
	Compliance with external regulations		
	Limitation with governmental regulations		
Organisational	Lack of time		
	Split incentives		
	Stakeholder alignment preference		
Technology	Existing technical challenge		
	Technology not available		

4.4.6 Case C conclusion

The conclusion for the individual case C analysis will be given in terms of the three sub-questions of this research.

***[SQ1]:** What is the state-of-the-art of energy efficiency retrofit of shopping centres?*

Initially, a clear distinction was expected from the EER decision-making process between shopping centres with a single and fragmented ownership type. However, this case study shed light on the understanding that within single ownership, other differences may arise. These include a shorter decision-making process linked to less management layering, the appearance of new stakeholders such as capital suppliers, or a different assessment for measuring the adequacy of energy-related investments. The latter because as a small owner seeking to sell upon completion, energy-related investments cannot be assessed based on future energy-savings, but rather on educated assumptions of what could bring a higher selling price based on experience and best-educated guesses.

Furthermore, this case also highlighted a disparity in the availability and accessibility of renewable energy opportunities, favouring larger tenants while excluding smaller ones. Such differentiation raises concerns regarding equity and fairness in the distribution of sustainable energy solutions within shopping centres. It underscores the need for inclusive approaches that extend the benefits of renewable energy to all tenants, irrespective of their size or business type.

[SQ2]: *How is the EERs' decision-making process of shopping centres taking place?*

This case is interesting as it demonstrates a different approach in the awareness stage where knowledge on inefficiencies and opportunities is gathered before making the decision to acquire the shopping centre and undergoing a retrofit process. As there is no doubt about the centre's need of a deep renovation, decisions are not a matter of *if* but of *what kind* of measures are needed.

Furthermore, being the only case that has undergone the complete renovation process, it provides valuable insights into the final stage of the process, confirmation. This aligns with the anticipated outcomes outlined in the theoretical framework. However, this case study also highlights the importance of implementing energy consumption monitoring through building data systems right from the initial stages of the process.

[SQ3]: *What are the barriers encountered during the decision-making process of EERs of shopping centres?*

In terms of stakeholders' behaviours, this case study has revealed three additional types of barriers that were not previously considered within the legal and organizational categories. The owners of the shopping centre, albeit at different stages of the process, have highlighted the challenges they face in acquiring external expertise in the saturated Dutch market. Furthermore, the case study has provided insights into the difficulties owners encounter in reconciling and complying with existing regulations from various sources.

Moreover, this case study has facilitated the identification of the current behaviours exhibited by external and supply-side stakeholders, including local authorities, energy suppliers, contractors, suppliers, capital providers, and large tenants. Additionally, it has allowed for the mapping of barriers that arise during the final stage of the process, shedding light on current trends in the allocation of tasks between owners and property managers.

[MQ]: *"How can owners support a better decision-making process to steer EERs of shopping centres?"*

This case study has yielded two potential strategies for owners to enhance the effectiveness of decision-making processes in energy efficiency retrofits for shopping centres. The first strategy involves investing in building data systems, which can play a crucial role in informed decision-making for future renovation projects. These systems have the capability to enable energy benchmarking across the entire portfolio over time, facilitating the identification of new requirements and promoting cross-learning on the effectiveness of measures across different assets. However, it is important to ensure that property managers are not duplicating their efforts with their own energy monitoring systems and that they are not excluded from the owner's systems. Their participation is essential for facilitating information exchange, as well as identifying opportunities and building specific needs, and implementing on-site measures.

The second strategy is about tackling the unequal access to renewable energy sources for smaller tenants. Although there is a legal limitation from the owner in this regard, as they cannot be direct energy suppliers, there is a possibility to explore incentives towards the roof's tenant to promote equal access to all.

4.5 Cross-case analysis

As a result of a comprehensive analysis of each case study, the goal of the cross-case analysis was to verify and compare the findings. To achieve this, the analysis was merged with the outcomes from the expert interview, and the results are presented here in two individual sub-sections, each related to sub questions 2 and 3 of this research. The first section proposes a merged version of the EER decision-making process based on critical discoveries from the individual cases. The second section elaborates on the barriers that were identified in each case by cross-validating them within the process and examining their causal relationships with various stakeholders involved. Lastly, a main findings section outlines cross-case analysis conclusions that will serve to answer the research questions.

4.5.1 Governance structures

The governance structure of shopping centres exhibits variation across different cases, with each case study revealing a unique system dependent on the type of ownership. In Case A, which is owned by a single large institutional investor, the governance system operates at two levels: portfolio and building. This structure introduces new stakeholders at the portfolio level, such as commercial, technical, and ESG managers. Additionally, multiple sustainability advisors are present across different levels, supporting individual teams within each level and tackling different aspects. However, communication across sustainability advisors was not found.

On the other hand, Case B demonstrates a governance system focused solely on the building level. Although it involves fewer management layers, external project managers are still engaged for renovations and report directly to the owners. It is worth noting that this case lacks a dedicated sustainability advisor, which may contribute to the lack of emphasis on sustainability goals within the shopping centre.

Furthermore, Case C highlights a change in the owner's governance structure, transitioning from a single small real estate investor to an institutional investor. While small real estate investors typically have fewer management layers and potentially more control over the renovation team, as indicated by the identification of more stakeholders, the absence of a property management team assigned to the centre in this case may have led to overlooking the diagnosis of shopping centre inefficiencies, which is crucial in the renovation process.

Overall, the case studies reveal a common trend of owners assuming direct oversight and contracting with supply-side stakeholders. Although the property management team, particularly the technical management, collaborates with external renovation teams, this collaboration appears to be limited to information exchange rather than true cooperation. It is important to note that not all external stakeholders were identified by the interviewees, which limited the ability to map their involvement. Additionally, cooperation with local authorities, energy suppliers or distribution net managers was not documented.

Finally, the engagement of external stakeholder teams was primarily observed in the context of deep renovations. Smaller renovations at the maintenance or component level are typically carried out directly by the technical management team. This indicates a significant disadvantage for

shopping centres that rely solely on in-house facility management tasks, as was the case in Case C before being purchased by the former owner.

4.5.2 EER Decision-making process of shopping

This section cross-analyses the findings from the individual case studies plus the expert interview to uncover a generalised EER decision-making process for shopping centres in the Netherlands, providing an answer to *[SQ2]: How is the EERs' decision-making process of shopping centres taking place?*

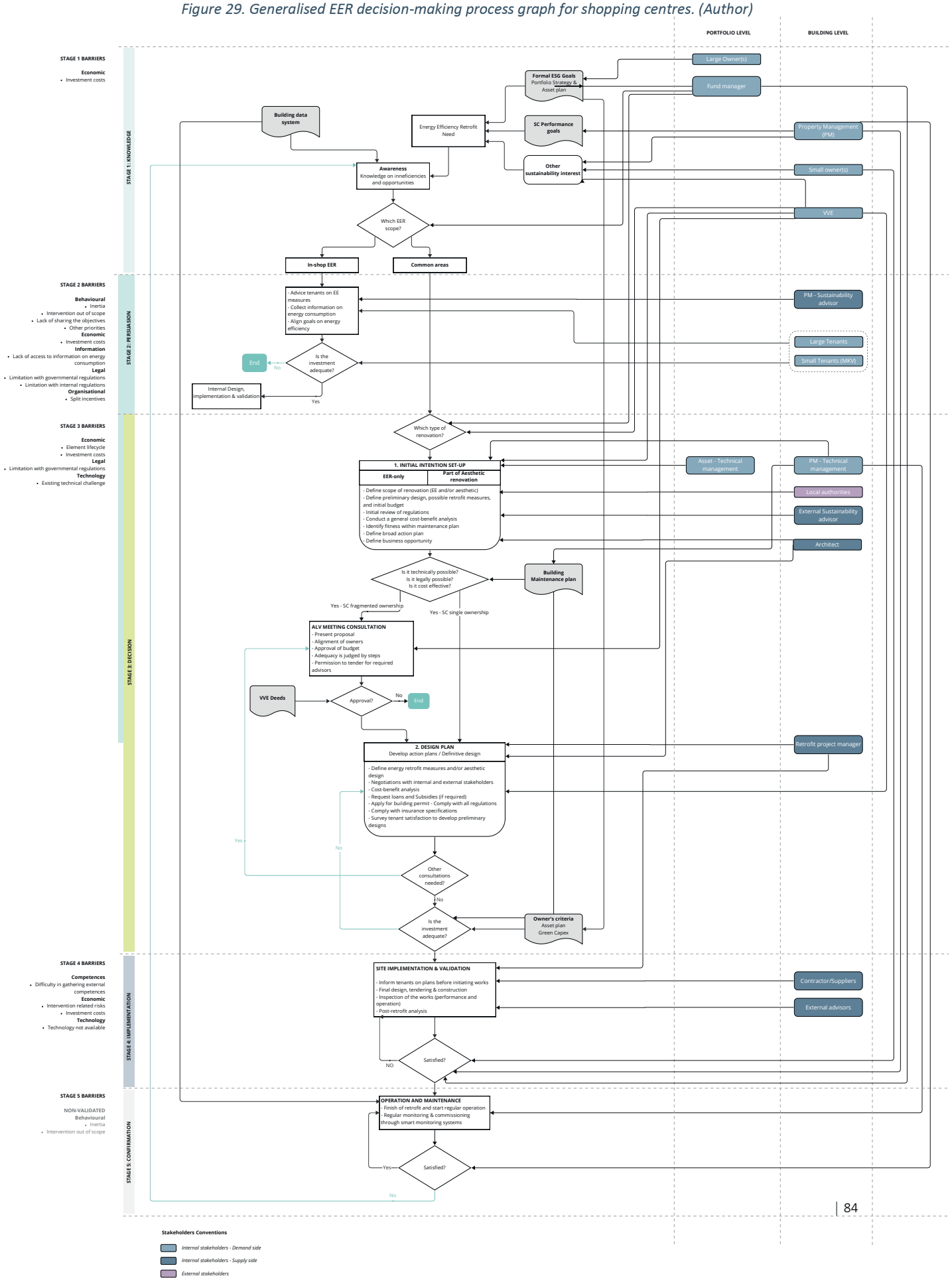
This process consisted on identifying the main takeaways by stage from each case study plus expert interview and combined them into a generalisation Table 18. Once the generalisation was found, then a final process graph was developed. This graph (Figure 29) not only identifies the different activities and decision moments by stage, but also links stakeholders to each stage dividing them by their participation on either a portfolio or a building level. Furthermore, it is important to indicate that generalisations in this graph were made from the compilation of different stakeholders' perceptions about the process. Although a variety of stakeholders were interviewed by case study, the studied perspective was non exhaustive. Therefore, additional relationships and actors may still be missing from practice.

Overall, although every shopping centre is its own universe, where decisions and decision-making respond to the building's specific needs and governance structures, it is possible to map the similarities within the five stages established from the theoretical framework. However, the ownership structure, whether fragmented or single, does impact the overlap between stages 2 and 3 (persuasion and decision). The results of these generalisations are observed in the resulting EER decision-making process graph. (Figure 29).

