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Energy transition in the retail sector: Revealing decision-making behaviours for energy efficiency retrofits of Dutch shopping centres

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ABSTRACT

Shopping centres hold significant energy retrofit potential in the retail sector. However, their complex multi-stakeholder governance structure complicates decision-making for Energy Efficiency Retrofits (EER). Although literature identifies some barriers linked to EER, they are often scattered and not identified within a process perspective that considers their contextual complexities. This study addressed this gap by examining stakeholders' behaviours, barriers, and relations during EER decision-making processes, to detect stakeholders' needs to catalyse the energy transition. Qualitative research was conducted on three representative Dutch shopping centres case studies. The cross-case analysis uncovered the decision-making process for EER and new barriers attributed to this building typology. Amongst other, detected barriers can be attributed to limitations with governmental and internal regulations, lifecycle conflicts, proposed interventions being out of scope, and existing technical challenges. The study also revealed causal relationships among stakeholders, showcasing varying interpretations of barriers and highlighting the roles of owners, property managers, and public authorities in overcoming them. Furthermore, the findings indicate the key role that different contextual variables play in the EER decision-making process, such as ownership type, governance structure, and leasing structure. This study offers insights and recommendations for shopping centre owners, property managers, and policymakers, to support them in navigating the energy transition of the retail building stock. Key recommendations include decentralizing decision-making, optimizing governance structure, streamlining sustainability advisors, and acknowledging the collaborative roles of property managers and policymakers in providing effective and holistic solutions.

1. Introduction

The building sector accounts for 40 % of the global energy consumption and contributes to 27 % of global carbon emissions [1]. Addressing the energy transition of the building stock is crucial in the current climate and energy crisis. To mitigate the environmental, health, economic, and social impacts of these crises, the building sector must reduce its dependency on fossil fuels and expedite the energy transition of its existing building stock [1,2].

Numerous international and national programs have been developed to achieve this goal. Examples include the Paris Agreement at the international level, The European Green Deal [3] with the EED[4] and EPBD [5,6], the SFDR [7], and the CSRD[8] Directive at the European level, and various agreements and decrees at the Dutch national level, such as the Dutch Climate Agreement [9], the Energy Agreement for Sustainable Growth [10], and adjustments to existing building decrees. However, despite these efforts, the focus has primarily been on residential buildings, 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 global building stock, in which retail has the highest percentage of floor area in Europe, with 28 % [11], and the highest share of non-residential energy consumption (28 %) [12]. Within the retail sector, shopping centres represent a relevant opportunity for energy efficiency improvement due to the following reasons. First, they require a high electrical and thermal load to operate [13], having therefore a significant impact on the environment. Second, in western Europe, they are part of a mature market that needs to be renovated in the upcoming years [14]. Third, they are buildings with a high retrofit rate (4,4 % compared to 1–1,5 %

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for housing) as they are being retrofitted either way to remain attractive for consumers [15]. And fourth, with approximately 6.9 million m^2 [16], shopping centres are an important segment for the decarbonisation of the Dutch existing building stock.

However, despite their potential, data gathered from previous research has demonstrated that their complex multi-stakeholder governance structure makes decision-making for energy efficiency improvement difficult as it relies on the achievement of consensus among the parties involved [2,17]. A recent study on the social relations of energy retrofits for the occupants of multi-owned properties highlighted that the additional relational work required to manage and achieve collective action acted as a barrier to building retrofits [18]. Moreover, other authors in the context of building energy-efficiency retrofits have also highlighted the need to understand stakeholders' perceptions and behaviours in the decision-making process. For example, owners and occupiers are identified as key actors in green retrofits decisions due to lease contracts requiring owner-occupier cooperation [19,20], while building managers play a crucial role because of their role in daily activities [21,22].

Furthermore, a recent literature review examining factors associated with stakeholders' decisions to implement energy retrofits highlighted the need to contextualise energy retrofits to understand the underlying reasons of *why*, *how*, and *whom* is involved—a relationship that is often unrecognized [21]. This explains a literature gap: although several barriers that hinder the adoption of energy-efficient measures in shopping centres or retail buildings have already been identified, they are often scattered and not identified within a process perspective that considers the complexities of their context. These barriers include mainly a lack of knowledge [23–25], split incentives [23,26,27], asymmetric information [23,25], and lack of regulations [23].

Therefore, this research aimed to fill this gap by revealing stakeholders' behaviours during the decision-making process of Energy-Efficiency Retrofits (EER) in shopping centres within a process perspective. This included identifying the interrelationships between the parties involved at various steps of the process and their relationship to other context variables. It sheds light not only on *what* barriers need to be overcome and *where* in the process they occur, but also on the causal relationships that indicate *who* should drive solutions and to *whom* they should be addressed. For the purpose of this paper, an Energy-Efficiency Retrofit (EER) is understood as a retrofit that seeks to improve the energy performance of existing aged or deteriorated buildings [17,28], and one of the most cost-effective and realistic strategies to reduce greenhouse emissions and building energy consumption [17,29].

The research focused on answering the following research question: *"How can owners support a better decision-making process to steer EERs of shopping centres?". Drawing* lessons from three representative case studies of shopping centres in the Netherlands, the results aim to provide practical recommendations for shopping centre owners and property managers to improve their decision-making when making their properties more sustainable. Additionally, they can be used to assist policy-makers in identifying areas of improvement for current policies and lacking incentives.

This study is conducted in three phases: a theoretical study, an empirical research phase, and a synthesis and conclusion phase. The theoretical study centred on investigating the state-of-the-art of the decision-making process of EER of shopping centres in the Netherlands and developing the theoretical framework to support the empirical research phase. This phase is documented on the Theory section of this paper. The remaining sections focus on explaining the methods employed during the study, the analysis of the results, the discussion of the findings, and the conclusions.

2. Theory

2.1. Understanding the context: Dutch shopping centres and current EER measures

Kim and Medal [21] highlighted that identifying the context in which building energy retrofits occur is fundamental to the understanding of the decision-making process behind it. The context for building energy retrofits can be classified in the physical, functional, and social contexts [30]. The physical context refers to the building's physical characteristics and surroundings, such as building type, typology, size, and geographical region; the functional context refers to the owners' and tenants' organisational values and building functions that impact the assessment of building energy retrofits, such as ownership type, organisational structure, lease structures among others; and the social context refers to stakeholders characteristics and perceptions that influence energy retrofits decision making, such as personalities, job title, and role [30]. Therefore, in order to contextualize the Dutch shopping centre landscape, this study used the Dutch Shopping centre registry database, also known as Strabo [31], to analyse the building stock in terms of its physical context, referring to the buildings' size, function, building form, and construction year; and in terms of its functional context, in relation to the ownership type, operation, and service charges. The social context was analysed in section 2.3 by relating existing barriers in the EER decision-making process to stakeholders' roles.

Shopping centres in the Netherlands are relatively compact. Approximately 40 % of these centres are smaller than 5,000 square meters, while 47 % fall within the range of 5,000 to 20,000 square meters. They serve as neighbourhood or community centres, catered to local communities and accommodate one or two supermarkets with a varied retail experience. Most of these centres adopt an open category, representing 54 % of the total. Open category centres are typically shops arranged in rows or in a U-shape configuration with an open courtyard [15]. However, given that this study focuses on energy efficiency renovations in both common and in-shop areas and, it focuses on the remaining 46 % with a covered or semi-covered building form. Furthermore, they are part of a mature building stock that will require renovation in the upcoming years, as 54 % of these centres were constructed prior to 1990, with an additional 22 % built before 2001.

