Investing in change:

Exploring the financial feasibility of convertible office buildings

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Abstract

This research investigates the financial feasibility of the design of new office buildings for future residential conversion in response to rising office vacancy rates (8%) and a housing shortage of approximately 400,500 homes in the Netherlands. Conversion is understood as the transformation of a building's function while preserving its structure, offering potential cost, time, and environmental benefits. However, the technical, functional, and legal challenges of converting existing buildings complicate their conversion. Although most buildings will require adaptation in the future, designing specifically for conversion remains uncommon due to financial uncertainties.

Existing research has explored the technical and functional aspects of convertible buildings, but little attention has been given to the financial feasibility of the design of buildings with future conversion potential. This gap limits investors' ability to assess whether convertible building designs offer financial advantages. This research aims to bridge that gap by evaluating the associated costs and benefits of the design of convertible buildings and their impact on financial feasibility.

The findings suggest that while convertible buildings require higher initial investments – due to enhanced structural features and design costs – they significantly lower long-term vacancy risks, improving rental income potential and allowing for favourable financing conditions. Sustainability benefits may also yield premiums that enhance property values and reduce tax liabilities, though their realisation is debated. The convertible design approach permits a lower discount rate, mitigating the time value of money effects on future cash flows. Financial feasibility does not solely depend on whether a building is converted; most factors remain relevant regardless of if the conversion actually takes place. The research concludes that designing for convertibility reduces long-term risks and enhances flexibility in adapting to market changes, though its financial feasibility varies based on market conditions and investor profiles.

This exploratory qualitative research contributes to filling a knowledge gap in the financial aspects of convertible building design, offering insights for investors, developers, and owners of office properties. It makes use of literature review, interviews with different stakeholders and a sensitivity analysis in form of a DCF model. The generalisability and validity of the findings may be limited because of its geographic focus on the Dutch market, the qualitative nature of data collection, and reliance on assumptions in the sensitivity analysis.

Keywords: design for conversion, building conversion, building adaptation, office building, residential building, financial feasibility, costs, benefits, DCF model

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List of abbreviations

Cap rate – Capitalisation rate

CAPEX – Capital expenditures

CBD – Central business district

CPI – Consumer price index

CSRD – Corporate sustainability reporting directive

DCF model – Discounted cash flow model

EGI – Effective gross income

ESG – Environmental, social and governance

GDP – Gross domestic product

GIY – Gross initial yield

GEY – Gross exit yield

IRR – Internal rate of return

LTV ratio – Loan-to-value ratio

NIY – Net initial yield

NOI – Net operating income

PGI – Potential gross income

ROI – Return on investment

Introduction

1. Introduction

The Netherlands has been grappling with vacant office buildings and a continuously growing housing shortage for years. While vacancy rates in the office sector are climbing higher, the residential sector faces an alarming scarcity of space.

Currently, the office vacancy rate stands at approximately 8.0%, translating to around 4 million square meters of vacant office space (Cushman & Wakefield, 2024b). In other words, out of the total 50 million square meters of office space, 4 million are unoccupied and unused. Although the vacancy rate of the Dutch office market today is lower compared to its unprecedented highs a decade ago, it remains persistently elevated with no prospect of improvement (Cushman & Wakefield, 2024a). Back then, a surge in new office space at the turn of the millennium, combined with the 2008 financial crisis, brought the office market to its knees (Bouwinvest Real Estate Investors, 2023). Today, it is the high user demands for quality and sustainability in office buildings, alongside rapidly evolving work patterns, that pose the greatest challenges to the office sector (Cushman & Wakefield, 2024a). As technology and ways of working advance, office buildings are struggling to keep pace. This has led to a market where outdated buildings are increasingly replaced by newer ones. Users tend to prefer the highest quality buildings with strong sustainability credentials in the most accessible locations. As a consequence, older buildings are left behind, standing vacant or, in some cases, facing demolition (Remøy, 2010). Notably, the majority of these buildings are less than 40 years old, as the highest vacancy rates are found in those constructed between 1990 and 2010 (Savills, 2023). The dynamic of new buildings replacing older ones and making them redundant has led to a growing polarisation within the office market (Cushman & Wakefield, 2024b).

Simultaneously, the Dutch housing market is under immense pressure, with a shortage of around 400,500 homes across the country (ABF, 2024). To put this in perspective, this shortage equates to about 5% of the total existing housing stock. Many publications are calling this shortage a housing crisis (World Economic Forum, 2021). And again, the long-term effects of the financial crisis play a role in the current shortfall, as it effectively halted housing construction at the time. Meanwhile, demand for housing has risen, driven by shrinking household sizes and increasing labour migration (Schweighöfer, 2023). And here, too, the forecasts do not paint a positive picture. While development pipelines in the housing sector are fuller compared to past years (ING, 2024a), population growth is expected to continue (Bouwinvest Real Estate Investors, 2023), keeping the housing market, especially in the Randstad, under persistent pressure.

A potential solution that addresses both issues simultaneously is the conversion of buildings. The concept of building conversion is known in literature and practice by various terms such as adaptive reuse, building transformation, or repurposing. In the context of this research, building conversion is understood as the change of a building's function from one use to another while preserving its main structure. Both in theory and in practice, the topic of building conversion has gained increasing interest in recent years. In the Netherlands, an average of approximately 11,000 new homes have been created annually through the conversion of existing buildings over the past five years. This equates to about 10% of all new housing additions (Centraal Bureau voor de Statistiek, 2023).

In the context and scope of this research, the focus lies on the conversion of office buildings to residential use. Instead of demolishing or leaving office buildings vacant, they can be converted into residential units. Converting existing buildings not only reduces the development time compared to demolition and new construction, but also offers potential cost savings by reusing the original structure (Langston et al., 2008; Manewa, 2012; Slaughter, 2001). Moreover, conversion is the more sustainable option, as it reduces resource and material consumption, lowers energy use, and minimises waste and pollution (Bullen, 2007; Hamida et al., 2022; Kamara et al., 2020).

The solution to addressing both the surplus of vacant office space and the growing demand for residential housing seems straightforward: converting empty office spaces into much-needed living spaces. This would be interesting not only from a societal perspective, as it would address the housing needs of many, and from an environmental standpoint, contributing significantly to the sustainability of the built environment, but also from an economic perspective. It revitalises properties for investors, potentially making them profitable again while enhancing the sustainability performance of their portfolios, with positive effects on their ESG (Environmental, Social, and Governance) reporting.

However, the conversion of existing buildings poses functional, technical and legal challenges. The existing construction and technical specifications of a building can hinder its convertibility (Manewa, 2012). Residential units for example typically require different infrastructure compared to office spaces, necessitating upgrades to installations, access, sound insulation, and fire protection, which can drive up conversion costs (Bourke & Adams, 2020). In addition, legal uncertainties can also delay the conversion process, potentially rendering it unprofitable (Schenk, 2009).

Considering the projection that most existing buildings will require adaptations in the coming decades to meet future demand (Bullen, 2007; Hamida et al., 2022), and recognising the challenges associated with converting existing structures, it is worth questioning why not more buildings are designed to be convertible in the future. Rather than viewing conversion solely as a reactive strategy, it could be considered a proactive measure. Convertible buildings could more easily accommodate market changes, reducing the risk of vacancy and demolition. Yet, the design of convertible buildings remains far from common practice and, in fact, is rarely realised at all (Schmidt III & Austin, 2016). This raises the question: Why aren’t certain prerequisites considered in new buildings that enable future conversions?

The answer is financial uncertainty. Investors are uncertain about the financial feasibility of convertible buildings (Arge, 2005; Geraedts & van der Voordt, 2007; Remøy & De Jonge, 2009; Remøy & van der Voordt, 2014). Acharya et al. (2020) note that investors overall see no financial incentive to build convertible, as there is no evidence of its economic benefits. And although research into building conversion is increasing, few studies focus on the financial aspects of conversions (Bourke & Adams, 2020; Carmichael & Taheriattar, 2018; Manewa, 2012).

1.1 Problem statement

Although research has been conducted on the prerequisites and feasibility of convertible buildings, the financial feasibility of the design of buildings with future conversion potential remains largely unexplored. This gap in knowledge influences investor decision-making and market adoption of convertible building designs. Without an understanding of the financial costs and benefits of the design of buildings for conversion, as well as their effect on financial feasibility calculations, investors lack the necessary information to determine whether investing in convertible buildings offers advantages. Thus, this research seeks to determine how the design for conversion impacts the financial feasibility of new buildings.

1.2 Aim

The aim of this research is to assess the financial feasibility of the design of convertible buildings by identifying the associated costs and benefits, and their effect on the financial feasibility calculations. Ultimately, the goal is to provide insight into the financial advantages or disadvantages that design for future conversion may present for investors.

1.3 Research questions

This research sets out to answer the following research question:

How does the design of a new office building for future residential conversion affect its financial feasibility?

To guide the research and address the main research question, the following sub-questions need to be answered:

1. How is the financial feasibility of a new office building evaluated?
2. How can an office building be designed to enable future conversion to residential use?
3. What are the costs and benefits of the design of a new office building for future residential conversion?
4. How do the costs and benefits of the design for residential conversion affect the DCF model of a new office building?

The main concepts examined in this research are presented in the conceptual model as illustrated in Figure 1. The conceptual model serves as a visual representation of key concepts and their relationships. It serves to clarify the theoretical framework by illustrating how different concepts interact and contribute to the research question.

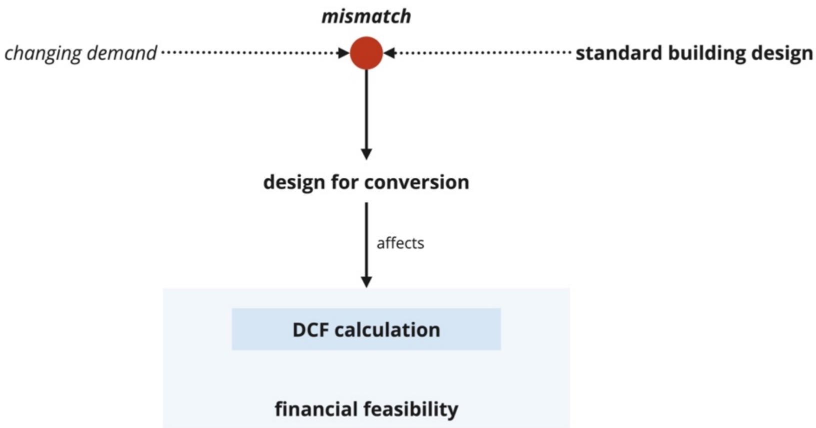

Figure 1: Conceptual model

1.4 Relevance

1.4.1 Scientific relevance

The scientific relevance of this research lies in addressing the knowledge gap regarding the financial implications of the design of new buildings for future conversion. To overview the existing literature, a distinction must first be made between a) convertible buildings, which are purposefully designed for future conversion, and b) the conversion of “standard” buildings, which are initially designed for a single function and later converted. While there is a substantial body of literature on “standard” building conversions, research on “design for conversion” remains relatively sparse, though it has been growing in recent years (Carmichael & Taheriattar, 2018). In the existing literature on the topic, the term “adaptable buildings” is frequently used synonymously with “convertible buildings”. Existing studies predominantly focus on the opportunities, risks, and technical feasibility of convertible buildings (Arge, 2005; Moffatt & Russell, 2001; Pinder et al., 2013; Remøy et al., 2011; Remøy & van der Voordt, 2014; Schenk, 2009). Potentials and challenges of convertible buildings are highlighted (Arge, 2005; Moffatt & Russell, 2001; Pinder et al., 2013; Remøy et al., 2011; Remøy & van der Voordt, 2014; Schenk, 2009), and particular attention is paid to the design parameters that enable conversion (Sadafi et al., 2014; Schmidt III & Austin, 2016; Schmidt III, 2014; Watt et al., 2023). However, there is limited research on the financial dimension of the topic (Manewa, 2012). Bourke and Adams (2020), for example, highlight that while the benefits and challenges of convertible buildings are often discussed, they are not frequently quantified. The research that does exist on economic considerations of convertible buildings largely focuses on construction costs (Manewa, 2012). This research aims to bridge this gap by providing insights into the financial feasibility of designing buildings for future conversion, thereby contributing to the body of knowledge in this area.

1.4.2 Societal relevance

Sustainability issues have never been more urgent, calling for changes particularly in the building sector which accounts for around 17% of total greenhouse gas emissions (European Commission, 2023a). Building conversion, along with the design of convertible buildings, can play a crucial role in making our built environment more sustainable. By avoiding the demolition of structurally sound buildings and reducing new construction on vacated land, conversion practices contribute to more efficient resource use. This approach minimises energy consumption, waste generation, and embodied carbon (Bullen, 2007; Moffatt & Russell, 2001; Wilkinson et al., 2014). As a result, the environmental impact of convertible buildings is significantly reduced (Andersen & Negendahl, 2023; O'Connor, 2004; Thomsen & Van der Flier, 2010). As already stated back in 1961 by Jacobs: "The greenest buildings are the ones we already have" (Jacobs, 1961, as cited in Langston et al., 2013, p. 234).

Beyond their contribution to sustainability, convertible buildings can also alleviate future vacancies and housing shortages in the market. Preventing future vacancies not only supports environmental goals but also helps maintain the vitality of urban districts, minimises land occupation, and mitigates urban sprawl (Bullen, 2007; Deloitte, 2022). Further, convertible buildings could serve as a strategy for addressing the ongoing housing shortage. In light of the projected population increase the pressing need for sufficient housing in the urban areas is only anticipated to keep growing in the coming years (European Commission, 2019; Thelen et al., 2019). Simplifying the conversion of empty office buildings into housing can help to tackle this problem by supplying more housing into the market and thereby simultaneously making the available housing more affordable (Remøy & van der Voordt, 2014; Wilkinson et al., 2014).

Research into the financial feasibility of convertible buildings is essential to stimulate investments that can address these broader societal challenges.

1.5 Scope

To ensure the feasibility of this research, the following scope has been defined. In this context, design for conversion refers to a design strategy that enables or supports the potential future conversion of a building. By incorporating design parameters, the necessary preconditions are set to facilitate the building's future conversion if needed. 'Convertibility' is seen as a spectrum, where buildings can be more or less convertible based on the extent to which convertible design parameters are incorporated into their design. Building conversion in the context of this research does not include the conversion of "standard" buildings that were originally designed for one function only.

Further, this research exclusively focuses on the programmatic change from office to residential use, excluding other potential functions. This focus is justified by both current market conditions and the technical feasibility of such conversions. As previously mentioned, converting offices to residential buildings is the most economically logical option in today's market, given the surplus of office spaces and the high demand for housing. Besides that, this conversion is also the most feasible from a constructive perspective, as the physical requirements for office and residential spaces are more closely aligned compared to other functions, such as for example healthcare or educational uses (Douglas, 2006; Manewa, 2012).

Context

2. Context

This first chapter serves a dual purpose. On the one hand, it situates the research question within its context. On the other hand, it forms the basis for the development of the research methodology.

To situate the research question within its theoretical and current context, this chapter first summarises the fundamental theory of real estate market dynamics, followed by an overview of the current market situation in the Netherlands. Since market dynamics differ across segments – for example, the office market operates differently from the housing market – and convertible buildings transition from one market segment to another over their lifespan, both the office and housing markets are examined. In addition, the relation of convertibility to durability and sustainability is discussed within its broader context.

Building on this knowledge, the research methodology is developed in the next chapter.

2.1 Market cycle

Both the office and housing markets are subject to general real estate market dynamics, which are elaborated below.

As in other markets, the dynamics of the real estate market are driven by two market forces: demand and supply. The interaction between demand and supply results in a cycle. Mueller (1999) describes this cycle as the physical market cycle. Based on the rate of change in demand and supply, the cycle can be divided into four distinct phases. Figure 2 illustrates the market cycle in relation to occupancy levels. The first and second phases of the cycle are growth phases (recovery and expansion), during which demand increases at a faster rate than supply. Conversely, the third and fourth phases are decline phases (hypersupply and recession), where supply growth exceeds demand growth.

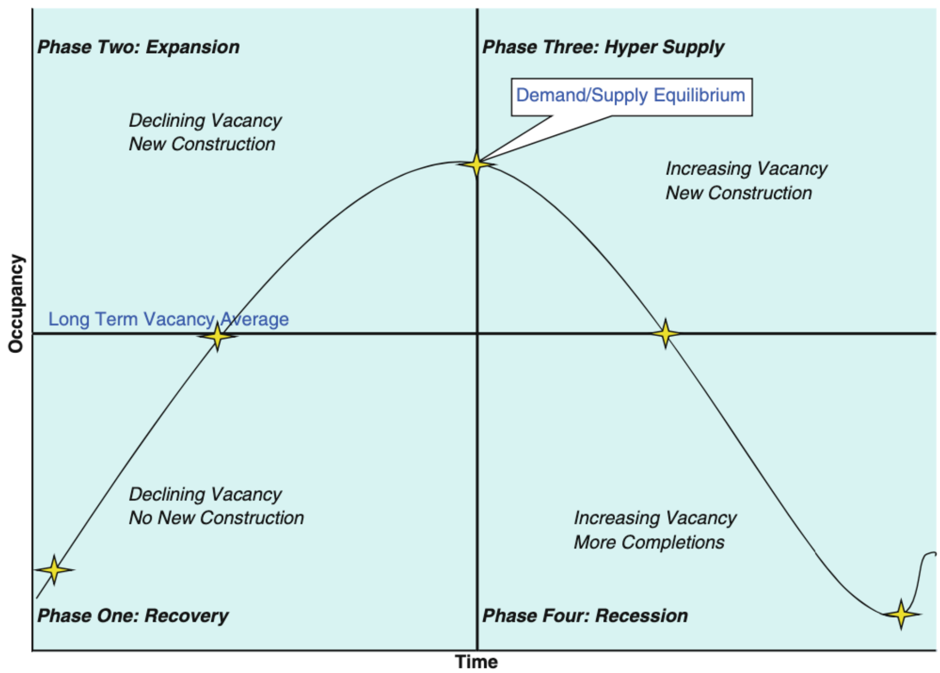

Figure 2: Market cycle quadrants (Goddard & Marcum, 2012; Mueller, 1999)

The first phase, recovery, begins at the cycle's low point and is characterised by an oversupply of space due to previous overbuilding or negative demand growth. At this stage, occupancy rates are at their lowest, resulting in peak vacancy rates. As the cycle progresses, demand starts to increase slowly, absorbing the existing oversupply while new construction remains minimal. During this phase, the growth of rent levels is negative or stagnant, but as occupancy improves and market sentiment shifts positively, rents gradually rise. Eventually, occupancy reaches its long-term average.

Expansion occurs as occupancy surpasses the long-term average, indicating a tightening supply. Rapid rent increases follow as demand continues to outpace supply. This phase may see speculative construction begin, as developers anticipate achieving "cost feasible" rent levels that ensure profitable returns on new developments. Historically, demand growth may reach around 3%, while supply growth lags at less than 2%, resulting in sustained rental growth.

The cycle reaches its peak when demand and supply growth rates stabilise, often at the highest occupancy and rental growth rates. Following this, the hyper-supply phase commences, marked by a shift where supply growth exceeds demand growth. Although occupancy remains high initially, new completions begin to compete for tenants, leading to a decline in rental growth. Eventually, as the market approaches the long-term average occupancy, rental growth slows to inflation levels.

Finally, the recession phase sets in when occupancy dips below the long term vacancy average, often driven by oversupply from the hyper-supply phase or rapidly declining demand. In this phase, landlords must lower rents to retain tenants, resulting in the growth in rent levels to fall below inflation or become negative. Market liquidity diminishes as the disparity between bid and ask prices widens. The cycle ultimately reaches its low point when new construction ceases and demand begins to increase at a rate higher than supply (Goddard & Marcum, 2012; Mueller, 1999).

If the cyclical developments of demand and supply are considered separately, the picture shown in Figure 3 emerges. The demand cycle often leads the supply cycle in the real estate market, a phenomenon known as the "hog cycle." Typically, the growth in supply trails behind economic cycles and demand trends by 2 to 3 years. This lag occurs because the lengthy planning and financing processes associated with new projects delay responses to changing market conditions (Phyrr et al., 1999; Remøy, 2010).

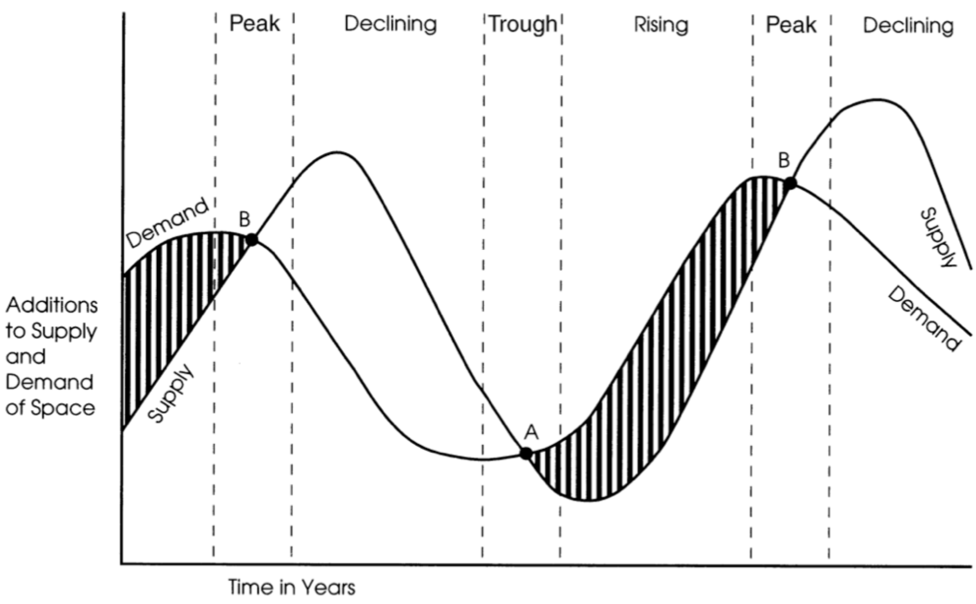

Figure 3: Phases of the Real Estate Supply and Demand Cycle (Phyrr et al., 1999)

When examining the market cycle, it becomes clear that vacancy is a natural phenomenon of the market, driven by fluctuations in demand and supply. A certain level of vacancy is even necessary for the market to develop and balance itself while striving for equilibrium between demand and supply. This level is known as natural vacancy. Though, if the vacancy rate remains persistently high, it indicates a mismatch between supply and demand, where vacancy exceeds its natural level. This mismatch can be both quantitative or qualitative in nature (Keeris, 2007; Remøy, 2010; Tse & Webb, 2003).

Although the basic market forces as described above apply to the real estate market in general, it cannot be directly compared with other financial assets. Real estate markets, unlike other global markets, are regional in nature and property prices are highly dependent on location and building characteristics. Even comparisons between markets within the same market segment are difficult. Each local, regional and national market has unique characteristics that make market comparisons difficult. Factors such as local politics and regulations play a significant role in shaping these markets, along with demography, economic fluctuations, technological advances and developments in financial markets, including interest rates (Remøy, 2010).

2.2 Office market

First, an overview of the office segment of the real estate market is provided, starting with a description of the general dynamics of office markets, followed by an analysis of the current market situation in the Netherlands.

DiPasquale and Wheaton (1992) describe the real estate market as consisting of two interconnected markets: the space market and the asset market. This distinction, when applied to the office segment of the real estate market, results in the office space market as well as the office asset market. In the office space market, tenants rent office space from property owners, with transactions centred on the use of office space for business operations. Conversely, the asset market involves the purchase and sale of office properties between investors, where prices are driven by the available supply and demand for office buildings and their expected financial returns. These two markets are closely linked, as the demand for office space by organisations – based on their size, type, and work style – directly influences the value of office buildings in the asset market.

On the demand side, the stakeholders are the users of the office space, primarily office organisations. These organisations view office space as a functional resource that accommodates and supports their core business. Organisations choose their office space on the basis of quantitative and qualitative needs and preferences (Remøy, 2010). The organisations' preferences for certain physical features of office space depend on the characteristics of the organisation itself, such as the size and type of organisation, its working culture, as well as its current economic performance. In times of economic upturn, for example, organisations are more likely to expand and hire new employees, which increases demand in the office market. Conversely, in times of economic downturn, organisations are often forced to cut costs and tend to be more cautious about renting new office space, which reduces demand in the office market (Fahrländer Partner AG, 2024). Also, changes in the work culture - in the way we work - have an influence on both the qualitative and quantitative demand for office space. The transition from the industrial to the knowledge economy over the course of the twentieth century, for example, has brought about radical changes in work culture that have significantly and permanently altered the requirements companies have for their office space. In particular, the rapid development of technology has changed the way we use office buildings over the last few decades and continues to do so (Ross, 2017; Schmidt III & Austin, 2016). A more recent example is the increasing adoption of remote and hybrid work models, partly a lasting effect of the Covid-19 pandemic, which has transformed traditional demand patterns towards an increase in demand for modern, flexible office space (Kamara et al., 2020; Pourebrahimi et al., 2020; Ross, 2017). With forecasts suggesting that it will continue to grow in the coming years (JLL, 2023). Naturally, the preferences of organisations change over time, which means that demand on the office market changes with them.

The other side, the supply side, is determined by the existing office space as well as the currently constructed office space. Stakeholders on the supply side are the owners and investors of office space. In theory, supply is expected to respond to market demand, with growing demand stimulating new developments to meet the need for office space. However, in practice, this relationship is more complex, as new developments depend largely on their profitability. And since profitability is determined not only by future revenue expectations but also by development costs, low interest rates, for example, reduce financing costs, which in turn lower development costs and can encourage the construction of new spaces, even when market demand does not necessarily demand it (Brounen & Eichholtz, 2004).

Figure 4 conceptually summarises the determinants of both the demand and supply sides, whose interaction determines rent levels and occupancy in the office market.

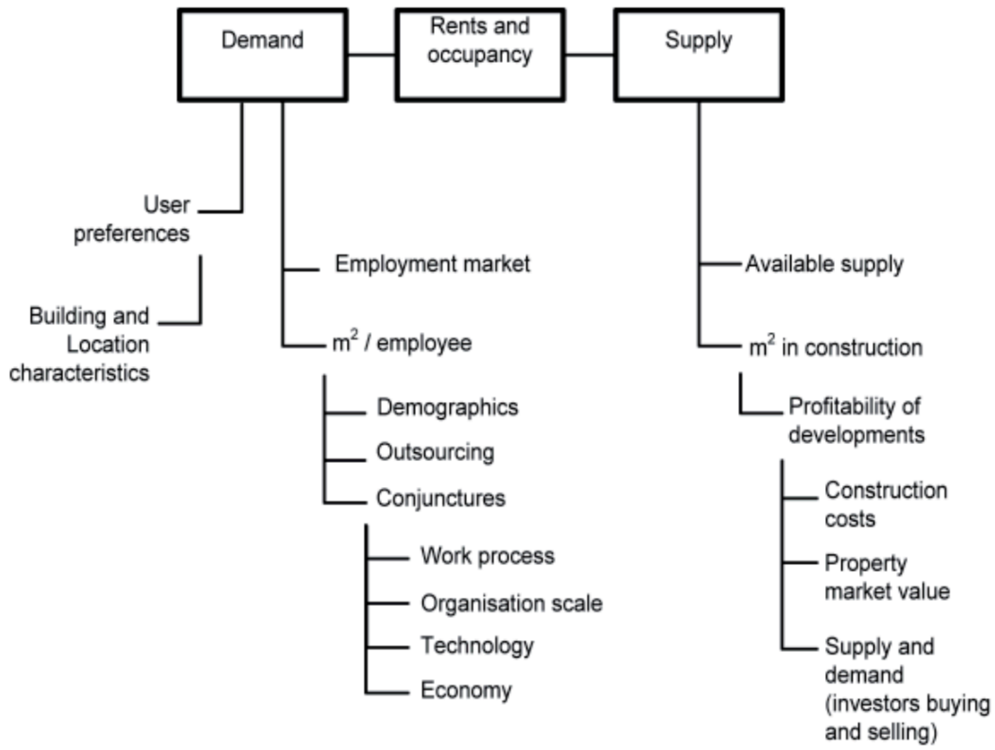

Figure 4: Demand and supply of office space (Remøy, 2010)

2.2.1 Current state office market

After summarising the general dynamics of the office market, the current situation in the Dutch office market will be examined in the following.

Overall, the sentiment on the Dutch office market is currently characterised by cautious optimism amid a backdrop of evolving work patterns and economic recovery (Bouwinvest Real Estate Investors, 2023). Following the disruptions caused by the COVID-19 pandemic, many organisations are adapting to hybrid work models, leading to a reassessment of office space needs (ING, 2024b). While demand for flexible and modern office environments is rising, concerns about oversupply persist, especially in older buildings that may not meet new standards for sustainability and functionality. This has led to an ongoing polarisation in the market, evident in high vacancy rates in one market segment and sharply increasing rent levels in another (Cushman & Wakefield, 2024a).

Today, the vacancy rate is around 8.0% in the Dutch office market (Cushman & Wakefield, 2024b). This equates to around 4 million m^2 of vacant office space out of the total of 50 million m^2. A look at its historic development shows that the office vacancy rate reached alarming heights in 2003 due to a significant influx of new office developments at the turn of the millennium, with high rates persisting until 2015. From 2015 onward, vacancy rates began to decline as unoccupied offices were repurposed for alternative uses and tenant demand rebounded (Bouwinvest Real Estate Investors, 2023). Despite significant decreases over the past decade, the vacancy rate has stabilised at a consistently high level since 2020 (see Figure 5). Looking ahead, Cushman & Wakefield (2024a) predicts that this rate will remain unchanged in the coming years.