Table 18. Cross-case comparative analysis on EER decision-making process. (Author)

Stage	Case A	Case B	Case C	Expert interview	Generalisation
1. Knowledge	- Awareness comes from strategic level ESG goals - Interventions are an assignment and the decision is about defining the scope of that assignment	- Awareness can come from multiple stakeholders but all ideas must be filtered by the Board of Supervisors	- Importance of having knowledge on inefficiencies and opportunities	- Process starts with an ESG strategy at a portfolio level - Led by owner and fund manager - Risk assessment	- Awareness from strategic ESG goals, SC performance or other sustainability interest. - Requires data on building performance to identify inefficiencies and opportunities
2. Persuasion	- Only tenants need to be persuaded	- Step-by-step process to define plans, persuade owners and take decisions. - A gradual process saves time and resources and guarantees that all stakeholders are being aligned - Communication is key to guarantee that all stakeholders are kept informed and are aligned with the process	- Stage not needed for a small real estate redeveloper. Decision-making is a shorter and simpler process. - Set roadmap with sustainability decision-making tool - More extensive process for tenants	- Property level: led by asset and technical manager - External company gathers data on building performance - Performs cost analysis of initial EE measure - Review regulations for building permit - Emphasis to collaborate with tenants to tackle in-store EE - Risk assessment	Occurs only when: - when the scope of the renovation is aimed at the in-shop EE scope. - There is a fragmented ownership in the SC. In this case stages 2 and 3 overlap and decision and alignment is done step-by-step
3. Decision	- Two types of renovations: EER specific or large aesthetic renovation. - Decision is about its adequacy of the plans within the portfolio strategy - Interventions considered within the building's maintenance plan		- Definition of adequate retrofit measures - Negotiation with external stakeholders - Decisions is about adequacy of investment based on best educated guesses and gut feeling. Investments cannot be calculated in terms of energy savings.	- Develop action plans - Approval of fund manager for large investments - Adequacy of invest based on CAPEX and sustainability portfolio goals - Risk assessment	- Two decision moments - Initial plans are drawn based on type of renovation, regulations, a broad cost-benefit analysis, and fitness within the building's maintenance plan - After identifying if the plans are technically, legally, and cost-effective, a definitive plan can be developed - Investment adequacy is judged based on owner's criteria
4. Implementation	- Regular design, tender, and construct process. - Inform and negotiate plans with tenants - Validate and inspect works - In charge of technical management or external project manager	- Tender and selecting providers - Undergoing works - Communicate plans to tenants and negotiate - Validate and inspect works - Led by technical management or external project manager	- Regular design, bid, construct project process	- Design, tender and construct project - Risk assessment - Validation of the works	- Regular final design, tender and construction process. - Inform tenants on plans before initiating works - Inspect works are review goals and targets were met
5. Confirmation	-	New energy monitoring system is being installed at the centre by property management team	- Energy monitoring as owner's responsibility - Trigger for new renovation: based on ESG portfolio strategy and Green Capex criteria	- Operation and maintenance	- Regular operation and maintenance of the building. - Perform energy commissioning. - Process requires input from centralised building data.

Figure 29. Generalised EER decision-making process graph for shopping centres. (Author)



4.5.3 Stakeholders' behaviours in the decision-making process

The second part of the cross-case analysis aimed to identify barriers encountered during the decision-making process of energy efficiency retrofits (EERs) in shopping centres, in response to the question: "What are the barriers encountered during the decision-making process of EERs of shopping centres?" This process involved three distinct analysis steps.

The first step involved creating a validated list of barriers that are specifically applicable to shopping centres, as depicted in Figure 30. Barriers included in this list were selected based on their replication across more than one case-study or expert interview. The second step involved classifying this list according to the decision stage in which each occurred. Similar to the first step, only barriers that were confirmed to occur in specific stages in more than one case-study or expert interviews were considered. The classification results are presented in Figure 30. Finally, the third step encompassed a causal relationship analysis to identify patterns and correlations among the different stakeholders involved in the process. The findings of this analysis are presented in Figure 32 and Table 20.

4.5.3.1 Validated barriers found in the EER decision-making process

A list of validated barriers in practice, specifically for shopping centres in the Netherlands, was drawn from this cross-case analysis. To achieve it, only repetitive barriers among two or more case studies plus expert interview were included in the list. Within this scope, it was found that although all seven (7) barrier types found in the literature occur in the process, the most recurrent sub-types are *Economic-investment costs* and *Legal-Limitations with governmental regulations.* These were found across all case studies and expert interview. The other set of barriers that were found among all 3 case studies but not the expert interview was *Technology-not available*, *Technology-existing technical challenge*, *Organisational-split incentives*, *Economic-element lifecycle conflict*,

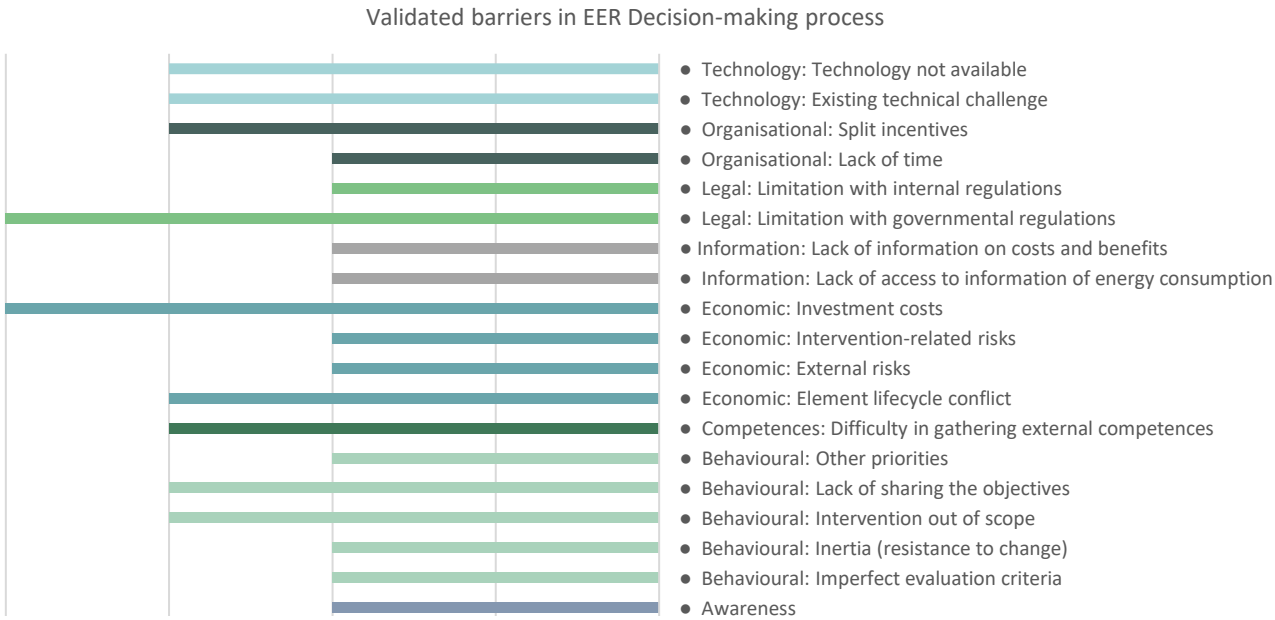


Figure 30. Validated barriers in EER decision-making process. (Author)

Behavioural-lack of sharing the objectives, and *behavioural-intervention out of scope*. It is important to consider that the lack of validation through the expert interview might be because the expert interview was conducted to a Fund manager. Therefore, some barriers might fall out of his role. Similarly, the barrier *Competences-difficulty in gathering external competences* was also found recurrent among 2 case studies and the expert interview.

4.4.3.2 Validated barriers encountered per decision-making stage

The second analysis mapped validated barriers within the EER decision-making process per stage. The degree in which they were named by stage, allows to map the most important perceived barriers by the different stakeholders involved. Figure 31 demonstrates that most barriers occur

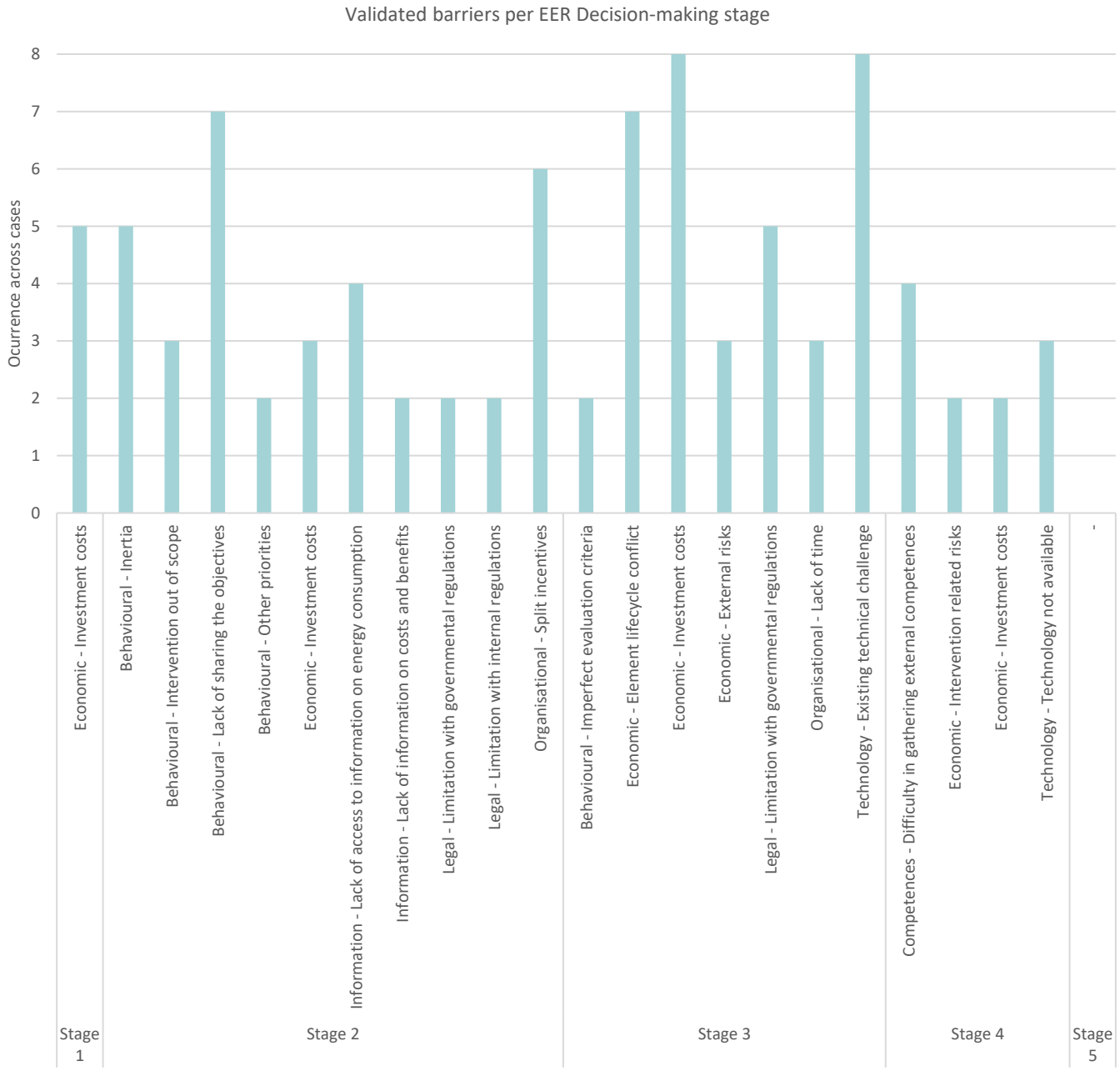


Figure 31. Validated barriers per decision-making stage. (Author)

within stage 2 and 3, persuasion and decision stage. Further, it can also be noted that some barriers are found repetitive across stages. The following paragraphs describe and analyse the barriers found per stage.