In terms of ownership, single ownership dominates the landscape (81 %) with a remaining 19 % attributed to centres with fragmented ownership. Ownership by single institutional investors, such as pension funds, insurance companies, and real estate investors, are prevalent. These owners lease shop areas to diverse tenants on a shell state. Operational costs and services are therefore divided between tenant and landlord services. Landlord services refer to the operational costs of common areas (e.g. staircases, storage areas, plant rooms, escalators, lifts, and cleaning, among others) that are operated and maintained by centre management and paid by tenants through a service charge. Differently, tenant services refer to the operation, maintenance, and management of in-store connections, metering, and contracts with service companies by the tenants [32].

Finally, mayor areas of energy consumption and inefficiencies of shopping centres are lighting, refrigeration, and HVAC [33]. These are areas focused on the demand side of retrofit designs. Therefore, energy retrofit measures should be aimed to decreasing the energy demand through the introduction of new technologies or passive technology systems [34]. For the purpose of this study, and to facilitate comparison among the cases, these measures are categorized based on their scale in three different retrofit packages based on the U.S. Department of Energy's Advance Retrofit Guide for Retail Buildings [35] classification system: (1) Existing building commissioning (EBCx), (2) Standard retrofit, and (3) Deep retrofit. A summary of these packages is observed in (Table 1) and was useful to compare the scales of EER measures found on each of the case studies.

Table 1
Packages of preferred retrofit measures.

	Package 1 Existing Building commissioning (EBCx)	Package 2 Standard retrofit	Package 3 Deep retrofit
Energy savings	15 %	15–45 %	>45 %
Description	Operation & maintenance of existing equipment	Component-level interventions	Equipment replacement/mayor interventions

Adapted from [36]

2.2. Mapping of the energy efficiency retrofit (EER) decision-making process

An EER decision-making process is a combination of the stages of the process with the different decision moments needed to move forward from one stage to the other. The stages of an EER process have been documented in the literature by authors such as Liang et al. [2] and Ma et al. [17], with small variations among them. While the former links the process to the internal and external stakeholders involved [2], the latter links it to the strategic planning and tools needed at each stage [17]. In general terms, the process starts with the initial intention setup; moves to a pre-retrofit survey and energy performance assessment; then a design stage; the site implementation of the measure; the evaluation and verification of the measure; and finally, the regular operation of the retrofit.

In order to effectively implement an EER process, an understanding of the decision-making steps that guide the progression from one stage to another is needed. Rogers' theory of the innovation-decision process [37] offers valuable insights in this regard, suggesting that decision-making unfolds over time through distinct stages, whereby individuals or organisations decide whether to adopt an innovation into their existing practices. The theory proposes a five-stage process consisting of: (1) a knowledge stage; (2) a persuasion stage; (3) a decision stage; (4) an implementation stage; and finally (5) a confirmation stage. While Rogers [37] describes this process in a linear way, Mlecnik et al. [38] 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.

The integration of these theories (Fig. 1) account for the EER decision-making process. For each step of the process, a decision node is added as a requirement to move to the next stage. The process consists of five stages that can be described as follows: (1) a knowledge stage in which the innovation or need for retrofit is identified, and a level of awareness is needed to move forward; (2) a persuasion stage in which a decision to launch an EER needs to be taken by the main decision-makers, followed by gathering knowledge on inefficiencies and opportunities in order to take informed decisions about goals and targets while aligning the attitudes of the different stakeholders involved towards those goals; (3) a decision stage in which designs and plans are developed, and their adequacy is judged in terms of risks, costs, and benefits; (4) an implementation stage in which the retrofit is executed, and its goals are inspected and validated; and finally, (5) a confirmation stage, which involves the regular operation and maintenance of the building, performing energy commissioning and keeping track that goals continue to be met, closing the loop when a new need is identified.

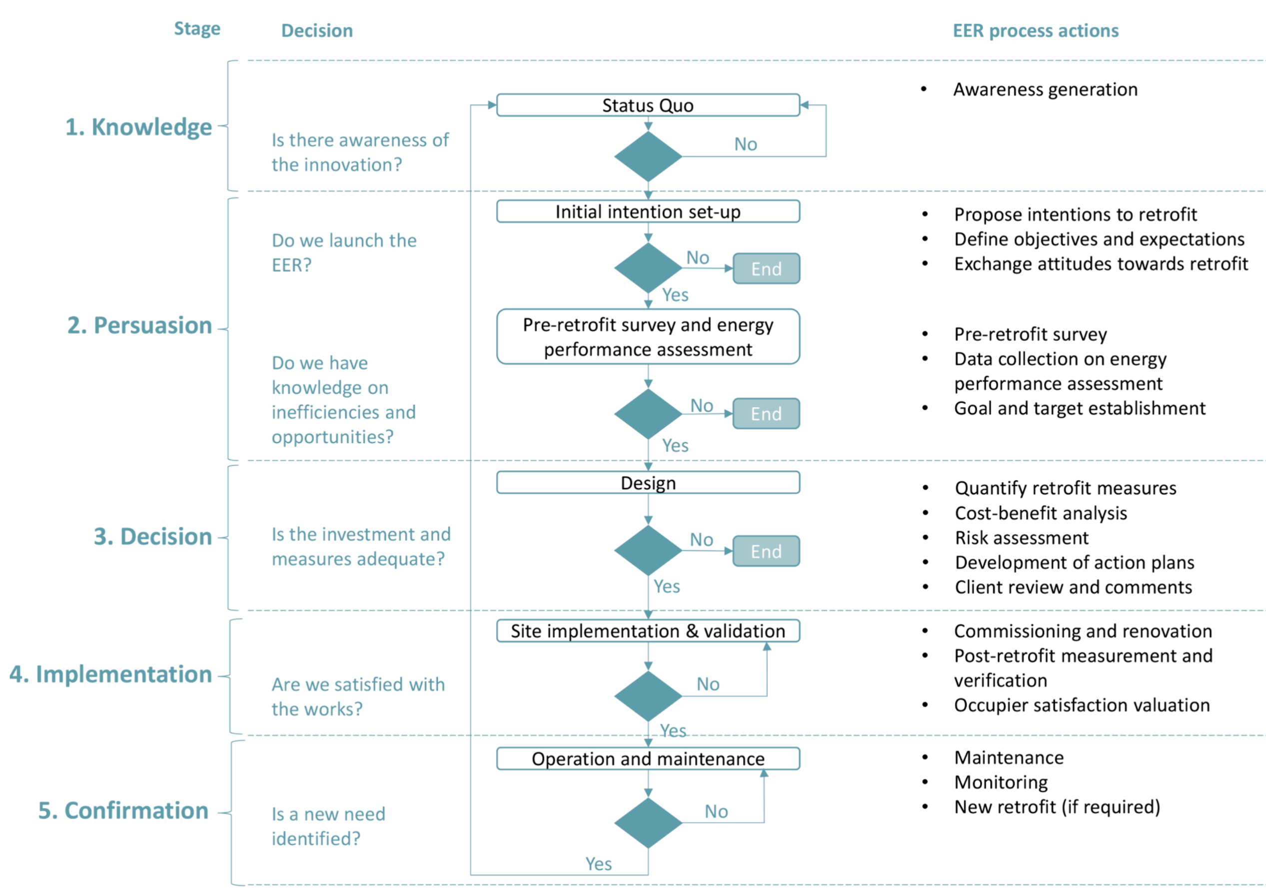

Fig. 1. EER decision-making process. Adapted and compiled from various sources [2,17,37,38].