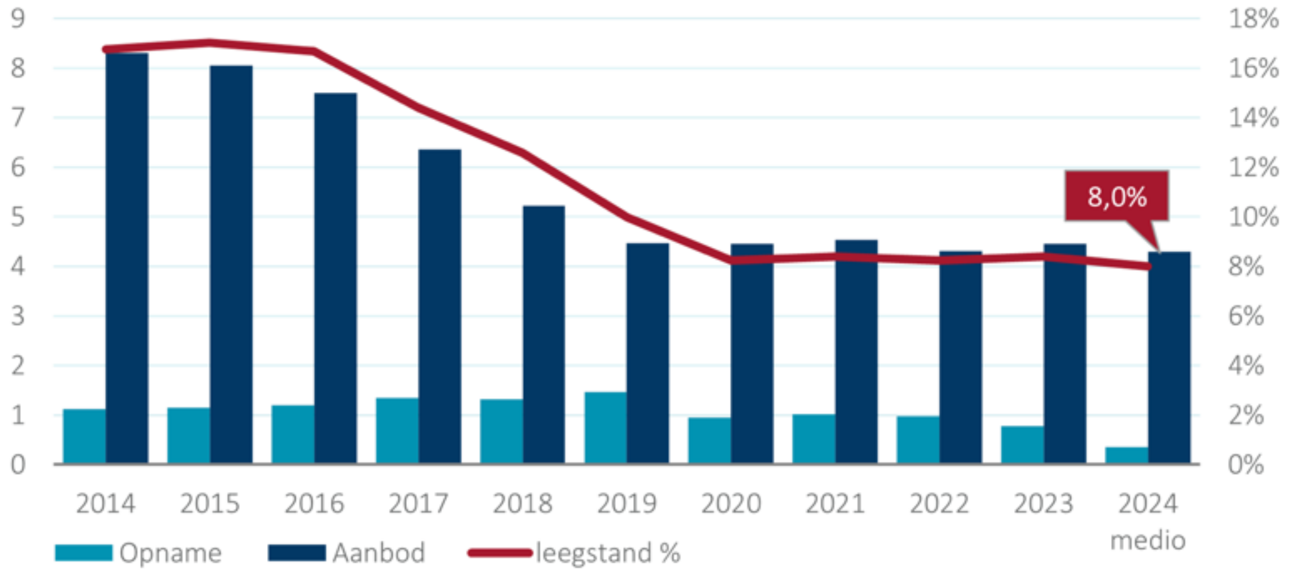

Figure 5: Dutch user market for office space. Take-up, supply (x 1 mln m² l.f.a., left Y-axis) and vacancy as % of stock (right Y-axis) (adapted from Cushman & Wakefield, 2024b)

According to Cushman & Wakefield (2024b), the high vacancy rates are not the consequence of a decrease in demand or an oversupply of office space. Instead, they result from the ongoing polarisation within the market. In other words, there is a "flight to quality" on the market. Office users increasingly demand higher standards in quality, design, location and sustainability from their buildings, moving towards the most modern, amenity-rich spaces and leaving older buildings with outdated layouts and designs behind (Savills, 2023). This shift has resulted in a shortage of high-quality office space, driving up rents for these sought-after buildings. Conversely, older buildings that do not meet current standards are experiencing rising vacancy rates (Cushman & Wakefield, 2024b).

A recent analysis of vacant office stock in the Netherlands, carried out by Savills (2023), confirms the correlation between vacancy rates and certain building characteristics. Building age, location and ESG properties of a building play a role in whether the building is more likely to become vacant or not. Office buildings constructed between 1990 and 2010 have the highest vacancy rates. One explanation for this is the lack of renovation of these buildings, their outdated layout and equipment, as well as their often secondary and tertiary locations. Notably, 86% of vacant space is concentrated in just 10% of buildings. Most of which were built before the year 2000 (76%), are either not environmentally certified at all or only marginally so (55%) and are located outside the G5 cities (73%). Only 4% of vacant space is in newer, high-quality buildings with top-tier environmental certifications.

Based on market movements, it is also clear that companies are increasingly seeking high-quality office space that meets growing sustainability requirements and is located in easily accessible locations (Cushman & Wakefield, 2024a). A recent market report by market researcher JLL (2024) finds that around 75% of the office space taken up in the G5 cities (Amsterdam, Rotterdam, The Hague, Utrecht and Eindhoven) in the first half of this year was Grade A. There are different reasons for this development. On the one hand, the trend towards hybrid work forms is developing rapidly, prompting organisations to look for alternative office space with excellent connections and a wide range of nearby amenities. Rather than reducing square footage, the focus is shifting towards using space differently in alternative locations (Cushman & Wakefield, 2024a). On the other hand, the provided office environment is being used by organisations in the "war of talent" to attract potential new employees with inspiring modern office spaces (Cushman & Wakefield, 2024b).

In addition, social pressure and, more importantly, EU-wide and national regulations to reduce CO_2 emissions are driving the demand for sustainable construction. By signing the Paris Agreement, the Netherlands has committed to reducing CO_2 emissions by 55% by 2030 compared to 1990 levels and to achieving climate neutrality by 2050 (Rijksoverheid, 2024b). Buildings, accounting for around 17% of total greenhouse gas emissions in the Netherlands, play a crucial role in the fulfilment of these ambitious targets (European Commission, 2023a). The EU's Corporate Sustainability Reporting Directive (CSRD) further encourages organisations directly to focus on their environmental impact by requiring annual reports on environmental and social risks (European Commission, 2023b). Consequently, organisations are increasingly seeking office properties that are well-accessible by public transport and meet the highest sustainability standards (CBRE, 2024b; Cushman & Wakefield, 2024a). This heightened demand is intensifying pressure on the already limited supply of such properties in CBDs (central business districts) and near railway stations.

The limited availability of high-quality office space has continued to drive up prime rents, leading to a 9% year-over-year increase in Amsterdam's CBD (JLL, 2024). This trend forces office users to weigh the benefits of modern, high-quality offices against the financial implications of rising rental costs (Cushman & Wakefield, 2024b). Savills (2023) analysis shows that newly leased offices with top environmental certifications command rents that are 3% to 17% higher, particularly in major cities. On top of that, office users often extend their current leases rather than settle for inferior options, putting upward pressure on rents for desirable properties.

Consequently, older buildings lacking these standards are at greater risk of becoming vacant as they are less appealing to tenants. The current demand dynamics reflect a polarised market: while there is a stable demand for high-quality offices, those that do not meet the evolving criteria face increasing vacancy risks (CBRE, 2024b). But what does that mean for these left-behind buildings, what happens to them? Owners have several options. They can maintain the building as is and reduce rents further to attract tenants, sell the property – likely at a discount compared to better-located buildings – or repurpose the structure or land through demolition or conversion for alternative uses (CBRE, 2022).

Looking ahead, demand for sustainable office space is expected to significantly outstrip supply by 2030, creating a substantial shortage that will likely drive rents even higher. The current supply pipeline is unlikely to alleviate these pressures in the short term. Out of the roughly 1.69 million m^2 of office space set for development between 2024 and 2028, only 15% is planned for CBDs or major station areas within the G5 cities, where demand is highest (JLL, 2024). As a result, the market for high-quality, sustainable office spaces is expected to remain competitive, with rents likely to continue rising, particularly in cities where development remains constrained (CBRE, 2024b).

2.3 Housing market

Although the housing segment of the real estate market is subject to the same general market forces as the office segment, it differs in its stakeholders and specific characteristics. The housing market will be elaborated on in the following.

The differentiation between the space market and the asset market, as described by DiPasquale and Wheaton (1992) and previously discussed in relation to the office market, can also be applied to the housing market. In the housing space market, prospective tenants seek properties that meet their specific living needs, with transactions centred on aspects like location, amenities, and overall suitability. Conversely, the housing asset market focuses on the buying and selling of residential properties as investment opportunities, where prices are shaped by the balance of demand and supply, as well as anticipated returns for investors. These segments are interconnected; for example, changes in housing demand – driven by factors such as population growth, economic conditions, and evolving lifestyle preferences – can significantly influence property values in the asset market. Once space is owned by its occupant, as is the case with most single-family homes, the differentiation into two separate markets becomes inapplicable. DiPasquale and Wheaton (1992, p. 181) note that "purchasing an asset and purchasing the use of space become one combined decision."

On the demand side, several factors significantly influence housing requirements. Population growth, economic conditions, and demographic shifts are primary drivers of demand for housing. An increase in population often leads to higher demand for homes, particularly in urban areas where job opportunities and amenities are concentrated (Thelen et al., 2019). Additionally, rising income levels can enhance purchasing power, enabling more individuals and families to enter the housing market. Changing preferences also play a critical role in demand dynamics. For instance, the trend toward remote and flexible work arrangements, accelerated by the COVID-19 pandemic, has shifted demand from urban centres to suburban and rural areas. Buyers are increasingly seeking homes with more space and access to nature, leading to a re-evaluation of what constitutes desirable living conditions. Furthermore, interest rates directly impact housing demand. Lower interest rates typically reduce borrowing costs, making mortgages more affordable and stimulating demand. Conversely, rising interest rates can dampen enthusiasm among potential buyers, leading to decreased demand (Fingleton, 2008; Muth, 1988).

On the supply side, the availability of housing is influenced by construction activity, zoning regulations, and market conditions. The development of new homes can lag behind rising demand due to various factors, including the time required for planning and obtaining permits, as well as construction delays. Economic uncertainties can also lead developers to hesitate in starting new projects, further constraining supply. Existing housing stock plays a critical role in the overall supply dynamics. The age and condition of housing can affect its availability in the market. Older homes may require significant renovations, making them less appealing to potential buyers. Additionally, the trend toward sustainability has led to a demand for energy-efficient homes, which may not be met by older stock that lacks modern amenities and environmental certifications. Local zoning laws and regulations can significantly impact housing supply as well. Restrictions on land use and development can limit the number of new homes built, exacerbating supply shortages in high-demand areas. In contrast, areas with more lenient regulations may see a surge in new construction, helping to meet rising demand (Fingleton, 2008; Kenny, 1999).

2.3.1 Current state housing market

After describing the general dynamics of the housing market, the current state in the Dutch housing market will be examined in the following.

The Dutch housing market is currently facing significant challenges driven by several key factors. A long-standing housing shortage, particularly in urban areas, has been exacerbated by rising construction and financing costs (CBRE, 2024b; Rabobank, 2024). Additionally, steady population growth and urban migration have led to a sustained demand for housing in a market that is already facing an unprecedented housing shortage today (CBRE, 2024b; Thelen et al., 2019). The increasing demand as well as the limited supply has also led to higher rents. In other words, rental markets have also seen sharp increases in prices, particularly in cities like Amsterdam, Utrecht, and Rotterdam (Rabobank, 2024). The demand for rental properties remains high due to the lack of affordable homes to buy, driving up rents and putting pressure on middle- and lower-income households (CBRE, 2024a).

Moreover, this imbalance between supply and demand has led to a continuous increase in housing prices, making homeownership less affordable for many, especially first-time buyers. In recent years, the affordability crisis has worsened due to rising interest rates, which have increased mortgage costs, further limiting access to the housing market (Rabobank, 2024).

At the same time, there has been a slowdown in new housing developments. For instance in 2023, only €1.1 billion was invested in new construction – a reduction of 59% compared to 2022 (CBRE, 2024b). High land prices, stringent regulations, and labour shortages in the construction sector have restricted the supply of new homes (CBRE, 2024a). Additionally, environmental regulations, particularly nitrogen emissions rules, have delayed or halted many housing projects, adding to the strain on supply. These regulations have also increased constructions costs and therefore worsened the problem (Rabobank, 2024). Moreover, uncertainty about rent regulations increase hesitation and therefore make new developments less attractive (CBRE, 2024b).

To solve this issue, the Dutch government has introduced several measures aimed at easing the housing crisis, such as plans for increased housing construction and more stringent rent controls (CBRE, 2024b). However, these efforts have yet to fully address the deep-rooted issues in the market, leaving the housing sector in a state of flux, with limited supply and growing demand continuing to drive up prices and rents (Rabobank, 2024).

2.4 Sustainability of convertibility

Building conversion is recognised as a driver of sustainability in the built environment (Bullen, 2007; Hamida et al., 2022). Sustainable development is broadly defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987). In this context, durability can be understood as an attribute of sustainability, and thus a characteristic of sustainable buildings (Douglas, 2006; Remøy, 2010; Zijlstra, 2006). Convertibility, by extending a building's functional lifespan, is viewed in this research as a means of enhancing the building's durability and, consequently, its overall sustainability. However, the sustainability of convertible buildings depends on their actual operational lifespan; without the extension of the lifespan of convertible buildings, their potential for enhanced sustainability may not be realised, and they could even become less sustainable due to increased material use associated with their design.

Buildings, unlike the environments they occupy, are often designed as static objects intended for a single purpose (Askar et al., 2021; Beadle et al., 2008; Brand, 1994; Hamida et al., 2022; Remøy, 2010; Remøy & De Jonge, 2009; Schmidt III & Austin, 2016). This mismatch between a building's static nature and its dynamic surroundings leads to an imbalance between supply and demand over time (Manewa, 2012; Schmidt III & Austin, 2016). As a result, buildings that lack the ability to adapt to changing needs may become functionally obsolete, leading to premature demolition even if they are still structurally sound and safe to use (Remøy & van der Voordt, 2014). Economic factors often drive demolition decisions, with a building’s economic life depending on its ability to generate income wird (O’Connor, 2004). Once a building no longer meets market demands or becomes unprofitable, it is often demolished, regardless of its remaining technical viability.

These premature demolitions present a major challenge to sustainability in the built environment as many buildings are demolished long before they reach the end of their technical lifespan. For example, a study by Andersen and Negendahl (2023) found that the average office building in the Netherlands is demolished at just 54 years old, even though these buildings could potentially last much longer, with a technical lifespan of 100 years or more. Premature demolitions result in the substantial generation of waste, which, combined with the resource use of new construction, creates a significant environmental impact (Thomsen & Van der Flier, 2010).

Convertibility addresses this issue by promoting flexibility in building design. A building designed for future conversion can more easily adapt to changes in demand, extending both its economic and functional life. This adaptability helps avoid the waste and environmental impacts associated with demolition and reconstruction, as convertible buildings can serve multiple purposes over time.

By extending a building’s life cycle, conversion reduces resource consumption, waste, and emissions. As Jacobs noted, “the greenest buildings are the ones we already have” (Jacobs, 1961, as cited in Langston et al., 2013, p. 234). Converting a building to a new use preserves its structural elements, reducing the need for new materials and avoiding the environmental impacts of demolition (Carmichael & Taheriattar, 2018). The preservation of existing buildings also reduces emissions from construction activities, as fewer resources are needed for both demolition and rebuilding (Thomsen & Van der Flier, 2010).

The environmental advantages of building conversion extend beyond waste reduction. Compared to demolition and new construction, conversion requires fewer materials and less time, lowering the overall environmental footprint of the process (Carmichael & Taheriattar, 2018; Gosling et al., 2013; Schmidt III, 2014). De Jonge (2005) demonstrates that conversion is often more cost-effective over a building's life cycle than demolition and rebuilding, further reinforcing its sustainability benefits.

Given that conversion can extend the lifecycle of a building and thereby enhance its durability, and reduce the environmental impact associated with demolition and reconstruction, convertible buildings are understood in the context of this research as inherently sustainable.

However, the sustainability benefits of convertible buildings depends on if they actually have a longer lifespan than standard buildings in practice. While convertibility presents significant potential for enhancing sustainability, it does not guarantee it unless the operational lifespan of the building is actually extended beyond that of a standard, non-convertible structure. For buildings designed for conversion to achieve sustainability, they need to remain operational for a longer duration than traditional buildings, which is essential for offsetting the initial environmental costs associated with construction and the subsequent adaptation process.

Although convertibility allows for the possibility of a longer lifecycle, this potential is only fulfilled if the building is actively repurposed and continues to be utilised. The concept of convertibility relies on the assumption that a building will undergo multiple use cycles. However, if market conditions, owner preferences, or regulatory barriers impede this process, the anticipated longer lifecycle may remain merely theoretical. In such scenarios, the environmental benefits associated with convertibility would not be realised. Moreover, convertible buildings could ultimately be less sustainable than standard buildings if their lifecycle does not exceed that of the standard buildings, due to the increased material use and resource consumption associated with the overdimensioning of components necessary for a convertible design.

Methodology

3. Methodology

Building on the background knowledge discussed in the previous chapter, a research methodology is developed. This methodology serves as both the theoretical and practical framework for the study, guiding the process of answering the research question. The following chapter details the methodology, beginning with an overview of the research design, followed by descriptions of data collection methods through literature review and interviews, and concluding with an explanation of the analysis and management of the collected data.

3.1 Research design

This research adopts an exploratory approach, using qualitative research methods to investigate the topic at hand. The initial phase involves the conduction of a contextual and theoretical literature review, subsequently interviews with practicioners are conducted and lastly, the findings from the literature and interviews are modelled and applied in a DCF model calculation. An overview of this research design is presented in Figure 6.

Given the limited exploration of this topic in existing literature, the qualitative approach serves two primary objectives. First, it aims to identify and evaluate the existing knowledge on the subject. Second, it seeks to collect new insights from practice, expanding the understanding of financial feasibility and convertible building design. One strength of qualitative research methods is its effectiveness in identifying relationships among subjects (Blaikie & Priest, 2019; Coyle, 2000). This strength is utilised here to link and contextualise the existing research on financial feasibility and convertible building design.

First, the literature review serves the purpose of exploring the existing knowledge on the topics. The literature review is divided in a contextual and theoretical part. The output of the literature review is a preliminary framework of the effects of design for conversion on the buildings financial feasibility. supplemented by insights from practice derived from stakeholder interviews (Bryman, 2012; Hoepfl, 1997). interviews are conducted with various stakeholders to gain a deeper understanding of the subject and gather new insights from practitioners in the field. The interviews will provide an in-depth perspective on the topic. The interviews are conducted in an iterative process with the literature review as they may uncover new ideas or concepts. The output of the synthesis of the findings from the literature review and the interviews is the final framework of the effects of design for conversion on the financial feasibility of the building. Following, the gathered findings will be applied in a discounted cash flow (DCF) model calculation. The findings from the interviews will serve as the foundation for the DCF model design. The design of the dcf model serves the prupose of applying and testing the findings from the previous research phases. This integration will occur through a sensitivity analysis conducted within the framework of the discounted cash flow calculation.

First, the literature review aims to explore the existing knowledge surrounding the main concepts of this research. The output of this literature review is a preliminary framework that outlines the effects of design for conversion on a building's financial feasibility.

Then, to gain a deeper understanding of the subject and collect new insights from practitioners (Bryman, 2012; Hoepfl, 1997), interviews will be conducted with various stakeholders. These interviews will provide an in-depth perspective on the topic and will be carried out iteratively alongside the literature review, allowing for the discovery of new ideas or concepts. The combination of findings from both the literature review and the interviews will result in a final framework of the effect of design for conversion on a building’s financial feasibility.

Finally, the insights gathered will be applied within a discounted cash flow (DCF) model calculation. The findings from the interviews will form the basis for the design of the DCF model, which is intended to apply and test the results of the previous research phases. The conduction of a sensitivity analysis within the DCF framework will enable the thorough evaluation of the financial implications of design for conversion.

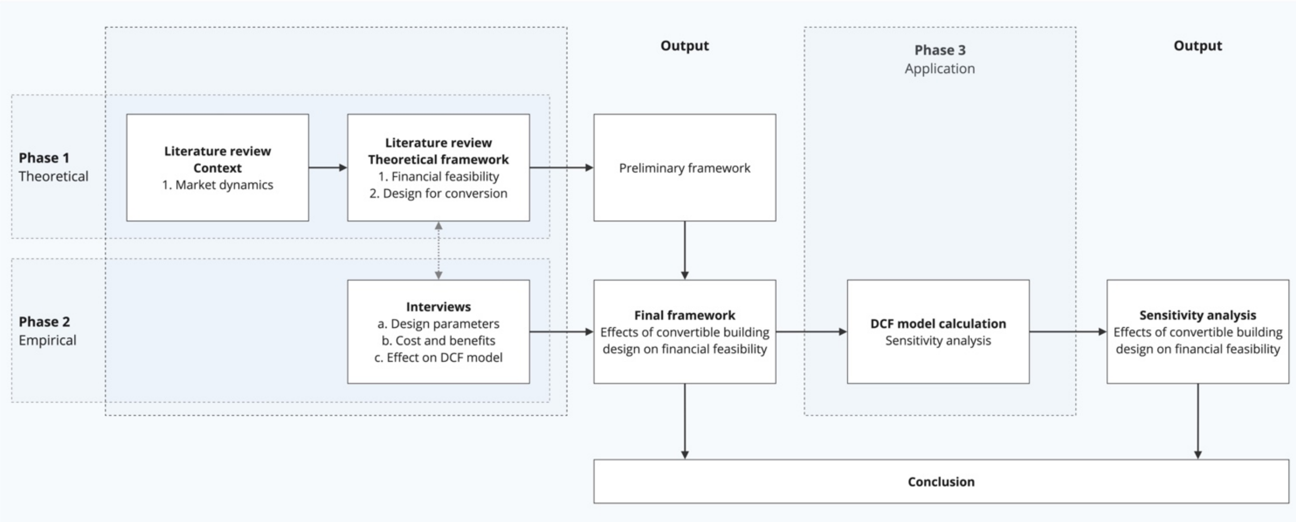

Figure 6: Overview research design

3.1.1 Data collection

As previously mentioned, this research adopts a mixed-methods research design. The data collection methods employed are described in the following section.

Literature review

First, a literature review is conducted. The purpose of this review is to provide an overview of the existing literature, understand the knowledge that has already been identified in the research field, and connect existing approaches (Bryman, 2012; Groat & Wang, 2002). Additionally, it aims to clarify the theoretical frameworks, definitions, and terminology used in the field. The literature review is divided into two parts: the context (Chapter 2) and the theoretical framework (Chapter 4).

The contextual literature review establishes a starting point and frame for further research, helping to define and delineate the scope of the study (Saunders et al., 2019). The context chapter offers background information on the market forces affecting the demand and supply of office space, while the theoretical framework chapter explores the two key concepts: financial feasibility and design for conversion. First, the assessment of the financial feasibility of an investment is explored. This includes an overview of different types of investors, an analysis of various financial feasibility analysis methods, and a detailed focus on the discounted cash flow (DCF) model as one of these methods. Second, the concept of design for conversion is investigated, focusing on design parameters that facilitate conversion and the associated costs and benefits of the design for conversion. Finally, the findings from the literature review on these two concepts are connected and synthesised to understand the effects of the costs and benefits of design for conversion on the DCF model.

The reviewed literature is gathered through academic search portals, primarily using Scopus, with some searches extended to Google Scholar. Additionally, the TU Delft Education repository is used to find relevant publications. The literature type is limited to peer-reviewed scientific articles and books, supplemented by relevant commercial or industry publications, such as company reports, when necessary. The selection of literature is guided by a search plan that establishes the main keywords for the search. Articles are chosen based on their title and abstract.

In addition to providing contextual understanding, the literature review produces a preliminary theoretical framework in the form of a correlation matrix. This matrix illustrates the link between the determinants of the DCF model and the costs and benefits of design for adaptability. The findings from this step are qualitative and will further serve as input for the sensitivity analysis.

Interviews

Since the literature on the effects of convertible buildings on their financial feasibility is fragmented, interviews will be conducted with stakeholders from practice. The content of these interviews builds on the theoretical foundation established in the literature review and generates new insights and explanations for the underlying research question (Barendse et al., 2012). Various stakeholders from the real estate sector will be interviewed, specifically those involved in building conversion and/or the assessment of financial feasibility for real estate investments. Moreover, the in-depth knowledge gained from these interviews can help illuminate investment decisions and considerations that may not be covered in the literature, as they may be based on current market dynamics. The goal of the interviews is to substantiate the insights from the literature, particularly the developed preliminary framework on costs and benefits and their influence on investment financial feasibility. The findings from the interviews will complement, expand, or even correct the theoretical findings, thereby contributing to answering sub-questions two, three, and four.

The interviews are conducted as semi-structured interviews. This approach can be described as a guided conversation: it has a clear structure while allowing for flexibility in responding to the interviewees' answers (Bryman, 2012). By following a defined framework, it ensures that the same topics are addressed in all interviews, making the results comparable while also allowing for adaptability in the interview process so that no potentially valuable information is overlooked. This type of interview facilitates a deeper understanding of the opinions and experiences of stakeholders involved in the process (Bullen & Love, 2011).

To gather diverse perspectives from practice (Yin, 2011), interviews are conducted with a variety of stakeholders involved in building conversion and/or the financial feasibility assessment of properties, including architects, consultants, municipal actors, real estate developers, and investors. A total of sixteen interviewees participated, as detailed in Table 1. To maintain confidentiality, the interviewees have been assigned identification codes.

Table 1: Interviewee codes and profiles

Code	Type of organisation	Role	Expertise
A.1	Architecture office	Founder	Convertible buildings
A.2	Architecture office	Managing partner	Convertible buildings
A.3	Architecture office	Associate	Convertible buildings
C.1	Consultancy	Consultant	Building economics
C.2	Consultancy	Consultant and researcher	Circularity
C.3	Consultancy	Consultant and researcher	Sustainability
C.4	Consultancy	Consultant	Financing
C.5	Consultancy	Senior information analyst	Financing
C.6	Consultancy	Senior consultant	Transactions

M.1	Municipality	Senior urban designer	Urban development
RD.1	Real estate developer	Managing partner	Conversion
RD.2	Real estate developer	Partner	Conversion
RD.3	Real estate developer	Development manager	Conversion
I.1	Real estate investor	Director	Investor developer
I.2	Real estate investor	Asset manager	Institutional office fund
I.3	Real estate investor	Acquisition manager	Institutional office fund

3.1.2 Data analysis

The qualitative data is analysed using an abductive reasoning approach, combining empirical observations with theoretical insights to create a broader contextual understanding. Abductive reasoning is particularly effective when a strong theoretical foundation is lacking, as it draws insights from observed data and refines the analytical framework by identifying and interpreting emerging patterns. This approach enables a flexible process, adjusting the framework as new themes and insights develop (Blaikie & Priest, 2019; Bryman, 2012).

For interview data analysis, thematic analysis is applied. The process begins with familiarising with the data, followed by coding significant segments and grouping these codes into broader themes that capture recurring patterns relevant to the research question. By focusing on keywords and recurring concepts, thematic analysis ensures that key insights are systematically explored and interpreted. The combination of abductive reasoning and thematic analysis allows for an evolving framework that connects empirical findings to theoretical concepts as new patterns emerge (Bryman, 2012; Naeem et al., 2023).

3.1.3 Data management and ethical considerations

Conducting research comes with the obligation to undertake ethical considerations about the collection and handling of research data. This ensures not only respectful treatment of the participants but also the validity and reliability of the data. Especially the collection of research data involving human research subjects requires the responsible handling of their personal data. For this reason, this research is subject to the human research ethics and data management guidelines set by the supervising institution, University of Technology Delft. The key measures to ensure transparent and confidential handling of participants' personal data within this research are obtaining informed consent prior to data collection and the anonymisation of private identifiable information. In this way, the rights of the participants are respected and their identity is protected. The approval report of the TU Delft Human Research Ethics Committee (HREC) contains an elaboration of the protective measures in place. In addition to these measures, a data management plan was drawn up to ensure and safeguard the responsible handling of data both during the execution and publication of the research. The data management plan regulates the collection, handling, storage and re-usability, as well as the ownership of data based on the FAIR principles for data handling: Findable, Accessible, Interoperable, and Reusable (Wilkinson et al., 2016).

3.2 Research output

This research aims to deliver two interconnected outputs. The first output is a framework that combines the costs and benefits of design for conversion with the determinants of the DCF model to assess their impact on the financial feasibility of buildings. The second output is a sensitivity analysis generated through a DCF model calculation, analysing the sensitivity of the most decisive DCF determinants: conversion year, additional initial investment for convertibility and annual rental income second use. As discussed in the previous chapter on research objectives, the output of this research is intended to provide an evidence base to inform investors. The outputs are also indicated in Figure 6.

3.2.1 Dissemination and audiences

This study targets two main groups. First, it is of interest for practitioners in the construction industry and real estate investment, specifically focusing on owners, investors, and developers of office properties. Given that the research concentrates on new office buildings, it is particularly relevant for investors in new developments and for developers themselves. Investors and owners play a crucial role as key stakeholders who can initiate a chain reaction of change throughout the construction value chain. By investing in convertible buildings, they can influence the entire construction value chain. Consequently, this research is also beneficial for other stakeholders within the built environment supply chain.

Second, the research is relevant for researchers and scholars in the fields of building conversion, convertibility, the transition to a circular economy, and real estate economics and finance. The findings aim to bridge the existing knowledge gap and enhance understanding of the topic, serving as a starting point for further research and raising new questions.

Theoretical framework

4. Theoretical framework

To better understand how convertible design impacts the financial feasibility of a new office building, it is essential to first examine the main concepts: financial feasibility and convertible buildings. How is the financial feasibility of any real estate investment assessed? And what is meant by convertible buildings? The following section offers a review of the theoretical background on both topics as discussed in the literature.

First, this chapter explores the financial feasibility of real estate investments by delving into the concepts of return and risk, examining various investor types and their respective profiles, and providing an overview of financial feasibility analyses. The emphasis is placed on the discounted cash flow (DCF) model calculation as a primary method for determining financial feasibility. Next, the chapter discusses design for conversion, focusing on the theoretical background of the concept, the design parameters that facilitate conversion, and their associated costs and benefits. Finally, the chapter synthesises these two concepts to assess the impact of design for conversion on the DCF model calculation for investments.

4.1 Financial feasibility

To understand how designing a building for future conversion impacts its financial feasibility, it is essential to first clarify how financial feasibility is assessed in real estate investments. Since financial feasibility is not an objective concept but depends significantly on the investor's interests, it is also necessary to explore the various types of investors and their influence on this assessment. Which methods of financial feasibility analysis are commonly used? And which parameters of the investment affect this assessment? The following chapter then clarifies how these parameters change when assessing a convertible building compared to a "standard" building.

In the context of the underlying research question, this chapter primarily focuses on evaluating the financial feasibility of new construction as opposed to existing buildings.