Stage 1: Knowledge

In this stage, a single barrier related to the Economic category was identified and validated: *Investment costs*. This concurs with previous findings that decision-making at this stage responds to higher strategic objectives and hence EERs become assignments from the owner that need to be carried out. *Investment costs* at this stage is considered a barrier while there may be sufficient funds available to finance energy efficiency (EE) interventions, the cost of investment must be carefully considered based on factors such as the expected return on investment, the planned capital expenditure for a particular asset, and the potential impact of the intervention on the overall portfolio.

Stage 2: Persuasion

In stage 2, most barriers are within the behavioural category. This concurs with the findings of the decision-making process as this stage requires a high level of stakeholder alignment with the tenants to achieve energy efficiency measures inside the stores. Specifically, the barrier *Behavioural-lack of sharing the objectives* was found to have the highest degree of occurrence at this stage. This barrier was not only found within the broad owner-tenant relationship but also between the large tenant-small tenant relationship (Table 19). Moreover, the barrier *organisation-split incentives* was also found at this stage as negotiation between owners and tenants about who invests in the intervention and who benefits from it had a high occurrence.

Table 19. Different levels of relationships within the behavioural – Lack of sharing objectives category. (Author)

Stage 2: Behavioural - Lack of sharing the objectives	
Relationship	**Description**
Owner-tenant	Different views on sustainability, sustainability policies or ESG strategy. *Example*: A large tenant might have their own energy contract with a specific energy supplier for all their store branches in the Netherlands, and this might interfere with the owner's specific building asset's plan.
Large tenant-Small tenant	While a large tenant has a more stablished target on EE efficiency that supports their long term ESG objectives, this might be different from a small entrepreneur whose main concern might be getting a pension out of its store. Therefore, their objectives require a different approach from the owner to engage both types of tenants with EE measures.

Stage 3: Decision

This stage presents the highest occurrence of economic and technology related barriers. Specifically, *(a)Investment costs*, *(b)Element lifecycle conflict,* and *(c)Existing technological challenge* were the most concurrent across the case studies. This is because this stage is where plans are made, and where the adequacy of the investment is analysed. This adequacy is judged based on weighting the return of investment of the measures; reviewing their fitness within the maintenance plan of the existing elements in the building, making sure elements fulfil their lifecycle and new ones fit within the asset specific Capex (or Green Capex) and its specific value capturing period; and reviewing the measures' feasibility within the existing installations. Therefore, all three are interconnected with

each other as barriers within element's lifecycle and existing technical challenge may increase the investment costs.

Stage 4: Implementation

Barriers in this stage include *(a)Difficulty in gathering external competences* and *(b)Technology not available*. The former was found as a market limitation in finding reliable and experienced contractors to develop the works, while the later refers to a market shortage of construction materials and equipment to supply project on time and within budget, also influencing the occurrence of the *(c)Investment cost* barrier in this stage.

Stage 5: Confirmation:

Barriers found on this stage could not be validated because there was only one case study in this stage. However, from case study C, it was found that barriers in this stage involve *(a)Inertia* and *(b)Intervention out of scope*. While *Inertia* in this particular stage responds to the inability to control user behaviours despite implementing the most sustainable measures, *intervention out of scope* refers to the barrier of performing energy commissioning on energy consumption inside the shops. This has been mentioned before as a limitation from owners and property managers as the inside of the shops falls out of the scope of their control. However, it was found in other case studies that property managers and owners are currently working on installing smart meters to monitor the building at an asset or even portfolio level even inside of the shops.

4.4.3.3 Causal relationships of validated barriers

Having mapped the validated barriers in the decision-making process, this section analyses the causal relationships of each one by linking stakeholders as causing-barrier or bearing-barrier agents (Table 20). The purpose is to identify the interrelationships between stakeholders and find patterns and correlations that could help identify possible points of improvement.

First, the analysis reveals that although similar types of barriers exist across different stages of process, they are specific to different situations and cause-agents. For instance, the barrier of *investment costs* was found in stages 1-4, with stage 5 not being able to validate as only one case-study is currently in this stage. However, in stages 1-3 it is caused by the owner and is related to the measure's insufficient contribution to portfolio outcomes and revenues, as well as its lack of alignment with expected capital and operating expenses. In contrast, in stage 4, the same barrier is caused by the government and is linked to the plethora of new sustainability regulations that are prohibitively expensive for owners to address all at once.

Similarly, the analysis highlights that a barrier identified within the same stage may have different cause and bearing agents, thus existing solutions are ineffective in addressing all causes at once. For example, the behavioural barrier of "*Lack of sharing the objectives"* in stage 2 can be caused by either the owner or the tenant. However, the nature of the owner or tenant can result in different experiences of this barrier. For instance, a large tenant may be a causing agent because their sustainability approach may conflict with that of the owner, whereas small tenants may lack a clear approach to sustainability. While a tenant advisory project may be suitable for the latter, the

challenge of having clashing ESG strategies and approaches to sustainability between owners and large tenants remains unaddressed.

Second, Figure 32 provides valuable insights into the role of asset owners as both causing and bearing agents. Although each all types of owners are identified as a cause-agents in less than 20% of all validated barriers, they bear the brunt of most validated barriers, accounting for more than 60%. This is because EER are assignments set by the owner, thereby being them the ultimately affected if the objectives are not met. As a result, there is no discernible pattern between identified solutions and owners due to their nature as causing or bearing-agents (Table 20). Consequently, owners are prone to attempt to overcome barriers from different perspectives, even if they are not the root cause of the problem.

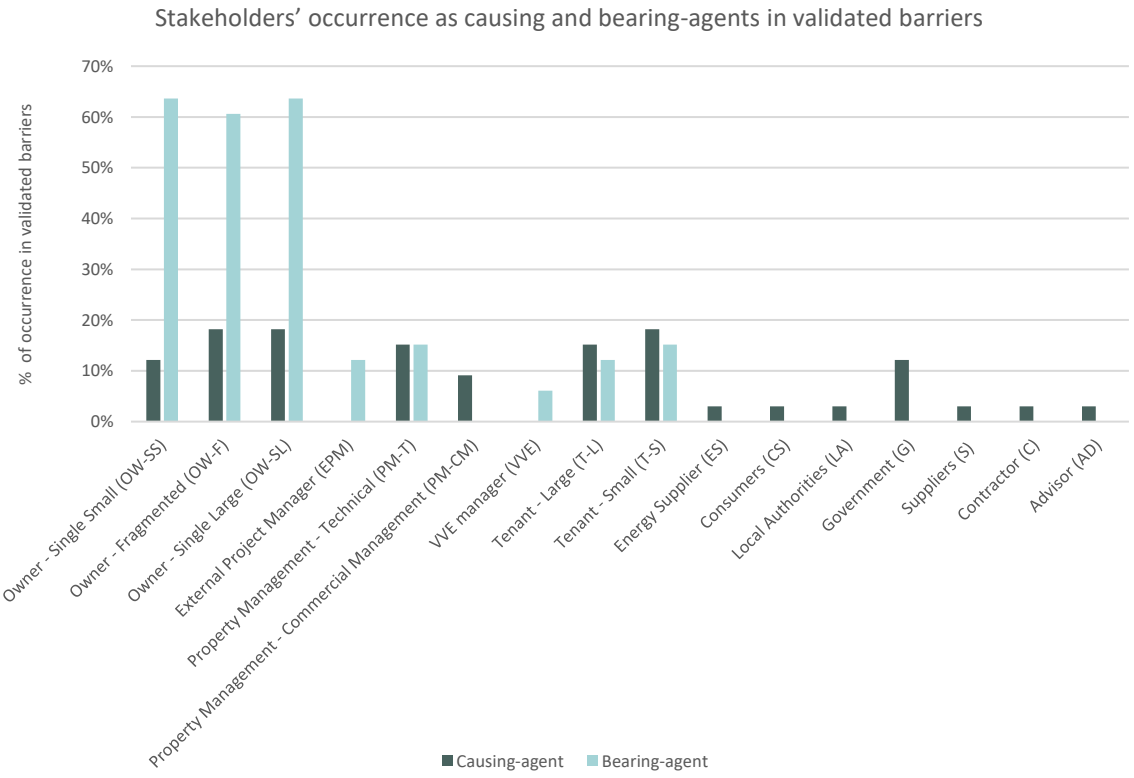


Figure 32. Stakeholders' occurrence as causing and bearing-agents in validated barriers. (Author)

Third, the analysis revealed that supply-side stakeholders, apart from retrofit project manager, were identified as cause agents only (Figure 32). This puts owners in a disadvantageous position as they have limited leverage to create solutions to overcome the barriers. Differently, the government, as the causing-agent with the highest rate of occurrence in this group, was identified as the stakeholder with the highest external influence given their ability to implement policies and regulations that can effectively address barriers at a broader scale.

Finally, by correlating the most occurrent validated barriers per stage (Figure 31) within the causal relationships analysis, the most urgent barriers in which owners must be focusing on are the ones highlighted with the green star on Table 20.

Table 20. Causal relationships of validated barriers in the EER decision-making process. (Author)

		Stakeholder			Identified solution	
Stage	**Barrier**	**Cause**	**Bearing**	**Explanation**	**Existing Solution**	**Who**
1	**Economic - Investment costs** ★	OW-SL	EPM	EEM not included in specification requirements		
		OW-SL	OW-SL, PM-TM	Contribute to outcomes and revenues on portfolio level, Fitness within asset budget		
2	**Behavioural - Inertia** ★	T-L, T-S, CS	OW	Unwillingness to change user behaviours		
		M	OW-SS	Sustainability interest not reflected on internal processes and consideration for actual decision-making		
	Behavioural - Intervention out of scope	EX	OW, VVE	Inside of shops out of scope	Tenant advisory project	OW, PM-CM
	Behavioural - Lack of sharing the objectives ★	OW, CM	T-L, T-S	ROI vs. climate comfort		
		T-L	OW	Clashing sustainability objectives and strategies with large tenants		
		T-S	OW	Lack of clear sustainability objectives with small tenants	Tenant advisory project	OW, PM-CM
		OW-F	VVE	Difficulty in persuading and communicating plans to all types of owners		
	Behavioural - Other priorities	PM-CM	OW	Lack of time for implementing green lease addendum		
		T-L, T-S	OW	Shops are focused on sales over modifying tenant and consumer behaviours		
	Economic - Investment costs	OW-F	VVE	Investment costs are not doable for some owners		
		T-S	OW	Opex concerns when splitting costs		
	Information - Lack of access to information on energy consumption	PM-TM, PM-CM	OW	Lack of data collection on energy performance assessment of common areas	Contract advisors for building assessments / Implementing building data systems	PM
		T-L, T-S	OW	Lack of access to data on energy consumption from shops	Implement green leases	PM
	Information - Lack of information on costs and benefits	T-S	OW	Lack of knowledge on energy efficiency measures, costs, and benefits from small tenants	Tenant advisory project	OW, PM-CM
	Legal - Limitation with governmental regulations	G	OW	Lack of regulations on reporting energy consumption from tenants		
		G	OW	Restrictions for owners to supply energy to shops		
	Legal - Limitation with internal regulations	PM-CM	T-L, T-S	Store measures in conflict with shopping centre deeds		
	Organisational - Split incentives ★	T-L, T-S	PM-TM, OW, EPM	Measures not generating revenues for owner	Split costs. (Investment, maintenance, services)	OW, T
3	**Behavioural - Imperfect evaluation criteria**	OW-SS	OW-SS	Difficulty in calculating ROI from savings in Opex		
	Economic - Element lifecycle conflict ★	PM-TM, OW	EPM	Conflict with existing element's lifespan and Capex value capturing period	Future planning for higher specifications, spread time for implementing renovation	OW
	Economic - Investment costs ★	OW	EPM, PM-TM	Conflict with maintenance plan and Capex of the building		
	Economic - External risks	EX	OW	Increased market prices affect the EER planning and budget alignment		
	Legal - Limitation with governmental regulations ★	G	T-S	Subsidies unfit for small energy consumers		
	Organisational - Lack of time	PM, OW	OW	Lack of time due to other functions to the role	Implement ESG specific functions in the organisation	OW
	Technology - Existing technical challenge ★	PM-TM, EPM	OW	Difficulty with fitness of measure within existing building structure and systems		
		ES	PM-TM	Difficulty in matching measures with grid capacity		
4	**Competences - Difficulty in gathering external competences**	C, AD	OW, EPM, PM-TM	Difficulty in finding reliable advisors and contractors in the current market.		
	Economic - Intervention related risks	EPM, PM-TM	T-L, T-S	Conflict with user comfort and overall happiness		
		EPM, PM-TM	T-L, T-S, OW	Uncertainty over risks of overschedule and costs	Open and constant communication with tenants and owners.	EPM, PM-CM
	Economic - Investment costs	G	OW	Increasing costs to comply with all new regulations		
	Technology - Technology not available	S	OW	Material and element shortage in the market		
5	-					