2.3. Integrating barriers in the EER decision-making process

Literature suggests that performing existing building EER can be challenging as the process deals with various uncertainties and barriers involving climate change, technologies, government policies, human behaviour, and financial limitations, among others [17]. The study of barriers towards the adoption of energy efficiency technologies in different sectors has been documented by different sources of literature. This study focused on Cagno et al. [23] as they developed a barriers taxonomy for empirical research to help identify critical factors.

The taxonomy consists of seven different barrier 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 to identify inefficiencies and opportunities, and implement the interventions; and finally, *awareness barriers*, related to the knowledge on EE of decision-makers [23].

Scattered barriers found specifically for retail and shopping centres were mapped within these categories and identified within a decision-making stage (Table 2). Furthermore, to contextualise them in terms of the retrofits' social characteristics, documented assumptions on how different stakeholders might relate to each barrier were also made. A description of the role of internal and external stakeholders involved in an EER of shopping centres is found in Appendix A. 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, [23], who 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.

3. Methods

This study used a qualitative multi-case study research method. It was selected because case-studies attempt to give light about how, where, why, and with what result certain decisions were taken [39]. The methodology consisted on three steps portrayed in Fig. 2.

The first step (1) focused on developing the theoretical framework that served as guideline for collecting and analysing empirical data. The selection criteria for the case-studies followed a systematic approach that aimed to capture representativeness of the Dutch shopping centre building stock (Table 3). Furthermore, as the reliability of the findings could be enhanced by conducting research across three or more cases with diverse circumstances [39], three shopping centres were selected with different ownership types as the perspectives of the owners were of primary importance. Given that the Dutch shopping centre building stock is representative of the saturated and mature building stock of western Europe, the selected case studies not only reflect the Dutch context but also provide valuable insights applicable to the broader region for which energy efficiency retrofitting and redevelopment is pressing [14,33]. An overview of the selected case studies is found in Table 4.

The second step (2) involved preparing, collecting, and analysing data from the case studies. The data collection technique included the revision of various case-project documents and fourteen semi-structured interviews with various stakeholders (Table 5) that included asset managers, owners, property managers, owner association manager, retrofit project managers, ESG project managers, and tenants across the case studies. The interview protocol was divided in three parts. The first part aimed at identifying the interviewee's context, participation and perceptions regarding energy efficient retrofits. The second part sought at identifying the EER decision-making process within the case study. This comprised showing and explaining the EER decision-making process mapped theoretically and asking them follow-up questions to identify similarities and differences in the process in practice. Finally, during the third part, interviewees were asked to identify experienced barriers and challenges along the process.

Following the data collection, the interviews were transcribed, anonymised, and analysed individually in Atlas TI using a deductive data analysis approach. Data was classified within the closed coding system of the framework for barriers, stakeholders, and stage in the decision-making process. When required, new codes were created to modify the theory by means of an inductive approach. Lastly, the third step (3) of the methodology involved performing a cross-case analysis and validation with an industry expert to compare all case-studies, drawing conclusions to modify existing theories and generate recommendations for industry practitioners and policymakers.

4. Results

4.1. EERs decision-making process in shopping centres in practice

When comparing the research framework with empirical evidence gathered from the case-studies, the study found that the biggest difference during an EER decision-making process of shopping centres is the assignment nature of the process. This assignment is set out by the owner and there are no decision nodes that lead the project to an end, except for those concerning in-shop EE scope. Therefore, stakeholders focus their effort on the *how* rather than on the *if*. When asked about the decision-making process, one of the interviewees, acting as the asset manager of the shopping centres studied, mentioned *"(…) our client tells us what to do on this subject. When they tell us, we need to be Paris-proof at this or that time, that's not a question. It's not about stakeholders getting on board. It's just an assignment for us"*. Therefore, the process aim lies on making the plans, negotiating, and defining how to implement it. Fig. 3 portraits the process found in practice, from which the following characteristics were observed by stage:

1. Knowledge stage: Gathering knowledge on inefficiencies and opportunities through data collection on energy performance was mentioned across the case studies as a priority for implementing sustainable measures in the centres. In the case of shopping centres, the case-studies demonstrated that setting out a retrofit assignment is usually a combination of the performance of the building's technical systems, ESG goals, and overall shopping centre performance data (e.g. shop vacancy, foot count, etc.). So far, what drove initial deep retrofits was improving shopping centre performance. However, there is an increasing awareness for the building's ESG and Paris-proof alignment and the incorporation of these targets in the building's long-term maintenance plans, particularly in shopping centres that are part of real estate portfolios. Although there are some pilot projects for gathering energy performance data, none of the case studies had yet building monitoring measures in place nor had used them for their recent EER process. The decision made in this stage is regarding the scope of the retrofit, as the assignment is set to either retrofits in the common areas or inside of the shops.
2. Persuasion stage: This stage was found to occur across the case-studies only when the scope of the renovation is aimed at an in-shop EER. The leasing structure of retail spaces in the Netherlands, where stores are rented on a shell state, determines that owners have no control over EE retrofits inside the stores. Some of the interviewees highlighted that *"Tenants use their own contract, so they have their own relationship with energy companies. Since we are not part of that, we cannot manage it"*. Therefore, tenants need to be persuaded

Table 2
Barriers in energy retrofit processes in retail. Literature findings mapped to Cagno et al.'s taxonomy [23].

Barriers taxonomy	Barrier	Step	Internal stakeholders											External stakeholders		
			Owner/ Asset manager	Property management	Owner association	Tenant	Employees	Designers/ Architect/ Energy consultants	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**	△													

(*continued on next page*)

Table 2 (*continued*)

Barriers taxonomy	Barrier	Step	Internal stakeholders											External stakeholders		
			Owner/ Asset manager	Property management	Owner association	Tenant	Employees	Designers/ Architect/ Energy consultants	Technology/ Manufactures	Developer/ Project manager	Capital suppliers	Energy suppliers	Distribution Net managers	Government	Local Authorities	Costumers
	Lack of internal control	4	X	X												
Competences	**Identifying the inefficiencies**	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

Conventions.
△ Assumptions from literature but not specifically related to retail.
X Barriers found in retail-related literature.

to work together to achieve them. This highlights one of the greatest challenges this sector faces and restricts a holistic approach towards achieving energy efficiency goals.

3. Decision stage: three decision moments were found across the case studies within this stage. The first one is regarding the definition of the scale of the renovation and can be compared to the different EE packages documented in the literature. While EE-only retrofits scale was found linked to Existing Building Commissioning (EBCx) and standard packages, an aesthetic scale is usually found combined EBCx, standard, and deep retrofit packages. Both EBCx measures, which involve energy-related improvements in building operation and maintenance, and the standard retrofit package, consisting of component-level measures without major disruptions to shopping centre operations, were found to be incorporated into the building's maintenance plan. On the other hand, the deep retrofit package, was typically associated with larger aesthetic renovations aimed at addressing various inefficiencies in shopping centres, such as vacancy issues and outdated infrastructure. The energy efficiency measures implemented in deep retrofit projects varied significantly, ranging from isolated changes like lighting fixture replacements to multiple measures such as adding skylights, improving insulation, and upgrading windows.