Before investing in any property, investors first need to determine the feasibility of the potential investment. This feasibility assessment is a crucial step in the investor's decision-making process (Björnsdóttir, 2010). To ensure an informed investment decision, investors assess the investment opportunity using feasibility analyses. These analyses consider the different dimensions of the investment, such as technical, social, legal, financial, and organisational feasibility (Mukherjee & Roy, 2017). In the context of this research, the financial feasibility of the investment is of particular interest. It also plays a crucial role in the investment decision, as investments are generally not pursued if they are not financially viable. Feasibility does, however, not guarantee a certain outcome; rather, a project is considered feasible if it is likely to achieve its objectives (Costello & Preller, 2010). In literature, the term is often used synonymously with economic feasibility (Mukherjee & Roy, 2017; Terblanche & Root, 2022).

Generally, an investment is considered financially feasible for an investor if it meets their return requirements (Bennett, 2003). An investment opportunity that fulfils these requirements is pursued further; one that does not is dismissed. Investors typically establish internal return and risk objectives as prerequisites for making an investment decision. Return expectations and risk appetite vary among investors and depend on their individual investment profiles. Generally speaking, the invested capital should yield a return that is at least as high as, or higher than, the return on other investments with comparable risk.

4.1.1 Return and risk

Central to any financial analysis are the return of the investment and its associated level of risk (Levy, 2020). But what do return and risk actually mean in the context of real estate investments? Investors fundamentally differ in their views on return and risk, just as investments themselves fundamentally vary in their return and risk characteristics. Generally speaking: the greater the risk, the greater the return (Goddard & Marcum, 2012). This very simplified relationship is illustrated in Figure 7. It is also generally true that the main aim of an investor is to achieve the highest possible return against an acceptable level of risk (van Driel & van Zuijlen, 2016). Since returns theoretically increase with higher risk, an investor must decide how much risk they are willing to accept; thus, an investment basically is a trade-off between expected return and acceptable risk (Goddard & Marcum, 2012).

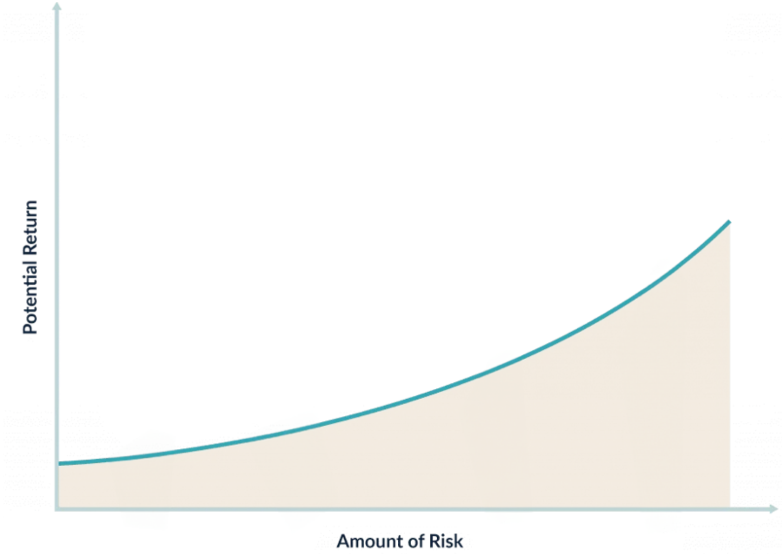

Figure 7: Risk versus return (adapted from George, 2021)

Like any type of investment, real estate is subject to different risks. In financial analysis, risk is defined as the potential fluctuations in future returns from a specific asset (Costello & Preller, 2010). This definition highlights the inherent relationship between return and risk. Viruly (1999, as cited in Costello & Preller, 2010) identifies several types of risks:

- Business risk: The risk arising from fluctuations in economic activity and factors that affect the variability of a property's income.
- Financial risk: The risk associated with using debt financing and the potential issues from excessive leverage.
- Liquidity risk: The risk stemming from a lack of consistent and continuous market activity.
- Inflation risk: The risk that property income may not counter rising inflation rates.
- Management risk: The risk related to inadequate property management.
- Legislative risk: The risk that changes in regulations, taxes, zoning laws, and other government-imposed restrictions could negatively impact property developments.
- Environmental risk: The risk that changes in the environment or new revelations about environmental hazards could affect real estate values.

The most pertinent risk when evaluating convertible buildings is the business risk, which generally stems from economic fluctuations (Brueggeman & Fisher, 2010). According to Goddard and Marcum (2012, p. 120) business risk "will appear in the financial statements of the investment property in changes from original projections in capital expenditures, gross potential income, vacancy factors and credit losses, operating expenses, and in the final property value." This type of risk is inherent in every form of investment (Goddard & Marcum, 2012). In addition to thoroughly evaluating the past operational performance of potential tenants, investors should closely monitor broader factors such as shifts in market demand, demographic trends, and changes in the core employment base in the area to mitigate the business risk of any investment.

Some of these risks can be partially mitigated through diversification, while others remain unavoidable. Goddard and Marcum (2012, p. 120) state: “The underlying goal is not the complete removal of risk from an investment, as risk and return are often related.” By categorising risks into those that can be managed by the investor and those that cannot, they continue to write, opportunities can arise to improve the potential return on investment.

One approach to mitigating risks is to diversify investments at the portfolio level. By investing in different properties, it is possible to prevent the risks associated with individual properties from offsetting each other or causing simultaneous problems across all properties. There are different options for an investor to spread risk throughout their portfolio (Goddard & Marcum, 2012; van Gool et al., 2007):

- Diversify investments across different regions or countries to manage geographic risk.
- Invest in different asset types, such as for example offices, retail, and residential properties.
- Allocate investments among multiple properties to spread risk.
- Diversify the tenant base to reduce risk from specific industries.
- Stagger lease expiry dates to avoid simultaneous vacancies.

One of the biggest risks in property investment is the potential for the property to become vacant, as this leads to a loss of rental income, which is crucial for generating returns. Real estate returns are generally categorised as direct or indirect, both of which depend on the rental income the property produces or is expected to produce. Direct returns are the immediate income received, such as rent, while indirect returns come from capital gains, like those realised from selling the property (Schenk, 2009).

The emphasis on direct or indirect returns depends significantly on the market in which the property is purchased or assessed. In markets characterised by stability and predictability, where rental demand is consistent and tenant turnover is low, direct returns become critical for investors. In such environments, the focus lies on securing reliable rental income, as this immediate cash flow is essential for covering expenses, servicing debt, and generating profit. Investors in these markets prioritise properties that demonstrate strong occupancy rates and long-term leases, ensuring that they can maximise their direct returns over time.

Conversely, in speculative or appreciating markets, where property values are expected to rise rapidly, future returns through capital gains may take precedence. In these contexts, investors might be more inclined to accept lower immediate rental income in exchange for the potential for significant appreciation in property value. The expectation of capital gains often leads to a focus on properties in up-and-coming areas or those that are undervalued, where the potential for resale at a higher price is attractive. Investors in these markets may prioritise factors such as location trends, urban development plans, and demographic shifts that could indicate future value appreciation, thereby shifting their focus away from direct returns and towards long-term investment strategies.

Long-term investors typically prioritise stable, ongoing rental income, making direct returns critical in their investment strategy. They seek properties with reliable cash flow and low vacancy rates to ensure consistent revenue over time. For these investors, the predictability of direct returns aligns with their strategy of building wealth gradually through steady income. In contrast, short-term investors often focus on quick capital appreciation and may be more inclined to pursue properties in speculative markets. These investors are usually more willing to accept lower immediate rental income, aiming instead for significant gains from resale within a short timeframe.

Direct returns are directly affected by the level of occupancy. Indirect returns are indirectly affected by the level of occupancy as they are calculated based on the property’s potential for future rental income. In other words, a rise in property vacancy results not only in a loss of current rental income but also in reduced indirect returns, such as those from the sale of the property. If assumptions about rental income do not materialise due to vacancies, the investment return is not guaranteed. Designing buildings to be convertible can directly address the risk of vacancy and potentially reduce vacancy by allowing the building to be repurposed when vacant (Schenk, 2009).

4.1.2 The investor

As the financial feasibility of a project – and ultimately the investment decision – largely depend on the investment profile of the investor assessing the project, it is important to outline the different types of investors in the office market. In general, investors in the office market are classified into two types: owner-occupiers and commercial investors (van Gool et al., 2007).

The owner-occupier utilises the real estate for their own business purposes and is primarily concerned with its suitability for their operational needs rather than with investment returns. For them, the property serves as a functional asset that supports their main business activities (Duffy, 1980). In the context of converting buildings from one function to another, the owner-occupier is of limited interest as an investor. Since they use the property for their own business, they are not concerned with preventing potential future vacancies or with converting the building for residential use. Designing convertible buildings is relevant to this investor only if they anticipate selling the property in the future.

For commercial investors, on the other hand, the property is a financial asset and their main interest is maximising the return on their investment. Commercial investors differ from each other in terms of their risk appetite and their legal structure.

When categorising commercial investors by their legal structure, a distinction is made between private and institutional investors. Institutional investors are defined as entities that, due to the nature of their operations, have access to funds that must be invested (Farragher & Kleiman, 1996). Institutional investors primarily focus on securing pensions and providing private investors with opportunities to invest according to their preferred risk profile. In the Netherlands, institutional investors include pension funds, investment funds, and insurance companies (Centraal Bureau voor de Statistiek, 2016). The key distinction between institutional and private investors lies in the scale of capital they manage. Institutional investors, handling large amounts of capital sourced from third parties, are subject to stringent regulatory oversight due to the substantial funds they control (Farragher & Kleiman, 1996).

Another categorisation can be made based on the investor's willingness to take risks. Investors typically establish internal return and risk objectives as prerequisites for making an investment decision, which are based on the minimum return they require and the maximum level of risk they are willing to accept (van Driel & van Zuijlen, 2016). The "European Association for Investors in Non-Listed Real Estate Vehicles" (INREV) defined four risk profiles used to categorise investments: core, core-plus, value-add and opportunistic. Investments with comparable risk and return characteristics are summarised in these four categories. Figure 8 illustrates the positioning of the four categories with respect to their risk and return profiles.

- Core: Core properties appeal to risk-averse investors due to their low default probabilities and are typically situated in prime locations with high-quality tenants. This results in near-full occupancy and strong tenant creditworthiness. However, their high purchase prices lead to modest return expectations of 4-6%, with limited potential for value appreciation. Financing generally involves a conservative low leverage ratio of 40-60% debt, and investors pursue a long-term, low-risk strategy, resulting in the longest holding periods among risk categories.
- Core-plus: Core-plus properties present a moderate risk and lower return expectations, typically situated in promising secondary locations with development potential. They often have shorter lease terms, allowing for rental income increases as market conditions improve. However, tenants tend to have lower creditworthiness compared to core properties. Return expectations range from 6-8%, with a debt ratio of 40-60%. Investments in this category are usually held for less than 10 years.

- Value-add: Value-add investments involve significant risk but offer higher return expectations, usually ranging from 8-11%. These properties are often in secondary locations and of average quality, where value can be increased through renovation and repositioning. With a debt ratio of 60-70%, the risk of default is higher due to lower equity stakes.
- Opportunistic: Opportunistic properties are characterised by high risk and potential high returns, often located in less desirable areas requiring significant renovations. They typically have high vacancy rates and lower-quality tenants. Investors exploit market inefficiencies to acquire properties at low prices, aiming for substantial value increases. These investments are held for 1-4 years, focusing on maximising value through renovations. With leverage over 75%, they target returns exceeding 10%, reflecting the associated high risk (Colliers, n.d.; INREV, 2012).

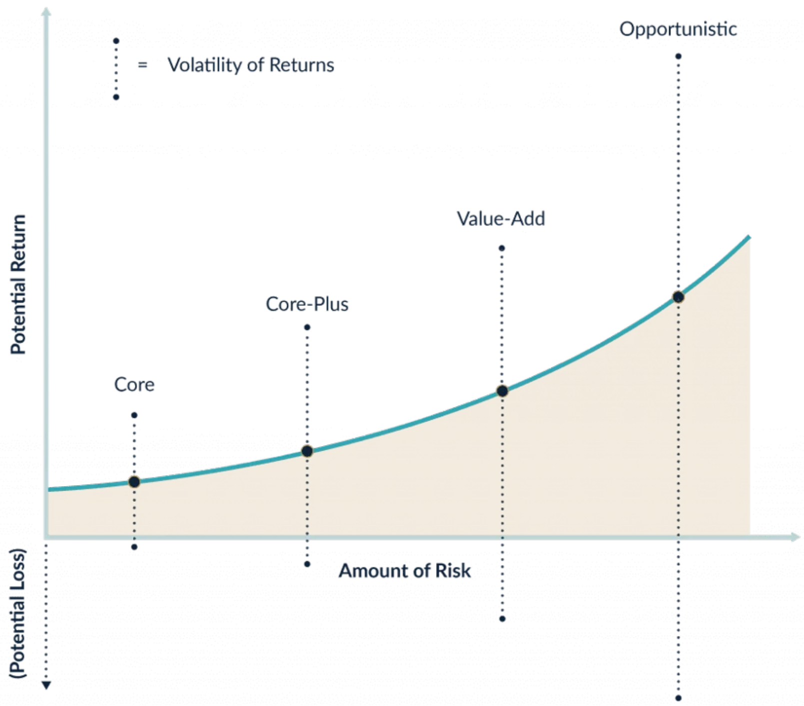

Figure 8: Investment risk classification (George, 2021)

As previously mentioned, investors' risk appetite is related to their investment horizon – the period they intend to hold the property and the timeframe in which they anticipate realising a return on their investment. Investors in core properties typically have the longest investment horizons and the highest risk aversion. In contrast, opportunistic investors have shorter investment horizons and are more willing to take on risk (Keeris, 2008).

Understanding the type of investor is crucial in a financial feasibility assessment because different investors have varying return objectives, risk tolerance, and investment horizons. These factors influence the inputs they prioritise in the analysis, such as expected cash flows, discount rates, or risk premiums. As a result, the outcomes of the financial feasibility assessment may be interpreted differently depending on the investor's profile, with each type seeking to meet their specific financial goals and constraints.

Similarly, the investor type also plays a decisive role in determining their interest in convertible building design. Investors with a long-term, sustainability-focused outlook may see the potential for higher returns through future convertibility and lower lifecycle costs, potentially making them more likely to invest in such designs. Conversely, those seeking short-term profits or with lower risk tolerance may view the initial costs and complexity of convertible buildings as less attractive. Therefore, the investor's profile significantly influences their level of interest in convertible building designs.

A study by Arge (2005) finds that office buildings created by owner-occupiers are often more adaptable than those built by developers focused on renting and managing properties, and significantly more adaptable than buildings developed for sale to investors. According to the findings of this study, developers with a short-term investment outlook, particularly those building for sale to investors, often overlook adaptability considerations. In contrast, a long-term investment perspective, particularly one that prioritises the building's use value – typically seen in the owner-occupier group – strongly supports the inclusion of adaptable features in office buildings.

4.1.3 Financial feasibility analysis

The financial feasibility analysis is the tool investors use to assess the financial feasibility of the investment. Conducting a thorough financial feasibility analysis is crucial for the investor's own informed investment decision. However, as noted by Hofstrand and Holz-Clause (2020), it can also have other purposes for the investor:

- Examining scenarios helps identify and refine alternatives, thereby focusing the project.
- In the investigative process new opportunities can be uncovered.
- Early identification of risks allows for timely addressing and mitigation.
- Clarification whether the project can secure funding from lending institutions.

Analysing the financial feasibility of an investment is one of the initial steps in evaluating an investment opportunity. "Every project", Levy (2020) writes, "begins with a financial analysis". At the outset, the analysis is conducted at a high level, with relatively little detail. This early assessment, often referred to as a "back-of-the-envelope" calculation (Linnemann, 2011), offers a preliminary evaluation of whether the investment has potential and should be examined further. As the evaluation progresses, more detailed and complex calculations are performed. Every analysis starts with assumptions about the specifics of the investment. Over time, these assumptions – and thus the analysis – become more concrete and reliable. However, it is important to remember that the data underlying these calculations are always based on assumptions and forecasts rather than certainties. Consequently, the validity of the analysis results depends on the accuracy of the input data and the specific context. Therefore, analyses often provide ranges or bandwidths rather than precise figures (Helfert, 2001).

Although there are different methods for conducting a financial feasibility analysis, one of the first and most critical steps in any financial feasibility analysis is to assess the market. As Costello and Preller (2010) state „only when the market and its demands are known, will we be able to have the basis for an effective property development plan". Similarly Finnerty (2007) emphasises that the property's marketability is a key factor in determining the investment's actual financial viability. If the property does not align with current market demands – in terms of for example price, volume, or quality – the project may become financially unviable. Market studies are essential for understanding the current market conditions by analysing both quantitative and qualitative aspects of supply and demand, as well as identifying trends and future developments. Without a thorough market assessment, feasibility study assumptions may be based on intuition, which can be a risky endeavour for the investor (Costello & Preller, 2010).

Essentially, a financial feasibility analysis evaluates the investment's income against its expenses to determine the potential return. For instance, an investor expects an office building to generate enough cash flow to meet both its construction and operating costs, while also providing a competitive return (Björnsdóttir, 2010; Costello & Preller, 2010).

There are three general approaches to calculating financial feasibility: 1) the income approach, 2) the sales comparison approach and 3) the cost approach. Since the commercial office investments considered in the context of this research are income-producing properties, the focus will be solely on the income approach. In contrast, the sales comparison and cost approaches, which do not directly consider the property's income-generating potential, will not be further discussed here.

Income approach

The reasoning behind the income approach is simple: Commercial property owners generally expect to generate cash flow from their investment through rental income and potential property value appreciation at the moment of sale (Ling & Archer, 2018). The property's income can be used to determine its value.

To draw conclusions about the property's value based on its income, logically, this income must first be determined. Therefore, the first step in calculating financial feasibility following the income approach is to project the property's net income throughout the anticipated holding period. In which the holding period is the time period the investor expects to own the property and net income is measured as annual net operating income (NOI). NOI of the property is the primary income metric used in real estate and is calculated as the projected rental income for the next year, adjusted for vacancies, and reduced by operating and capital expenses (see Figure 9).

The derivation of the NOI is explained in more detail in the following chapter.

	PGI	Potential gross income
-	V	Vacancy allowance
=	**EGI**	**Effective gross income**
-	OE	Operating expenses
-	CAPEX	Capital expenditures
=	**NOI**	**Net operating income**

Figure 9: Reconstructed operating statement NOI (adapted from Ling & Archer, 2018)

However, the property investor rarely keeps the entire NOI. One portion is typically used to cover debt and interest payments if the investment was financed. Another is collected by the government as taxes. Despite these deductions, NOI is regarded as the key measure of a property's income-generating potential (Ling & Archer, 2018) and therefore serves as “baseline” for all income approach calculation methods.

The next step when using the income approach is translating the projected NOI to an estimated value of the real estate, a process known as income capitalisation. The current property value reflects the amount an investor is prepared to pay for the investment at present (Riggs, 1996). In the context of investment decisions for new construction – such as those considered in this research – the current property value corresponds to the total investment the investor must commit. Determining the property's value allows for an assessment of the investment's financial feasibility by comparing the investment costs with the property's value. There are various techniques for the calculation of the property’s value, which fall into two main categories: 1) direct capitalisation models and 2) discounted cash flow models (Ling & Archer, 2018).

Direct capitalisation

The first method is direct capitalisation. Direct capitalisation models apply a ratio or multiple to the anticipated income generated in the first year. These ratios are generally known as capitalisation (cap) rates (Ling & Archer, 2018). The most commonly used ratio for this purpose is the net initial yield (NIY) (Goddard & Marcum, 2012). The basic income capitalisation equation expresses the relation between net operating income and property value as follows:

$$V_0 = \frac{NOI_1}{NIY}$$

where V_0 is the current property value, NOI_1 is the net operating income over the first year and NIY is the net initial yield (Ling & Archer, 2018).

This equation serves two purposes. First, it can be used to determine the income-to-value ratio of an investment, where a lower NIY indicates a higher total investment relative to the income generated. Consequently, a higher NIY signals greater risk and a lower property value (Goddard & Marcum, 2012). Alternatively, the equation can be applied to determine the market value of a property, using a ratio based on sales data from comparable properties that reflect current market conditions (Ling & Archer, 2018).

The gross initial yield (GIY) is a variant of the net initial yield (NIY) that uses potential gross income instead of net operating income as income measure. It is useful in early project stages when detailed information about the expenses of the property is not yet available. Consequently, the GIY is generally higher than the NIY.

Discounted cash flow

The second method for calculating financial feasibility within the income approach is the discounted cash flow (DCF) method. DCF models, as opposed to direct capitalisation models, assess the property’s income and expenses over multiple years, covering the entire holding period of the investment (Goddard & Marcum, 2012). To make future cash flows comparable to present cash flows, DCF models then discount future cash flows to their present value.

Discounting adjusts future cash flows to their present value, essentially recognising that a sum of money today has a higher value than the same amount in the future. Ling and Archer (2018, p. 384) describe time-value-of-money the following: “Future benefits of a proposed investment cannot simply be added up to determine their current value to investors because the present value of future benefits declines as the time the investor must wait for the future benefits increases.” To accurately discount future cash flows, an appropriate discount rate must be determined that represents the return required by the investor.

The projections of future cash flows include a) the annual net cash flows generated by the property during its holding period and b) the estimated cash proceeds from its eventual sale at the end of that period (Ling & Archer, 2018). Both cannot, as in the direct capitalisation method, be directly derived from past sales of comparable properties.

The most commonly used feasibility criteria when calculating DCF models are the net present value (NPV) or the internal rate of return (IRR).

The DCF calculation method is discussed in more detail in the following chapter.

Applicability of both methods

The main difference between the two models is the time period that calculations are based on. Direct capitalisation models are based on first year returns, while discounted cash flow models are based on the entire intended holding period of the investment (Farragher & Savage, 2008).

The other main difference between the two methods is their reliance on comparable sales data. Direct capitalisation relies on current sales data from similar properties to determine ratios, whereas the DCF model operates mainly independent of recent sales figures. DCF model critics contend that incorrect value assessments might arise from future cash flow projections that lack market data (Ling & Archer, 2018). However, independence from market data can also be an advantage.

These differences between the two calculation methods make them applicable for different situations. The direct capitalisation method provides insight into a property's market value at a specific moment, whereas the discounted cash flow approach offers a view of the property's value throughout the entire anticipated holding period. As the direct capitalisation method requires less detailed data, it is well-suited for providing estimates during the early stages of the investment assessment process. In contrast, the discounted cash flow (DCF) model is better suited for a detailed assessment, as it considers detailed input data on future income and expenses, making it more complex and time-consuming to undertake. However, it is important to recognise that the data used in the DCF model are largely based on assumptions. Depending on the model's time horizon, these assumptions about future income and expenses can extend many years into the future. Consequently, very detailed projections must be made about variables such as rental income and vacancy rates, which are uncertain and subject to change. The DCF model, therefore, generates relatively accurate predictions based on these uncertain assumptions, which can result in outcomes that may be unreliable or misleading. This also means that the DCF model is only as good as the assumptions made for its input data.

Furthermore, direct capitalisation models are typically more suitable for properties with available comparable sales data, meaning those that can be compared with other similar properties (E. Geurts, personal communication, November 22, 2022). Given the heavy reliance of direct capitalisation on such data, the subject property and the comparable sale need to be rather similar for its effective implementation. However, achieving this level of comparability can be challenging, as real estate is inherently local, and no property is exactly identical in terms of building and location characteristics. For unique properties that cannot be easily compared with others on the market, the financial feasibility is often better assessed using the DCF model.

To summarise, with regard to the assessment of the financial feasibility of convertible buildings, it can be stated that the DCF model is the most suitable of the methods commonly used today. This is because a) the assessment of convertible buildings is a long-term assessment and b) the lack of comparable properties on the market today as a basis for data. While some sources suggest that alternative methods, such as the real options approach, might be more suitable for calculating convertible buildings (Carmichael & Taheriattar, 2018; Greden, 2005), these relatively new models are not yet widely adopted in the real estate investment industry and are far from being common practice. The DCF model remains the most commonly used approach for calculating return on investment (Liapis et al., 2011), making it the preferred method for this research to ensure practical applicability of the results.

The following chapter delves deeper into the logic and the determinants of the DCF model calculation, providing a foundation for understanding how the design of convertible buildings influences these determinants and thereby the calculation.

4.1.4 DCF model

In the previous chapter, it was established that the financial feasibility of a building is assessed using a DCF model. To thoroughly analyse how designing a building for conversion affects its financial feasibility – and, by extension, its DCF model – it is necessary to first examine the operation and components of a common DCF model in greater detail.

DCF model calculation

As described above, DCF models involve three key components: projecting the annual net cash flows generated by the property during its holding period, estimating the cash proceeds from its eventual sale at the end of that period, and discounting these projected cash flows to their present value (Ling & Archer, 2018).

Again, as previously discussed, DCF models evaluate a property’s cash flows over its entire holding period. To do this, the first step is to determine the anticipated holding period. Once the holding period is established, all relevant cash flows within this timeframe must be identified, including the initial investment, annual cash flows from property operations, and the terminal value of the property at the end of the holding period. In the DCF model, cash inflows and outflows are represented at the time they occur. The initial investment is recorded at the beginning of the holding period, projected annual income and expenses are shown in the respective years they occur, and the income from the property's eventual sale is displayed in the final year of the investment's holding period (Goddard & Marcum, 2012). Figure 10 symbolically illustrates this logic.

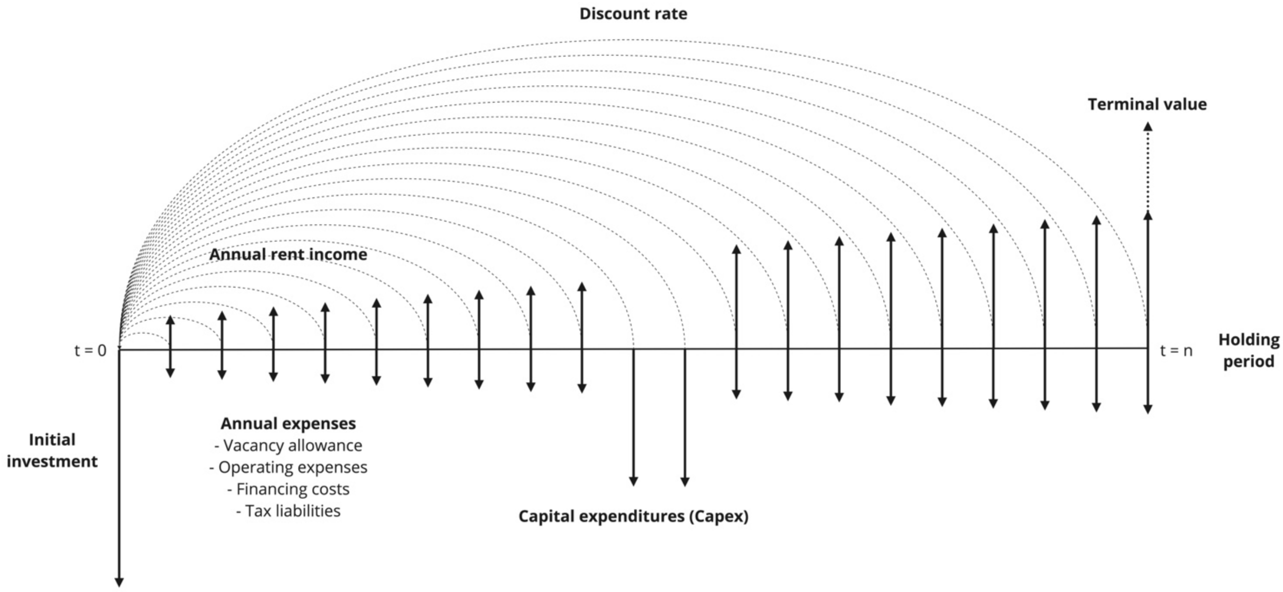

Figure 10: Symbolic overview DCF calculation

Next, after estimating all the property's cash flows, according to Ling & Archer (2018) each year's net cash flow is discounted to its present value to account for the time-value-of-money. The discount rate reflects the return an investor would expect from any other investment with similar risk levels. Therefore, this rate is based on the investor’s required return and the investment's risk profile (Ling & Archer, 2018). Essentially, the discount rate is equivalent to the investor's required IRR, as detailed below. A higher discount rate results in a lower NPV, while a lower discount rate leads to a higher NPV.

DCF model assessment criteria

Once the cash flows have been determined and discounted back to their present values, the last step in the DCF model calculation is to assess the feasibility of the investment against the investor's return requirements. The most commonly used criteria for this assessment are the net present value (NPV) and internal rate of return (IRR) (Costello & Preller, 2010).

First, the NPV is essentially the output of the DCF calculation. It is defined as “the difference between the present value of all cash inflows and outflows” (Ling & Archer, 2018, p. 405). The NPV calculation can be expressed with the following equation:

$$NPV(r) = \frac{CF_0}{(1+r)^0} + \frac{CF_1}{(1+r)^1} + \cdots + \frac{CF_n}{(1+r)^n} = \sum_{n=0}^{N} \frac{CF_n}{(1+r)^n}$$

where CF_n is the net cash flow at the end of period n, r is the rate of return and N is the anticipated holding period (E. Geurts, personal communication, November 11, 2022; Park, 2002). The NPV is that value that is found when discounting the expected future cash flows at the investor’s minimum required rate of return (Goddard & Marcum, 2012). The height of the NPV indicates to the investor whether the investment opportunity is acceptable given their required return (Sdino et al., 2016). A positive NPV indicates that the project's returns exceed its required return, making it a profitable investment and advisable to pursue. Conversely, a negative NPV indicates that the project does not reach the required rate of return and is therefore considered unfeasible. An NPV of zero means the project will return the original investment plus the required rate of return, leaving the investor neutral about its attractiveness (Ling & Archer, 2018; Park, 2002). Summarising the NPV decision rule as follows:

- If $NPV(r) > 0$, accept;
- if $NPV(r) = 0$, neutral;
- if $NPV(r) < 0$, reject.