Stakeholders conventions

OW-SS	Owner - Single small REI	**PM-T**	Technical management	**T-S**	Tenant small	**G**	Government
OW-F	Owner - Fragmented	**PM-CM**	Centre management	**ES**	Energy supplier	**S**	Suppliers
OW-SL	Owner - Single large fund	**VVE**	Owners association	**CS**	Consumers	**SA**	Sustainability Advisor
RPM	Retrofit project manager	**T-L**	Tenant large	**LA**	Local Authorities	**C**	Contractor

Other conventions

Owner as causing-agent

Owner as bearing-agent

★ Validated barrier with occurrence ≥ 5

4.6 Main Findings takeaways

This section summarises the main findings from the empirical part of the research. They will be used as input to reflect in the discussion section of this thesis and will assist to develop the list of recommendations for owners to improve the EER decision-making process for shopping centres, the main output of this research.

EER decision-making process takeaways (SQ2)

01 The scope of the renovation has an impact over the stages of the process. For instance, the persuasion stage only occurs at the level of in-store EER. For common areas, no persuasion is needed as the retrofit is seen as an assignment and not an idea that has to be weighed among stakeholders.

02 The type of ownership also has an impact over the process. For example, a difference was observed between shopping centres with fragment ownership type versus those with single ownership: the merger between the persuasion and the decision stages. As decision-making in these centres is done gradually, persuading and developing plans step-by-step not only guarantees owners' attitude alignment but also ensures that resources in terms of time and costs are optimised.

03 Knowledge on inefficiencies and opportunities is required at the beginning of the process to be able to take informed decisions from a strategic level.

Stakeholder barriers takeaways (SQ3)

01 Most barriers were found within the persuasion and decision stage. This is in line with EER being considered an assignment from a higher management layer.

02 Findings on stakeholders' behaviours brought to light a new barrier type: the legal category with *limitation with governmental regulations* and *limitation with internal SC regulations as validated legal subtypes*. Moreover, other barriers classified within pre-existing categories were validated for this building typology. These included *Intervention out of scope*, *Element lifecycle conflict*, *Lack of access to information on energy consumption* and *Existing technical challenge*.

04 Among all three case studies and expert interview, investment costs and limitations with governmental regulations were the two most named barriers. *Investment costs* is the only barrier found across all stages in the process, highlighting the intrinsic business-driven nature of EER within shopping centres. Moreover, it was surprising to find that *limitations with governmental regulations* is perceived as a barrier across different stakeholders because it is contradicting with the government's goal to steer the energy transition of the entire building stock.

05 It was also interesting to find a differentiation between tenant types. Large tenants are given more attention by owners as they have higher CO_2 emissions and energy consumption. Moreover, this group also has a higher level of awareness towards energy efficiency and often have their own ESG goals. Although this is seen as a positive

aspect towards EER, it can sometimes play against the plans as there is more layering in decision-making, as well as some conflicting goals between their company's and the owner's ESG strategy. On the other hand, small tenants might require a different approach and more time to engage them in EER inside their shops as more knowledge needs to be shared. However, they take decisions quicker as they have less layering in their decision-making.

06 Solutions found in the case studies confirm that a lot of attention is being given to tenants' engagement in EER inside their shops. This is a good start, although results are not yet measurable.

07 It was interesting to find that a barrier can have a different meaning depending on the stage it occurs, and which actor causes and bears it.

08 The complexity of the governance structure in a shopping centre is not solely determined by the number of stakeholders involved, but also It also encompasses the relationship between the building under study and its relationship to a broader real estate portfolio. Specifically, owners who have real estate funds are faced with not only a greater number of management layers but also additional levels at which the building operates, including the portfolio and asset levels, which adds a layer of complexity to the decision-making process.

Owners' possible recommendations (MQ)

01 Establish a clear sustainability strategy that incorporates specific energy efficiency targets, especially for shopping centres with a fragment ownership type. Moreover, owners in this ownership type might also benefit from having a sustainability advisor as an extra stakeholder to guide the process.

02 Decentralise decision-making by implementing participatory mechanisms for other stakeholders to transition from task-driven actors to active participants in the process to enrich the process from other viewpoints and specialised knowledge.

03 Invest in building data systems that allow to perform energy benchmarking for each asset and set out better informed assignments. Moreover, the interoperability of this system across inter-organisations involved in this process, such as that pertaining to the property management team, is necessary to guarantee project success.

04 Explore solutions to overcome barriers related to the unequal access to renewable energy sources for all types of tenants.

05 DISCUSSION

In this chapter, the interpretation of the findings from the empirical data analysis is thoroughly examined in relation to the theoretical background. The section begins by considering the generalization of the findings, followed by an exploration and reflection of four discussion themes that will serve to answer the research questions.

CONTENT

5.1 Generalisation of the findings

Before introducing the discussion themes, it is important to reflect on the extent to which the listed findings can be generalised.

While statistical generalizations cannot be drawn from the findings, they provide insights and allow to convey a theory into what can be expected in cases with similar variables, which Yin (2009) refers to as analytical generalization. During this research, analytical generalisability was improved from two fronts. First, the selection criteria for the case studies followed a systematic approach that aimed to capture the typical characteristics of the Dutch shopping centre building stock, rather than relying solely on convenience. Variables such as opening year, size, form, and function were chosen based on their representativeness in the Dutch shopping centre building stock, which explains why these variables remained constant across most case studies. Second, Yin (2009) also argued that the reliability of generalizations can be enhanced by conducting research across three or more cases with diverse circumstances. Therefore, this research addressed the different circumstances requirement by selecting case studies with a different independent variable -Ownership type- as the perspectives of the owners were of primary importance of this study, and identifying differences stemming from this variable was crucial. The comparative analysis across cases allowed to map where the process converged and diverged depending on this variable.

Furthermore, the cases demonstrated a complementary relationship in two distinct aspects: the decision-making stage and the types of packages utilized during the renovation process. Firstly, this complementarity facilitated the mapping of the entire process from a comprehensive perspective, as not all cases had concluded with the execution of the Energy Efficiency Retrofit (EER) process. Secondly, it was observed that the implementation of energy-related measures varied across different retrofit scales. The identification of these scales, which were found to be partially associated with the packages outlined in the literature review, enabled a holistic examination of the process and behaviour by studying cases featuring diverse retrofit packages (see section 5.2.2).

5.2 EERs Decision-making process in Shopping centres

During the literature review, this study compiled an Energy Efficiency Retrofit (EER) decision-making process from various sources, with documented assumptions of how this process takes place in retail buildings, specifically in shopping centres. The proposed framework identified Rogers' five innovation-decision process stages (Rogers, 1983) and merged it with Liang et. Al (2016), Ma et al. (2012), and Cagno et al. (2013) retrofit phases and activities required to undergo a green retrofit process. The resulting process consisted of five stages: (1) a knowledge stage in which the innovation or need to implement the retrofit was identified; (2) a persuasion stage in which knowledge on inefficiencies and opportunities needed to be collected to take informed decisions about goals and targets, whilst aligning the attitudes of the different stakeholders involved towards those goals; (3) a decision stage in which designs and plans were developed, and their adequacy was judged in terms of risks, costs, and benefits; (4) an implementation stage in which the works took place, and the retrofit's goals were inspected and validated; and finally, (5) a confirmation stage, which implied the regular operation and maintenance of the building, performing energy commissioning and keeping track that goals continued to be met until a new need was identified.

As Rogers (1983) suggested, the proposed framework adopted a gradual step-by-step process with specific decision moments in which uncertainty was reduced over time, and stakeholders could decide at each stage whether or not continue with the process. However, in practice, this study found that the biggest difference for EERs in shopping centres lies in the fact that the decision to implement an EER is set as an **assignment** from the owner at stage 1, impacting the process in three main areas. First (1), unlike the theoretical framework, the identified decision-making process has no decision nodes that lead the project to an end, except for those concerning in-shop EE scope. Therefore, stakeholders focus their effort on how to make it happen rather than if it should be done. This sets it aside from the Triple-A project where each step in the homeowner renovation decision-making process for implementing energy-saving technologies represents a moment in which they can quit adopting the technology (Mlecnik et al., 2018). In shopping centres, quitting the assignment is not questioned but rather the focus lies in making the plans, negotiating and defining how to make it happen.

Second (2), depending on the ownership type, persuasion and decision stages are occur at the same time. This is true in shopping centres with a fragmented ownership type where owners' attitudes and decisions are taken in gradual step-by-step process as discussed in section 4.4. Third (2), contrary to the suggestion put forth by Liang et al. (2016) and Cagno et al. (2013), gathering knowledge on inefficiencies and opportunities through data collection on energy performance should be done prior to forming a will or initial intention to retrofit. This is because, during the initial knowledge stage, owners require this knowledge to make informed decisions at a wider strategic portfolio-level.

In addition to the previous points, this research revealed a predominantly linear decision-making process, with a small feedback loop observed during the confirmation stage. This loop occurs when the regular operation and maintenance of a building lead to the identification of new needs, initiating a new energy-efficient retrofit (EER) process. However, in comparison to existing literature, a closed loop system similar to the one described in the Triple-A project (Mlecnik et al., 2018) could potentially be established at a portfolio level within the same organization. In this scenario, lessons learned from one EER process could serve as examples for other assets in the portfolio. Nevertheless, further investigation is required to explore collaboration and encouragement among large retail investors in this context.

5.2.1 Effects of the leasing structure on EERs decision-making process

The leasing structure of retail spaces in the Netherlands, where stores are rented on a shell state, determines whether the **scope** of the retrofit is conducted in common areas or inside individual shops. The literature study suggested that this scope differentiation can pose a challenge and restrict a holistic approach towards achieving energy efficiency goals (Haase, Woods, et al., 2015). This was confirmed across the case-studies and leads to reflect on the role of retail lease structures play in EER, suggesting that a different type of leasing structure could provide greater control over EE measures inside the stores.