   The second decision in this stage is during the drafting of the initial plans. Plans need to answer positively to the analysis of the technical and legal feasibility, cost effectiveness, and overall fitness within the building's maintenance plan. And the third one is deciding about the adequacy of the investment and the proposed measures. In shopping centres with a fragmented ownership, additional consultations need to be taken within the ownership association (VVE) and in alignment with the deeds of each centre.
4. Implementation stage: this stage was found similar across the case studies to what literature suggested. It is where the work takes place, and the retrofit's goals are inspected and validated. Therefore, the decision node is about work satisfaction.
5. Confirmation stage: regular operation and maintenance activities were found across the case studies through energy commissioning and keeping track that goals are met until a new need is identified. Interviewees from asset and property management mentioned that implementing building data systems to track compliance to ESG goals and shopping centre performance is vital. Although not all centres currently implement it, they recognize its importance and are making plans to do so.

4.2. Attributed barriers in the EERs decision-making process of shopping centres

Validated barriers, specifically for shopping centres in the Netherlands, were drawn from the cross-case analysis (Table 6). Only repetitive barriers among two or more case studies plus the expert interview were included and compared to the original theoretical framework. Within this scope, it was found that all seven (7) barrier types from the theoretical framework—namely *Technology, Information, Economic, Behavioural, organisational, Competences, and Awareness* barriers—were present. However, findings suggest that not all subtypes from this taxonomy apply and new ones are required to explain barriers for this specific building typology. Moreover, findings also indicate that *Legal barriers* require their own category with *Limitations with governmental regulations* and *Limitations with internal regulations* as individual subtypes. The following paragraphs describe new barriers found from empirical evidence.

Legal – Limitations with governmental regulations: refers to the absence of regulations mandating tenants to share their energy consumption data with property owners, resulting in challenges assessing energy usage within individual shops. Additionally, owners are prohibited from functioning as energy providers, posing a significant constraint on the deployment of solar panels on shopping centre roofs, as the benefits are

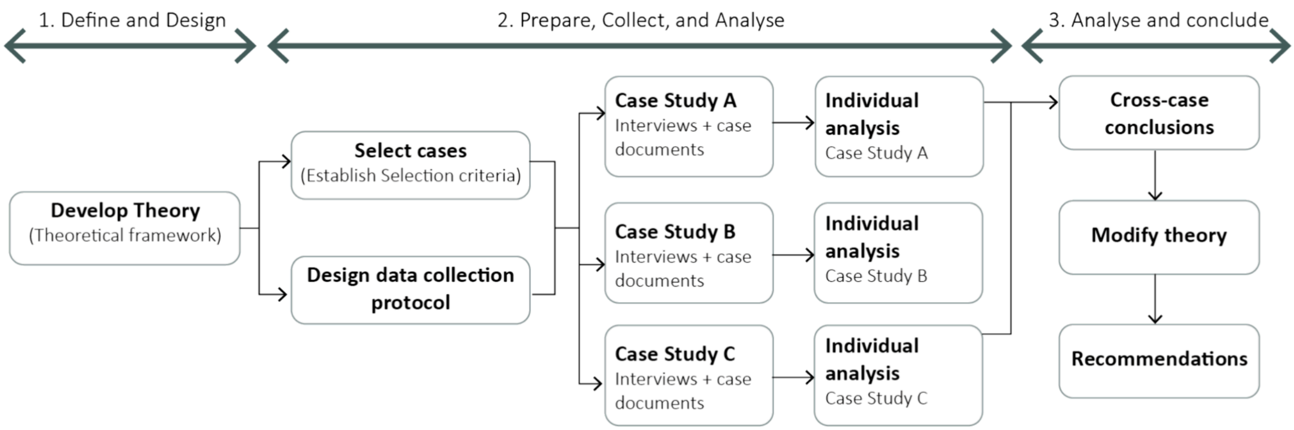

Fig. 2. Research methodology.

Table 3
Case-study selection criteria matrix.

	Criteria	Case A	Case B	Case C
Required	1. The shopping centre has undergone recently (5 years or prior) or is currently undergoing an EER process	✓	✓	✓
	2. Shopping centre GLA must be within the covered category	✓	✓	✓
	3. Shopping centre must be >5,000 m^2	✓	✓	✓
	4. The opening year of the shopping centre is prior or close to 1990		✓	✓
	5. Shopping centre has at least 1 supermarket	✓	✓	✓
Desirable	1. At least one of the shopping centres is in the small or medium size range	✓		✓
	2. At least one of the shopping centres has a fragmented ownership type		✓	
	3. At least one shopping centre has a neighbourhood or community centre function	✓		✓
	4. Select complementary cases that present different ranges of EE measures and EE drivers.	✓	✓	✓

less likely to accrue to the tenants.

Legal – Limitation with internal regulations: involve tenants seeking approval from the property management system to implement measures that affect the common areas. For instance, if a tenant wishes to install photovoltaic (PV) panels on the roof, permission from the property managers is required. This stringent internal regulation underscores the need for collaboration and approval processes, potentially impeding the swift adoption of sustainable energy solutions at shops.

Table 6 also depicts the comparison between barriers found in literature versus new barriers found in practice for shopping centres.

Table 5
Interviewee profiles.

Case A	Case B	Case C
Asset manager – Owner organisation	Director Board of supervisors	Owner (During renovation)
Property management – Commercial manager	Property management – Technical management	Fund manager (from current owner)
Property management – Technical management	Retrofit project manager	Property management – Commercial management
Retrofit project manager	Owner association manager	Project manager ESG – Owner organisation
	Tenant (non-food retailer)	Tenant (food retailer)

New sector-specific barriers were added to existing categories and respond to the specific characteristics of leased and communal areas, ownership types, business nature, and building complexity of shopping centres.

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

Behavioural – Intervention out of scope: occurs when an 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 is assigned.

Technology – Existing technical challenge: the building's existing characteristics can increase the difficulty of 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.

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 lifecycle. This is not only not sustainable, as some elements are still in good state, but also plays against the reduction

Table 4
Case projects overview.