In the comparison of mutually exclusive alternatives, the option with the highest positive NPV is preferred, because it has the highest potential for the largest profit. To make a valid comparison between investment alternatives, the NPVs must be calculated consistently, using the same discount rate and time horizon. Additionally, the investment options should be comparable, for example, in terms of size (Remer & Nieto, 1995).

However, comparing investment opportunities based on their absolute present value in euros can be problematic, particularly when assessing real estate investments of different sizes or comparing real estate to other asset classes like stocks or bonds (Ling & Archer, 2018; Park, 2002). To make the expected return on one investment comparable to another, investors commonly use the IRR as evaluation criterion.

Before further defining the IRR, it is important to distinguish between the required and expected IRR. The required IRR represents the investor’s minimum acceptable return and can be equated to the discount rate used in the calculation. It reflects the investor's target return. In contrast, the expected IRR is the rate of return that the investment is predicted to realise, as calculated through the DCF model. This rate is used as a criterion for evaluating profitability (E. Geurts, personal communication, November 12, 2022).

The expected IRR is essentially the compound rate of return throughout the holding period of the investment. Ling and Archer (2018, p. 510) describe the expected IRR as "the discount rate that makes the net present value of the investment equal to zero." Thus, the expected IRR is the rate at which the NPV function from above equals zero:

$$NPV(r^*) = \sum_{n=0}^{N} \frac{CF_n}{(1 + r^*)^n} = 0$$

where CF_n is the net cash flow at the end of period n, r^* is the expected IRR, and N is the anticipated holding period (Park, 2002). Consequently, if the expected IRR meets or surpasses the investor’s required return, the investment is deemed favourable and should be pursued. Conversely, if the IRR is below the required return, the investment is considered unsatisfactory and should be rejected (Park, 2002). Summarising the IRR decision rule as follows:

- If $r^* \geq r$, accept;
- if $r^* < r$, reject.

where r^* is the expected IRR and r is the required IRR (Ling & Archer, 2018; Park, 2002).

In addition to evaluating the financial feasibility of a property investment using NPV and IRR, a sensitivity analysis plays a crucial role in assessing the risk associated with the investment. Sensitivity analysis involves varying key assumptions – such as rental growth, operating expenses, or discount rates – to determine their impact on the NPV and IRR. This helps investors understand how sensitive the investment's financial performance is to changes in underlying assumptions. By analysing different scenarios, investors can identify potential risks, assess the investment's resilience under varying market conditions, and determine the factors that most influence its financial feasibility. This risk analysis is essential for making informed decisions, especially when uncertainties in market dynamics or future cash flows exist. It complements the DCF model by highlighting the range of possible outcomes and the risks inherent in achieving the expected returns (Levy, 2020; Sdino et al., 2016).

In their investment decision, the investor uses one of the two evaluation criteria to assess the investment opportunity against their own return requirements and also against competing investment opportunities (Goddard & Marcum, 2012).

To perform the DCF model calculation, the following components must be identified or determined (Ling & Archer, 2018):

1. Anticipated holding period
2. Initial investment
3. Annual cash flows from property operations
    a. Potential gross income
    b. Vacancy allowance
    c. Operating expenses
    d. Capital expenditures
    e. Debt services
    f. Tax liabilities
4. Sale proceeds (at the end of the holding period)
5. Required rate of return

These components will be further elaborated in the remainder of this chapter.

Holding period

The first step is the specification of the investment's anticipated holding period. In Figure 10, the holding period equals n. Typically, investors purchasing or developing new property have an intended holding period from the outset (Gibson et al., 1996). This holding period is influenced by various factors. First, it depends on the transaction costs. As there are typically significant costs associated with the purchasing and selling of real estate assets, the holding period must account for how long an asset needs to be held to cover the generally high transaction costs (Collett et al., 2003). There is a direct relationship between the level of transaction costs and the holding period, as higher costs often lead to longer holding durations (Zwueste, 2023). Second, the holding period is impacted by the volume of the investment – in size and the value. Larger, more expensive properties trade less frequently due to the entry barriers that limit potential buyers, and the substantial investment required (Collett et al., 2003). Additionally, tax laws and depreciation schedules can significantly influence holding periods, with certain tax regimes incentivising property sales at specific points to take advantage of depreciation benefits (Fisher & Young, 2000). Fourth, as mentioned in the chapter about different investor types, the investment profile of the respective investor also impacts the holding period. Institutional investors, for instance, may aim for longer holding periods due to their strategic, long-term investment goals, while private investors might seek shorter holding periods to maximise returns or adapt to market conditions more flexibly (Goddard & Marcum, 2012).

The actual holding period may deviate from the intended one due to active asset management and fluctuations in market conditions. However, the most common holding period is assumed to be between 10 and 15 years (E. Geurts, personal communication, November 22, 2022).

Throughout the entire holding period, during which the property remains in the investor's possession, there are essentially three categories of cash flows: the initial investment used to acquire the property, the annual cash flows generated regularly throughout the holding period (including capital expenditures), and the terminal value of the property at the time of sale at the end of the holding period. These will be discussed in the following sections.

Initial investment

In order to acquire an investment, the investor must make an initial investment. These are the costs the investor incurs at the outset to secure the investment. The initial investment is illustrated at the beginning of the holding period in Figure 10. Typically, the initial investment costs represent the largest expense over the investment's entire holding period. The initial investment encompasses all costs associated with either acquiring an existing property or developing a new one. As this research focuses exclusively on the financial feasibility of new developments, the initial investment costs discussed here are limited to those related to the development and construction of a new building. Beyond construction costs, these also include expenses for land acquisition, professional fees for design and engineering services, and regulatory fees, such as those related to obtaining building permits (Winch, 2012). The key components of these initial costs are outlined in Table 2 (Glickman, 2014; Kirk & Dell'Isola, 1995; Manewa, 2012; Winch, 2012).

Table 2: Main components initial investment costs

Land costs	Determined by the purchase price or lease terms for the land.
Professional fees	Including fees for consultants such as lawyers, architects, engineers, and urban planners, all of whom contribute to planning, project design, engineering, and compliance with statutory requirements. Professional fees are typically calculated as a percentage of the total construction costs.
Regulatory fees	Account for local council charges for development approval applications, building permits, zoning changes, and subdivision or strata title fees. Regulatory fees can differ significantly in relation to the project's location and scope.
Construction works	Construction costs cover the cost of building infrastructure, materials, labour, and fittings. Additionally, taxes on construction goods and services, such as VAT, are factored into the total cost. They also include costs for temporary works such as site clearance and other works to prepare the land for construction. Construction costs are typically calculated based on the design or size of the development at a per square metre rate.
Contingencies	Along with the direct construction costs contingencies are included to account for any unexpected expenses that may arise during the building process.

Annual cash flows

The next step is to calculate the future annual cash flows that are expected to be generated by the operation of the property throughout the entire holding period. Looking back at Figure 10, the annual cash flows are distributed as the sum of the projected cash flows over the entire holding period. The starting point for deriving the annual cash flows is the potential gross income (PGI) – the maximum income potential of the property – from which all other ongoing costs are deducted. After adjusting the PGI for vacancy and collection losses, the effective gross income (EGI) remains. From the EGI, operating and capital expenditures are subtracted to calculate the net operating income (NOI), the most widely used metric in real estate investment analysis (Costello & Preller, 2010). However, debt service and tax liabilities must still be deducted to arrive at the after-tax cash flow, which ultimately summarises all income and expenses from the property's annual operations. An overview of this derivation is illustrated in the form of a reconstructed operating statement in Figure 11.

	PGI	Potential gross income	(Rental income potential without losses)
-	V	Vacancy allowance	(Natural vacancy and collection losses)
=	**EGI**	**Effective gross income**	
-	OE	Operating expenses	(Repairs and maintenance for efficient operation and upkeep of the property)
-	CAPEX	Capital expenditures	(Replacements and improvements for extension of the property lifespan)
=	**NOI**	**Net operating income**	
-		Debt services	(Interest and amortisation payments)
=		**Before-tax cash flow**	
-		Tax liability	(Income and property tax)
=		**After-tax cash flow**	

Figure 11: Reconstructed operating statement after-tax cash flow (adapted from Ling & Archer, 2018 and Zwueste, 2023)

Potential gross income (PGI)

The starting point of any DCF model is the potential gross income (PGI), which reflects the theoretical full rental potential of the property. In other words, PGI represents the total potential annual rental income a property could generate, assuming full occupancy and no losses from uncollected rent (Ling & Archer, 2018). The majority of analysts typically estimate the cash flows from a property on an annual basis, even though operating expenses occur each month and rent is often paid from tenants on a monthly basis. The potential gross income is typically calculated by multiplying the estimated base rent per square meter by the total amount of lettable square meters (Linnemann, 2011). The estimated rent level is derived from market analysis and projected for the entire anticipated holding period of the property. Typically, the consumer price index (CPI) is used as a benchmark for annually adjusting future rent rates, ensuring that rent payments keep pace with expected price increases throughout the rent period (Goddard & Marcum, 2012).

Effective gross income (EGI)

However, it is highly unlikely that an investor achieves the maximum potential income of a property. Even in a market with no surplus of available office space, there are typically early vacancies, rental income losses during the time needed to renovate and re-lease vacated spaces, and occasional delays in rent payments. The natural vacancy rate, also known as frictional vacancy, represents the portion of potential gross income that remains uncollected, even when the rental market is balanced with supply equalling demand (Goddard & Marcum, 2012; Tse & Webb, 2003). In a weak or oversupplied market, buildings may experience prolonged periods of occupancy falling significantly below expectations. Additionally, unexpected changes in vacancy rates can greatly impact the accuracy of financial models (Linnemann, 2011). Consequently, estimating the property's anticipated vacancy and collection losses in accordance with market conditions is the next step in the DCF calculation. These losses are typically based on the historical performance as well as the current vacancies when considering an existing property, and the performance of similar competing properties. Vacancy allowances and losses from the collection for office properties generally range from 5 to 15 percent of potential gross income (PGI) (Ling & Archer, 2018). After estimating these losses, they are subtracted from the PGI. The result after subtracting vacancy losses is the effective gross income (EGI), as illustrated in Figure 11.

Net operating income (NOI)

Next, to arrive at the net operating income (NOI), all operating and maintenance expenses are subtracted from the property's effective gross income (Goddard & Marcum, 2012). These expenses are either categorised as operating expenses (OE) or capital expenditures (CAPEX).

Operating expenses refer to the regular and necessary costs incurred throughout the year to keep the property functioning and competitive. In other words, operating expenses refer to the costs necessary for the efficient operation of the property (Linnemann, 2011). These expenses do not significantly increase the property's value but are essential for its upkeep. Typically, there are 1) fixed and 2) variable operating expenses. Fixed expenses, such as building insurance payments, remain constant regardless of the property's occupancy level, meaning they must be paid whether or not the property is fully occupied. Variable expenses, on the other hand, fluctuate with occupancy rates. As occupancy increases, so do variable costs like maintenance, repairs, and property management, and they decrease when occupancy drops (Ling & Archer, 2018). While property taxes are theoretically also considered variable operating expenses, they are typically treated separately as they are determined by the local tax rate (Levy, 2020).

Unlike operating expenses, capital expenditures (CAPEX) refer to significant replacements or adaptations to the building that extend its economical life and enhance its value. An yearly "allowance" to account for the capital costs required to replace ageing building components is frequently included in operating statements. This amount is usually designated as a reserve for replacement. Examples of CAPEX include roof replacements, additions, and HVAC systems. Additionally, costs incurred by owners to modify spaces for specific tenants (i.e., "tenant improvements") are typically included in CAPEX. In practice, there are differences in how capital expenditures are handled when estimating annual net operating income. In some cases, a general annual reserve is set aside for anticipated capital expenditures, while in other cases, the actual expenditure is estimated in the period when it is expected to occur. Multiyear DCF valuation models, however, allow for greater precision in determining the timing of future capital expenditures (Goddard & Marcum, 2012; Levy, 2020; Ling & Archer, 2018).

After subtracting operating expenses and capital expenditures from the effective gross income, the net operating income (NOI) remains. To reiterate, NOI represents the income after operating and capital expenses but before financing payments, such as debt service, and tax liabilities (see Figure 11). Since these expenses are specific to every owner and unrelated to the property's general income-generating capacity, NOI is typically used to assess the fundamental financial health of the project (Goddard & Marcum, 2012), for instance, in property valuations.

However, financing payments and income taxes are crucial factors in investment decisions and will therefore be examined in greater detail in the next chapter.

Financing costs

Estimating cash flows to equity requires accounting for financing obligations, such as amortisation and interest payments from debt financing, to accurately determine the cash flow available to equity investors (Linnemann, 2011). Financing is a critical aspect of any investment, with structures varying significantly based on the type of investment, associated risk, and the investor's creditworthiness (Fabozzi & Peterson, 2003).

Financing costs are a crucial factor in real estate investment, with two primary reasons driving investors to use debt financing. First, many investors do not have enough capital to purchase properties directly and rely on borrowing to bridge the financial gap. Second, even financially capable investors often opt for mortgage financing to amplify their returns. Positive financial leverage occurs when returns on equity exceed borrowing costs, encouraging investors to partially finance their investments with debt. However, as highlighted by Ling and Archer (2018), leverage also increases risk, as it can magnify losses if the investment underperforms.

The loan-to-value (LTV) ratio, defined as the mortgage amount divided by the property value, measures financial leverage:

$$LTV\ ratio = \frac{Mortgage\ amount}{Property\ value}$$

This ratio indicates the proportion of the property's value that is financed through debt. By capping the LTV ratio, lenders protect their capital against potential declines in property values. Lenders typically limit the LTV ratio to between 65% and 80% for commercial properties to mitigate risk and to ensure that a significant portion of the property's value remains unburdened by debt. A higher LTV ratio increases leverage but reduces the net cash flow available to equity investors after meeting debt obligations (Ling & Archer, 2018).

A critical consideration in financing costs is the interest rate, either fixed or variable. Loans can have either fixed or variable interest rates. Fixed-rate loans provide predictable payments, while variable-rate loans fluctuate with market conditions, potentially raising financing costs if interest rates increase. Long-term, fixed-rate financing is well-suited for properties with stable cash flows, such as those leased to high-credit tenants on long-term leases in stable markets, as they tend to yield consistent returns. Conversely, higher-risk assets, such as newer properties or older ones in need of renovation, may experience fluctuating cash flows, making them more appropriate for short-term, flexible financing strategies that align with their development or repositioning timelines (Glickman, 2014). Repayment terms between lenders and borrowers are influenced by economic conditions at the time of closing and the strategic objectives of both parties (Goddard & Marcum, 2012). The interest payment is calculated as:

$$Interest\ due = Principal\ balance * Interest\ rate$$

Investors must also consider the type of loan they choose, whether it is amortising or interest-only. An amortising loan requires regular payments that include both interest and principal, gradually repaying the loan over time. By the end of the term, a fully amortising loan will have repaid the entire principal (Goddard & Marcum, 2012). Debt service for an amortising loan includes regular payments to a lender, covering both interest and principal repayment:

$$Debt\ service = Interest\ due + Principal\ due$$

In contrast, an interest-only loan involves no principal payments during the term, resulting in a "balloon payment" at maturity. Interest-only loans are commonly used for speculative projects, offering flexibility to investors who plan to sell the property before the loan term ends (Glickman, 2014).

The chosen interest rate structure, LTV ratio, and loan type significantly influence cash flows and the potential for both returns and risks. Once financing costs are deducted from the NOI, the before-tax cash flow is obtained. This amount must then be adjusted for tax payments in the next step to arrive at the final after-tax cash flow.

Tax liability

Once the before-tax cash flow is determined by subtracting the financing costs from the net operating income, tax liabilities need to be considered to ultimately arrive at the final after-tax cash flow. Taxes can significantly impact net income, cash flow, and ultimately, the investment's return. As elaborated, commercial real estate generates cash flows from renting and the future sale of the property. However, these cash flows are subject to income taxation. Investors only receive the income remaining after government entities take their share, leading to substantial combined tax rates that can exceed 40% (Ling & Archer, 2018). Since tax rates depend on the investor, the property, and regional regulations, its specific calculation will not be addressed further here.

The complexity of tax law adds an additional challenge, as taxable income often differs from actual cash flows. For example, certain expenses like capital expenditures and mortgage principal payments do not provide immediate tax deductions, while depreciation can reduce taxable income (Park, 2002). However, tax liabilities can generally be expressed as follows:

$$Tax\ liability = Taxable\ income * Tax\ rate$$

Further, changes in tax regulations can significantly influence investment decisions, especially in an environment where potential tax code adjustments are being considered. As a result, it is essential for investors to incorporate tax considerations into their financial analysis to accurately assess the feasibility and potential returns of office real estate investments (Levy, 2020). Understanding these tax implications ensures that investors are supposed to make conversant decisions regarding the structuring of their investments to optimise cash flow and returns. Consequently, the after-tax cash flow is the most relevant specific measure for investors.

Terminal value

At the end of the holding period, the investor expects to receive a certain value for the property, referred to as the terminal value (or exit value). This value can also be understood as the sales price the investor anticipates receiving upon disposal of the asset. In the DCF model, the terminal value is treated separately from the annual cash flows and is considered a payment at the end of the holding period.

The direct capitalisation method is the most widely used approach for determining a property's terminal value (Hordijk & van de Ridder, 2005). This calculation is based on the same principles as the direct capitalisation method discussed in the financial feasibility analysis chapter. However, rather than valuing the building at present, it is utilised to assess the property's value at the time of sale. However, instead of valuing the building today, it is used in this case to value the building at the point of time of sale. The logic of the calculation is the same – dividing annual cash flows by yield – however, the yield ratio used in this calculation is a different one. Instead of the gross initial yield (GIY), now the gross exit yield (GEY) is used. The cash flow considered is the cash flow of the last year of the holding period plus one additional year (Hordijk & van de Ridder, 2005). This additional year essentially represents the first year of exploitation from the buyer's perspective (Pagliari, 1991). The formula used to calculate the terminal value is:

$$Terminal\ value_n = \frac{CF_{n+1}}{GEY + (n+1)}$$

Where n refers to the final year of the forecasting period, CF refers to cash flow and GEY refers to the gross exit yield.

The weakness and potential drawback of this method lies in accurately estimating the gross exit yield (GEY) (E. Geurts, personal communication, November 22, 2022). In many real estate investments, the terminal value often represents a significant portion of the total valuation. If the assumptions underlying the GEY prove incorrect, it can lead to misinformed investment decisions. Terminal values are particularly sensitive to changes in the cap rate; fluctuations in market conditions can significantly alter the calculated exit value, making sensitivity analysis essential for evaluating investment risks. Understanding terminal value helps investors estimate their expected returns over different investment horizons and provides insights into potential liquidity and exit strategies (Goddard & Marcum, 2012). The terminal value of the property is depicted in Figure 10 as cash inflow at the end of the holding period.

Discount rate

After determining all cash flows over the holding period—including the initial investment, annual cash inflows and outflows, and the terminal value of the property—these must be discounted to their present value. The rate used for this adjustment is called the discount rate. As Ling and Archer (2018) describe, discounting cash flows in a DCF analysis accounts for the time-value of money, which recognises that future sums are worth less today. The discount rate reflects the return required by an investor, factoring in the risks of the investment, the opportunity cost of capital and inflation (Goddard & Marcum, 2012; Phyrr et al., 1999). Essentially, it captures the investor's likely return from comparable investments, indicating the rate at which they could otherwise invest their money (Ling & Archer, 2018; Park, 2002).

The discount rate is generally composed of two elements, the risk-free rate, which is based on returns from risk-free investments such as government bonds, and a risk premium that compensates the investor for the specific risks associated with the real estate property, such as market volatility or tenant stability. This relationship can be expressed as:

$$r = R_f + RP$$

where r is the discount rate (equivalent to the required IRR), R_f is the risk-free return (typically derived from government bonds), and RP is the risk premium that reflects the specific risks of the investment (Ling & Archer, 2018). The risk-free rate serves as the minimum return an investor would expect, typically less than 4%, while the risk premium accounts for the additional uncertainty and higher risk inherent in real estate investments (Goddard & Marcum, 2012).

"Since risk and return are typically related, the higher the associated risk for a given investment option, the higher the required rate of return" (Goddard & Marcum, 2012, p. 51). Market conditions, such as prevailing interest rates and economic trends, influence the risk-free rate and risk premium. Additionally, property-specific risks – including location, tenant quality, and lease structure – may justify a higher premium. Investor expectations also vary, as institutional investors often have different return thresholds than private investors, leading to differences in discount rates. By incorporating these elements, the discount rate reflects the overall return an investor requires, based on the risk and market conditions surrounding a specific real estate asset. Therefore, however, determining the discount rate is a subjective process that is tailored to the specific investor. This subjectivity can be seen as a weakness of the DCF method (Ling & Archer, 2018).

The discount rate is equivalent to the required IRR, representing the investor's minimum acceptable return (Kishore, 1996). Therefore, the discount rate, or required IRR, can serve as a benchmark or hurdle rate for determining the required return in relation to the associated risks, thereby assessing the financial feasibility of an investment.

When evaluating the financial feasibility of an investment, again, conducting a sensitivity analysis can be useful in determining the discount rate. This analysis explores how changes in the discount rate impact the NPV, as even small adjustments can lead to significant variations in NPV, ultimately influencing the overall attractiveness of the investment. Increasing the discount rate decreases the present value of future cash flows, making the investment less appealing, while lowering the discount rate has the opposite effect, increasing the present value and improving the perceived profitability of the investment.

4.1.5 Chapter summary

This chapter answers the first sub-research question: *How is the financial feasibility of a new office building evaluated? (SQ 1). It* highlights the importance of financial feasibility analysis for investors in making informed investment decisions. Generally, the financial feasibility of a new office building is evaluated by assessing its potential to generate sufficient returns relative to its risks and costs. Central to financial feasibility is the relationship between return and risk, with investors typically expecting higher returns for higher risks.

The chapter elaborates on different types of risks inherent in real estate investments as well as the differing risk profiles across investor types. Importantly, financial feasibility is not an objective measure but largely depends on the investor's interests. Ultimately, the investor's profile – including their return objectives, risk tolerance, and investment horizon – significantly influences their assessment of financial feasibility and their interest in convertible building designs. For instance, long-term, sustainability-focused investors may be more attracted to buildings with potential future conversion to residential use, while short-term investors may find the added complexity less attractive.

In assessing financial feasibility, three primary approaches exist, but this research focuses on the income approach due to its relevance in commercial office investments, which generate income. Specifically, the discounted cash flow (DCF) method is highlighted. This method forecasts cash flows over the building's holding period and discounts them to their present value, producing key indicators such as net present value (NPV) and internal rate of return (IRR), both of which are used to assess profitability and expected returns.

There is an inherent relationship between NPV, IRR, and the discount rate in a DCF calculation. If the NPV of an investment is zero, the expected IRR is equal to the discount rate used. Conversely, if the NPV is negative, the expected IRR is lower than the discount rate, and if the NPV is positive, the expected IRR exceeds the discount rate (E. Geurts, personal communication, November 12, 2022).

Table 3 provides a summary of the DCF model determinants, including a brief description and an overview of the factors that influence each determinant.

Table 3: DCF model determinants

DCF model determinants		Description	Influenced by
Non cash flow items	Holding period	The duration an investor intends to own a property, typically ranging from 10 to 15 years.	Influenced by investment strategy, transaction costs, property size, market liquidity, and tax regulations. Institutional investors may prefer longer periods, while private investors might seek shorter holding times.
	Discount rate	Reflects the time value of money and the risk profile of the investment.	Primarily influenced by the perceived risk of the investment, the risk-free rate, and market risk premium. It also reflects the investor's required rate of return, factoring in the property's risk profile (e.g., core, value-add) and broader economic conditions.

Cash flow items	Initial investment	Covers upfront costs, including land acquisition, construction, and professional fees.	Influenced by acquisition costs, construction or renovation costs, and professional and regulatory fees. Market conditions and property size also play a role.
	Potential gross income (PGI)	Represents the maximum income achievable, assuming full occupancy.	Driven by market demand, rental rates in the area, property quality, location, and tenant type.
	Vacancy allowance	Vacancy allowance is determined by the vacancy rate and accounts for potential income loss due to unoccupied units, reducing the projected rental income.	Influenced by market vacancy rates, property location, tenant turnover, and the strength of the local economy. For convertible buildings, adaptability to different uses can impact vacancy risk.
	Operating expenses (OE)	Reflect the costs necessary for running the building and maintaining its value over time.	These depend on property type, management efficiency, location, and utility costs. They are influenced by maintenance needs and regulatory requirements.
	Capital expenditures (CAPEX)	Capex refers to the funds allocated for major property improvements or replacements, essential for maintaining or increasing the building's value over time.	Reflects future investment needs for repairs, upgrades, or renovations, influenced by the age of the property, building design, and expected tenant requirements.
	Financing costs	Financing costs encompass the interest payments and fees associated with debt used to fund a property investment.	Influenced by the loan-to-value (LTV) ratio, interest rates (fixed or variable), lender requirements, and overall borrowing terms. Market interest rates and investor creditworthiness also play key roles.
	Tax liabilities	Tax liabilities are the amount owed to tax authorities.	Affected by the specific tax regulations in the investment region.
	Terminal value	The estimated resale price of the building at the end of the holding period.	Primarily influenced by market conditions at the time of sale, projected future rental income, and the exit yield or capitalisation rate.

4.2 Design for conversion

As urban environments evolve and real estate markets shift, the need for convertible buildings has gained increased attention. Designing buildings for future conversion addresses the limitations of traditional static architecture, which fails to accommodate the changing demands of users and functions. This chapter delves into the theoretical foundations of designing buildings for future conversion, focusing on the concept of convertibility, which refers to a building's capacity to adapt to changing functions and user needs over time.

Convertibility is rooted in the understanding that business functions often have shorter life cycles than the buildings that house them. This discrepancy is especially apparent in the office market, where the economic lifespan of buildings is often constrained by their inability to evolve with shifting market demands (Bullen, 2007; Kendall, 1999; Manewa, 2012). For instance, as shown in Figure 12, the life cycles of business functions, represented by the right curve, tend to be shorter than those of buildings (Schmidt III et al., 2009). This results in a mismatch between the needs of users and the capabilities of static office buildings.

To address this issue, designers must integrate convertibility into the very structure of a building. This can be achieved through flexible spatial configurations, structural designs that allow for modifications, and systems capable of accommodating various future uses (Askar et al., 2021; Langston, 2014). The theoretical framework for convertibility argues that buildings should be seen as dynamic entities rather than static structures, capable of evolving alongside changing societal and economic conditions.

A critical aspect of designing for future conversion is understanding the relationship between a building's economic and technical lifespans. The economic lifespan, often shorter than the technical lifespan, is affected by market fluctuations and changing demand (O'Connor, 2004). Property owners frequently base investment decisions on the economic life of a building, prioritising income potential over technical durability. This focus on short-term economic returns can lead to the demolition of buildings that are still structurally sound but economically obsolete (Remøy & van der Voordt, 2014). Designing for convertibility necessitates a re-evaluation of this relationship. By anticipating future uses during the design phase, developers can prolong a building's economic lifespan while ensuring its technical viability. Integrating convertibility into the design process can mitigate risks associated with vacancy and premature demolition, allowing buildings to transition to new functions without major structural changes (Acharya et al., 2020; Remøy et al., 2011).

Convertibility also aligns with sustainability principles, emphasising the reuse of existing structures to minimise material and energy consumption. As Jacobs stated, "the greenest buildings are the ones we already have" (Jacobs, 1961, as cited in Langston et al., 2013, p. 234). Extending the life of buildings through conversion reduces waste from new construction and supports urban sustainability by addressing urgent housing shortages through the conversion of vacant office spaces into residential units (Remøy & De Jonge, 2009). Sustainable design principles also advocate for resilience in buildings, enabling them to withstand market shifts and future uncertainties (Pelsmakers & Warwick, 2022; Wilkinson et al., 2014).

Conversions can reactivate vacant office spaces, thus bridging the gap between functional and technical lifespans. Douglas (2006) emphasises that converting a redundant building is one of the best ways to secure its useful life expectancy. Moreover, the end of a building's economic life often necessitates conversion, as it responds to shifts in demand (Douglas, 2006). The future value of a building depends on its ability to adapt to user needs and the broader market landscape.

Through conversion vacant office space can be reactivated and repurposed (Remøy & De Jonge, 2009; Remøy & van der Voordt, 2014). Moreover, the service life of the building can be prolonged avoiding the mismatch between its functional and technical lifespan. In fact, the life cycle of a functionally obsolete building can be extended by another use cycle through conversion to a new function. The extension of the building life cycle by adding one or even several use cycles is illustrated in Figure 12. Douglas (2006) underlines this by stating that “the conversion of a redundant building offers the best way of prolonging, if not securing, its useful life expectancy” (p. 96).

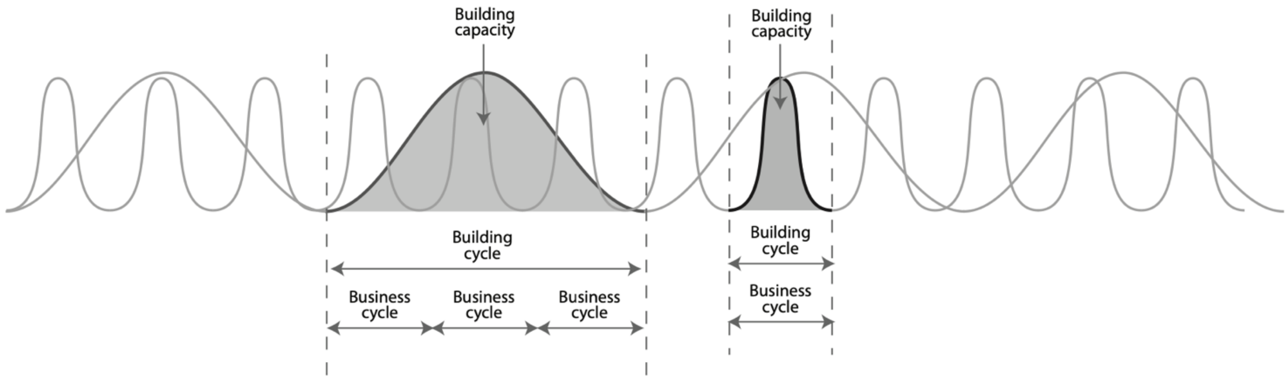

Figure 12: Extended lifecycle of the building through conversion (Schmidt III et al., 2009)

4.2.1 Theory

A fundamental idea in convertibility is to view a building as an assembly of layers as opposed to a single, solid structure (Moffatt & Russell, 2001; Ross, 2017; Slaughter, 2001; Watt et al., 2023).