5.2.2 Scale of EE measures vs. retrofit packages

The scale of EE measures also allowed to categorise the current state of EERs of shopping centres in the Netherlands. This scale was first acknowledged during the literature study of this research, where three different types of energy retrofit packages were proposed according to the U.S. Department of Energy guidelines for Energy Retrofit for Retail Buildings (2011) and the Advanced Energy Retrofit Guide for Grocery stores (2013), namely *(1) Existing building commissioning (EBCx)*, *(2) Standard retrofit*, and *(3) Deep retrofit*. While a comparison of the target energy savings percentage per package was not feasible, and measures towards refrigeration fell out of the scope of the studied retrofits, some similarities within the scale of each package were identified across the cases.

For instance, *Existing building commissioning (EBCx)*, referring to energy-related measures associated to the operation and maintenance of the building that represent minimal risks and small capital requirements for the owners, were found to be already implemented in practice in the building's specific maintenance plan as this plan sets the roadmap by which the building operation, maintenance, and overall performance is optimised. Therefore, it is possible to state that, based on the case studies analysis, this package is already being implemented without greater difficulty.

Similarly, the *standard package* from the literature*,* accounting for component-level measures that do not require whole building system replacements, a design process, and nor result in disruptions in the SC operation, was also identified as measures that are being incorporated in the building's maintenance plan by the technical management team owner of the SC (e.g. adding smart meters, lighting sensors, etc).

Finally, the *deep retrofit* package was also found in practice as a type of EER. However, it was found to be always linked to a larger aesthetic renovation that tackles first other shopping centre inefficiencies, such as solving vacancy issues, adapting to new consumer demands, or upgrading outdated and unattractive infrastructures. Therefore, EE measures within this type of retrofit are not representative of the energy efficiency impact in the centre. For instance, one SC *deep retrofit* can involve only replacing lighting fixtures, whilst another centre can choose to implement various measures at the same time (e.g. changing lighting fixtures, adding skylights, replacing wall insulation, upgrading windows, etc).

5.3 Barriers in the EERs decision-making process

The proposed taxonomy of barriers for empirical investigation of energy-efficiency technologies by Cagno et al. (2013) suggested seven (7) different barriers typologies under which internal and external barriers would have been able to be investigated. However, this research's findings suggest that Legal barriers require their own category as *Limitations with governmental regulations* and *Limitations with internal regulations* could not be linked to any of the validated barriers from practice. Furthermore, this comparison also brought light to sector-specific barriers such as *Lack of access to information of energy consumption*, *Intervention out of scope*, *Existing technical challenge*, and *Element lifecycle conflict* that respond to the specific characteristics of leased and communal areas, ownership types, business nature, and building complexity of shopping centres and, possibly,

the retail sector. Table 21 depicts the comparison between barriers found in literature versus new barriers found in practice for shopping centres.

Table 21. Comparison of barriers taxonomy from Cagno et al. (2013) and barriers found in practice for shopping centres. (Author)

Taxonomy	Barrier	Literature	Practice-SC
Technology-related barriers	Technology not adequate	x	
	Technology not available	x	x
	Existing Technical challenge		x
Information barriers	Lack of information on costs and benefits	x	x
	Unclear information by technology suppliers	x	
	Trustworthiness of the information source	x	
	Information issues on energy contracts	x	
	Lack of access to information of energy consumption		x
Economic	Low capital availability	x	
	Investment costs	x	x
	Hidden costs	x	
	Intervention-related risks	x	x
	External risks	x	x
	Interventions not sufficiently profitable	x	
	Element lifecycle conflict		x
Behavioural	Lack of interest in energy-efficiency interventions	x	
	Other priorities	x	x
	Inertia (resistance to change)	x	x
	Imperfect evaluation criteria	x	x
	Lack of sharing the objectives	x	x
	Intervention out of scope		x
Organisational	Low status of energy efficiency	x	
	Split incentives	x	x
	Complex decision-chain	x	
	Lack of time	x	x
	Lack of internal control	x	
Competences related	Identifying the inefficiencies	x	
	Identifying the opportunities	x	
	Implementing the interventions	x	
	Difficulty in gathering external competences	x	x
Awareness	Lack of awareness or ignorance	x	x
Legal	**Limitation with governmental regulations**		x
	Limitation with internal regulations		x

New barrier

5.4 Influence of the governance system on the EER decision-making process

5.4.1 Governance complexity of shopping centres

In terms of governance, the literature review conducted for this research highlighted the intricate governance structure of shopping centres due to the involvement of multiple stakeholders such as owners, asset managers, centre managers, owners' association, tenants, among others (refer to Table 6). Liang et al. (2016), citing Ma et al., emphasised that decision-making processes for EER in multi-stakeholder governance structures can be challenging as they rely on the achievement of consensus between the parties involved. Thus, this research included a shopping centre with a fragmented ownership structure in its case study mix, recognizing that the greater number of owners and roles posed greater complexity in decision-making.

However, this research revealed that complexity extends beyond the number of owners involved, resulting in lengthier decision-making processes. It also encompasses the relationship between the building under study and its relationship to a broader real estate portfolio. The case studies indicate that buildings facing this circumstance encounter significant challenges due to the following reasons.

First, assets in these organizations must align with portfolio-level objectives, meaning that the sustainability of energy efficiency measures is not solely determined by the building's needs but also by their impact on overall portfolio performance. Second, the number of stakeholders with whom owners must engage during an EER process multiplies across assets within the portfolio. This is significant not only because owners must sometimes deal with different property management teams across their portfolio, but also because owners frequently establish supplementary teams to manage renovations in an effort to ease the workload of property managers. However, it is crucial to acknowledge that this approach can place a significant burden on owners in terms of hidden costs and the inability to leverage the specialized on-site knowledge possessed by the property management team for a successful EER process.

Third, there is a potential for duplicated roles within the layered management system. For example, the analysed case studies identified multiple sustainability advisors operating across various management layers and decision-making stages. In case study A, at least three (3) sustainability advisors were involved: one at the portfolio level, one within the property management team focusing on regulations and tenant advisory programs, and another providing technical expertise to the technical management team. The adequacy of having multiple sustainability advisors in EER decision-making is debatable, especially when communication among them is lacking. This can lead to redundant efforts, conflicting solutions, and suboptimal outcomes.

Fourth, existing energy-related regulations for retail buildings primarily target larger companies or funds that typically own large portfolios. As a result, these owners face challenges in understanding and complying with numerous existing regulations. Although this challenge was found as a barrier (see section 4.3.4), these regulations have also prompted the establishment of clearer environmental, social, and governance (ESG) objectives. Thus, despite the obstacles, these shopping centres benefit from having a more structured strategy to achieve sustainability objectives.

5.4.2 Enhancement in governance structure: stakeholder management

Building governance structures should prioritize stakeholder management and engagement to address the complexity arising from multiple owners and stakeholders, especially in the context of real estate portfolios. To optimize these processes, the following actions are recommended.

First, the assignment nature of the EER decision-making process found in this research indicate a centralised decision-making process with little participation from key stakeholders such as the property management team and tenants. Therefore, the governance structure of the centre should aim to decentralise decisions by promoting the involvement of the property management team and tenants in these processes.

> *Involvement of property management:* as holders of expert knowledge of the building's technical systems, this team has the capacity to provide valuable input for the planning of the sustainability strategy and the EER assignment definition. Furthermore, owners could

find valuable hiring project management services from this team is it already holds knowledge on needs and a close relationship with tenants, employees, and consumers, all key stakeholders that need to be kept satisfied and that are usually burdened by deep renovations.

Involvement of tenants: The research findings demonstrate that tenants' participation in Energy Efficiency Renovation (EER) activities is dependent upon the specific scope of the renovation. In the case of inside-shop EER scope decisions, tenants are perceived by owners as active participants, whereas their involvement is limited to being kept informed in the context of EER initiatives focused on common areas. Although this difference is attributed to the leasing structure, a governance structure that considers tenant's participation at both scopes could promote this stakeholder engagement and commitment to foster a better collaborative approach towards the attainment of a holistic EER strategy.

Second, an optimised governance structure should foster collaboration across different property management teams. As large real estate portfolios involve more than one property management team, owners should enable information exchange across organisations and transfer learned lessons about EER processes across assets in the portfolio.

Third, shopping centre's governance structure could benefit from streamlining sustainability advisors. While some centres lacked this stakeholder, others had too many. Shopping centres with fragmented ownership structures could benefit from having a dedicated sustainability advisor to develop and oversee the implementation of the sustainability strategy. Differently, shopping centres owned by institutional investors should revise the number of existing sustainability advisors at various levels to avoid duplicated efforts and conflicted solutions.

5.4.3 Stakeholders' role in EERs in shopping centres

While identifying precise solutions for barriers falls beyond the scope of this study, this section examines where could different stakeholders address their efforts and discusses identified patterns. Table 22 links each barrier found per stage to three different stakeholders that could bring forward solutions to overcome them. The selected stakeholders - owners, the property management team, and public authorities - were chosen due to their influential role in decision-making. While it is distinguishable that owners operate at a portfolio/strategic level, the property management team at a building operational level, and public authorities at a place level, collaboration and joint efforts could facilitate steering solutions to existing barriers.

Role of asset owners in the EER decision-making process

The role of owners in EER decision-making is crucial, as highlighted in previous literature. According to Salm et al. (2016), owners are the most interested actor in energy efficiency, although their concerns revolve around financial factors such as return on investment, net present value, and minimum holding period of properties. This study's findings have corroborated this statement for single institutional investors and small real estate redevelopers. Consequently, it is not surprising that

investment costs was the only validated barrier found at all stages. However, it was observed that owners of shopping centres with fragment ownership lack a clear interest in energy efficiency or other sustainability improvements, unlike single institutional investors and small real estate redevelopers who have well-structured long-term objectives in this regard. Therefore, it can be inferred that the type of shopping centre ownership structure impacts their role in EER. However, this could be changed by defining of a cohesive and integrative sustainability strategy that could support overcoming economic barriers by setting clear and attainable targets on how to reach them on the short, middle and long term.

As ultimate decision-makers, owners possess the highest level of influence in driving solutions to overcome barriers. This is particularly applicable to stages 1-3, as exemplified in Table 17, where the causative agents are either the owners themselves or internal stakeholders on the demand side. However, effective partnership with the property management team is essential to overcome numerous hurdles and achieve energy efficiency goals, as indicated in Table 17. The hierarchical governance structure of shopping centres presents challenges that require improved collaborative mechanisms. Thus, owners should strive to enhance the governance structure by decentralizing decision-making, fostering collaboration among property management teams, and streamlining sustainability advisors, as detailed in Section 5.4.2.

Furthermore, owners can play a role in overcoming barriers by investing in centralized building data systems to improve data collection, which can facilitate energy management and provide input for more specific and informed assignments at the outset of the EER process. Their involvement is also valuable in addressing tenant-related barriers, such as *lack of sharing the objectives* and *other priorities*. While some programs are already in motion, it is crucial to increase awareness of the importance of developing tailored solutions to address individual barriers, particularly for small tenants.

Table 22. Barriers linked to stakeholders that can steer solutions. (Author).