	Case A	Case B	Case C
Size	Small – (5,000–20,00sqm)	Large – (40,000—70,000sqm)	Small – (5,000–20,00sqm)
Opening year	1990's	1970's	1970's
Building form	Covered	Covered	Covered
Ownership type	Single – Large Real Estate Investor	Fragmented – +100 owners	Single – small Real Estate Investor (during retrofit moment)
EE stage	2 EER processes running in parallel. R1: Stage 4 Implementation R2: Stage 2 Persuasion	2 EER processes running in parallel.R1 & R2: Stage 2 (Implementation)	Stage 5 (Confirmation)
EER scale	EBCx & Standard package (Maintenance and component level measures)	Standard & deep package (Component and deep level measures)	Deep package (Deep level measures)

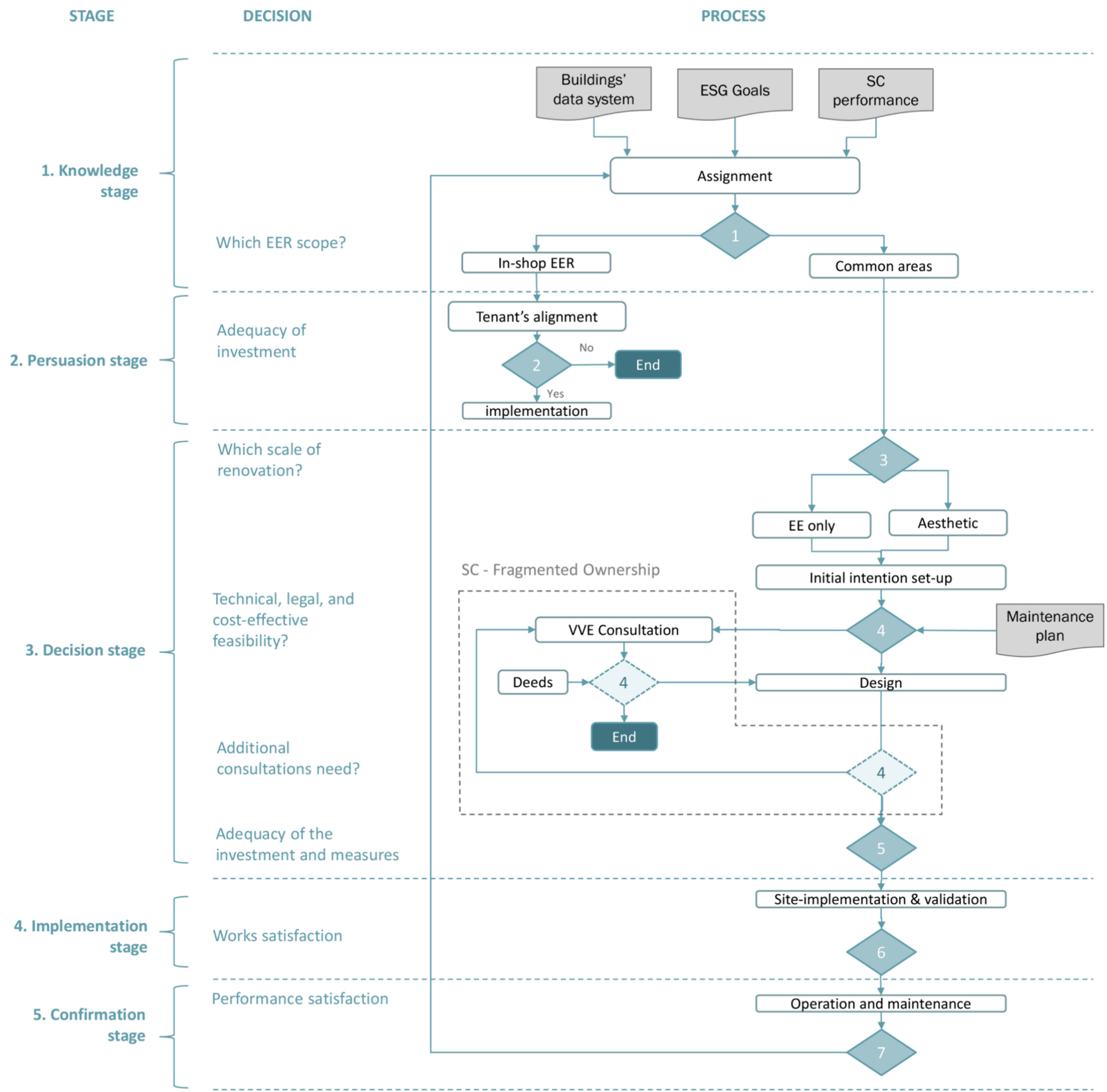

Fig. 3. EER decision-making process for shopping centres in the Netherlands found in practice.

of its CapEx capturing period. Shortening this period may require extra costs in the building's maintenance plan.

> *"(…) we should be very cautious with replacing things that are not at the end of their lifespan."* (Asset manager)

Validated barriers were also mapped within the EER decision-making process per stage. The degree in which they were named by stage, allowed to map the most important perceived barriers. Fig. 4 demonstrates that most barriers occur within stage 2 and 3, persuasion and decision stage. Further, it can also be noted that some barriers are found repetitive across stages.

4.3. *Causal relationships analysis of barriers*

An analysis of the causal relationships between each barrier and the stakeholders was conducted to identify their interrelationships, patterns, and correlations. This approach aimed to uncover potential areas for improvement. The results of this analysis are presented in Table 7, where barriers are examined by stage and by the agents causing and bearing them. Additionally, the table provides specific descriptions for each barrier and links them to existing solutions and involved stakeholders, if applicable.

The analysis revealed 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 validated 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 represent an additional transaction cost for owners and become too expensive to address all at once.

Similarly, the analysis highlights that a barrier identified within the

Table 6
Comparison of barriers taxonomy from Cagno's et al. Taxonomy [23] and barriers found in practice for shopping centres.

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

Conventions.
New barriers shown in bold.

same stage may have different cause and bearing agents, which leads to question the effectiveness of existing solutions. For example, the behavioural barrier of "*Lack of sharing the objectives*" in stage 2 can be caused by either the owner or the tenant. While a large tenant may be a causing agent because their sustainability approach may conflict with that of the owner, small tenants may lack a clear approach to sustainability. Therefore, while the solution of the 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.

Provides valuable insights into the role of owners as both causing and bearing agents. Although all types of owners are identified as a cause-agents in less than 20 % of all validated barriers, they bear the brunt on more than 60 % of most validated barriers. This is because EER are assignments set by the owner, thereby being them the ultimately affected if the objectives are not met. Consequently, owners are prone to attempt to overcome barriers from different perspectives, even if they are not the root cause of the problem.

Furthermore, the analysis revealed that supply-side stakeholders, apart from retrofit project manager, were identified as cause agents only (Fig. 5). 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 frequent validated barriers per stage (Fig. 4) within the causal relationships analysis, the most urgent barriers in which owners must be focusing on are the ones highlighted with the black star in Table 7.

4.4. Governance systems

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 (Fig. 6), 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 (Fig. 7) 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. 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 (Fig. 8) was owned by a single small real estate investor at the moment of the renovation. While small real estate investors typically have fewer management layers and potentially more control over the renovation team, as indicated by the identification of less stakeholders, the absence of a property management team in this case may have led to overlooking the diagnosis of shopping centre inefficiencies, which is crucial to 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, their on-site knowledge is not being exploited. Rather, collaboration from them appears to be limited to information exchange rather than true cooperation. Moreover, the engagement of an external stakeholder team 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.