The underlying idea of the shearing layer concept is to divide the building system into several layers, each defined by elements and functions with a similar service life. Literature emphasises the importance of independence as a fundamental adaptation principle when integrating systems or layers inside a structure (Acharya et al., 2020; Askar et al., 2021; Watt et al., 2023). This approach permits components to be improved, replaced, or removed without compromising the functionality of the systems that surround them. According to Askar et al. (2021), understanding a building's composition and temporal layers is a crucial first step towards enabling its adaptive capability. This allows for the longer-lasting components to be durable for the layers or components with shorter lifespans to be flexible.

The shearing layers concept is developed further by Brand (1994) as the six “shearing layers of change”. The underlying principle remains the same, but Brand develops the layer division further by adding new layers. According to Brand (1994) the six layers are site, structure, skin, services, space plan and stuff. Compared to Duffy’s categorisation, Brand adds the stuff layer, which is furniture and equipment in the building (Remøy, 2010). His space plan layer is the interior layout of the building and equals Duffy’s scenery. They both regard services as separate layer. However, Brand separates Duffy’s shell into the two distinct layers structure and skin (building envelop) (Remøy, 2010; Wilkinson et al., 2014). Here too, the categorisation of the building elements is based on their lifespan, which Brand specifies on a sliding scale of time (Wilkinson et al., 2014). A summary of the characteristics and expected lifespan of each shearing layer can be found in Table 4.

Table 4: Characteristics and life expectancy of the six shearing layers

Shearing layer	Characteristics	Life expectancy
Site	Site boundaries	Eternal
Structure	Foundations & load-bearing components	30-300 years
Skin	Cladding & roof systems	20+ years

Services	Installations of the building	7-20 years
Space plan	Interior layout	3 years
Stuff	Furniture	<3 years

As shown in Figure 13, while the location is permanent, the structure lasts between 30 and 300 years, the skin lasts more than 20 years, services last between 7 and 20 years, the space plan lasts between 5 and 7 years and the stuff has a lifespan of less than 3 years (Brand, 1994). The idea behind the concept is that the construction of the building as a layered structure enables the replacement of components with a shorter service life while retaining the use of components with a longer service life. Every layer can be mounted and dismounted separate from the other layers. Therefore, the enclosure of elements with shorter lifespans with elements with longer lifespans is to be avoided. Connections between the layers should also be avoided, as these can hinder adaptation and increase its costs. The durability of the structure is critical for the lifespan of the entire building and therefore should to be optimised.

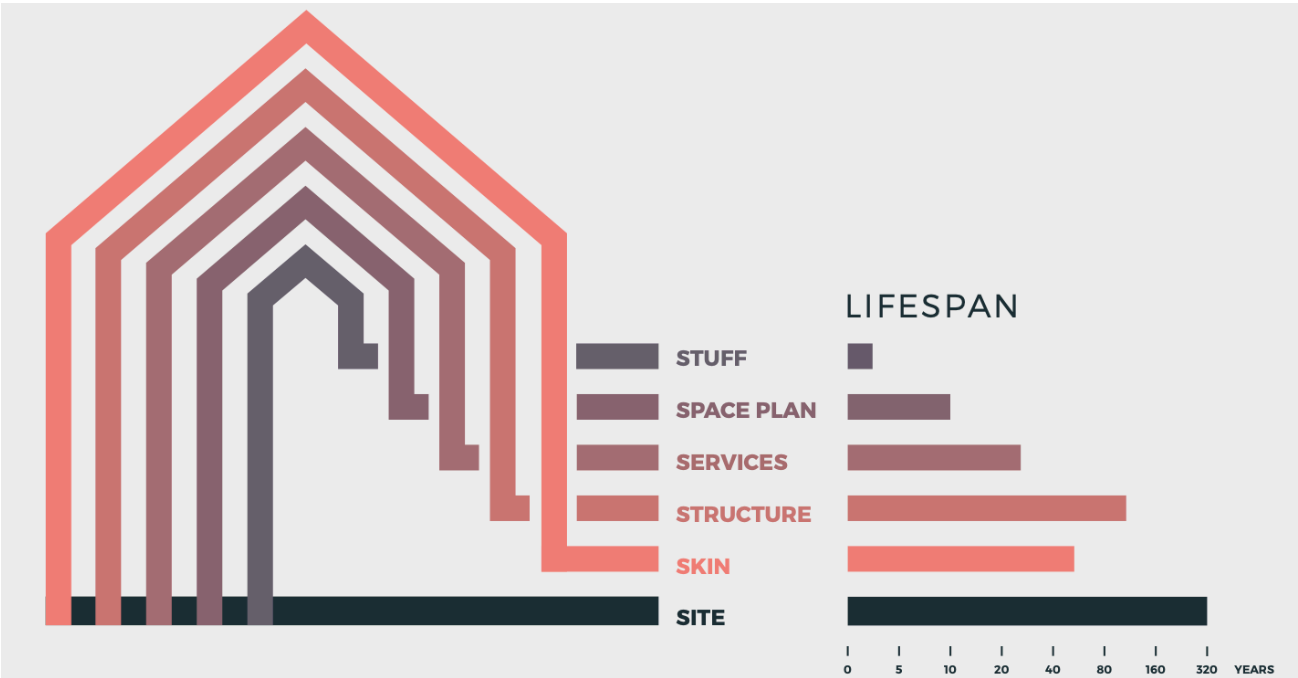

Figure 13: Brand's shearing layers (Fischer, 2019)

A historical perspective on the theory of adaptable buildings is included in Appendix A.

4.2.2 Design parameters

The following chapter gives an overview of the most important design parameters that enable or facilitate the conversion of office buildings to residential uses. The chapter is structured according to the layers by Brand and mentions the site, structure, skin, services and space plan layer of the building. This chapter aims to answer sub-question two: *How can an office building be designed to enable future conversion to residential use? (SQ 2)*

Site

Designing office buildings for future residential conversion requires careful consideration of the site layer, as it significantly influences the feasibility and success of the conversion. The site layer encompasses key factors such as location, zoning, urban context, environmental conditions, infrastructure, and mobility – all of which shape a building's convertibility over time. Additionally, spatial quality plays a critical role in the future value of buildings, affecting both their economic and emotional appeal.

Location is one the most important factor when designing office buildings with conversion potential in mind. Buildings situated in city centers or residential areas are often more suitable for future conversion than those in monofunctional office zones. Location characteristics that could serve as a veto-criterion for residential conversion, according to Remøy and van der Voordt (2014), are excessive noise levels at the façade and poor air quality. Proximity to public transport, road networks, and amenities, such as parks, retail, and schools, enhances the desirability of a building for residential use. In contrast, office buildings in monofunctional areas may struggle to attract residential tenants without significant broader area redevelopment (Remøy, 2010). While industrial or monofunctional office zones are generally less appealing for conversion, residential projects targeting specific groups can succeed in business parks, especially if they are near central business districts and social or commercial amenities. Large-scale projects that spur wider redevelopment may make such areas more attractive for residential use (Remøy & van der Voordt, 2014).

Zoning and the regulatory environment also play a critical role in determining whether an office building can be successfully converted into housing. Flexible or mixed-use zoning regulations make it easier to adapt buildings for residential purposes. Other location factors, such as the presence of nearby housing, can also influence the suitability for conversion. Areas with established housing or mixed-use developments tend to attract more interest for residential conversions, as these settings are already aligned with residential use. Developers and housing associations are generally more cautious about converting office buildings in isolated industrial locations due to the lack of appeal for most target groups (Remøy & van der Voordt, 2014). Potential changes in local zoning laws can make a future conversion unfeasible (Manewa, 2012).

Infrastructure and utilities are another critical consideration for the convertibility of office buildings into residential functions (Geraedts & van der Voordt, 2007).

Structure

An overview of the different convertible design parameters of the structure of the building is illustrated in Table 5. As shown in the table, six parameters emerge as the most decisive factors. These six parameters are:

- Floor-to-floor height
- Plan depth
- Position cores
- Position entrances
- Structural grid
- Surplus of load bearing capacity

One of the most critical structural parameters for an office building designed with future residential conversion in mind is the floor-to-floor height (Manewa, 2012). Office buildings typically have higher floor-to-floor heights compared to residential buildings, primarily to accommodate extensive mechanical systems such as HVAC. Ideally, the free floor height should be at least three meters, as building codes require a minimum of 2.6 meters for new homes (Dutch Green Building Council, 2024). The additional height in office spaces facilitates the inclusion of suspended ceilings or raised floors, allowing for concealed installations. The floor-to-floor height is important to provide sufficient space for converting the office into residential units while allowing flexibility in interior layouts.

Plan depth, or the distance between the building’s exterior walls, is another key consideration. Office buildings are often designed with deep floor plans to accommodate large, open office spaces or cubicle layouts, but such depths can present challenges when converting these spaces into residential units, which require natural light and ventilation (Hermans et al., 2014). Ideally, a plan depth of 10 to 18 meters is suitable for residential use, as it allows for sufficient daylight and natural ventilation. A deeper plan, while beneficial for open-plan offices, may result in darker, less desirable interior spaces in residential units. To address this issue, office buildings designed for future conversion should avoid excessive depths or incorporate strategies such as internal courtyards or light wells to introduce more natural light into the building's core (Douglas, 2006).

A building's basic layout plays a crucial role in its ability to accommodate flexible use and the adaptation of its components. This layout is defined by the 'fixed' elements, including access points, stairwells, elevator cores, shafts, circulation areas, and sanitary facilities. Ideally, individual use units should feature their own entrances and sanitary facilities, enhancing the ease of reclassifying or subdividing the building (Dutch Green Building Council, 2024). Therefore, the position of the building’s cores – such as elevators, stairwells, and mechanical shafts – is also essential in the design for future conversion. In office buildings, cores are typically placed centrally to provide efficient circulation and maximise the usable floor area. However, for residential use, centrally positioned cores can divide floor plates in ways that limit flexibility in apartment layouts. Additionally, the cores should be sized appropriately to accommodate the higher number of users in a residential building, which typically requires more elevators and staircases compared to office buildings (Geraedts, 2016; Moffatt & Russell, 2001).

Further, literature emphasis the importance of the entrances to the building that must be designed to support both current office use and future residential conversion (Acharya et al., 2020). Office buildings typically require a single, prominent entrance to manage the flow of employees and visitors. In contrast, residential buildings often need multiple, more discrete entrances to provide easy access to various parts of the building and to maintain a sense of privacy for residents. Designing an office building with multiple potential entrance points or flexible entrance areas can simplify the conversion process.

The structural grid – the spacing of columns and load-bearing walls – directly influences the flexibility of an office building's internal layout and its potential for future conversion to residential use (Remøy & van der Voordt, 2014). Office buildings typically use larger grid spacing, with column-free floor plates that enable open-plan office layouts. In contrast, residential buildings benefit from a tighter grid configuration. A grid spacing of around 6 to 9 meters is often ideal, as it can accommodate both office and residential uses without significant structural changes (Manewa, 2012). Consequently, the possibility of layout adjustments according to a defined grid size or the depth of the supporting structure enhances the building's versatility, as larger free spans contribute to a more flexible internal arrangement (Dutch Green Building Council, 2024).

Finally, the load-bearing capacity of the building structure and especially the floors is a critical factor in facilitating function changes and classifying the building for different uses. This is due to the varying standard minimum load requirements associated with different building functions. Specifically, when considering future conversion, it is essential to design the building with adequate load-bearing capacity in mind. Residential buildings typically demand greater load-bearing capacity because of the higher density of internal partitions and the heavier construction materials used in walls and floors. In contrast, office buildings are often designed for open-plan layouts, which may not provide the necessary load-bearing capacity for residential conversion without structural reinforcement. By incorporating surplus load-bearing capacity into the design of an office building, the need for costly and time-consuming structural modifications during conversion can be significantly reduced (Dutch Green Building Council, 2024; Schmidt III & Austin, 2016).

Table 5: Literature review design parameters structure

	Design parameters	Gann and Barlow (1996)	Moffatt and Russell (2001)	Remøy (2010)	Remøy et al. (2011)	Manewa (2012)	Conejos et al. (2013)	Hermans et al. (2014)	Remøy and van der Voordt (2014)	Schmidt III (2014)	Geraedts (2016)	Schmidt III and Austin (2016)	Acharya et al. (2020)	**Total**
Structure	Expandability			x	x			x	x		x			5
	Fire resistance structure	x		x	x						x			4
	Fire safety design and escape routes	x		x		x			x					4
	Floor space size					x		x	x	x	x			5
	Floor-to-floor height	**x**		**x**	**x**	**x**		**x**	**x**		**x**	**x**	**x**	**9**
	Insulation	x		x	x				x		x			5
	Material durability			x			x			x				3
	Plan depth	**x**	**x**	**x**	**x**	**x**		**x**	**x**	**x**			**x**	**9**
	Position cores		**x**	**x**	**x**	**x**		**x**	**x**		**x**		**x**	**8**
	Position entrances	**x**		**x**	**x**	**x**		**x**			**x**		**x**	**7**
	Possibility of attaching interior walls to structure							x		x	x			3
	Separation of structure and infill			x	x	x	x	x			x			6
	Structural design	x		x		x			x	x		x		6
	Structural grid		**x**	**x**	**x**		**x**		**x**	**x**	**x**	**x**		**8**
	Surplus of load bearing capacity			**x**		**x**	**x**	**x**	**x**		**x**	**x**		**7**

Skin

Considering the skin layer of the building, the literature suggests that daylight admission and a removable façade are the most important design parameters when designing for convertibility. The overview of the findings of the literature review on this topic can be found in Table 6.

Daylight admission is a crucial factor in the design of both office and residential buildings, albeit with differing standards based on their intended use (Conejos et al., 2013). For an office building designed for future residential conversion, it is essential to ensure ample daylight access in at least 70% of the living areas, as compliance with daylight access requirements is mandatory. While office spaces can function with less direct sunlight, residential units, particularly living areas and bedrooms, require more natural light to meet building regulations and foster desirable living conditions (Dutch Green Building Council, 2024). Consequently, for an office building designed with future residential conversion in mind, the façade should include design elements that allow for sufficient daylight to enter the building. This can be achieved by incorporating large windows and optimising window placement (Schmidt III, 2014). By ensuring that these elements are incorporated into the initial design, the future conversion process becomes less invasive and more efficient, reducing the need for extensive structural changes (Schenk, 2009).

The ability to remove or significantly modify the façade can have a major impact on both the ease of conversion and the overall cost (Geraedts, 2016; Hermans et al., 2014). Residential buildings often require additional architectural features, such as larger windows, which may not be present in standard office buildings. A façade system designed with flexibility and removability in mind can simplify these modifications, making it easier to meet residential building standards. It is desirable for a large part to almost the entire façade to be demountable. The more easily the façade can be dismantled, the easier it is to reconfigure, expand or dispose of the building or building section (Dutch Green Building Council, 2024). The smaller the size system of the façade, the easier a building is to subdivide. Ideally, starting from a fixed unit of measurement of 3.00 m (Dutch Green Building Council, 2024).

Table 6: Literature review design parameters skin

		Author												
	Design parameters	Gann and Barlow (1996)	Moffatt and Russell (2001)	Remøy (2010)	Remøy et al. (2011)	Manewa (2012)	Conejos et al. (2013)	Hermans et al. (2014)	Remøy and van der Voordt (2014)	Schmidt III (2014)	Geraedts (2016)	Schmidt III and Austin (2016)	Acharya et al. (2020)	**Total**
Skin	**Daylight admission**			**x**	**x**		**x**		**x**	**x**	**x**			**6**
	Façade grid			x	x							x		3
	Natural ventilation						x				x			2
	Possibility of attaching interior walls to façade			x	x			x		x	x			5
	Removable façade	**x**		**x**	**x**		**x**		**x**		**x**	**x**		**7**

Services and space plan

When considering the services and space plan layer of the building, three main design parameters emerged that facilitate the future conversion of the building: raised floors, shaft location and a surplus of services and shaft capacity. An overview of the design parameters mentioned in literature is illustrated below in Table 7.

Raised floors are commonly used in office buildings to provide flexibility for the installation of various services such as electrical wiring, data cables, and ventilation ducts. In the context of designing for future conversion, raised floors offer significant advantages. Office environments tend to have a higher demand for cabling and data infrastructure compared to residential spaces. However, when an office building is converted into housing, the layout and arrangement of services often need to be adjusted to suit the new residential functions. Raised floors facilitate these changes by offering easy access to services and enabling the redistribution of wiring, plumbing, or heating systems without alterations to the building structure (Remøy & van der Voordt, 2014; Schmidt III & Austin, 2016).

The placement of vertical shafts, which house essential services such as plumbing, electrical wiring, and ventilation, is another critical design parameter in the services layer. In office buildings designed for future conversion, the strategic location of these shafts can significantly impact the ease and cost of conversion (Moffatt & Russell, 2001). Preferably, the pipe zones and vertical shafts are positioned at the central level and at the unit level. By positioning the pipe zones and vertical shafts at both central level and unit level, the building can be more easily subdivided or rearranged (Dutch Green Building Council, 2024). Residential units typically require more localised service points than office spaces, particularly for plumbing and ventilation (Manewa, 2012). Further, residential units require a higher density of vertical transport than offices; while offices require more lifts than residential units (Dutch Green Building Council, 2024). Therefore, the shafts must be distributed in such a way that they can efficiently serve the future residential layout. Placing shafts near core areas of the building, such as stairwells and elevators, can allow for easy access and modification during conversion (Acharya et al., 2020).

Lastly, one of the crucial aspects of designing for future conversion is providing a surplus in service and shaft capacity (Geraedts, 2016; Remøy et al., 2011). Ideally, the capacity and distribution (pipework, shafts and ducts) of the installation systems are reasonably to well oversized (Dutch Green Building Council, 2024). Office buildings generally have different service requirements compared to residential buildings. For instance, while offices need more intensive IT and electrical services, residential spaces require higher capacities for plumbing, ventilation, heating. Therefore, designing office buildings with a surplus capacity in key services is essential to ensure that these systems can be adapted to meet the demands of residential use without requiring major upgrades.

Table 7: Literature review design parameters services and space plan

	Design parameters	Gann and Barlow (1996)	Moffatt and Russell (2001)	Remøy (2010)	Remøy et al. (2011)	Manewa (2012)	Conejos et al. (2013)	Hermans et al. (2014)	Remøy and van der Voordt (2014)	Schmidt III (2014)	Geraedts (2016)	Schmidt III and Austin (2016)	Acharya et al. (2020)	**Total**
Services	Accessibility of services		x	x			x				x	x		5
	Distribution of services					x	x		x		x	x		5
	Raised floors			**x**	**x**	**x**			**x**		**x**	**x**		**6**
	Shaft location	**x**	**x**	**x**	**x**		**x**						**x**	**6**
	Surplus of services and shaft capacity			**x**	**x**			**x**	**x**		**x**	**x**	**x**	**7**
	Suspended ceilings			x		x			x		x			4
Space plan	Adaptable interior walls			x								x		2
	Dismountable connection detailing interior walls			x				x				x		3
	Standardised components									x		x		2

4.2.3 Chapter summary

The previous chapter elaborates upon the concept of the design of a building for future convertibility and gives an answer to the second sub-question: *How can an office building be designed to enable future conversion to residential use? (SQ 2)* The chapter explores the critical design parameters associated with the services layer of office buildings designed for future conversion to residential use. As the urban landscape and market demands evolve, the adaptability of buildings becomes essential. Convertible office buildings are designed with the foresight to accommodate future changes, making the transition to residential use more efficient and cost-effective.

The main design parameters identified by the literature that enable and facilitate building conversion from office to residential use are the following:

Structure

- Floor-to-floor height

- Plan depth
- Position cores
- Position entrances
- Structural grid
- Surplus of load bearing capacity

Skin

- Daylight admission
- Removable façade

Services and space plan

- Raised floors
- Shaft location
- Surplus of services and shaft capacity

4.3 Costs and benefits of design for conversion

The following chapter identifies the costs and benefits that accompany the design of a building for future residential conversion. The aim of this chapter is to find an answer to sub-questions three: *What are the costs and benefits of the design of a new office building for future residential conversion? (SQ 3)*

Financial considerations play a crucial role in the decision to invest in convertible office buildings. One of the main barriers to developing such buildings is the perception of high initial costs, with the long-term advantages not always being evident from the outset (Geraedts, 2008, 2009). As Remøy (2010) states, stakeholders are more likely to invest in future-proof buildings if they can clearly perceive the benefits over time. Schmidt III and Austin (2016) support this thought by noting that investors are unlikely to prioritise adaptability unless they perceive it as adding value or if it is mandated by regulations. They are typically motivated to invest in convertible design solutions only if they foresee a net financial return or other business advantages (Schmidt III & Austin, 2016).

In this context, one of the biggest challenges regarding the financial dimension of the adoption of convertibility remains the "split incentive" problem – where the party incurring the initial investment in convertibility is often perceived to differ from the party benefiting from it in the future. This disconnect, Geraedts (2001) concludes, discourages early investment in convertibility unless lifecycle costs are given more weight than the upfront expenses.

Similarly, Hermans et al. (2014), find that to realise the value of adaptability, it is essential to consider lifecycle costs, rather than just the initial investment. Convertible buildings may seem less attractive to investors when only upfront costs are evaluated, but when the total lifecycle – encompassing design, construction, maintenance, operations, refurbishment, and demolition – is factored in, the long-term value becomes clearer (Geraedts et al., 2017; Slaughter, 2001). Lifecycle costs refer to the total expenses incurred over a building's entire lifespan while meeting its performance requirements (Kirk & Dell'Isola, 1995). Conversely, converting standard buildings without incorporating convertibility can lead to significantly higher expenses in the future, making lifecycle costs a particularly important factor (Geraedts, 2001). However, investors generally face challenges in forecasting future value increases tied to convertibility, especially since it is uncertain when or if a building will need to be converted (Remøy et al., 2011). The uncertainty in cost estimates tends to grow over time, as predicting future costs becomes less reliable (Carmichael & Taheriattar, 2018). A long-term perspective is therefore crucial for investments in convertibility.

Despite this uncertainty, there are key arguments for investing in convertible office buildings, such as risk management, and potential long-term value appreciation. Additionally, given the rising importance of sustainability in investment decisions, convertibility is increasingly recognised as a sustainable measure, which may lead to better performance for adaptable properties compared to traditional ones (Dutch Green Building Council, 2010). Ultimately, Hermans et al. (2014) state, convertible, and thus sustainable, buildings can enhance financial value, as their interchangeable functions increase their usability and long-term viability.

Arge (2005) concludes that the profitability of these investments largely depends on whether property owners, tenants, or investors are willing to pay for convertibility, which in turn relies on the perceived benefits over time and the frequency of functional changes in the building. The rate of change is often determined by tenant turnover and the types of businesses occupying the space (Arge, 2005).

Building on the DCF determinants that were identified previously (Chapter 4.1), the analysis of the costs and benefits is subdivided into the following topics:

- Initial investment
- Potential gross income and vacancy rate
- Operating expenses

- Capital expenditures
- Terminal value

4.3.1 Initial investment

Literature mainly agrees that designing office buildings for future conversion requires a higher initial investment (Bourke & Adams, 2020; Geraedts, 2001; Manewa, 2012). These additional costs result from higher construction costs on the one hand and additional design and planning costs on the other hand which are incurred when including the convertible design parameters.

Many authors state that the design measures to make a building adaptable will increase the construction costs of the building. Design measures that enable the buildings convertibility refer to design parameters such as, for instance, layout flexibility and capacity expansions of building parts (see Chapter 4.2.2). The opinions about which design measure has the most impact on the additional construction costs diverge. According to Geraedts (2001), the technical installations play a crucial role in convertibility; buildings with flexible systems are much easier to adapt in the future, reducing the risk of high conversion costs. In some cases, facility costs make up more than 60% of initial building investments. Other authors see the façade or the surplus of load-bearing capacity as main cost factors in the construction costs.

While literature mainly agrees that additional initial costs are incurred to design a building for conversion, there are different perspectives on the height of these costs. Schenk (2009) finds that specific designs, like single-corridor layouts, can raise construction costs by 3-5%. Additionally Schenk (2009) concludes that adaptable developments may increase total building costs by about 3%, equivalent to an additional €0.6 million on a €20 million project, although land costs can significantly affect this percentage. Slaughter (2001) suggests that prefabrication and overcapacity designs can minimise the cost increase to 1-2%, making adaptability a cost-effective option to future-proof buildings against market risks.

In contrast to the relatively low percentages of additional construction costs found by Schenk (2009), Arge (2005) concludes that adaptability measures, such as greater floor-to-floor heights and enhanced technical grids, can add 20-25% to the lowest-cost solutions for buildings without convertibility (standard buildings). Another study similarly found that employing design measures like system walls, soundproof suspended ceilings, and higher floor-to-ceiling heights could raise initial construction costs by roughly 20-25% (Arge & Landstad, 2002). "However," Bourke and Adams (2020, p. 3) find that "other adaptable design solutions, such as easily divisible building forms and floor plans, were found to be cost neutral."

It is important to recognise that not all convertible buildings are designed to be convertible to the same extent, making convertibility a sliding scale with varying degrees of convertibility based on design parameters. Therefore, the costs for these design parameters can not be generalised or universally applied.

Besides the rise in construction costs, literature also finds that design for conversion increases other initial costs such as the design and planning costs involved in the design of the building. Provisions for convertibility, including structural elements like facades, services, and internal spaces, Fischer (2019) and Schmidt III (2014) state, lead to increased project management, architectural, and permit costs. Geraedts (2001) finds that flexibility impacts architectural costs – particularly for installations and fixed designs – and raises project supervision efforts compared to traditional projects.

Although designing for conversion may seem less financially attractive when only considering initial investment costs, a life-cycle cost analysis, rather than just investment or construction costs, provides a more accurate assessment of a building's future value. Design measures to increase convertibility ultimately extend the building's lifespan and lower future conversion expenses (Hermans et al., 2014).

Acharya et al. (2020) find that the additional construction costs of a convertible can be up to 110% of the construction costs of a standard building to reach a break-even point in terms of profitability.

Nonetheless, flexibility measures that require minimal extra investment are the most attractive to stakeholders, while those with higher costs face resistance unless clear financial advantages can be demonstrated (Geraedts, 2001).

4.3.2 Potential gross income and vacancy rate

Literature mainly agrees that investing in buildings designed for conversion presents an opportunity for generating steady rental income, as these adaptable structures are less vulnerable to future vacancy risks.

Lower vacancy rates, as a result of the lower long-term investment risk of convertible buildings, allow investors to achieve more consistent occupancy levels, ultimately enhancing the financial viability of the investment (Geraedts et al., 2017). This stability not only supports a more reliable income stream but also strengthens the property's position in a competitive real estate market (Bourke & Adams, 2020).

(Baum's1994) empirical study highlights the importance of convertibility in maintaining rental value. By examining 125 office buildings in London, he found that flexible internal configurations, such as floor-to-ceiling heights and layout, as well as quality specifications, played a critical role in reducing depreciation. He concluded that flexibility helps mitigate the risk of a significant loss in a building's market value over time.

Additionally, properties certified for adaptability, such as those with LEED or BREEAM certifications, have been shown to increase rental values by 5% and sale values by 25%, increasing their appeal to investors (Pinder et al., 2013).

4.3.3 Operating expenses

According to Geraedts (2001), operational costs are influenced by factors such as building ownership and usage – whether the building is owner-occupied, maintained for continued use, or leased to third parties. With the combination of these usage scenarios also affecting operational costs.

Buildings designed for future conversion tend to have lower operating expenses. This is largely due to improved operational efficiency, as noted by Hermans et al. (2014) and Schmidt III (2014). These designs allow for easier maintenance access, which leads to reduced maintenance costs (Slaughter, 2001). Hermans et al. (2014) emphasise that adaptive buildings better support users' primary processes and result in lower operational costs. Investing in convertible buildings, therefore, not only improves financial feasibility but also supports long-term operational savings.

Convertible buildings that are more easily leased generally incur lower operational and administrative costs, as their higher occupancy rates minimise rent losses. Similarly, buildings designed for conversion often maintain higher occupancy, ensuring a steady cash flow and quicker sales, which in turn reduces management and administrative expenses (Schmidt III & Austin, 2016).

4.3.4 Capital expenditures

Investing in buildings designed for conversion typically leads to more manageable capital expenditures compared to standard buildings. The cost savings arise mainly during conversion because the existing structure, foundation, and other components can be reused, leading to lower material expenses and shorter construction times. Factors that contribute to lower capital expenditures also include easier access for maintenance (Slaughter, 2001) and decreased ongoing maintenance costs.

Carmichael and Taheriattar (2018) highlight that convertible buildings tend to be more profitable primarily due to significant savings in conversion costs. Similarly, Hermans et al. (2014) agree that convertible buildings lead to lower adaptation costs compared to standard buildings. Research by Langston et al. (2008) indicates that conversion costs are generally lower since many necessary building components are already in place.

Further, comparing the adaptation of a building in general to its demolition and redevelopment, Shipley et al. (2006) find that the benefits of adapting existing structures are evident, as construction costs can be reduced by up to 22% when utilising existing buildings. Conversely, not investing in future convertibility can lead to excessively high costs when building modifications are required.