Stage	Barrier	Explanation	Existing Solution	Owner	PM	Policy makers
1	**Economic - Investment costs**	EEM not included in specification requirements		X		
		Contribute to outcomes and revenues on portfolio level, Fitness within asset budget (Green Capex)		X		
2	**Behavioural - Inertia**	Unwillingness to change user behaviours			x	
		Sustainability interest not reflected on internal processes and consideration for actual decision-making				x
	Behavioural - Intervention out of scope	Inside of shops out of scope	Yes	x	x	
	Behavioural - Lack of sharing the objectives	ROI vs. climate comfort		x		
		Clashing sustainability objectives and strategies with large tenants		x		
		Lack of clear sustainability objectives with small tenants	Yes	x	x	
		Difficulty in persuading and communicating plans to all types of owners			x	
	Behavioural - Other priorities	Lack of time for implementing green lease addendum		x	x	
		Shops are focused on sales over modifying tenant and consumer behaviours				x
	Economic - Investment costs	Investment costs are not doable for some owners				x
		Opex concerns when splitting costs		x	x	
	Information - Lack of access to information on energy consumption	Lack of data collection on energy performance assessment of common areas	Yes	x	x	
		Lack of access to data on energy consumption from shops	Yes	x	x	
	Information - Lack of information on costs and benefits	Lack of knowledge on energy efficiency measures, costs, and benefits from small tenants	Yes	x	x	
	Legal - Limitation with governmental regulations	Lack of regulations on reporting energy consumption from tenants				x
		Restrictions for owners to supply energy to shops				x
	Legal - Limitation with internal regulations	Store measures in conflict with shopping centre deeds			x	
	Organisational - Split incentives	Measures not generating revenues for owner	Yes	x		
3	**Behavioural - Imperfect evaluation criteria**	Difficulty in calculating ROI from savings in Opex		x		
	Economic - Element lifecycle conflict	Conflict with existing element's lifespan and Capex value capturing period	Yes	x	x	
	Economic - Investment costs	Conflict with maintenance plan and Capex of the building		x	x	
	Economic - External risks	Increased market prices affect the EER planning and budget alignment				
	Legal - Limitation with governmental regulations	Subsidies unfit for small energy consumers				x
	Organisational - Lack of time	Lack of time due to other functions to the role	Yes	x	x	
	Technology - Existing technical challenge	Difficulty with fitness of measure within existing building structure and systems		x	x	
		Difficulty in matching measures with grid capacity			x	x
4	**Competences - Difficulty in gathering external competences**	Difficulty in finding reliable advisors and contractors in the current market.				
	Economic - Intervention related risks	Conflict with user comfort and overall happiness			x	
		Uncertainty over risks of overschedule and costs	Yes		x	
	Economic - Investment costs	Increasing costs to comply with all new regulations				x
	Technology - Technology not available	Material and element shortage in the market				
5	-					

Role of property managers in the EER decision-making process

The property management team plays an essential role in the decision-making processes for energy efficiency retrofits (EER). It does not only possess the on-site knowledge about the building's operation and specific needs, but also drives the relationship between owners and tenants. Section 5.1, identified that technical managers, as part of the property management team, are actively involved in implementing energy-efficient measures within the first two types of energy-efficiency packages described in the literature, namely Existing Building Commissioning (EBCx) and Standard Retrofit (National Renewable Energy Laboratory, 2013; Pacific Northwest National Laboratory & PECI, 2011). Through careful planning in the maintenance plan, they continuously strive to optimize the building's operation. While their primary focus is on the operational aspects of the building, Table 22 highlights other barriers that could be overcome with their support and in collaboration with the owner(s) throughout all stages of the process. Possible solutions to these barriers are:

Stage 1

- Property managers' early involvement as consultants in the development of the shopping centre's strategic sustainability strategy helps overcome investment cost barriers. Their expertise is crucial in addressing conflicting costs, such as energy measures versus maintenance plans, element lifecycle, and technical challenges. Addressing these barriers at an early stage facilitates a more streamlined decision-making process.
- Property managers can offer sustainability strategy development services to owners of shopping centres, particularly those owned by small real estate investors or with fragmented ownership structures. These centres often lack a clear roadmap for future sustainability goals, presenting an opportunity for property managers to provide additional support.
- Owners are seeking to assume responsibility for building data collection to exert greater control over their portfolio performance. While centralizing data can enhance portfolio-level decision-making, the potential introduction of new barriers by disengaging the property management team from this task remains uncertain. Therefore, property managers can coordinate and cooperate with owners on the centralisation of building data systems to ensure the interoperability of new systems, enabling effective data utilization and sharing among all relevant organizations.

Stage 2

- Property managers can exploit their existing on-site relationships with tenants to drive holistic energy efficiency renovations. By engaging all types of tenants, property managers can create and implement programs to enhance their participation in both common and inside-shop area renovations.

Stage 3

- Owners face challenges in gathering external competencies due to perceived market saturation of advisors and service providers. Property managers can seize this opportunity by offering in-house design and development services to carry out deep retrofits. Their knowledge of the building and proximity to tenants can facilitate information exchange and negotiations between owners and tenants.

Stage 4

- Property managers play a crucial role in overseeing user comfort and satisfaction during deep retrofits. Their familiarity with stakeholders can help mitigate conflicts and address intervention-related barriers that may cause discomfort to tenants and impact client satisfaction.

Stage 5

- Property managers can promote end-user engagement towards sustainability by addressing inertia and change aversion among employees, consumers, and shopkeepers. Implementing programs that lead stakeholders towards common sustainable goals can help overcome barriers to energy efficiency.
- Collaboration among property management teams within the same portfolio is essential. Open communication channels facilitate the transferability of learned lessons and good practices, optimizing the EER processes.

Role of policymakers in the EER decision-making process

Policymakers play a crucial role in addressing barriers that extend beyond the control of owners and property managers and promoting energy-efficient renovations (EERs) through the development of policy incentives. The initial literature review identified multiple European and national initiatives and regulations that are beginning to guide the energy transition of the existing retail building stock. However, this research identified two key areas that require attention and improvement in this area to facilitate the EER decision-making process.

Firstly, owners of shops subject to these regulations encounter challenges in integrating the requirements of multiple initiatives and regulations, as well as keeping up with the pace of new regulations. Although the specifics of these policies are not outlined in this research, the diversity of regulations raises concerns about potential additional burdens imposed on shopping centre owners. To address this issue, policymakers should prioritize the streamlining and integration of existing regulations. By harmonizing requirements and ensuring their compatibility, policymakers can alleviate the burden on owners and facilitate compliance efforts.

"(…) there are several assessments and policies that are sometimes challenging to combine. For example, we have BREEAM, energy label, GRESB as the benchmark for investors… Although they have a lot of shared goals, they can be a little bit different as well".
(Shopping centre owner)

Secondly, it is observed that existing regulations, such as the SFDR and CSRD, and subsidies often prioritize larger energy consumers or market participants, inadvertently overlooking the specific needs of small owners and tenants. This issue is particularly pronounced in shopping centres with fragmented ownership structures. Policymakers should develop targeted incentives and support mechanisms specifically tailored to this segment of stakeholders. By offering tailored assistance and resources, policymakers can enable small owners and tenants to overcome barriers and actively engage in energy efficiency initiatives.

5.5 Implications for future scenarios

5.5.1 Net-zero shopping centres

Addressing the energy transition of shopping centres with more ambitious goals, such as achieving net zero-shopping centres, may induce technology not adequate and Inertia type barriers that will require additional efforts that go beyond the building's boundaries and current governance structures. This is because to meet these objectives more renewable energy supply and efforts to modify consumer behaviour to reduce energy demand will be needed. These efforts will require active collaboration among owners, energy suppliers, distribution net managers, local authorities, and end-users to carry them down.

Shopping centre owners play a crucial role in collaborating with energy suppliers to ensure a reliable and sustainable energy supply that aligns with their net-zero objectives. This collaboration may involve procuring renewable energy from suppliers or implementing on-site renewable energy generation systems such as solar panels. Furthermore, distribution net managers are also key players in this collaboration as they are responsible for managing the distribution networks and ensuring the smooth integration of renewable energy sources. They need to work closely with both owners and energy suppliers to assess the capacity of the grid and make necessary adjustments to accommodate the increased renewable energy generation from shopping centres and provide energy flexible systems to support it. Finally, local authorities also have a significant role to play in incentivizing these collaborative partnerships and implementing programs to encourage favourable end-user behaviour, such as promoting the practice of operating with closed doors. Their active involvement is crucial in creating an enabling environment and supporting the successful implementation of net-zero initiatives in shopping centres.

This collaboration among owners, energy suppliers, distribution net managers, and local authorities will introduce an additional urban/municipal level into the existing portfolio and building levels of governance. This requires a careful consideration of the alignment among internal and external stakeholders from stage 2 of the energy efficiency retrofit (EER) process to ensure a successful transition towards net-zero shopping centres.

5.5.2 AI integration towards the energy transition of shopping centres

Embracing AI technologies and smart building solutions holds immense potential in steering the energy transition of the retail sector. By leveraging algorithms, stakeholders can gain valuable insights, optimize energy usage, and make data-driven decisions. Smart building systems enable real-time monitoring, automation, and predictive analytics, further enhancing energy efficiency decision-making. Investing in AI energy management and integrating smart building technologies can pave the way for a more sustainable and energy-efficient retail sector.

However, the adoption of AI integration and smart building solutions may bring new barriers that need to be addressed. These include concerns related to data privacy and security, interoperability issues among different systems and devices, and the need of new roles in the governance system for skilled personnel to manage and interpret the data generated by AI algorithms. Despite these challenges, embracing AI technologies and smart building solutions offers significant potential to assist in this decision-making process, enhancing energy efficiency, and ultimately driving the successful energy transition of shopping centres.

06 CONCLUSION

This research aimed to map EERs decision-making process of shopping centres in the Netherlands and reveal different stakeholders' behaviours within that process, finding the interrelationships between the different parties involved and giving light on the areas that need to be addressed in other to guarantee a smoother process. To achieve it, the following main research question was formulated: ***"How can owners support a better decision-making process to steer EERs of shopping centres?".***

Through a multi-case study design and qualitative data collection, the research focused on addressing three main areas to answer the main research question. These involved first, identifying the state-of-the-art of shopping centres EER. Second, mapping how the decision-making process for EER in shopping centres is taking place. And lastly, identifying the barriers encountered in the EER process and the interrelationships between these barriers and the various stakeholders involved. The subsequent sections provide the conclusion to each sub-question and culminate in a comprehensive response to the main research question.

CONTENT

6.1 SQ1: What is the state-of-the-art of energy efficiency retrofit of shopping centres?

This question aimed to establish a comprehensive background concerning relevant characteristics of shopping centres, such as their governance system, operational characteristics, and preferred retrofit measures. As discussed in section 2.1-2.3, such factors were thought not only to constitute influential aspects in an EER decision-making process, but also provided the basis for the case studies criteria for shopping centres in the Netherlands, which enabled a greater relevance and generalisation of the findings.

The study highlights the shift in awareness towards energy efficiency in shopping centres and the need for intentional implementation of energy-efficient renovations (EERs). Previously, energy efficiency measures were often implemented coincidentally rather than intentionally. However, with the global and European focus on achieving Net Zero values in buildings, there is now a growing emphasis on EERs, coinciding with the need to renovate the existing building stock, as more than half of the shopping centres are over 30 years old. While some EE measures are already being integrated in the building's maintenance plan, in terms of retrofits at a maintenance or component level, deep EERs cannot be considered isolated from aesthetical renovations. Moreover, the cases evidenced a preference to implement solar panels as renewable energy sources to power primarily common areas.