5. Discussion

5.1. Owners' role in accelerating EER in shopping centres

The results of this study indicate the particularities of the EER decision-making process of shopping centres, the main one being the assignment nature of the process. Decisions to implement energy-efficiency measures rely on the owner's willingness to put in motion the assignment to renovate. Therefore, the role of owners in EER decision-making proves crucial, as highlighted in previous literature. According to Salm et al. [40], owners are the most interested actors in

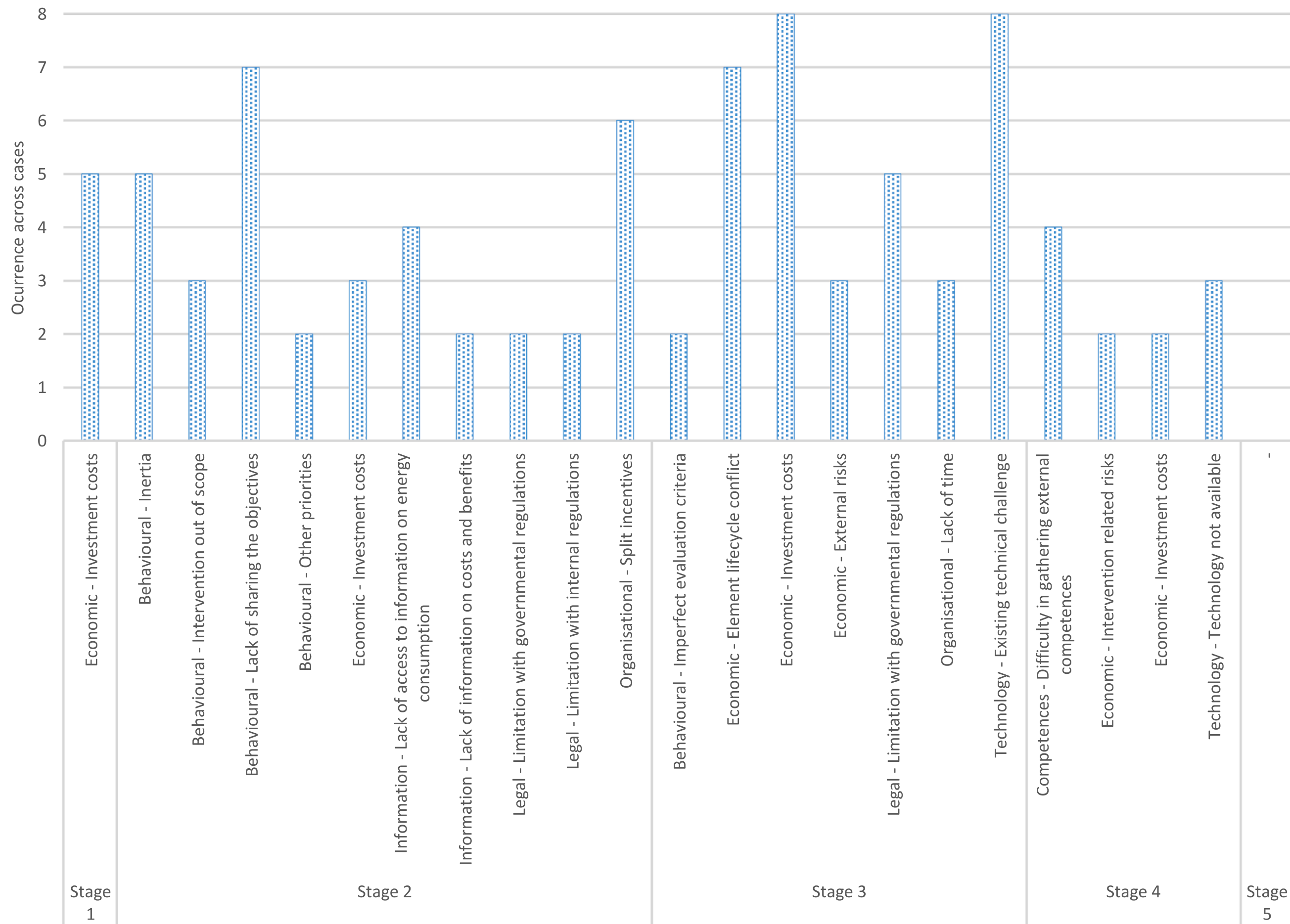

Fig. 4. Validated barriers per decision-making stage.

energy efficiency, although their concerns revolve around financial factors. Therefore, finding *investment costs* as the only validated barrier across all stages was not surprising. As ultimate decision-makers and bearing agents for most barriers, owners possess the highest level of influence in driving solutions to overcome them.

However, this study found that gathering knowledge on inefficiencies and opportunities is vital for setting informed and timely assignments. Therefore, centralised building data systems, clear sustainability strategies or targets—especially for centres with fragmented ownership—and the role of shopping centre performance indicators is paramount for steering EER. Together, they could facilitate energy management, benchmarking against performance targets, and provide input for more specific and informed assignments at the outset of the EER process.

5.2. Holistic energy retrofits: dealing with in-shop EER main challenges

The leasing structure of retail in the Netherlands limits owners' control over implementing energy efficiency measures inside stores, resulting in a significant division between common and inside-shop renovations. This division poses a major challenge for achieving holistic energy-efficiency renovations. While owners are striving to enhance tenant engagement through initiatives like tenant advisory programs and fit-out guides, these efforts primarily target small tenants. However, conflicts arise between owners and large tenants regarding sustainability strategies, posing an additional challenge for stakeholder alignment in energy efficiency renovations. Therefore, joint efforts between owners and property managers can also prove valuable to drive holistic energy efficiency renovations. Property managers can assist 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 barriers individually. Furthermore, property managers can also assist by leveraging their rapport with tenants to implement programs, enhancing their participation in renovations, overseeing user comfort and satisfaction, and promoting end-user engagement towards sustainability, recognizing that user behaviours significantly impact energy efficiency.

5.3. Navigating governance complexity: collaboration between owners and property managers

Initially anticipated to primarily affect multi-owner centres, governance structure complexity poses challenges even for single real estate investors. Institutional investors, managing multiple layers of decision-making and aligning with building and portfolio goals, face intricate stakeholder management. For instance, duplicated roles—like sustainability advisors operating at different levels, as in Case A—can lead to inefficiencies. Therefore, decentralizing decision-making, optimizing governance structure and streamlining sustainability advisors can prove valuable for EER processes. However, this requires of enhanced stakeholder management through collaboration and joint efforts particularly between owners and property managers.

While owners operate at a strategic level, property management teams are crucial at an operational level. They not only possess on-site knowledge but also drive relationships between owners and tenants. For example, technical managers within the property management team are already active implementing energy-efficient measures, such as

Table 7
Causal relationships of validated barriers in the EER decision-making process.

Stage	Barrier	Stakeholder			Identified solution	
		Cause	Bearing	Explanation	Existing Solution	Who
1	**Economic — Investment costs ★**	OW-SL	RPM	EER 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		
		LA	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, PM-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, RPM	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	RPM	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	RPM, 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, RPM	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, SA	OW, RPM, PM-TM	Difficulty in finding reliable advisors and contractors in the current market.		
	Economic — Intervention related risks	RPM, PM-TM	T-L, T-S	Conflict with user comfort and overall happiness		
		RPM, PM-TM	T-L, T-S, OW	Uncertainty over risks of overschedule and costs	Open and constant communication with tenants and owners.	RPM, 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	–					

CONVENTIONS
OW-SS Owner – single small REI; **OW-F** Owner – Fragmented; **OW-SL** Owner – Single large fund; **RPM** Retrofit project manager; **EX** External cause; **PM-TM** Technical management; **PM-CM** Centre management; **VVE** Owners association; **T-L** Tenant large; **OW** Owners (all types); **T-S** Tenant small; **ES** Energy supplier; **CS** Consumers; **LA** Local authorities; **G** Government; **S** Suppliers; **SA** Sustainability Advisor; **C** Contractor