In addition to the decreased conversion construction costs, convertible buildings lead to a shorter conversion time. Manewa (2012) claims that flexible solutions result in up to 75% shorter building time. Johnson (1996) suggests that the time required for transformation is typically between 50% and 75% of the time needed for demolition and new construction of the same floor area. This shorter conversion period not only reduces financing costs – due to reduced borrowing periods – but also lessens the impact of inflation on construction expenses. On top, this shorter timeframe also minimises disruptions to operations and cash flows, allowing organisations to avoid temporary accommodation expenses (Langston et al., 2008). And, Slaughter (2001) found that three-quarters of adaptable design strategies shorten the time needed for building adaptations, which further facilitates maintenance access.

Summarising, Shipley et al. (2006) conclude that adapting is typically cheaper than demolishing and rebuilding because existing structural components remain in place and borrowing costs are reduced, given that contract periods are generally shorter.

Figure 14 compares the lifecycle costs of a standard building design with those of a convertible design, revealing a significant profit loss for the standard design at the point of redevelopment (Geraedts et al., 2017).

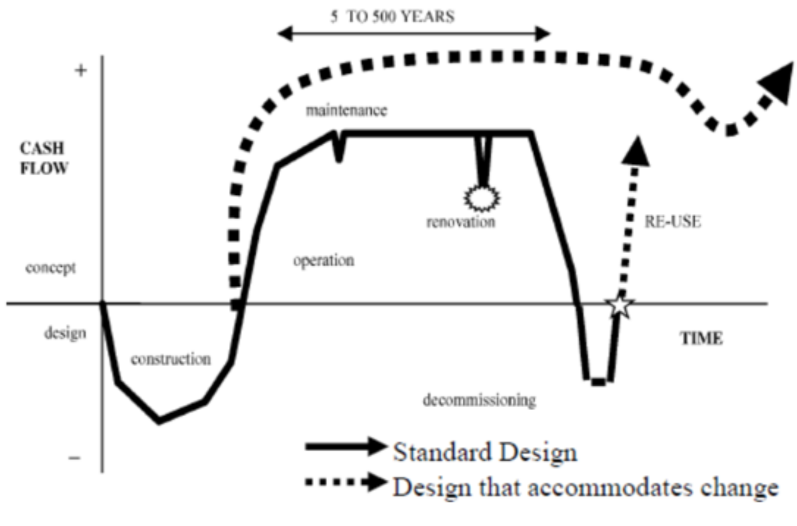

Figure 14: Expected lifecycles and potential impact of design accommodating convertibility (Slaughter, 2001)

However, O'Donnell (2004) points out, that an adapted building may not achieve the same operational energy performance as a new building, and the life expectancy of materials in older buildings might not match that of newer constructions, potentially leading to higher ongoing maintenance costs.

4.3.5 Terminal value

The terminal value of buildings is crucial in assessing their financial feasibility, particularly for convertible buildings, which tend to hold higher future value due to their adaptability. This adaptability allows them to meet evolving market demands, enhancing their appeal to both buyers and tenants. The flexible design ensures that these buildings can adjust to future needs, making them attractive to prospective buyers seeking properties with potential for alterations (Carmichael & Taheriattar, 2018). According to Schmidt III and Austin (2016) and Bourke and Adams (2020), adaptable architecture helps property owners respond effectively to market changes, thereby extending the economic viability of their investments. This adaptability improves lettability, boosts potential sale prices, and leads to lower long-term ownership costs (Hermans et al., 2014).

Manewa (2012) states that the flexibility of convertible buildings not only makes convertibility attractive to future buyers but also supports extended economic lifespans, ensuring ongoing value. Design decisions that emphasise convertibility contribute significantly to maintaining a property's worth over time. Consequently, the prolonged lifecycles of convertible buildings enhance their terminal value, as their capacity to adapt to new uses helps sustain their economic value over the long term.

A key factor in this financial assessment of the terminal value is the choice of the discount rate, which significantly impacts long-term investments such as adaptable buildings. Bourke and Adams (2020) highlight that discounting is based on the concept of time preference, where immediate benefits are valued more than future ones. High discount rates place more emphasis on early cash flows and can discourage long-term adaptability investments by devaluing future benefits. However, adaptable buildings offer long-term value by meeting future user needs, even though empirical evidence supporting this is scarce in the literature.

Additionally, the terminal value of adaptable buildings increases due to the frequency with which a building's use can change. Properties that can be easily and inexpensively converted for new functions offer greater future value than single-purpose buildings. Investors, knowing that a building can be re-let after a tenant's lease ends – potentially for a different use – are more likely to invest (Bourke & Adams, 2020). However, short-term investment visions, typically five to ten years, and a limited recognition of adaptability in property valuations often hinder this potential. Ellison et al. (2007) found that current commercial property valuations only consider a narrow view of adaptability, focusing on internal space flexibility, while overlooking other critical forms, such as the ability to change the building's function.

4.3.6 Chapter summary

The costs and benefits of designing for conversion, as outlined in the literature, can be summarised as follows:

- Lifespan: Lifespan of the building is extended.
- Planning complexity: The increased complexity of a convertible building requires more extensive planning.
- Construction costs: Convertible building design requires additional material use due to, for example, additional load-bearing capacity, additional MEP needs, higher quality materials to meet residential standards, higher fire safety etc.
- Vacancy risk: Convertibility results in reduced long-term vacancy risk.
- Maintenance costs: Lower maintenance costs due to design for change of components, for example, easier access to installations.
- Conversion costs: Lower conversion construction costs due to convertibility of building.
- Conversion time: Shorter conversion time due to pre-configuration of the building to be converted.
- Investment risk: Lower long-term risk of investment yielding higher exit value.

4.4 Synthesis

Now, the insights from the previous chapters regarding a) the determinants of the DCF model and b) the costs and benefits of design for conversion need to be connected. By synthesising the two topics, a preliminary answer to sub-question four can be formulated: *How do the costs and benefits of the design for residential conversion affect the DCF model of a new office building? (SQ 4)*

To achieve this, the costs and benefits of design for conversion are linked to the corresponding DCF model determinants they influence. An overview of the costs and benefits along with the affected DCF determinants is illustrated in Table 8. The effect of the costs and benefits on the DCF determinants, as well as on the NPV of the investment, is illustrated.

For example, the increased planning complexity of convertible buildings leads to higher design and planning costs, which negatively impacts the NPV of the property. As shown, the effect of reduced conversion costs is indicated in brackets, as this benefit is only realised if the building is eventually converted. The extended holding period, however, has no direct influence on the NPV.

Table 8: Preliminary framework effects of convertibility on DCF model (derived from literature)

Costs and benefits convertibility	Effect on DCF determinant		Effect on NPV
• Planning complexity: The increased complexity of a convertible building requires more extensive planning.	Design and planning costs	↑	–
• Material use: Convertible building design requires additional material use due to, for example, additional load-bearing capacity, higher floor heights and associated structural requirements.	Construction costs	↑	–
• Vacancy risk: Convertibility results in reduced long-term vacancy risk.	Vacancy rate	↓	+
• Maintenance costs: Lower maintenance costs due to design for change of components, for example, easier access to installations.	Operating expenses	↓	+
• Conversion time: Lower conversion time due to pre-configuration of the building to be converted. • Conversion costs: Lower conversion construction costs due to convertibility of building.	Capital expenditures	↓	(+)
• Maintenance costs: Lower maintenance costs due to design for change of components, for example, easier access to installations.	Capital expenditures	↓	+
• Investment risk: Lower long-term risk of investment yielding higher exit value.	Terminal value	↑	+
• Lifespan: Lifespan of the building is extended.	Holding period	↑	0

Findings

5. Findings interviews

The following chapter presents the findings from the conducted interviews. These interviews were held as semi-structured discussions with 16 different stakeholders, all of whom are either involved in building conversion or financial feasibility assessment. The backgrounds of the interviewees varied, ranging from architects and municipal actors to investors, ensuring a broad spectrum of perspectives. The general aim of the interviews was to explore the potential costs and benefits of the design of buildings for future conversion and how these impact the DCF calculation and, consequently, the financial feasibility of the investment.

The objective of the interviews was to provide answers to sub-questions three and four: *What are the costs and benefits of the design of a new office building for future residential conversion? (SQ 3); How do the costs and benefits of the design for residential conversion affect the DCF model of a new office building? (SQ 4)*

The interviews provided insights into the following areas:

- Boundary conditions
- Design parameters
- Costs and benefits
- Effects on the DCF model
- Adoption in practice

The following chapter outlines the interview findings based on these overarching themes. Subsequently, the findings will be discussed and related to the literature in the discussion chapter.

5.1 Boundary conditions

The interviews revealed that designing for conversion typically only makes sense if certain boundary conditions are met for the property. The most important preconditions for a plot or property that to be suitable for conversion that emerged from the interview are its zoning and location. Both the zoning and location of the property must be appropriate for future residential use in order to be considered for a convertible design.

5.1.1 Zoning

Interviewees mostly agreed that one of the main challenges of developing convertible buildings in general is that zoning often acts as a precondition that may limit the conversion potential for a property. This is because zoning is crucial in determining whether office buildings can be converted into residential buildings as it determines allowed and prohibited uses for a property. It was also largely agreed upon that while it can majorly hinder the development of convertible buildings, it can also enable future conversions and thereby drive the adoption of convertibility. This section highlights insights from interviewees on the challenges and opportunities zoning presents, emphasising the need for flexible zoning to facilitate potential building conversions.

Interviewee C.6 described the legal feasibility as a significant concern when discussing convertible buildings, emphasising that "one of the hardest things is the legal part… you have to have the right zoning plan." As a legal framework that determines allowed uses on a plot, zoning must be aligned with the conversion potential of the building. If suitable zoning regulations are not in place, the future process of converting a building's function is likely to meet legal, financial, and bureaucratic hurdles. As a result, the conversion process may face delays or, in some cases, become entirely unfeasible due to the inability to align with the existing zoning regulations.

Several interviewees pointed out that the current system of zoning in the Netherlands is relatively inflexible, particularly when it comes to anticipating future changes in building function. Interviewee

RD.2 described the challenges when trying to introduce flexible zoning, highlighting the difficulties municipalities face in handling these changes: "We always try to create some flexibility but it's difficult because when changing a zoning plan, you change so many legal aspects of the plot that the change of the zoning planning will be very difficult for the municipality to handle. And they already think it's very difficult to change the zoning plan to single use." And changing the zoning plan can be a complex undertaking particularly when trying to introduce flexibility. The traditional nature of zoning and the reluctance of municipalities to develop more flexible models apparently can lead to delays and complications in projects that include conversion potential in the building design. Interviewee RD.2 elaborated, "when there's a single-use zoning plan and you as a developer are negotiating with the municipality to change it, it's very hard to make clear that you want to change the zoning plan, but also want to keep the old zoning." Further, interviewee C.2 emphasised that, even though changing zoning is legally possible in most cases, the sector tends to be traditional, with both developers and municipalities finding it "really hard to do things differently." This resistance to change is found to be particularly challenging when developers or investors attempt to introduce innovative concepts such as flexible zoning plans.

This has the consequence that in some cases, developers or investors are forced to work within the constraints of the existing zoning plan, even if it does not fully align with their future intentions. Interviewee RD.2 further explained that "developing within the existing zoning plan" reduces the risk, as changing the zoning plan is time consuming and uncertain.

Despite the challenges, the interviews also revealed that flexible zoning could offer significant opportunities for developers aiming to develop convertible buildings. Interviewee RD.2 stressed the importance of incorporating mixed use zoning from the start, stating, "when developing a new office building, it would be very beneficial to create a mixed-use zone in the zoning plan. I think that would be the most attractive element actually." So, having the suitable zoning in place from the outset, is said to be an opportunity for the development of convertible buildings as it provides clarity to potential investors and reduces risks associated with future changes. Investors are particularly keen on certainty, and zoning provides a legal guarantee that the building can be converted to residential use when needed. From an investor's perspective, having the appropriate zoning in place from the beginning reduces the risk profile of the development. Interviewee RD.3 explained that "if you can have all that already locked up in the zoning, it might throw you back a bit, but it's clarity, and that's what an investor wants." In this context, zoning serves as a critical risk mitigation tool, ensuring that the building's future use is legally protected, which in turn enhances the attractiveness of the investment. Interviewee RD.3 extends the idea beyond the basic categorisation of building functions per zone by suggesting that the specification of additional plot details within the development plan could offer significant advantages for the adoption of convertible buildings. As Interviewee RD.3 highlighted, municipalities in the Netherlands often impose specific requirements, such as ensuring a mix of social, mid-segment, and liberal housing. Having these conditions already defined within the zoning plan provides developers and investors with the security that their project will meet legal requirements and may even be an opportunity to secure conditions now that might be beneficial in the future.

The potential benefits of flexible zoning are mentioned to not just be hypothetical but to already exist in practice. Interviewee M.1 mentioned the case of Rotterdam, where mixed-use zoning plans are prevalent in the inner city. These plans allow for both office and residential uses without the need to specify exact percentages or conditions. As a result, the process of adding residential units to an office development is relatively straightforward. This example demonstrates the practical advantages of flexible zoning and highlights how such an approach can ease the conversion process.

However, it is important to note that not all municipalities are as open to flexible zoning. Interviewee I.1 shared an experience where they believed the location of their project was ideally suited for housing, but the municipality disagreed. As a result, the zoning was not changed and the building is now being developed primarily as office building.

Summarising, zoning represents both a challenge and an opportunity when designing office buildings with potential for residential conversion. The rigidity of existing zoning laws and the reluctance of municipalities to embrace flexible zoning models can hinder the development process. At the same time, securing the right zoning plan from the outset offers significant advantages by reducing risks, ensuring legal feasibility, and providing clarity to investors. The varying perspectives of the interviewees highlight the complexities involved in negotiating zoning plans. While some see the potential for more innovative, flexible zoning approaches, others recognise the deep-rooted challenges in changing traditional practices.

5.1.2 Location

In addition to zoning preconditions, which must align with a property's potential for future residential conversion, the interviews found that location is a critical factor in determining convertibility. Interviewees agree that if the future residential use does not fit the property's location, designing the building for future conversion is not feasible. Interviewee C.5 clearly emphasised the importance of location by stating: “I think the biggest risk if you just look at residential conversion, is the location.”

Factors such as proximity to urban amenities, transport links, and the characteristics of the surrounding area were found to play a decisive role in determining whether a location is suitable for residential use. One of the main reasons an office building may be considered for residential conversion is the suitability of its location for residential purposes. As noted by one interviewee, RD.1, "the building’s location was perfect for apartments, close to the city centre, the highway, and the central station." Accessibility was mentioned as the biggest in the success of a conversion project. Interviewee C.3 noted that "it also depends on how good the accessibility is. So, is it next to a train station or is next to a road and things like that.”

Conversely, buildings in isolated office parks or near highways often face significant barriers to conversion, both in terms of market demand and physical feasibility. Buildings located in monofunctional office parks, as noted by interviewee C.2, are less attractive for residential conversion: "No one wants to live there... there’s no facilities, no schools, nothing that makes people want to live there. But then if there's an office building in a nice neighbourhood with other houses, then that would be very suitable." As highlighted by several interviewees, many office parks or "B locations" were initially designed with car access in mind and lack the social infrastructure for residential life. For example, buildings located near highways that are ideal for offices may be less suitable for housing due to their dependence on car access and lack of other transport options. Interviewee C.5 pointed out that, in such cases, "not only your office building has to be converted, maybe more the complete area has to be converted." Otherwise, there is a risk that even after conversion, the location will remain undesirable and will be vacant in the end.

Beyond geographic location, the physical characteristics of the plot can also influence conversion feasibility. Interviewee RD.1 explained the case of a building conversion where the ability to increase the building's volume on the plot was critical for making a realistic business case for conversion. This highlights the importance of specific characteristics of the plot, such as the potential for extension, which can enhance the financial attractiveness of a conversion project.

And also the surrounding neighbourhood’s support was mentioned as another factor that can influence conversion success. RD.1 stressed the importance of community support: "You always need everyone around to support your plan." When a building is already part of an existing neighbourhood, obtaining such support can be easier because the building is familiar to the community. Interviewee RD.1 further noted that in this context, “it's easier when you just use the current building because you know it's already there.” This underlines that location is not just about physical attributes but also about the social fabric around the building.

While some locations may be suitable for multiple uses, Interviewee C.4 stresses that others are limited in their suitability for alternative uses. "Reuse possibilities are not unlimited" (Interviewee C.4) and depend heavily on variables, such as noise pollution from near highways or the lack of amenities. Similarly, interviewee RD.3 noted that while most currently vacant office buildings are near highways they likely require substantial noise mitigation measures to be suitable for residential use.

As the interviews show, understanding the location-specific challenges and opportunities is key to making design and investment decisions when planning for future conversion. In conclusion, the location also acts as a precondition, without the suitability of which a convertible building design makes little sense and offers no financial advantages.

5.1.3 Chapter summary

This chapter explores the boundary conditions crucial for designing office buildings that can be converted into residential use, focusing on zoning and location suitability as key prerequisites.

Zoning plays a critical role in the development and potential conversion of convertible office buildings. Without the appropriate zoning in place, developers or investors alike cannot proceed with conversion projects. While interviewees recognised that flexible zoning could facilitate conversion, they also noted that changes to zoning are complex and challenging due to legal constraints. However, once established, zoning can provide certainty to investors, reducing project the investment’s risk. Opinions differed among interviewees on the difficulty of navigating zoning changes, highlighting both the obstacles and opportunities zoning presents.

Location suitability is another essential boundary condition impacting the feasibility of conversion. For example, proximity to urban amenities and transport links, as well as the character of the surrounding area were identified as decisive factors in determining a location’s potential for residential use. Buildings situated in vibrant, well-connected areas are more likely to be viable for conversion, whereas those in isolated office parks or near highways often face significant barriers.

Overall, meeting these boundary conditions is essential for the successful design and conversion of office buildings into residential properties.

5.2 Design parameters

Overall, the interviewees rendered the functional conversion from office use to housing use the most feasible functional conversion compared to other functions. As Interviewee C.6 highlights, "What’s the most realistic transformation? It is from office to housing, probably.” According to several interviewees, this is largely due to the high floor-to-ceiling heights commonly found in office buildings, which provide the flexibility needed to accommodate residential functions later on. As Interviewee I.1 notes, "In my opinion it’s always easier to transform or redevelop offices into apartments because you have this rather high floor to ceiling height." Offices typically offer larger, open spaces that can be more easily reconfigured for residential purposes. In contrast, residential buildings often lack the flexibility required for office use due to their lower ceilings and load-bearing walls. Interviewee I.1 summarises this by stating, "It’s not very logical to do it the other way around because a lot of the residential developments have concrete walls and if they don't have, then at least the ceiling height is not what you would like to have for an office.”

Which design parameters the interviewees also consider important for the convertibility of a building will be explained and summarised in the following chapters. For this, the design parameter table that was set up in the associated literature review chapter is reused as a framework.

5.2.1 Structure

First, the design parameters related to the structure of the building are examined. The interviews revealed that the most important parameters of the building structure that enable or facilitate convertibility are the floor-to-floor height and the structural design of the building. These are followed by a surplus of load-bearing capacity, sufficient plan depth, and a suitable structural grid of the building. Additionally, one design parameter was mentioned that has not yet appeared in the literature: the possibility of incorporating balconies or access to outdoor space. An overview of the findings is presented in Table 9. The parameters mentioned most are highlighted.

Floor-to-floor height was mentioned in six interviews as a fundamental design parameter influencing the convertibility of a building's function. Interviewee C.1, for example, emphasised that higher ceiling heights are beneficial for accommodating various uses, stating, “Offices would be perfect because you already have a bit of a higher floor height.” Interviewee M.1 noted that these higher ceilings facilitate the integration of diverse functions within the same space, while Interviewee I.1 pointed out that existing buildings with appropriate heights often support better residential configurations. Notably, Interviewee C.3 highlighted that insufficient floor height can lead to the need for demolition and reconstruction instead of conversion, stressing the importance of planning for adequate height from the outset.

Equally, six interviewees noted that the structural design of the building is also critical for future convertibility. In particular, a skeleton structure – consisting of columns and beams – was frequently mentioned as being beneficial. Interviewee C.1, for example, described the benefits of a skeleton structure for convertibility, as it allows for flexible floor plans and the easy modification of the space. This structural design can support different functions, as noted by Interviewee I.1, who explained that such flexibility is vital for accommodating residential units.

The structural design also directly impacts load-bearing capacity, with Interviewee RD.2 advocating for over dimensioning structural components to enhance adaptability and reduce future retrofit costs. Accordingly, having an excess load-bearing capacity was named as another essential design parameter for facilitating conversion. As Interviewee RD.2 pointed out, creating additional load-bearing capacity in the foundations and other structural elements can significantly ease the transition from office to residential use. This foresight in design minimises unexpected costs associated with reinforcing structures during conversion.

Further, the plan depth of the building was found to be vital for ensuring optimal daylight admission and spatial quality in residential units. Interviewee RD.1 remarked that deeper office layouts can hinder residential quality, indicating a preference for more balanced plan depths. This was confirmed by Interviewee M.1, who noted that while deeper plans might meet initial volume requirements, they can compromise the overall quality of living spaces. However, M.1 also found that, on the contrary, too little depth in the layout can also lead to inefficient office layouts.

Lastly, the structural grid was identified to significantly impact the convertibility of office buildings for residential use. According to Interviewee C.1, a strict grid can offer flexibility in redevelopment, particularly when the spacing allows for varied apartment layouts. Smaller grids apparently generally provide greater flexibility, making it easier to adapt spaces to residential functions. Interviewee RD.1 emphasised that a well thought-out structural grid can enhance the feasibility of converting office spaces into attractive housing.

A notable new parameter identified in the interviews is the demand for balconies or outdoor space in residential units. Interviewee RD.3 pointed out that outdoor areas have become essential in residential buildings to attract residents and investors, particularly in light of regulations like the WWS (Woningwaarderingsstelsel) in the Netherlands, where the absence of such amenities is penalised. “Balconies, obviously, and outdoor space… With conversions, it's not always needed, but it's a quality” (Interviewee RD.3).

Table 9: Findings interviews design parameters structure

	Design parameters	A.1	A.2	A.3	C.1	C.2	C.3	C.4	C.5	C.6	M.1	RD.1	RD.2	RD.3	I.1	I.2	I.3	**Total**
		Interviewee																
Structure	Expandability				x							x						2
	Fire resistance structure		x	x										x				3
	Fire safety design and escape routes		x											x				2
	Floor space size										x	x	x					3
	Floor-to-floor height	**x**		**x**	**x**		**x**				**x**		**x**	**x**	**x**			**8**
	Insulation	x	x	x										x				4
	Material durability		x															1
	Plan depth		**x**	**x**			**x**				**x**	**x**	**x**		**x**			**7**
	Position cores	x	x	x							x	x						5
	Position entrances	x	x								x	x						4
	Possibility of attaching interior walls to structure	x			x									x				3
	Separation of structure and infill	x		x	x									x				4
	Structural design		**x**		**x**		**x**				**x**	**x**	**x**		**x**			**7**
	Structural grid		**x**	**x**	**x**						**x**	**x**	**x**					**6**
	Surplus of load bearing capacity	**x**	**x**	**x**	**x**						**x**	**x**	**x**	**x**				**8**
	Balconies and outdoor space	x												x				2

5.2.2 Skin

When considering the key design parameters of the building's skin layer, daylight admission was identified as the most important factor in the interviews, as shown in Table 10. It is worth mentioning that daylight admission is directly related to the previously discussed plan depth of the building, as the plan depth significantly influences the amount of daylight that can enter the building.

In addition to the considerations mentioned above about the plan depth of the building it was found that while the amount of natural daylight directly impacts the quality of living spaces, achieving the right balance between open and closed façades is essential to meet both daylight requirements and energy efficiency standards. As noted by Interviewee C.1, “the façade will also be different…in terms of how much you can have open.” This underscores the necessity to find a compromise: while an open façade facilitates daylight, it can lead to significant energy loss, which is particularly concerning under the stricter BENG 1 energy requirements for residential buildings compared to offices.

Table 10: Findings interviews design parameters skin

	Design parameters	Interviewee																
		A.1	A.2	A.3	C.1	C.2	C.3	C.4	C.5	C.6	M.1	RD.1	RD.2	RD.3	I.1	I.2	I.3	**Total**
Skin	**Daylight admission**			**x**			**x**				**x**	**x**		**x**				**5**
	Façade grid			x	x									x				3
	Natural ventilation		x											x				2
	Possibility of attaching interior walls to façade	x			x									x				3
	Removable façade	x		x	x									x				4

5.2.3 Services and space plan

Lastly, on the services and space plan layers the distribution of services and a surplus of services and shafts capacity were found to be the most decisive parameters that enable convertibility, as highlighted in Table 11.

The distribution of services refers to the placement of essential installations, such as plumbing and electrical systems. As Interviewee RD.1 noted, existing construction often limits retrofitting options, resulting in high costs or compromises in floor plan quality. Bathrooms and kitchens, which have to be more widely distributed in residential units than in offices, complicate the design. Interviewee C.1 pointed out the need for strategic planning in order to be able to install the necessary installations during the conversion without affecting the building structure.

The conversion from office to residential use typically requires more installations per unit, as highlighted by Interviewee C.5: “A big challenge in current conversions is creating bathrooms and kitchens for the apartments after the conversion. Most of the time, old buildings get demolished because of the high costs.” Each residential unit requires individual connections, including water and electricity, requiring a sufficient shaft capacity. Interviewee C.1 emphasised that effective design must incorporate sufficient ducting and piping to facilitate these installations.

Table 11: Findings interviews design parameters services and space plan

	Design parameters	A.1	A.2	A.3	C.1	C.2	C.3	C.4	C.5	C.6	M.1	RD.1	RD.2	RD.3	I.1	I.2	I.3	**Total**
Services	Accessibility of services	x																1
	Distribution of services	**x**			**x**				**x**			**x**		**x**				**5**
	Raised floors	x		x	x								x					4
	Shaft location	x			x				x			x						4
	Surplus of services and shaft capacity	**x**	**x**		**x**				**x**			**x**		**x**				**6**
	Suspended ceilings	x		x	x								x					4
Space plan	Adaptable interior walls	x			x									x				3
	Dismountable connection detailing interior walls				x									x				2
	Standardised components					x												1

5.2.4 Chapter summary

To summarise key findings from the interviews regarding design parameters that enhance the convertibility of office buildings into residential use. This chapter complements the findings from the literature review to answer sub-question two: *How can an office building be designed to enable future conversion to residential use? (SQ 2)*

The most critical structural parameters identified are floor-to-floor height and the building's structural design, which are crucial for facilitating future conversions. Additional important factors include surplus load-bearing capacity, sufficient plan depth, and an appropriate structural grid, which collectively support convertibility. A notable insight from the interviews is the importance of incorporating balconies or access to outdoor spaces, a design parameter not commonly highlighted in existing literature but seen as valuable in enhancing the building's quality.

Regarding the building's skin layer, daylight admission emerged as the most important design aspect. This parameter is closely tied to the building's plan depth.

For the services and space plan layers, the distribution of services and surplus capacity for services and shafts were identified as crucial factors. These elements ensure that the building can accommodate the additional infrastructure required for residential conversion.

5.3 Effect of convertibility on the DCF model

The following chapter elaborates on the findings from the interviews regarding the costs and benefits of design for conversion, organised around the following key themes:

- Initial investment
- Rental income
- Operational expenses
- Conversion costs
- Financing costs
- Tax liabilities
- Exit value

The subsequent chapter will explain the findings related to the effect on factors of the DCF model calculation.

5.3.1 Initial investment

The interviews revealed that designing for conversion has an influence on the initial investment in terms of both the design and planning costs as well as the construction costs. The findings are elaborated upon below.

Several interviewees noted that designing a building for conversion typically increases design and planning costs, along with other professional fees associated with the building project. Interviewee C.1 supposes "that the advisory cost would be higher. The architect or whatever other advisor, they don't just have to think about one function, but also another function and what the requirements will be in the future rather than now of course." The high complexity of the building adds effort to the design phase, requiring more extensive planning to accommodate not only current needs but future uses as well. Interviewee C.1 continues stating: "The effort is not just the extra function, but also the function in the future that you have to think about." Besides the design costs, Interviewee C.6 emphasises that securing the appropriate zoning plan "is going to take longer" and will "cost you more," reflecting the additional time and resources required for navigating the regulatory frameworks.

Construction costs emerge as the largest factor influencing the initial investment. As stated by Interviewee C.1, "They [construction costs] are... the most important factor on the cost side." Initial investments tend to be higher due to the specific materials and structural elements required for convertible designs. Interviewee C.5 highlights that "the investment is higher" at the outset, while Interviewee C.4 notes that the initial contract period will involve higher costs due to "higher building costs and more materials." Interviewee A.1 notes regarding the additional construction costs incurred due to higher floor-to-floor heights of convertible buildings: "If you say, I don't make the apartment 2.60 m, which it has to be, but 2.85 meters or 3 meters. That costs extra. Also the additional facade. But that is part of the flexibility. An important part."

In addition to the more obvious factors that increase construction costs, such as over-dimensioning parts of the building to create additional load-bearing capacity, construction costs are also influenced by more indirect features of convertible buildings that arise from other design decisions. An increased floor-to-floor height, for example, results in significant additional construction costs by affecting other components such as the height of the inner walls or façade. Interviewee C.1 indicates that the need for higher columns and internal walls due to additional height translates into higher expenses: "Any extra height that you have you need your columns or your internal walls to be higher, and you need more façade."

The estimates for additional construction costs vary, with Interviewee I.1 roughly estimating that costs can exceed typical office construction costs by up to 10-15%, primarily due to extra load-bearing capacity as well as heightened floor heights and the associated structural requirements. Other contributing factors include the complexities of installations, which are also more pronounced in convertible office buildings.

5.3.2 Rental income

Next, the interview findings regarding the impact of designing office buildings for residential conversion on the income potential of the property as well as on vacancy rates will be discussed. Generally, it is agreed that one of the primary advantages of convertibility is the potential for higher rental income because of the reduced long-term vacancy risks. “In the long term, you may have a higher rent or a lower vacancy” (Interviewee C.4).