This research also identified a significant division between EER in common and inside-shop areas. Although this was found linked to the preferred leasing structure of shopping centres in the Netherlands, it highlights an intrinsic difficulty in implementing holistic renovations that target both common and shop areas.

In terms of ownership structure, this research indicates that ownership type currently influences the EER process. While shopping centres owned by single institutional investors were found to be already active in implementing measures to update their assets in compliance with European and national regulations, those with fragmented ownership structures are lagging.

Finally, in terms of actors involved in the process, this research emphasizes the key role of owners, property managers, and policymakers in the transition of the existing shopping centre building stock. However, the success of these renovations relies on adequate collaboration among these actors. Further, stakeholder engagement from tenants is especially crucial to achieve integral renovations at the whole-building level.

6.2 SQ2: How is the EERs' decision-making process of shopping centres taking place?

This question aimed to map how is the EERs of shopping centres in the Netherlands taking place. To address it, the theoretical framework with documented assumptions of how this process took place in literature (Section 2.4) was contrasted with qualitative empirical data from the case studies. Although this process is explained in detail in section 4.5.2, in hindsight, it is possible to map it within Rogers' Innovation-decision phases (1983). However, it was found that in contrast to energy efficiency renovations in the residential sector, where homeowners have the option to opt-out at

any stage, the **assignment** nature of renovations in the retail sector shifts decisions from determining *if* the renovation should take place to plan *how* it will be implemented. This particularity also demands the existence of robust building data systems to support knowledge of inefficiencies and opportunities, a clear sustainability strategy, along with shopping centre performance indicators at the beginning of the process.

Furthermore, it is also important to recognise that the process can deviate depending on the scope of the renovation (common or shop areas) and the ownership structure of the centre. However, these deviations were identified and allowed a standardisation of the process (Figure 29).

6.3 SQ3: What are the barriers encountered during the decision-making process of EERs of shopping centres?

This research question aimed to explore the barriers that arise during the decision-making process of EERs in shopping centres. It sought to uncover stakeholder behaviours, map them within the decision-making process, and identify their interrelationships. By comparing the existing barriers identified in the literature with the findings from the cross-case analysis, a new list of validated barriers specific to EERs in shopping centres was developed (Figure 30).

Overall, the findings suggest that that barriers have different meanings depending on the stage that they occur and on the stakeholder that causes them. Therefore, solutions should be tailored and addressed to each one individually. Moreover, the biggest hurdles in the process correspond to barriers found in the persuasion and decision stage. These barriers include investment costs, split incentives, lack of shared objectives, limitations with governmental regulations, existing technical challenge, and element lifecycle conflict. Being the last three, new barrier types found for the shopping centre typology.

Furthermore, the research revealed a distinction between tenant types concerning their engagement with EERs. Therefore, owners and policymakers should place particular emphasis on addressing the specific needs of different tenant segments to achieve comprehensive EERs at the whole building level.

Lastly, the complexity of the governance structure in shopping centres goes beyond the number of stakeholders involved. It is also influenced by whether the building is part of real estate portfolio, particularly for owners with real estate funds. In such cases, the decision-making process becomes more intricate due to the presence of multiple management layers and additional operational levels within the portfolio.

6.4 MRQ: How can owners support a better decision-making process to steer EERs of shopping centres?

Based on the answer to the previous sub-questions, it can be assumed that EERs decision-making of shopping centres is complex, yet attainable. This study has demonstrated that shopping centre owners play a critical role in supporting a more effective decision-making process to steer EERs, by optimizing the process and overcoming identified barriers. Additionally, targeted solutions must be

tailored to address each barrier individually, considering their varying meanings and the stakeholder responsible for causing them. Special attention should be given to overcoming barriers in the persuasion and decision-making stages, particularly those related to the EER scope within shops and the compatibility of the EER with the building's maintenance plan and existing technical systems. This implies a collective effort between shopping centre owners and property management to deliver optimal and holistic solutions that promote energy efficiency and sustainability in shopping centres.

To give a detailed answer to the main question, the following set of recommendations are outlined for owners per stage to implement in their shopping centres:

Stage 1 – Knowledge

1. Develop a cohesive and integrated sustainability strategy: Owners, especially those in fragmented ownership structures, should set and incorporate clear short, medium, and long-term goals into the building's maintenance plan to guide energy-efficient renovations (EERs).

2. Optimize governance structure of shopping centres: Actions should be addressed into facilitating stakeholder management and engagement through the process. To achieve this, the following areas of improvement are proposed:
    a. Decentralize decision-making: Involve the property management team and tenants in the EER process to tap into their expertise and foster collaboration. Property management teams can provide valuable input in planning the EER strategy and assignment definition while also offering project management services. Similarly, involving tenants in both in-shop and common area EER decisions could increase their engagement and commitment to achieve a more holistic approach.
    b. Foster collaboration across different property management teams: as large real estate portfolios involve more than one property management team, owners should enable information exchange across organisations and transfer learned lessons about EER processes across assets.
    c. Streamline sustainability advisors: while some centres lacked this stakeholder, others had too many. Shopping centres with fragmented ownership structures could benefit from having a dedicated sustainability advisor to develop and oversee the implementation of the sustainability strategy. Differently, shopping centres owned by institutional investors should revise the number of existing sustainability advisors at various levels to avoid duplicated efforts and conflicted solutions.

    d. Collaborate with other external and supply-side stakeholders: Collaboration among owners, energy suppliers, distribution net managers, and local authorities is essential to achieve more ambitious goals, such as net-zero shopping centres. This will allow to address technology barriers, securing renewable energy supply, managing distribution networks, and incentivizing energy-efficient behaviour.

3. Invest in centralized building data systems: This will enable energy management efforts by implementing systems that collect, analyse, and assess data with energy indicators. These systems can establish benchmarks, identify areas for improvement, evaluate energy management effectiveness, and facilitate informed decision-making for energy efficiency assignments at both portfolio and building levels.

Stage 2 - Persuasion

1. Address unequal access to renewable energy sources for tenants: Small tenants are currently facing challenges in benefiting from renewable energy sources in shopping centres. These challenges include hidden costs associated with energy suppliers that rent the roof space, limitations with internal regulations, difficulties in obtaining subsidies from the government as small energy consumers, and legal limitations preventing owners from becoming energy suppliers. A possible solution from the owner's perspective is to explore incentives that promote equal access to renewable energy for all tenants, such as providing incentives to tenants occupying rooftops.

2. Address tenant-related barriers in EERs: Shopping centre owners are already taking measures to address some of these barriers with the assistance of the property management team, mainly through the provision of advisory programmes or fit-out guides to support mainly small tenants in their EE journey. However, the study found that different types of tenants require distinct approaches. Therefore, it is recommended for owners to develop tailored solutions to address each individually, thereby ensuring a more comprehensive approach towards EE.

Stage 3 – Decision stage

1. Foster collaboration with the technical management team: Given that most of the barriers in this stage are related to the fitness of the EER with the building's maintenance plan and technical challenges of implementing measures within the existing structure and systems, it is recommended for shopping centre owners to collaborate with this team. Joint efforts and close communication can ensure that the EER is well-aligned with the maintenance plan, and technical challenges are effectively addressed.

2. Hire project management, design, and construction services from the property management team's organization: This is because property managers possess valuable knowledge about the building and have proximity to tenants, enabling effective information exchange and facilitating negotiations between owners and tenants. By leveraging their expertise and proximity, property managers can contribute to the successful implementation of energy-efficient renovations (EERs) and improve the overall decision-making process within shopping centres.

3. Explore circular economy approaches to overcome elements' lifecycle barrier: This study found that considerations over the existing element's lifecycle is another significant barrier in implementing energy-efficient measures in shopping centres at this stage. Exploring circularity solutions can be a good start to overcome this barrier by ensuring a sustainable and long-lasting EER.

Stage 4 – Implementation

1. Entrust property managers with overseeing user comfort and satisfaction during deep retrofits: Given their familiarity with stakeholders, property managers can help manage conflicts and address intervention-related barriers that may affect tenant comfort and client satisfaction.

Stage 5 – Confirmation

1. Encourage end-user engagement towards sustainability: Collaborating with the property management team, owners can initiate programs that target barriers associated with user behaviours concerning energy usage by employees, consumers, and shopkeepers.

2. Foster interorganizational collaboration across different property management teams: Owners of large portfolios with multiple property management organizations should establish channels for open communication and collaboration, facilitating information exchange and promoting the transferability of learned lessons gained across all assets in the portfolio.

By implementing these recommendations, shopping centres can improve their governance structure, promote sustainability, and overcome barriers to energy-efficient renovations.

07 LIMITATIONS AND RECOMMENDATIONS

1. The main limitation of a case-study design is the inability to replicate the findings to a larger sample. Although some measures were taken to reduce this factor, such as choosing case studies that were representative of shopping centres in the Netherlands (e.g. building's size, typology, construction year and type of ownership), each decision-making process is particular to the specific needs of each building. Moreover, a larger sample could have facilitated the validation of more barriers that were already found in each individual case study analysis but could not be validated from other sources.

2. Since case studies complied to different criteria, comparability among similar cases was restricted. As type of ownership was found to be a decisive factor in decision-making, especially for owners with a large real estate portfolio, further studies should focus on studying the EER decision-making process among a larger sample with the same type of ownership structure.

3. Time and resources limitations led this research to focus on interviewing internal stakeholders only. Although the views of external stakeholders were studied through their lenses, future research should focus on studying external stakeholders' behaviour, how they fit within the EER of shopping centres, and collaborative mechanisms to joint efforts toward the energy transition of the retail sector.

4. Despite tenants not being the primary focus of this research, the language barrier and lack of interest in participating in the interviews limited the direct findings from this stakeholder. Therefore, future research should delve deeply into tenant perspectives as this actor was found crucial in addressing the in-shop EER scope.

5. This research found that the current leasing structure of shops in shopping centres, where shops are leased on a shell state, limits the scope of EER. Further research could explore the applicability of other leasing structures as a solution to overcome barriers associated to this limitation.

6. This research created a systematic overview of stakeholders' behaviours during an EER decision-making process. Yet, researching specific solutions to overcome these barriers remains unaddressed. Therefore, future research should focus on how to overcome these barriers, specifically from the owner and policymakers' perspective.

7. The scope of this research was limited to shopping centres. Further research could focus on validating the findings in other retail structures.

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APPENDIX

Appendix A - Interview Protocol

Interview protocol

Management in the Built Environment

Graduation Lab 2022/2023

Maria Fernanda Villalba Muñoz

Interviewee name: [Name] Organisation: [Name]

The interview begins with a formal introduction of the thesis study, the interview purpose, and an explanation of the consent. Moreover, permission for interview recording should be granted. Then the concept of informed consent needs to be explained. After that, questions about the basic background information of the participant and his/her work will be asked. The interview will be transcribed for further analysis and checking. At the same time, the audio recording will be kept during the processing period.

Purpose of the interview: Understanding the role, functioning of shopping centres in the Netherlands, perspective towards EE, and clarifying the EER process.

Introduction

Hello, nice to meet you and thank you for accepting the invitation for this interview. I am a student of the Master in Management in the Built Environment from the Faculty of Architecture of TU Delft, and now intern of the Research team at Colliers. This interview is part of my master's thesis research project. It is about the energy transition of the retail sector, specifically about the decision-making process of Energy Efficient Retrofits of shopping centres.