OTHER CONVENTIONS
★ Validated barrier with occurrence ≥ 5

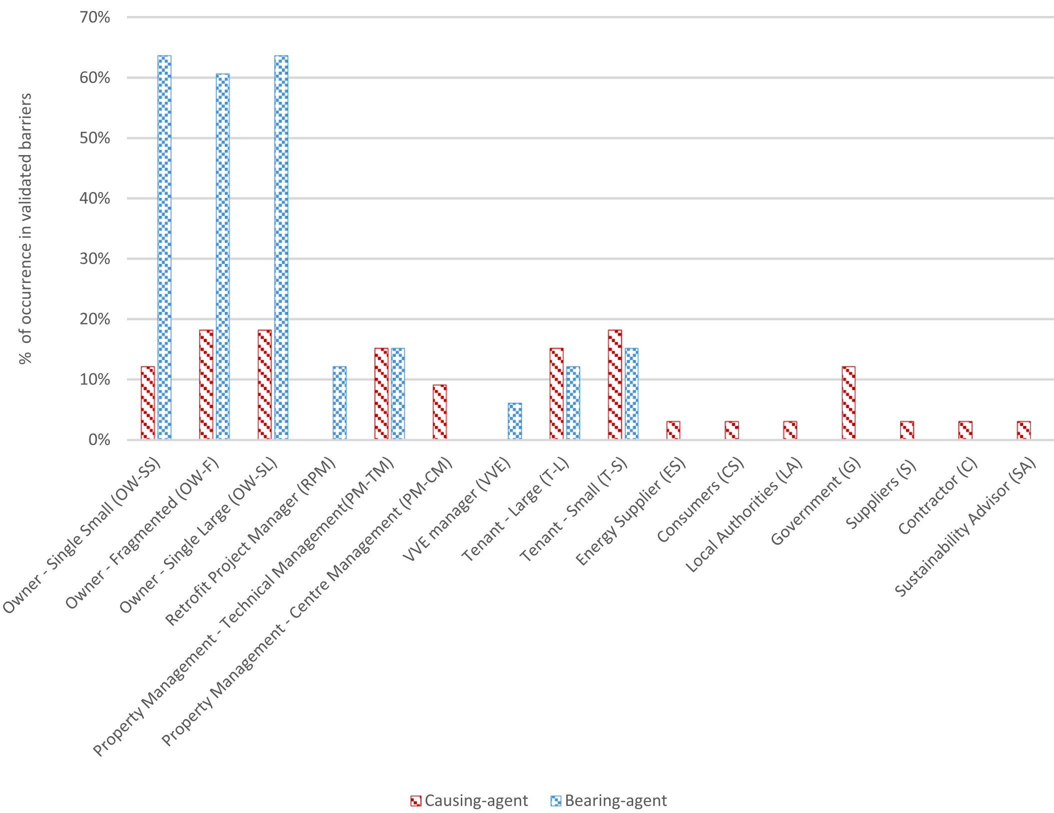

Fig. 5. Stakeholders' occurrence as causing and bearing-agents in validated barriers.

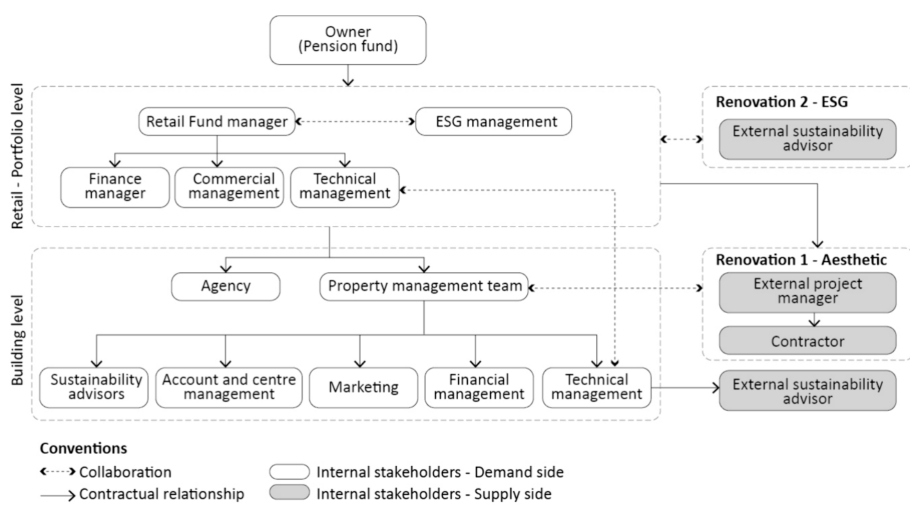

Fig. 6. Governance structure case study A.

those related to Existing Building Commissioning (EBCx) and Standard Retrofit packages, by optimizing building operations through meticulous maintenance planning. However, their contribution could be further exploited by serving as consultants in strategic sustainability strategy development, addressing *investment cost* barriers and reconciling conflicting costs, *element lifecycle conflict*, and *technical challenges* barriers with maintenance plans. Additionally, collaborating with owners on building data collection initiatives can ensure effective interoperability among stakeholders. By assisting owners in setting up this system, property managers can ensure interoperability among stakeholders and benefit from real-time energy data to monitor usage and overall operational performance effectively.

Furthermore, property managers can facilitate deep retrofits by offering project management services and in-house design expertise. Their proximity to tenants can foster better information exchange and negotiation, addressing owners' *difficulty in accessing external competencies*. Finally, collaboration among property management teams within the same portfolio can optimize EER processes. Open communication channels could facilitate the exchange of best practices, enhancing efficiency and effectiveness across the board.

5.4. *Policy challenges: streamlining regulations and targeted incentives*

This study highlights the role of ownership type in EER processes within shopping centres. Particularly, shopping centres owned by large institutional investors are proactively preparing for forthcoming

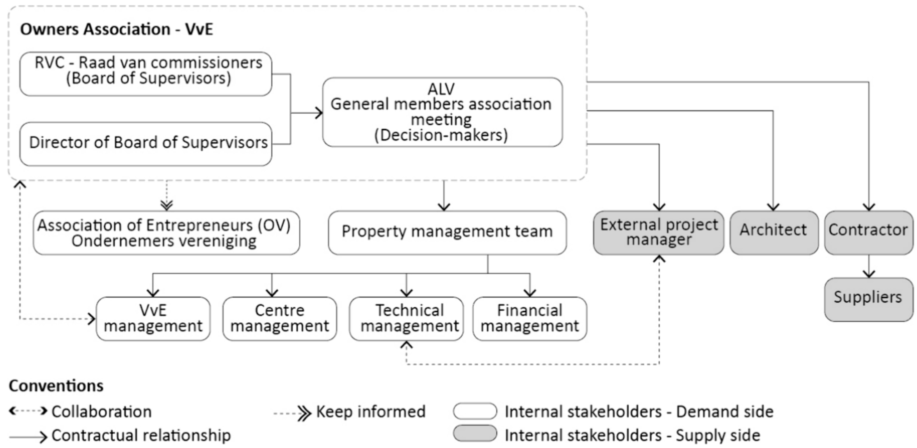

Fig. 7. Governance structure case study B.