The interviews revealed that the rent level for the initial office use is not directly impacted by the building’s convertibility. As Interviewee C.5 states: “Probably you don't get higher rents from the office part.” However, as the building can be converted as soon as its vacancy rate begins to rise, the anticipated vacancy risk is lower. This flexibility allows property owners to respond quickly to changing market conditions, keeping occupancy levels high and minimising the financial impact of vacancies. In other words, the vacancy rate during the initial office rental period can be reduced. After the conversion to residential use, the rent level typically increases, as residential functions generally yield higher rental returns than offices. Interviewee C.6 pointed out that after the conversion, “then you have a higher rent income.”

Some interviewees suggested that the improved sustainability of the building can increase rental income. Interviewee RD.3 stated, “The user will always pay more for a sustainable building, especially when it's a big company and it's part of their ESG reporting.”, emphasising the growing market value of sustainable buildings. As more tenants prioritise sustainability in their office accommodation choices, properties that incorporate an increased sustainability are likely to command higher rents. However, it is important to note that other interviewees did not agree with this perspective, explaining that sustainability premiums are more of a theoretical phenomenon than a reality in practice.

An interesting finding from the interviews that was not explicitly mentioned in literature was the fact that designing for conversion might result in a loss of usable floor space. There are two reasons for a potential loss of usable space: the lower plan depth and the lower overall space efficiency of convertible buildings.

First, the reduced floor plan depth of a convertible office building compared to a standard office building means that, in many cases, less can be built on the same plot of land. The same applies to the higher floor-to-floor heights. In addition to the potential loss of usable floor space due to the lower plan depths, Interviewee M.1 added that the trend toward narrower buildings affects economic viability, as most office users prefer spacious layouts. The narrower designs required for convertible office buildings can therefore reduce the marketability of the space.

Second, it was found that convertible building designs may also lead to less efficient floor plans. “You lose efficiency in your design when you design also for other uses.” (Interviewee RD.2). For instance, the requirements for the surplus of services and shafts capacity, that was identified as one of the most decisive design parameters to enable conversion, may result in a less efficient space use within the building layout. Interviewee C.1 explains, “If you have to design it [the building] in such a way that it fits more than one function, you have to take into account the most extreme and least beneficial scenario. So if you have your offices and housing on the other side, you would have to go for the highest floor to floor heights.” According to interviewees RD.2, RD.3 and C.1 this inefficiency translates into financial implications, particularly for developers who are motivated by maximising space utilisation. Interviewee RD.2 continues: “And that will cost you serious money.”

5.3.3 Operational expenses

Changes in operational expenses caused by convertible building design were only mentioned in one interview. Interviewee C.4 suggested that the potential additional space due to higher floor-to-floor heights of the building could result in higher exploitation costs stating, “In the investments higher building costs more materials but also in the exploitations because of the energy bill and more space.” However, the interviewee emphasised that they were not certain about this effect. The topic also did not come up in any other interview and will therefore be disregarded. It will not be elaborated upon further here and it is assumed that the potential changes in the operational expenses are marginal.

5.3.4 Capital expenditures

Overall, the only change to any capital expenditures mentioned in the interviews concerned the conversion itself. Some interviewees compared the conversion costs to those of transforming a standard building, while others contrasted them with the costs of demolishing and redeveloping the building. Insights from the interviews emphasise conversion construction cost and time savings due to the preconfigured convertibility of the building.

When looking at the conversion moment itself, a significant advantage of designing a convertible building is the potential for shorter development and construction time that is needed to convert the building.

Interviewees frequently mentioned time as a critical cost factor in any developments or redevelopments, especially in urban areas. For instance, one interviewee compared the conversion scenario to a demolition and redevelopment scenario, stating, "And turning this building into residentials also saves you some time." (Interviewee RD.1). The reduced construction timeline has direct financial implications, especially in inner-city locations, where construction space is limited, making time a significant cost factor. As RD.1 further explained, demolishing and rebuilding a structure in a city centre would most definitely result in higher costs: “If we had to demolish it all and rebuild it up in the city centre where it's located it would cost us let's say at least six months more for construction time.”

On top of that, it was mentioned that quicker conversion time has the advantage of faster revenue generation – less rent income is lost due to the conversion process itself. According to interviewee C.5, completing a conversion project sooner allows for earlier rental income: "Maybe you can also take a look at the conversion time. Because you have sooner new revenues because you can rent it sooner to the people." By reducing the overall construction time, developers can rent out the space again more quickly, improving cash flow and reducing the financial loss during the conversion or redevelopment.

Comparing building conversion to the demolition and redevelopment scenario, interviewees also found that the use of the existing structure of the building can minimise the construction costs during conversion. Building conversion projects benefit from having the structure already in place, reducing the need for significant new construction or material use. Interviewee I.1 noted, "The costs will differ a little bit, but since the structure was already there," the additional costs during conversion remain marginal.

Comparing the conversion of convertible buildings to that of standard buildings, Interviewee RD.2 noted that the risk of the conversion of convertible building is significantly lower. They remarked that it is "Far more beneficial… It saves a lot of time and money, a lot of financing costs and the risk profile is lower." (Interviewee RD.2).

When considering the conversion construction costs, multiple interviewees identified the façade the most costly factor. Interviewee RD.3 identified the façade as the most significant cost factor in conversion projects, stating: "It’s also the investment of the façade [that] is the most expensive part." Updating or redesigning the façade to meet residential standards can require substantial costs. “You’re not free in choosing the façade you want because you know it has to be attached to the current building. So… the façade is going to be really expensive.” (Interviewee RD.1).

5.3.5 Financing costs

Two interviewees indicated that financing costs could potentially be lower when considering convertibility in the design of the building.

The relationship between risk and interest rates is a critical aspect of financing costs. Due to the inherently lower risk profile of convertible buildings, it was suggested that financial institutions might offer lower interest rates for these properties, resulting in more favourable financing conditions for investors. Interviewee C.6 pointed out, “There are multiple factors that connect back to the risk, which is the interest rate as well, because the bank gives you better conditions.” When a project is perceived as less risky – due to its adaptability for residential use – lenders may offer lower interest rates. Lower interest rates lead to reduced financing costs, thus positively impacting the overall financial feasibility.

Interviewee C.2 additionally commented on the importance of financing structures in practice, noting: “but then in practice, the financial structures are so, so important to what happens in reality.”

5.3.6 Tax liabilities

The influence of designing for conversion on the tax liabilities of the investment was only discussed in one interview. The interviewee suggested that tax liabilities might be reduced by designing the building for future conversion. Many regions offer tax incentives for properties that promote sustainable development or meet specific criteria for residential use. Designing for conversion may qualify a property for these incentives, reducing the overall tax liability that the investor incurs. However, the regional and local regulations differ in this context significantly.

5.3.7 Exit value

Finally, the effects of the design of a new office building for conversion on its terminal (or exit) value are discussed below. Within the DCF model, the exit value holds significant weight and can substantially influence the project's NPV. The perspectives of interviewees reveal both optimistic and cautious views on how convertible design can influence the investment's terminal value.

On the one hand, several interviewees noted that designing buildings with conversion potential significantly enhances their exit value, particularly in inner-city locations. Interviewee C.2 stated, "If you compare demolition or transformation, then you know the transformation really delivers value later." This statement indicates that a convertible building not only keeps its value over time but may also increase it, especially when compared to standard buildings that may eventually require demolition. In addition to that Interviewee A.1 stated that “if they want to sell it in the future, I can not imagine that it is not worth more. Because it is easier to change.“ Interviewee C.6 further supported this view by highlighting how lower risk factors into the exit yield: "And the exit yield where your risk is factored in." The implication is that the reduced risk associated with convertible buildings leads to a higher perceived value, which positively influences the exit yield. Additionally, interviewee RD.2 emphasised the higher residual value that a building designed for conversion can yield when sold to opportunistic developers after the initial lease period: "For that developer, it's very convenient... they should be able to pay more for the building when it's designed already for conversion." This suggests that convertible buildings can attract higher offers because they are able to adapt to the developing market. Interviewee C.6 also remarked on the long-term benefits of flexible design, stating, “And also do you think that a flexible building has a longer life cycle? Because if it does, that should be reflected in the exit value. So, the exit value should be higher because you don't need to make the demolition costs in like say in 50 years, but maybe in 100 years or something like that.” By extending the lifespan of the building, the initial investor can postpone costs associated with demolition, enhancing the terminal value calculated in a DCF model.

Contrasting these positive assessments, some interviewees expressed scepticism about whether the terminal value would actually increase due to future conversion potential. Interviewee I.1 argued, "I don't think that any investor will pay you more just for the fact that it might be transformed in the future." This perspective shows a critical view of the market's willingness to give a premium for potential convertibility, suggesting that any additional future value may not be fully realised in practice.

In addition to that, I.1 pointed out the influence of the depreciation of value over time. “Let's say an existing office building is old and worn out, then investors might pay more with the idea of transforming it into residential units, than what you would normally pay for an office building. But then a lot of the value has been flushed away." In other words, the value of the building is lost over time. Similarly, interviews also discussed the influence of discount rates on future values. Interviewee C.2 noted this issue, stating, "The challenge is this discount factor, which kind of diminishes any future cost." Suggesting that while future benefits from building conversion may exist, they do not weigh as much today because of the time-value-of-money phenomena – that future cash flows have to be adjusted back to present value.

Sustainability also emerged as a factor in the discussion of exit values. Several interviewees noted the potential for a sustainability premium, which could raise the exit value of a building designed for reuse. Interviewee RD.2 pointed out that "the chance of extending the lifetime of the building will be far bigger," indicating that sustainability factors could influence investment decisions positively. Interviewee C.3 emphasised the growing importance of sustainability certifications, stating, "When you have a BREEAM certificate, the value of your office buildings is also higher." However, as mentioned above, scepticism remained regarding the immediate financial impact of sustainability, as Interviewee C.6 stated, "The sustainability premium is more theoretical." This highlights that theoretical benefits may not translate into tangible market advantages.

5.3.8 Holding period

This chapter explores how building convertibility influences the holding period as considered in the DCF model calculation.

All interviewees implied that convertible buildings hold a long-term value. Interviewee C.4 clearly states that "in the context of convertible buildings, it makes sense to consider a long-term holding period." This perspective suggests that when designing buildings with future conversion in mind, investors should adopt a longer time horizon. This is essential for accurately assessing the potential returns on the convertible investment.

One recurring theme from the interviews is the distinction between the short-term focus typically associated with office developments and the longer-term outlook required for convertible buildings. Interviewee C.4 pointed out that, "The business case for offices is mainly a short-term business case. While the transformation possibilities and the reuse possibilities are mostly a long-term opportunity and an uncertainty." This highlights a tension between the investment horizon and the long-term value of convertible buildings: while the office sector often operates on a short-term business model – where lease lengths typically range from five to ten years – the potential for converting office spaces into residential units presents a long-term investment opportunity. This perspective was shared by Interviewee RD.3, who noted that "for residential investments they have a longer timeline, but for offices, 10 years is far away. Leases are generally five years; sometimes when you're lucky, 10 years." This tension is further elaborated in the following chapter discussing the adoption of convertibility in practice.

It becomes apparent that the decision regarding the holding period should align with the broader strategy of the investment. For instance, if an investor prioritises a quick return from office operations, a shorter holding period may be justifiable. However, if the intention is to capitalise on the long-term benefits of residential conversion, then a more extended holding period could be justified and needed. Interviewee C.4 highlights it ultimately "depends on the belief of the investor."

5.3.9 Discount rate

Lastly, the effect of design for conversion on the discount rate applied in a DCF calculation is examined and elaborated below.

The discount rate serves as a critical factor in DCF models, reflecting the required return on investment and capturing risks associated with the project. Interviewee C.5 highlights the complexity involved in determining the appropriate discount rate, stating, "Normally a big part of the risk will be incorporated in discount rates you use in the DCF method. I think that's the most difficult question." highlighting the challenges in accurately assessing risk, particularly when considering the unique characteristics of convertible buildings.

One prominent theme emerging from the interviews is the necessity to differentiate between discount rates for the residential or the office function. A pre-leased office space for example reduces uncertainty, thus justifying a lower discount rate. According to Interviewee C.5, "I think it also depends, when you built an office building, whether you already have a company that will rent the building or not. That makes it a little bit more sure." Conversely, the residential use is perceived as inherently more secure: "you have to maybe make a distinction between the discount rate for the office part and the residential part. So the residential part is more secure." Similarly, Interviewee C.6 emphasises that the risk and with it the discount rate change when the building is converted: "And also after the 10 years, you should not work with the same discount rate. Because the risk also changes. So the risk rate should also change."

Other interviewees rather suggest the overall discount rate of the investment should be lower – for both the initial office use and the latter residential use. Because the overall risk of the investment decreases according to Interviewee C.6. They further suggest that "the discount rate for a flexible office unit should be lower than the discount rate for a normal office unit." (Interviewee C.6).

Though, both perspectives agree that the discount rate is lowered due to the reduced long-term risk associated with the investment.

5.3.10 Chapter summary

The findings from the interviews concerning the costs and benefits of the design of an office building for future residential conversion and their effects on the identified DCF determinants are summarised below. In combination with the findings from the literature review, this chapter answers both sub-question three and four: *What are the costs and benefits of the design of a new office building for future residential conversion? (SQ 3); How do the costs and benefits of the design for residential conversion affect the DCF model of a new office building? (SQ 4)*

The initial investment for buildings designed with future conversion in mind is higher than for standard office buildings. Key cost drivers include elevated design and planning fees due to the building's increased complexity and the more challenging regulatory process, such as zoning. The largest expense is in construction, driven by the need for additional load-bearing capacity, greater floor heights, and associated structural requirements, leading to increased use of materials.

One of the main benefits of convertibility identified by interviewees is the potential for higher rental income resulting from reduced long-term vacancy risks, translating into a lower vacancy rate in the DCF model. Although initial rent levels may remain comparable to non-convertible buildings, the lower vacancy rates enhance overall income stability. Some interviewees also suggested a potential sustainability premium from office tenants, although this was debated. However, there could be a reduction in rental income due to lower space efficiency, often resulting from less efficient floor plans, larger plan depths, or higher ceilings.

Operational expenses were only briefly mentioned in one interview, and there was uncertainty regarding their exact impact. Therefore, any changes in operational costs due to convertibility are assumed to be marginal.

Capital expenditures influenced by convertibility mainly involve the conversion process itself. Convertible buildings typically have shorter conversion times, leading to lower construction costs and reduced rent loss during conversion periods. The reuse of materials from the existing structure further lowers conversion costs. The main costs factor of the conversion was found to be the façade.

Lower perceived risk associated with convertible buildings could result in lower interest rates from financial institutions, reducing overall financing costs for investors.

Some interviewees mentioned potential tax incentives or concessions for buildings designed with enhanced sustainability, which could positively impact tax liabilities.

There were mixed views on the exit value of convertible buildings. Some interviewees believed that the reduced investment risk could lead to a higher exit value, while others were sceptical about whether this value would be actually realised in practice. It must be noted that the present impact of the exit value is significantly diminished in the DCF calculation because it is adjusted back to today's value. Some interviewees also noted the potential for a sustainability premium at exit, though this was by others seen as theoretical rather than practically achievable in the market.

Interviewees emphasised that convertible buildings are seen as long-term investments, contrasting with the short-term focus typical of office developments. Convertible buildings offer potential long-term value, which suggests a need for a longer holding period. The decision ultimately depends on the investor’s strategy, where aligning the holding period with the investment’s broader goals is crucial to capturing the full benefits of convertibility.

Lastly, overall, there was a consensus that the lower risk of the investment reduces the discount rate. How exactly the new discount rate is determined was less clear.

Table 12: Preliminary framework effects of convertibility on DCF model (derived from interviews)

Costs and benefits convertibility	**Effect on DCF determinant**		**Effect on NPV**
• Planning complexity: The increased complexity of a convertible building requires more extensive planning. • Regulatory complexity: More challenging regulatory process (for example zoning). Other professional fees increase.	Design and planning costs	↑	–
• Material use: Convertible building design requires additional material use due to, for example, additional load-bearing capacity, higher floor heights and associated structural requirements.	Construction costs	↑	–
• Sustainability premium: Potential sustainability premium on rental income, especially from office tenants.	Potential rent income	↑	+
• Usable floor space: Potential loss of useable floor space due to narrower plan depths and higher floor heights. • Space efficiency: Reduced space efficiency of layout as a result of, for example, additional shaft and services capacities.	Potential rent income	↓	–
• Vacancy risk: Convertibility results in reduced long-term vacancy risk.	Vacancy rate	↓	+

• Conversion time: Lower conversion time due to pre-configuration of the building to be converted. • Conversion costs: Lower conversion construction costs due to convertibility of building.	Capital expenditures	↓	(+)
• Investment risk: Lower long-term risk of investment potentially leads to lower interest rates.	Financing costs	↓	+
• Tax concessions: Potential tax concessions because of increased sustainability of the building.	Tax liability	↓	+
• Investment risk: Lower long-term risk of investment yielding higher exit value. • Sustainability premium: Potential sustainability premium on exit value because of increased sustainability of the building.	Terminal value	↑	+
• Lifespan: Lifespan of the building is extended.	Holding period	↑	0
• Investment risk: Reduced long-term risk of the investment due to market flexibility.	Discount rate	↓	+

An overview of the costs and benefits as well as their effect on the previously identified DCF determinants is summarised in Table 12. Again, for example, the increased planning complexity of convertible buildings leads to higher design and planning costs, which negatively impacts the NPV of the property. As shown, the effect of reduced conversion costs is indicated in brackets, as this benefit is only realised if the building is eventually converted. The extended holding period, however, has no direct influence on the NPV.

5.4 Adoption in practice

Besides the design implications and the costs and benefits of convertible office buildings, the interviews also identified both barriers and drivers to the adoption of convertibility in the real estate investment landscape. These are further discussed below. First, the barriers are mentioned, then the drivers of adoption.

5.4.1 Possible barriers to adoption

One of the main takeaways from the interviews was the fact that the adoption of convertibility brings challenges in practice that go far beyond the building and its design itself. This chapter explores the long-term investment horizon and the split incentive it brings with it, the implications of the time-value-of-money concept, uncertainties and cost barriers, the influence of specialised investment profiles and valuation practices, concluding with general reluctance of the sector to adopt innovative approaches.

Investment horizon and split incentive

Probably the most relevant topic that emerged from the interviews as barrier to the adoption of convertible building design was the investor's short investment horizon versus the long-term value of convertibility. The long-term nature of convertible investments poses a challenge as many investors operate within relatively short time horizons, often looking at returns over 10 to 20 years or less, which does not fit with the 25 to 30-year or longer timelines required to realise the benefits of convertibility. Interviewee I.1 stated, “it might be beneficial, but it's a benefit that comes around in 25 or 30 years and that's so far away...it's difficult to calculate that benefit.” The interviews showed that, for investors focused on quick returns, the long-term flexibility offered by convertible designs is often seen as irrelevant or too uncertain to factor into their financial models. And Interviewee C.4 confirms this saying, "the business case for offices is mainly a short-term business case. While the transformation possibilities and the reuse possibilities are mostly a long-term opportunity and an uncertainty.”

This difference in time horizons was mentioned to create a perceived split incentive – the assumption that the first investor is most likely not the one who will benefit from the convertibility of the building. Interviewee C.4 explained, “everything that comes in the future, it's nice and it's for the investor that buys the building at long term, but not for the first investor.” This misalignment of incentives discourages investments in convertibility.

Time-value-of-money

The impact of the time value of money magnifies the questions about the long-term value of convertibility. Any future benefits, such higher rental income after conversion or a higher exit value, are discounted in the DCF model, reducing their future value to todays present value. This means that the potential benefits of convertible buildings, which may not materialise for decades, play little role in current investment decisions. Interviewee C.4 pointed out that “at the long term you may have a higher rent or a lower vacancy... but because of this long term – and look at the discounted cash flow – the impact at the front of the investment is less.” Interviewee C.2 confirmed this by stating, "if you look at costs in the future, then with the discount rate, they kind of diminish."

Uncertainty and costs

In addition to the long-term value of convertibility, the uncertainty of whether the cost of the additional initial investment will actually be returned over time will be the most frequently cited barrier to adoption, confirming the hypothesis underlying this research.

One of the main barriers to designing buildings for conversion is the alleged high initial costs, which are a burden on the already low profit margins in the construction and real estate industry. As Interviewee C.1 noted, "there has to be an incentive to deviate from your function. At a certain point, that incentive has to outweigh the extra cost that is connected to that." Interviewee C.2 similarly emphasised, "Why don't we build adaptive buildings in the first place? And it's always costs. The benefits are very marginal… even though a lot of money goes around, the profits are actually not that much.” The construction and real estate industry operates on low profit margins, prioritising immediate cost savings. For example, while converting a building could lead to higher income down the line, the upfront investment is a major obstacle. Interviewee I.1 noted, "The income drives feasibility when there is an existing building being converted, different when it’s a new development." This reflects a common view: the immediate financial burden often outweighs the potential long-term gains, making the investment seem less attractive. Designing for convertibility often involves higher initial construction costs, making business cases thin, especially when immediate residential use is not foreseen. As Interviewee I.1 stated, “Today, it’s not feasible. So in the end, the question is: Do we keep investing in flexibility for the future, or do we want to build today and optimise the building to get a feasible project?” This perspective underscores the challenge of justifying additional upfront expenses when the financial benefits of adaptability may only be realised far into the future.

In addition, the success of an adaptable building depends on the assumption that market conditions will eventually favour conversion, but this is by no means guaranteed. Interviewee C.4 summed up the challenge: “the transformation possibilities and the reuse possibilities are mostly a long-term opportunity and an uncertainty. So, therefore, it mostly stays a theoretical possibility.” When designing and investing in convertible buildings, it is therefore always necessary to consider the possibility that the building will never be converted.

Specialised investment profiles

Another – maybe more tangible – challenge for the adoption of convertible buildings is the growing specialisation of investors and developers in either office or residential real estate. Investment funds are often segmented by asset class, with distinct allocations for office and residential properties. Interviewee C.4 noted that “investors in the real estate sector work with large funds and they are really separated so there's an office fund, residential funds.” This separation limits the market appeal of buildings designed for potential future conversion for most specialised investors. Interviewee M.1 similarly explained, "developers normally only develop housing or only develop office... there are also not very many developers who are looking for this mix."

Valuation practices

Moreover, valuation practices present a significant obstacle to the widespread adoption of convertible office designs as the value of convertibility is typically not reflected in the financial assessments conducted by property valuers, making it difficult for investors to justify the additional costs associated with adaptable designs. Interviewee I.2 explained, “we love the flexibility, but it's hard to quantify the additional value. When we ask a valuer...he’s not going to value that flexibility when there's a lease for the next five or 10 years.” This disconnect between the potential long-term benefits of adaptability and current valuation practices discourages developers from adopting convertible concepts.

Interviewee I.3 added, "if I can choose between two equally good buildings and one can be turned into apartments and one cannot, I will choose the one that can be turned into apartments for sure." This preference underscores a practical appreciation of adaptability, but without corresponding changes in valuation practices, the financial benefits of flexibility remain largely theoretical and difficult to leverage in real-world investment decisions.

Reluctance towards new practices

Zooming out to a broader scope, adopting new practices in the construction industry is overall hindered by a general reluctance among market parties to embrace new practices. This hesitancy stems from the industry's cost-driven mentality and a lack of incentives that outweigh the additional investment required for convertible buildings. Interviewee C.3 compared the market to a "bike race," describing a small group of frontrunners willing to take risks and adopt innovative practices, while the majority lag behind, constrained by traditional thinking and regulatory frameworks. This analogy illustrates the slow pace of innovation adoption, such as building convertibility, as only a minority of industry players are currently exploring the potential of adaptable building designs.

Further Interviewee C.2 noted that creative thinking, which is essential for developing adaptive buildings, is often lacking in the sector. Interviewee C.2 highlighted this issue, stating that “building for adaptivity requires some creative thinking, and I think creativity is kind of pushed out of the construction sector.”

5.4.2 Possible drivers of adoption

However, there were also possible drivers for the adoption of convertible building designs identified in the interviews.

Market flexibility and risk

As is clear, one of the primary drivers behind the adoption of convertible building designs is the ability to adapt to shifting market conditions, thereby reducing investment risk. In today’s rapidly changing real estate market, consumer demand is increasingly unpredictable. Convertible designs allow buildings to change functions in response to these market dynamics, providing a significant advantage over traditional single-use structures. Interviewee C.1 emphasised the value of convertibility, noting that designing buildings for multiple potential uses can significantly lower overall risk: “This is also a big factor that could make it beneficial to design buildings for two functions because of the market. It reduces your risk overall.” By planning future conversions, building owners can protect themselves against market fluctuations and ensure that buildings remain valuable and functional even if market demand changes unexpectedly. This flexibility is especially crucial in urban environments where space is limited, and the need to maximise the utility of existing structures is important.

Shifting focus on sustainability

As mentioned above, sustainability has become a central concern in the real estate sector, driven by growing awareness of environmental issues, regulatory requirements, and societal pressures for greener practices. Convertible building designs directly contribute to sustainability by enhancing the circularity of the built environment, allowing buildings to be reused rather than demolished and replaced. Interviewee M.1 highlighted how convertibility contributes to a building's sustainability: "And I think this is one important point for also the circularity. That, you don't have to tear down a building because the use is changing." By designing new office buildings with future adaptability in mind, developers can extend the lifespan of the structure and reduce the environmental impact associated with demolition and new construction. Interviewee C.3 provided an example: "And for example, in the street here there's an office building, it's only 30 years old, and they're going to demolish and build a new building just because the height of the office is not high enough. Because they want to convert it to housing, but they say we cannot convert it because the office is not high enough."

However, the sustainability benefits of convertibility must be carefully balanced against the potential downsides of over-dimensioning, Interviewee C.3 points out. They explained that flexible buildings often require additional materials, which can contradict other sustainability objectives: "flexibility building it contradicts also other sustainability parts. Because when you have the NPG, how much materials you use in your building, when you have like more flexible buildings, part of that is having a higher height to the ceiling, but then you use more materials than you would initially use."

Regulatory Drivers

It was further found that regulations play a crucial role in driving the adoption of sustainable and convertible building designs. Increasingly strict environmental standards, such as the Dutch BENG (Nearly Zero-Energy Buildings) and MPG (Environmental Performance of Buildings) requirements, are pushing developers and investors to consider the long-term adaptability of their buildings. Interviewee C.3 emphasised the importance of considering CO2 emissions and sustainability alongside financial costs: "Yeah but you also don't have to look only at the money. You also need to take in consideration your CO2 advantage when you reuse it." And regulatory frameworks are evolving to incorporate broader environmental impacts. Designing for the future also involves anticipating changes in sustainability standards. Interviewee C.1 noted that "In the future demands for your BENG and MPG are going to be stricter and stricter."

Interviewee C.3 noted that despite the regulatory push towards sustainability, the value of convertibility itself is not always directly quantified or mandated by law, unlike other sustainability measures: "It's difficult because we are steering on an MPG and the energy and things like that. This is also part of it, but it's not quantified."

Green portfolio ambition

Beyond regulatory compliance, some developers and investors are driven by the ambition to create a green portfolio, where sustainability is a core objective rather than a regulatory requirement. Interviewee C.3 reflected on this motivation, stating that investors who prioritise sustainability "want a green portfolio where they are more likely to invest in the beginning than where they are buying and selling." For these investors, convertibility is seen not just as a functional benefit but as a strategic advantage that aligns with their broader goals of sustainability and long-term asset management. The drive to maintain a green portfolio can also lead to a greater willingness to invest in convertible designs, even when the immediate financial benefits are not fully quantifiable.

5.4.3 Chapter summary

The interviews identified both barriers and drivers of the adoption of convertible designs practice.

A key barrier is the mismatch between investors' short-term horizons, especially in office investments, and the long-term benefits of convertibility, which often require a longer time to materialise. This misalignment creates a perceived split incentive, as initial investors assume that they do not benefit from the long-term flexibility, leading them to undervalue these future advantages. The time-value-of-money concept further complicates this, as discounted cash flow (DCF) models diminish the relevance of future benefits, such as a higher exit value, making them less impactful in current investment decisions. High initial costs associated with convertible designs pose another challenge, particularly in an industry characterised by low profit margins, where immediate financial burdens can overshadow potential long-term gains. The specialisation of most investors that focus on either office or residential properties limits their interest in convertible buildings. This is exacerbated by valuation practices that often overlook the benefits of convertibility, discouraging widespread adoption.

Despite these challenges, drivers for adopting convertible designs were also identified. The ability to adapt to shifting market conditions helps reduce investment risk, while the emphasis on sustainability aligns with regulatory requirements and societal pressures. Stricter environmental standards compel developers to consider long-term convertibility, encouraging a more holistic approach to building performance. Additionally, some investors are motivated by the ambition to create a green portfolio, promoting a willingness to invest in convertible designs even when immediate financial benefits are unclear.

6. Findings sensitivity analysis

The following chapter first discusses sensitivity analyses as tool in financial feasibility assessments and then presents the findings of the sensitivity analysis conducted as part of this research.

The following three key parameters that mainly affect the financial feasibility of convertible buildings were analysed:

- The additional initial investment for convertibility
- The conversion costs
- The gross exit yield (GEY)

The aim of the sensitivity analysis was to test and apply the findings from the literature review as well as the interviews and thereby provide further answers to sub-questions four: *How do the costs and benefits of the design for residential conversion affect the DCF model of a new office building? (SQ 4)*

6.1 Sensitivity analysis

Sensitivity analysis is a widely used tool in the financial feasibility assessment of real estate investments that evaluates how different variables impact the outcomes of a financial analysis. In the context of real estate investment, particularly when using a DCF model to determine the financial feasibility of a project, sensitivity analysis helps investors and developers understand how changes in key assumptions affect the projected financial performance (Manganelli, 2015). By doing so, it provides insights into the risks and uncertainties associated with real estate investments (Hermans et al., 2014). Ling and Archer (2018) highlight the necessity of realistic input assumptions for cash flow projections. Since investors' estimates of factors like rental income growth and future vacancies are prone to error, conducting sensitivity analyses using both optimistic and pessimistic assumptions is recommended (Goddard & Marcum, 2012). This approach allows investors to assess the sensitivity of key metrics like Net Present Value (NPV) and Internal Rate of Return (IRR) to variations in input assumptions, aiding in risk assessment and decision-making (Park, 2002).