Before we begin, there are a few formalities that I need to settle. The first one is concerning the signed consent form, I will need it before starting the interview. Second, I would like to ask your permission to record this interview to facilitate the transcription process and serve for further analysis. The information here will remain confidential and we may stop this interview at any time if you feel uncomfortable. If required, you can always ask to not include and revise your responses, even after the interview.

I have planned this interview to last no longer than one hour. During this time, I have several questions that I would like to cover. If time begins to run short, it may be necessary to interrupt you in order to push ahead and complete this line of questioning.

Questions – Generic questions (to be adapted for each role)

A. Background / Context (10min)

- Can you please introduce yourself and tell me about your role in this shopping centre?
- Does this shopping centre have a sustainability plan to future-proof it? If so, does it consider both common areas and shop areas?
- Do you perceive that energy-related renovations were (or still are) needed?

B. EER decision-making process (25min)

I compiled a generic process graph from multiple sources from the literature that shows how the decision-making process for energy-efficiency retrofits takes place. During the interview, I will explain it to you and the idea is that you feel free to add, remove, correct, or give any remarks on how this process develops in practice. For this purpose, the following questions will be asked:

- Do you recognize these steps, and can you point out if there are differences in practice?
- In which stages of this decision-making process did you participate? In what way?
- Who lead the process and what other stakeholders were involved?
- Were you made aware of the need for an energy renovation at any moment? Was energy efficiency a primary driver?
- What motivated you to develop a positive attitude towards the renovation?
- In your view, what role did external stakeholders play in this process (e.g. energy suppliers, government, local authorities, etc), did you cooperate with them in any way?
- During the decision stage, what kind of criteria did you consider when evaluating the adequacy of the renovation measures and investment? Perhaps there are standardized SMART criteria (specific, measurable, attainable, relevant, time-based) that are already set for this kind of decision?
- How did you validate and measure the results after the renovation?

C. Barriers (25min)

I will then move to identify the barriers that occur along the process.

- From your perspective, can you indicate in which part of the process you found the most barriers?
- Which barriers did you perceive as the most important to address and how did you overcome them?

From the literature, I have identified that there are 7 types of barriers that may occur in an EER process. These include technology, information, economic, behavioural, organisational, and awareness-related barriers (explain barriers).

- Do you recognize any of these barriers during the renovation of this shopping centre? Which ones and when did they occur?
- Were there other barriers or challenges that we haven't discussed that you experienced during this process?

Appendix B - Informed consent letter

Informed Consent Letter

Amsterdam, March 10th 2023

Reference: Inform consent to participate in research "Energy transition in the retail sector: Revealing decision-making behaviours for Energy Efficiency Retrofits (EER) of shopping centres"

Dear Sir or Madame,

You are invited to participate in a master's thesis research study titled "Energy transition in the retail sector: Revealing decision-making behaviours for Energy Efficiency Retrofits (EER) of shopping centres". This study is conducted by **Maria Fernanda Villalba Muñoz**, student from the TU Delft and research intern at Colliers.

The purpose of this research study is to map how the decision-making process for energy-efficiency renovations takes place. Furthermore, the research study aims to assess the stakeholder's behaviours and examine if and how this influences the process. The interview will take approximately *60* minutes to complete. During the interview, I will ask you to describe your role in an energy-efficiency renovation process, how this process takes place, and what have been the different barriers and challenges that you have experienced along the process.

As with any online activity, the risk of a breach is always possible. To the best of my ability, your answers in this study will remain confidential. I will minimize any risks by:

- Safely storing your personal data in a designated project drive. Upon completion of this research, your name and contact names will be deleted
- All processed data will be anonymised by removing direct identifiers linked to your name.
- Interview recordings will be deleted after the transcripts are made

Your participation in this study is entirely voluntary and you can withdraw at any time. You are also free to omit any questions and may request to not include or revise your responses after the interview.

Sincerely,

Maria Fernanda Villalba Muñoz
Msc student Management in the Built Environment – TU Delft
Intern – Colliers Research & Consultancy B.V.

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated [*DD/MM/YYYY*], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions. Moreover, I am aware that I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves: • An audio, video recording, and written notes in case the interview is held online • Audio recording and written notes in case our interview is held in person • All recordings will be destroyed after the interview has been transcribed	☐	☐
4. I understand that the study will finalize in summer 2023	☐	☐

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
5. I understand that my participation is voluntary, and I may always choose to not answer certain questions or stop the interview at any time.	☐	☐
6. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) and associated personally identifiable research data (PIRD) with the potential risk of my identity being revealed. PII and PIRD data involves: • PII: name, phone number, business email address, and employer • PIRD: video and audio recordings	☐	☐
7. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach: • Pseudo anonymisation: Your name will be replaced by a code and your organisation name will not be disclosed. However, for the purpose of this research, a general role and name of the shopping centre, if applicable, may be disclosed • Audio and video recordings will be deleted once they have been transcribed into text	☐	☐
8. I understand that personal information collected about me that can identify me, such as name, phone number, email, and organisation, will not be shared beyond the study team.	☐	☐
9. I understand that the (identifiable) personal data I provide will be destroyed by deleting it permanently from the drive upon completion of this research (summer 2023).	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
10. I understand that after the research study the de-identified information I provide will be used for: • Master thesis report published in the open-access TU Delft student repository • Research publication by Colliers and other possible applications of the results in decision-making protocols • Policy-making support for public authorities	☐	☐
11. I agree that my responses, views or other input can be quoted anonymously in research outputs	☐	☐

Signatures

_____	_____	_____
Name of participant	Signature	Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name	Signature	Date

If you have any questions, about this research, please contact:

- Maria Fernanda Villalba Muñoz,
- TU Delft supervisor: Queena Qian,
- Colliers supervisor: Richard Buijtendijk,

Appendix C - Research management plan

Energy transition in the retail sector: Revealing decision-making behaviours of shopping centres' Energy Efficiency Retrofits (EER)

0. Administrative questions

1. Name of data management support staff consulted during the preparation of this plan.

Diana Popa

2. Date of consultation with support staff.

Question not answered.

I. Data description and collection or re-use of existing data

3. Provide a general description of the type of data you will be working with, including any re-used data:

Type of data	File format(s)	How will data be collected (for re-used data: source and terms of use)?	Purpose of processing	Storage location	Who will have access to the data
Audio and video recordings	.mp4 Video meetings through MS Teams	Interviews and focus group	Document the interviews and focus group for later transcription. Video will only be used when meeting is online because of visual aid needed.	Designated project drive in organisation's server	Main researcher and supervisors
Signed consent forms	.pdf	online form handed to the participants of interviews and focus groups	Control the consent of the participants who agreed to be in the research for personal data, video and audio recordings	Designated project drive in organisation's server	Main researcher and supervisors
PII data. Employer, name, e-mail, job title, job description, phone number.	.cvs file	From company database	To be able to contact people for different phases of the project	Designated project drive in organisation's server	Main researcher and supervisors
anonymised Interview/focus group transcripts	.pdf	Gathered from interviews		Designated project drive in organisation's server, personal drive and local copy to process the data	Main researcher and supervisors
Other PIRD data about case studies	.pdf, .exl	Company's database server	Case study data about energy measures, energy consumption, others.	Designated project drive in organisation's server	Main researcher and sueprvisor

4. How much data storage will you require during the project lifetime?

- < 250 GB

II. Documentation and data quality

5. What documentation will accompany data?

- Methodology of data collection
- Data will be deposited in a data repository at the end of the project (see section V) and data discoverability and re-usability will be ensured by adhering to the repository's metadata standards

III. Storage and backup during research process

6. Where will the data (and code, if applicable) be stored and backed-up during the project lifetime?

- OneDrive

Data will be mainly stored in a designated project drive in the organisation's server. This includes audio recordings, video, and signed consent forms.
Anonymized transcripts of the interviews will be stored as a local copy in hard drive for data processing.

IV. Legal and ethical requirements, codes of conduct

7. Does your research involve human subjects or 3rd party datasets collected from human participants?

- Yes

8A. Will you work with personal data? (information about an identified or identifiable natural person)

If you are not sure which option to select, ask your Faculty Data Steward for advice. You can also check with the privacy website or contact the privacy team: privacy-tud@tudelft.nl

- Yes

8B. Will you work with any other types of confidential or classified data or code as listed below? (tick all that apply)

If you are not sure which option to select, ask your Faculty Data Steward for advice.

- Yes, confidential data received from commercial, or other external partners

9. How will ownership of the data and intellectual property rights to the data be managed?

For projects involving commercially-sensitive research or research involving third parties, seek advice of your Faculty Contract Manager when answering this question. If this is not the case, you can use the example below.

Any intellectual property rights to outcomes produced by the Intern while carrying out
their Internship, including any in an Internship report, thesis or any other research findings, such as a report, written machine language and/or source code but excluding the copyright to the Internship report or other report or thesis shall be vested in the Internship host.
During the research, the main researcher will manage the access and the rights of the data.

10. Which personal data will you process? Tick all that apply

- Other types of personal data - please explain below
- Data collected in Informed Consent form (names and email addresses)
- Signed consent forms
- Photographs, video materials, performance appraisals or student results
- Email addresses and/or other addresses for digital communication
- Telephone numbers
- Names and addresses

Job role and description

11. Please list the categories of data subjects

Shop owners, tenants, owner association, managers

12. Will you be sharing personal data with individuals/organisations outside of the EEA (European Economic Area)?

- No

15. What is the legal ground for personal data processing?

- Informed consent

16. Please describe the informed consent procedure you will follow:

All participants will be asked for written consent for taking part in the study and for data processing prior to the start of the interview and focus group. They will be introduced to the project and their rights.

17. Where will you store the signed consent forms?

- Same storage solutions as explained in question 6

18. Does the processing of the personal data result in a high risk to the data subjects?

If the processing of the personal data results in a high risk to the data subjects, it is required to perform a Data Protection Impact Assessment (DPIA). In order to determine if there is a high risk for the data subjects, please check if any of the options below that are applicable to the processing of the personal data during your research (check all that apply).
If two or more of the options listed below apply, you will have to complete the DPIA. Please get in touch with the

privacy team: privacy-tud@tudelft.nl to receive support with DPIA.
If only one of the options listed below applies, your project might need a DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to get advice as to whether DPIA is necessary.
If you have any additional comments, please add them in the box below.

- None of the above applies

22. What will happen with personal research data after the end of the research project?

- Anonymised or aggregated data will be shared with others
- Personal research data will be destroyed after the end of the research project

23. How long will (pseudonymised) personal data be stored for?

Question not answered.

24. What is the purpose of sharing personal data?

Question not answered.

25. Will your study participants be asked for their consent for data sharing?

- Yes, in consent form - please explain below what you will do with data from participants who did not consent to data sharing

Personal data will be deleted after processing

V. Data sharing and long-term preservation

27. Apart from personal data mentioned in question 22, will any other data be publicly shared?

- All other non-personal data (and code) produced in the project

29. How will you share research data (and code), including the one mentioned in question 22?

- My data will be shared in a different way - please explain below

Data will be shared as part of master thesis in the TU student repository

31. When will the data (or code) be shared?

- At the end of the research project

VI. Data management responsibilities and resources

33. Is TU Delft the lead institution for this project?

- Yes, leading the collaboration - please provide details of the type of collaboration and the involved parties below

34. If you leave TU Delft (or are unavailable), who is going to be responsible for the data resulting from this project?

First mentor, Queena Qian.

35. What resources (for example financial and time) will be dedicated to data management and ensuring that data will be FAIR (Findable, Accessible, Interoperable, Re-usable)?

Question not answered.