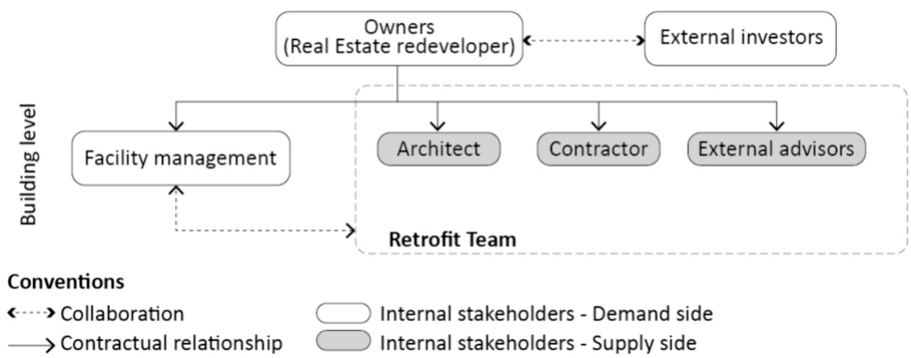

Fig. 8. Governance structure during renovation Case Study C.

regulatory mandates, such as the Sustainable Finance Disclosure Regulation (SFDR) and the Corporate Social Reporting Directive (CSRD), as well as multiples assessments through BREEAM certifications, energy label requirements, GRESB benchmarks, among others. These regulations and standards represent two distinct challenges that policymakers should address.

Firstly, policymakers are urged to streamline and integrate existing regulations. The current multitude of regulations poses a significant hurdle for owners, leading to increased complexity and compliance difficulties that manifest as an *investment cost* barrier in the form of a transaction cost on stage 4. Harmonizing and integrating regulations would reduce this complexity and facilitate compliance, thereby fostering a more favourable environment for energy efficiency improvements. Secondly, existing regulations and subsidies often prioritize large energy consumers or market participants, inadvertently overlooking the specific needs of small owners and tenants, particularly evident in shopping centres with fragmented ownership structures. This was evidenced by the concurrence of *Lack of sharing the objectives* barrier on stage 2. Therefore, policymakers must develop targeted incentives and support mechanisms tailored to this stakeholder segment. By offering tailored assistance and resources, policymakers can enable small owners and tenants to overcome barriers and actively engage in energy efficiency initiatives.

6. Conclusion

This study aimed to reveal stakeholders' behaviours during the decision-making process of Energy-Efficiency Retrofits (EER) of shopping centres within a process perspective that considers the complexities of their context. The analysis mapped a generalised EER decision-making process, stemming from three representative shopping centres in the Netherlands. The results highlight an assignment-driven retrofit process that requires building data systems, clear sustainability strategies or targets, and shopping centre performance indicators as necessary drivers. Moreover, the functional contextual characteristics such as governance structure, ownership type, and lease structure, as well as the building's social context are key in the decision-making process.

In terms of stakeholders' behaviours, the study revealed new barrier types for this specific building typology. These included 'existing technical challenge', 'lack of access to energy consumption', 'element life-cycle conflict', 'intervention out of scope', 'limitation with governmental regulations', and 'limitation with internal regulations'. The finding also indicate that barriers have different meanings depending on the stage and the causing agent. Therefore, solutions should be tailored and addressed to each one individually.

The results also demonstrate that shopping centre owners play a critical role in supporting a more effective decision-making process to steer EERs by giving answer to the main research question: *"How can owners support a better decision-making process to steer EERs of shopping centres?"*. While owners can support this process by decentralizing decision-making, optimizing governance structure, and streamlining sustainability advisors, this study recognizes the collaborative role that property managers and policymakers play to deliver optimal and holistic solutions that promote energy efficiency and sustainability in shopping centres.

The contribution of this study to the existing body of knowledge lies in being the first, to the extent of the author's knowledge, to map the decision-making process for EER of this building typology and its related stakeholders' behaviours. Moreover, by placing attention to the cases' contextual complexities, the study not only identified specific barriers and stakeholders' behaviours towards EER, but also interrelated them to the decision-making process and to the functional and social characteristics of their context.

Limitations of this study stem from its case-study research design, which restricts statistical generalisation and comparability. However, this study offers analytical generalisation—one that provides valuable insights, allowing the conveyance of a theory into what could be expected in cases with similar variables [39]. The selected cases' representativeness of Dutch shopping centres and the depth of the analysis, as well as the maturity of this building stock [31] being comparable to other Western European countries [14,33], allow for practical recommendations to policymakers and industry professionals, such as shopping centre owners and property managers, to be applicable to other cases with similar variables in the national and wider Western European region. Other limitations include constraints in time, resources, and language, along with tenants' lack of interest, which hindered interviewing a larger sample and other supply side stakeholders such as energy providers, distribution net managers, and capital suppliers.

Further research should aim to study supply-side stakeholders' behaviour and their potential contribution to the EER of shopping centres, as well as collaborative mechanisms to join efforts toward the energy transition of the retail sector. Other areas for exploration include using shopping centres for implementing energy communities, the applicability of other leasing structures that support EER within shop areas, potential solutions to overcome identified barriers, and the validation of the findings across different retail structures.

CRediT authorship contribution statement

Maria Fernanda Villalba Muñoz: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Queena K. Qian:** Writing – review & editing, Supervision, Conceptualization. **Erwin Mlecnik:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Maria Fernanda Villaba Munoz reports travel was provided by Colliers International. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Anonymised interview transcripts can be shared upon request

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Appendix A

Stakeholders' mapping in the EER decision-making process.

		Stakeholder	Role
Internal stakeholders	Demand side	Owners/managers	This group, including institutional investors, private investors, and asset managers, is highly interested in energy efficiency but is driven by factors such as return on investment (ROI), net present value (NPV), minimum holding period [13,40], risks [27] and pay-back time [27,41] of the selected energy measures.
		Property management	Responsible for organizing and managing the property, facilities, and tenant mix on behalf of the owner, property management teams play a crucial role in optimizing the operation and management of shopping centres [42].
		Association of owners (VVE)	In cases of fragmented ownership, the owners' association ensures collective decision-making and unified action among all owners, addressing maintenance, operation, and communal rules and regulations [43].
		Tenants	While tenants prioritize consumer satisfaction over energy efficiency, their interest may vary depending on billing systems and the potential for energy bill reduction [14,24].
		Employees	
	Supply side	Designers/Architects/ Energy consultant	This group designs and advises on energy efficiency retrofits, considering client goals, budget, and energy requirements.
		Technology/manufacturers	Provide the technology, product and services that are needed during the renovation.
		Contractor/Project manager	Responsible for planning, managing, and executing energy efficiency projects or building renovations.
		Capital suppliers	Financial institutions providing loans for energy retrofit measures.
		Energy suppliers	Supplying energy to homes and businesses.
		Distribution Net managers	Organisations managing the physical infrastructure of the distribution network, ensuring reliable delivery of electricity or gas to end-users.
External stakeholders	Private	Costumers	They are the end-users. While the energy wave has influenced purchase decisions of services or goods, they are not yet interested on the place of purchase [14,25].
	Public	Government	Governments define energy efficiency standards through policies and regulations, provide subsidies or financial support [17].
		Local Authorities	Relevant in shopping centre renovations, local authorities provide building permits and contribute to community benefits such as job generation and improved community cohesion.

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