While the DCF model provides a detailed projection of future financial performance, it is highly sensitive to the assumptions used in the analysis. Small changes in these assumptions can have significant effects on the outcome. For instance, the future rental income, vacancy rates, operating expenses, and discount rate are all critical inputs that can vary based on market conditions, economic factors, and property-specific variables (Goddard & Marcum, 2012; Ling & Archer, 2018).

This is where sensitivity analysis becomes important. Sensitivity analysis systematically alters one or more of these key inputs to assess how changes impact the overall financial outcome, typically focusing on NPV and IRR. By doing so, investors can better understand the degree of risk and uncertainty involved in the project and make informed decisions. Sensitivity analysis is an essential part of managing financial risk (Goddard & Marcum, 2012).

Manganelli (2015) states that identifying the most important sources of danger is the first step in risk control. In a real estate DCF model, several key variables are often subjected to sensitivity analysis. These include:

- Discount rate: The discount rate reflects the time value of money and the risk profile of the investment. Sensitivity analysis can help assess how changes in the discount rate affect the NPV and IRR, indicating how the risk level might impact the financial feasibility of the project.
- Rental income growth: The growth rate of rental income is a key driver of future cash flows. Sensitivity analysis can evaluate how variations in rental growth rates, influenced by market demand, lease terms, and economic conditions, affect the investment's profitability.

- Vacancy rates: Changes in the vacancy rate directly impact the property's income stream. Testing different vacancy rate scenarios helps investors assess how resilient the project is to fluctuations in occupancy levels.
- Operating expenses: Sensitivity analysis helps to determine how increases or decreases in these expenses impact the project's overall financial viability.
- Capital expenditures: Future capital expenditures, such as renovations, upgrades or conversions, can significantly impact cash flows. Sensitivity analysis helps investors understand how variations in capital expenditure estimates affect the project's profitability and long-term financial feasibility.
- Terminal Value: The terminal value is often based on assumptions about future market conditions and capitalisation rates. Sensitivity analysis can show how changes in the assumed terminal value affect the overall financial outcome of the investment.

To conduct a sensitivity analysis, the investor typically adjusts one variable at a time while keeping all others constant to isolate the impact of that specific variable on the investment's financial performance (Björnsdóttir, 2010; Park, 2002). Generally, new values are found for the key variables (optimistic, pessimistic, and base scenarios) (Manganelli, 2015; Park, 2002). For instance, the analyst might adjust the discount rate (e.g., from 5% to 7%) and observe the resulting changes in the NPV or IRR. This process is repeated for each key input, producing a range of potential outcomes for the project.

Generally, even minor changes to the key parameters can have a big impact on the outcomes. It goes without saying that the decision maker must carefully analyse those crucial components of the projection that, if they change even a little, might make the investment less profitable (Manganelli, 2015).

A common way to present the results of a sensitivity analysis is through a sensitivity matrix, which visually demonstrates which variables have the greatest impact on the investment's financial performance. Next, each variable is shown as a distinct line on the same graph. The output's sensitivity to changes in each variable is indicated by the line slopes; the steeper the slope, the more sensitive the result is to changes in a given variable (Park, 2002) . By identifying the most sensitive variables, investors can better understand which assumptions introduce the most uncertainty into the analysis and focus on managing those risks.

There are a number of reasons why investors using a DCF model make use of sensitivity analysis. It helps identify key risk factors by analysing how changes in assumptions impact financial outcomes, enabling better risk management and decision-making. By evaluating different investment scenarios, it offers a broader understanding of potential outcomes (Björnsdóttir, 2010). Sensitivity analysis also improves negotiations by quantifying the effects of variable changes on financial performance and aids in strategic planning through identifying impactful variables.

Manganelli (2015) concludes that while sensitivity analysis is a valuable tool, it does have certain limitations. First, it requires a clear framework that defines the risk factors and their relationship to fundamental values. Additionally, analysing each variable in isolation fails to recognize that uncertainties can influence multiple factors at once. Finally, the theoretical outcomes of the analysis do not account for the likelihood of various events occurring.

In the case of convertible buildings and in the context of this research the sensitivity analysis is used to clarify the effect of the costs and benefits of designing a building for conversion on it's financial feasibility. In other words, to determine how resilient the IRR, and thus the profitability of the investment, is to changes in these parameters. When considering the previous findings of this research, three main variables seem to be perceived as most decisive for the financial feasibility of a convertible office building: the additional initial investment for convertibility, the conversion costs and the gross exit yield (determining the exit value of the investment).

The first key variable, the additional initial investment costs, captures the costs associated with making a building adaptable for future use. These costs can include structural modifications, compliance with new building codes, or enhancing design features to meet residential standards. Including this variable in the sensitivity analysis is essential because it allows to evaluate the trade-off between the upfront costs required for convertibility and the potential long-term benefits of increased flexibility. As the previous chapters of this research have concluded, the rise in initial investment costs is seen as main barrier to the adoption of more convertible buildings. By understanding how changes in this initial investment impact financial viability, investors can better assess whether the expected returns justify the costs.

When the time comes to convert the building to a new, conversion costs will be incurred. These costs may vary depending on market conditions, labour prices, and the extent of modifications required. Sensitivity analysis allows to test different cost scenarios, providing an estimation of how fluctuations in conversion expenses will affect profitability. This is particularly important since the main objective of the inclusion of convertibility in the building's design essentially is to lower future conversion costs.

The gross exit yield is a critical variable, reflecting the return an investor expects to receive when selling the building at the end of the investment period. As the previous chapters have concluded, because convertible buildings are designed to adapt to changing market demands, their future value may be higher than that of standard buildings. Additionally, there was some discussion around the topic of sustainability premiums on the exit value. Analysing different exit yield scenarios helps assess how the building's future adaptability influences its resale value. This variable is especially important for long-term investors, as it determines the ultimate profitability of the project and the attractiveness of the building in the future real estate market.

6.2 DCF model calculation

In the context of this research, the sensitivity analysis is used to apply and thereby test the findings of the previous research phases from the literature review and the interviews conducted. Therefore, the assumptions that serve as input for the designed DCF model are derived from the previous chapters.

The conducted DCF model calculations are divided by the design of the building (standard or convertible) and the considered scenario (no conversion, conversion, demolition and redevelopment). The following combinations are calculated:

- Standard building design: scenario no conversion
- Standard building design: scenario conversion
- Standard building design: scenario demolition and redevelopment
- Convertible building design: scenario no conversion
- Convertible building design: scenario conversion

The DCF model calculations and their complementary input assumptions for each scenario can be found in Appendix C.

Generally, the analysis considers two different investment scenarios and compares these. The first scenario is the construction of a new office building in the form of a standard (non-convertible) design. The second scenario is the new construction of a new office building designed for convertibility. It is assumed that – apart from the design parameters of the convertible building that enable convertibility – both scenarios involve the same building at the same location, with the same usage. The building in question is a medium-sized office building located in Amsterdam. The investment horizon considered is 40 years. The IRR is used as the measure of profitability.

An overview of the assumptions made in the calculations can be found in Table 13. In addition, Table 13 also lists the sources that the assumptions are based upon. All assumptions for the different scenarios are detailed in the DCF model calculation inputs and can be found in Appendix C.

The convertible building is assumed to be designed based on the key design parameters that enable future conversion, as outlined in previous chapters and quantified in Appendix B. Compared to the standard building, the convertible building has a smaller lettable floor area (LFA), amounting to 4,400 m² versus 4,500 m² for the standard building. This reduction in LFA is due to the lower space efficiency associated with convertible buildings, which results in a loss of usable floor space. However, both scenarios assume the same plot size and land costs, as these are unaffected by the building's design. Similarly, the number of parking spaces remains identical for both investment scenarios.

The construction period for both the standard and convertible buildings is set at three years. The initial investment for the standard building, covering construction, land, design, and planning costs, is derived from common benchmark values. In contrast, the initial investment for the convertible building is a variable in the sensitivity analysis and will be further discussed in the subsequent chapter.

Once operational, the rental income for both buildings is assumed to be at the same level. While the possibility of sustainability premiums impacting rent was mentioned in interviews, there is insufficient evidence to confirm whether such premiums actually materialise. The initial vacancy rate for both buildings is set at 15%. However, over the building's lifetime, the standard building is expected to experience a higher vacancy rate compared to the convertible building, as the flexibility of convertibility reduces long-term investment risk.

Although literature suggests that convertible buildings may have lower operational costs, such as for maintenance, repairs, and property management, interviews did not confirm this. Therefore, operational costs are assumed to be similar for both scenarios.

Three potential lifecycle scenarios are considered: the building is not converted and continues in its current use; the building is converted to a different use at a specific point in time; or the building is demolished and reconstructed. If the building is converted, conversion costs and conversion time are expected to be lower for the convertible building than for the standard building. These variables are also included in the sensitivity analysis. Redevelopment, the third scenario, is assumed to have the longest construction period, leading to rent losses during reconstruction.

Regarding financing, the key distinction between the two scenarios is that convertible buildings are expected to secure a lower interest rate. The loan-to-value ratio remains the same for both. Additionally, convertible buildings are presumed to benefit from tax concessions.

Finally, the terminal value is primarily driven by the gross initial yield, which is further examined in the sensitivity analysis of this variable.

Table 13: Overview assumptions DCF model calculation

		Standard design	**Convertible design**	**Explanation**
Building	Building size	4.500 m^2 LFA	4.400 m^2 LFA	
	Plot size	2.000 m^2		
	Number of parking lots	80		(according to building code)

Initial investment	Land costs	3.000.000€		Assumption based on (City of Amsterdam, 2024)
	Initial investment	14.000.000€	See sensitivity analysis	Construction costs and design costs, assumption based on (Bouwkostenkompas, 2024; KeeValue, 2024)
Potential rent income	Rent first use (office – new built)	250€/m² p.a.		CPI indexed, assumption based on (Funda, 2024; Statista)
	Rent second use (housing – new built)	350€/m² p.a.		
	Rent second use (housing – converted)	330€/m² p.a.		
	Rent parking lot	200€/n p.a.		
	Inflation (CPI)	2.0%		(CBS, 2024)
Vacancy rate	Initial vacancy rate	15%		During first two years of operation, (see literature review)
	Friction vacancy rate	Depending on use case (see DCF model)	5,0%	(see literature review)
Operating expenses	Repairs and maintenance	10%		% of gross rent income
	Property management	5%		% of potential gross rent income
Capital expenditures	Conversion costs	50%	See sensitivity analysis	% of initial investment, (see literature review)
	Demolition costs	500.000€	-	CPI indexed, assumption based on (Bouwkostenkompas, 2024; KeeValue, 2024)
	Reconstruction costs	10.000.000€	-	Assumption based on (Bouwkostenkompas, 2024; KeeValue, 2024)
	Conversion time	2 years	1 year	(see literature review)

Financing	Loan-to-value ratio (LTV)	75%		Assumption
	Interest rate	5%	4,9%	Assumption based on (Statista, 2024b)
	Principal payments	1,8%		% of loan amount (amortisation)
Taxation	Annual depreciation	3%		% of the building value, linear depreciation of building value, assumption based on (PwC, 2024a)
	Corporate tax rate	25,8%	25,5%	Tax concessions (see findings interviews), assumption based on (PwC, 2024b)
Exit value	Gross exit yield (GEY)	Depending on use case (see DCF model)	See sensitivity analysis	Based on potential gross income, assumption
Discount rate	Going-in IRR	Depending on use case (see DCF)	Depending on use case (see DCF)	Required rate of return

Figure 15 illustrates the comparison of the profitability of the different investment scenarios, measured by their internal rate of return (IRR). The results show that the lowest IRR is associated with the scenario where a standard office building undergoes conversion. This is followed by the scenario where the standard building is left in its original state, receiving only maintenance and repairs over the 40-year investment horizon.

In contrast, the scenarios involving the convertible building – whether it is eventually converted or not – demonstrate higher IRRs compared to the standard building in both its converted and unconverted states. Under these assumptions, this highlights the financial advantage of designing for future convertibility.

Interestingly, the scenario where the standard building is demolished and redeveloped generates an IRR that is comparable to that of the convertible building in both its converted and unconverted states. However, the highest IRR is observed in the scenario where the convertible building is eventually converted to a different use and the redeveloped standard building. This slightly outperforms the unconverted convertible building.

The results suggest that while conversion and redevelopment can yield similar financial returns, designing for future adaptability through convertibility provides additional long-term flexibility, allowing investors to capitalise on market opportunities without the need for full-scale redevelopment. This makes the convertible building a more resilient investment option, offering financial stability across various scenarios.

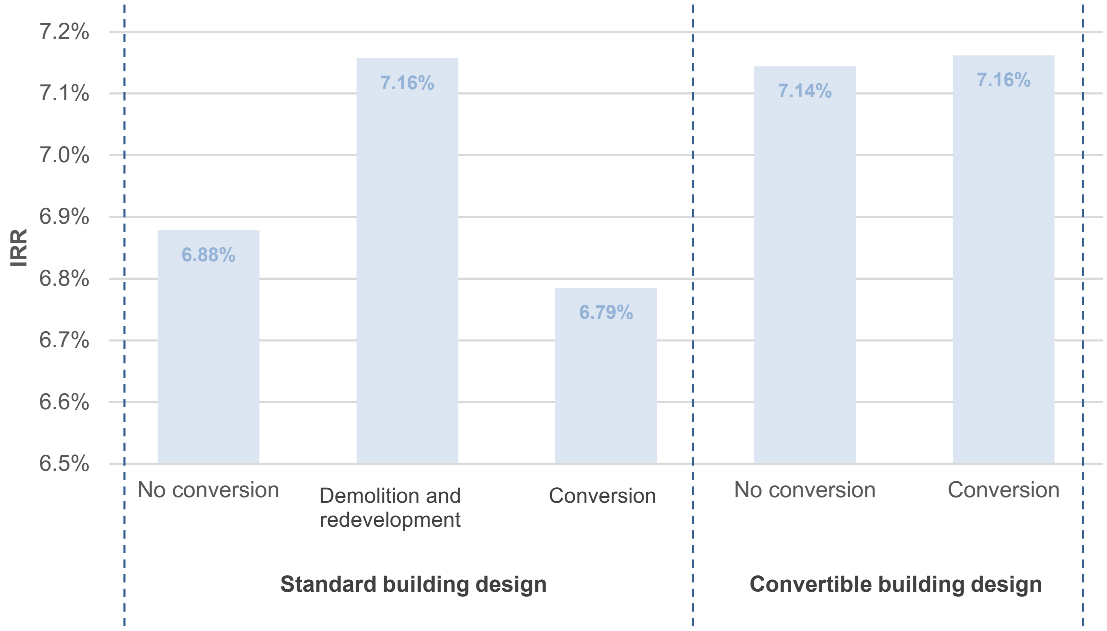

Figure 15: Overview IRR scenarios

6.3 Sensitivity additional initial investment

Figure 16 illustrates the sensitivity analysis of the IRR concerning the additional initial investment required for designing convertible buildings, expressed as a percentage of the initial investment. This refers to the increase in, for example, construction and design costs that arises when a building is designed for future conversion. These costs are part of the initial investment. It compares the IRR for the two design scenarios. All sensitivity analyses are conducted taking into account the scenario of the convertible building that is converted throughout its life and the standard building that is redeveloped over time.

The IRR for convertible buildings decreases as the additional initial investment increases. It starts at approximately 7.8% when no extra investment is made (0%) and gradually declines to about 7.1% when the additional investment reaches 11%. The IRR of convertible buildings exceeds that of standard buildings with additional investments of up to around 8%. However, once the additional investment surpasses this threshold, the IRR for convertible buildings falls below that of standard buildings.

To summarise, the analysis indicates that convertible building designs have higher profitability, as indicated by their IRR, compared to standard designs when the additional initial investment is limited to around 8%. Beyond this point, the financial advantages of convertible designs diminish due to increased costs associated with convertibility. In other words, the initial investment costs could increase up to 108% before reaching the profitability threshold of the standard office building; up to 108% of the original construction costs could be incurred before the convertible scenario becomes less advantageous compared to the standard scenario.

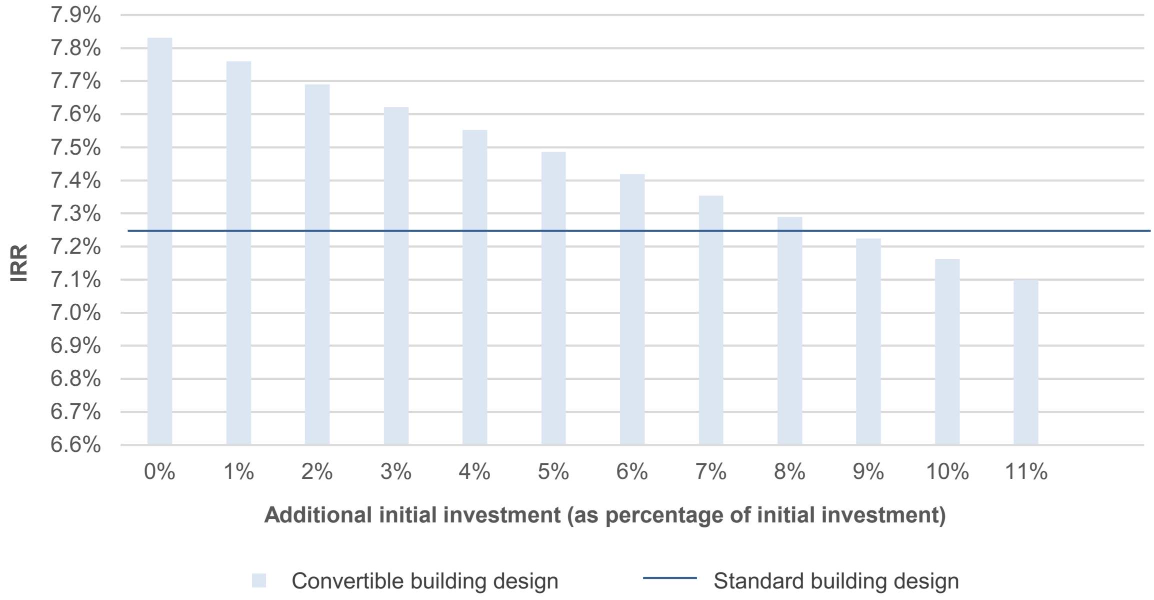

Figure 16: Sensitivity of IRR to additional initial investment for convertibility

6.4 Sensitivity conversion costs

Next, the sensitivity of the profitability of the investment in a convertible building to its conversion costs was analysed. The conversion costs are expressed as a percentage of the initial investment costs.

The analysis, shown in Figure 17, compares the IRR of convertible and standard building designs. The IRR of the convertible building design decreases as conversion costs rise, indicating that while the design offers adaptability, higher conversion costs can significantly reduce profitability. At low conversion costs (around 15%), the convertible design yields a higher IRR than the standard design, but as conversion costs approach 40%, its IRR drops below 7.0%, making it less attractive. The break-even point where the profitability of the convertible building matches that of the standard building occurs at conversion costs of approximately 25%.

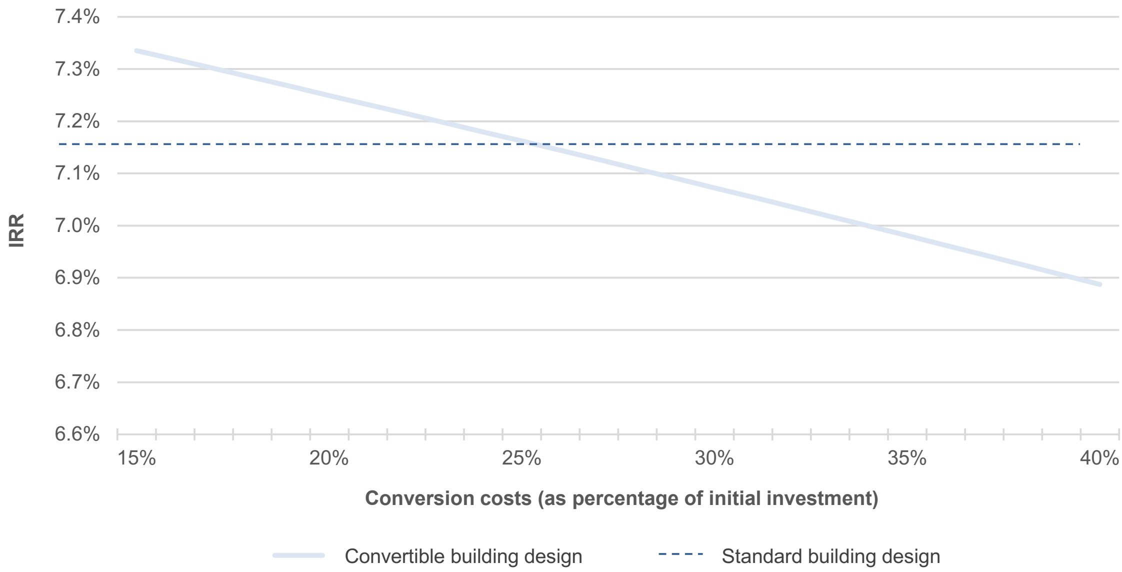

Figure 17: Sensitivity of IRR to conversion cost

6.5 Sensitivity gross exit yield

The third sensitivity analysis was conducted concerning the relationship between gross exit yield (GEY) and the IRR for both convertible and standard building designs. The relationship between the applied GEY and the investment's IRR can be seen in Figure 18.

For the convertible building design, the IRR decreases as the GEY increases. At lower GEY levels (around 6.5%), the IRR is relatively high, above 7.3%. However, as the GEY rises towards 8.5%, the IRR declines to below 7.0%. The key finding from this analysis is that at lower GEY levels (below 7.2%), the convertible design offers higher profitability than the standard design. However, as the GEY increases beyond this point, the convertible building becomes less profitable, with its IRR falling below that of the standard design. This suggests that while a convertible building may be more profitable under favourable market conditions with lower exit yields, its profitability decreases as yields rise. Investors must carefully consider the applied exit yield when assessing the financial feasibility of a convertible building.

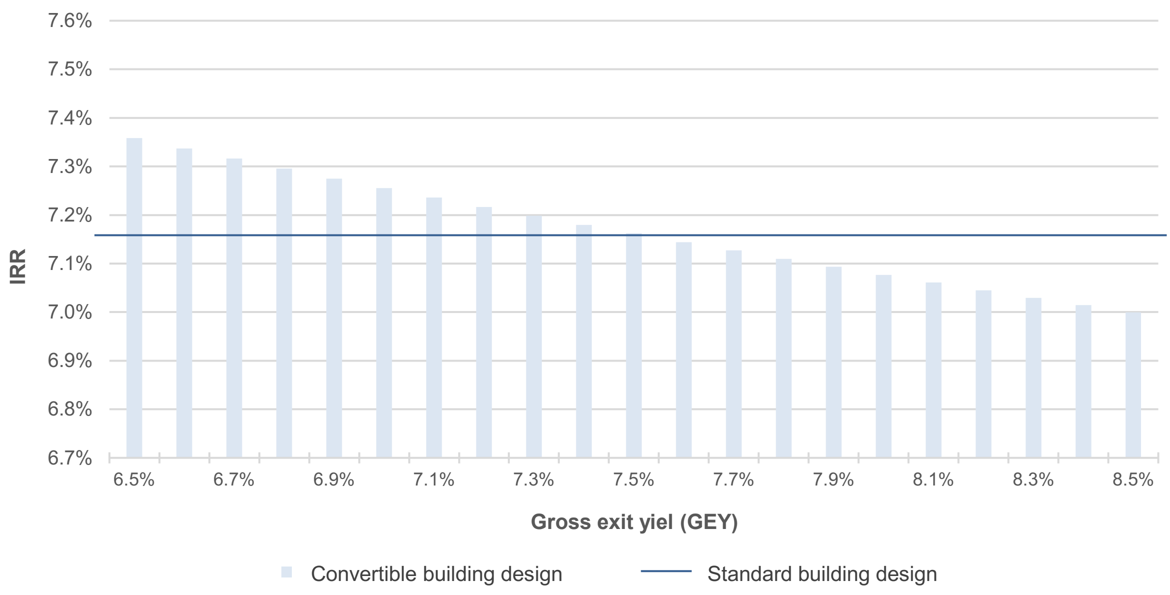

Figure 18: Sensitivity of IRR to gross exit yield (GEY)

Discussion and conclusions

7. Conclusions

In this final chapter of the research, the findings are discussed, a conclusion is formulated, and attention is given to the limitations of the study as well as potential questions for further research.

7.1 Discussion

Regarding the findings, the greatest discrepancy between the perspectives of different stakeholders emerged around the topics of zoning, sustainability practices and the influence of common valuation practices, and the attractiveness of convertibility for the different investor types.

Perspectives on zoning

On the topic of zoning, the opinions of the interviewees varied significantly. Some saw zoning as an opportunity for the adoption of convertible buildings, while others considered it an impossible obstacle that almost makes the entire idea of convertibility unfeasible.

What stood out in these discussions was the stark contrast in perspectives between market participants and the municipal actor. While the market stakeholders described the process of changing zoning plans as highly complex and bureaucratic, the municipal actor viewed the transition toward flexible zoning as relatively straightforward. This demonstrates a considerable divide in perceptions. However, it’s important to note that every municipality and region operates under its own regulations and procedures, making it difficult to generalise these findings across all municipal authorities.

Despite the limitations of drawing conclusions from a single municipal actor, this difference in viewpoint may also present an opportunity. The expressed openness from the municipality’s side toward flexible zoning plans suggests a willingness to collaborate, which could help overcome some of the barriers perceived by the market.

Implications of reduced vacancy rate

One of the key benefits of convertible buildings highlighted in the interviews is the reduction of long-term investment risk, which subsequently leads to a lower vacancy rate in the DCF calculations for the investment. The convertibility of a building enhances the owners' ability to respond flexibly to market changes and shifts in demand, thereby minimising the risk of vacancy.

Although this flexibility does not necessarily guarantee a real lower vacancy rate during the building's operational phase – particularly if demand remains stable – the option to convert offers a safety net that mitigates future risks. This means that even if market conditions do not change significantly, the potential for conversion allows investors to lower their anticipated vacancy rates in their financial projections.

Consequently, incorporating a reduced vacancy rate into DCF calculations can make the investment more favourable.

Realisation of sustainability premiums

When considering the topic of exit values for convertible office buildings, the discussion centred around whether a sustainability premium is truly realised or remains more of a theoretical concept. Some interviewees debated the extent to which higher rental income and exit values can be attributed to sustainability features in a building. While sustainability is increasingly seen as a value driver in real estate, opinions diverged on whether this translates into concrete financial gains, such as higher exit values, or if the impact remains largely speculative and theoretical.

Several cost factors are tied to improved sustainability, including lower financing costs, potential tax concessions, and the added value that a sustainability premium might bring. However, the specific value of convertibility is difficult to quantify in terms of sustainability benefits. Unlike measurable factors like energy consumption, the assessment of long-term adaptability of a building is not as straightforward. This makes it challenging for investors and appraisers to capture the added value of convertibility in financial models.

Ultimately, the question of whether convertibility leads to a measurable increase in exit value remains unanswered. While the potential is there, particularly as the market emphasises sustainability more and more, the difficulty in quantifying the sustainability benefits of convertibility means that its impact on realisable value needs to be viewed with caution.

The discussion of the realisation of sustainability premiums ties back to the question of the sustainability of a convertible building itself, as introduced in the context chapter (Chapter 2.4). In the context of convertibility, durability is understood as an attribute of sustainability. Convertibility, by extending a building's functional lifespan, is viewed as a means of enhancing the building's durability and, consequently, its overall sustainability. However, the sustainability of convertible buildings fundamentally depends on their actual operational lifespan. Without the extension of the building’s lifespan, their potential for enhanced sustainability may not be realised. Therefore, while the notion of a sustainability premium associated with convertible office buildings appears promising, it requires a thorough examination of the actual operational performance of these structures. The interplay between convertibility, sustainability, and exit values is complex, and future research should focus on creating frameworks that can effectively capture and quantify these relationships. Only with such insights can investors and stakeholders make informed decisions about the real value of convertible buildings in the context of sustainability.

Also valuation practices play a critical role in this context. Current valuation practices tend to overlook the potential long-term benefits of convertibility. This creates a significant barrier to recognising the potential exit value of convertible buildings. The difficulty in quantifying the future adaptability of a property, along with the speculative nature of sustainability premiums, means that convertibility's impact on exit value is rarely reflected in traditional appraisals. As a result, even though the market may increasingly value sustainability and flexibility, the absence of convertibility from standard valuation frameworks makes it difficult for investors to fully justify the higher upfront costs associated with designing convertible buildings. Without evolving valuation practices that account for these long-term benefits, the potential exit value of convertible office buildings remains underappreciated and largely theoretical.

Tying this question back to the literature, McAllister (2009) highlights that property valuations, which rely on past transaction data, can sometimes slow down innovation in the property market. If a design feature hasn’t been shown to add value in the past, valuers are unlikely to give it additional worth in current valuations. This creates a cycle where developers avoid using these features because valuers don't recognise their value, and valuers don’t consider them valuable because developers don’t include them (Pinder et al., 2013). Despite this, (McAllister, 2009) stresses that property valuations still play an important role as a substitute for actual market prices (Bourke & Adams, 2020).

Understanding of different investor types

Similarly, the discussion about which type of investor is most likely to invest in convertible office buildings shows different opinions among the interviewees.

Some interviewees emphasised that long-term investors, such as institutional investors and owner-occupiers, are better positioned to benefit from convertible buildings. They pointed out that these investors typically have a longer investment horizon, allowing them to appreciate the future value of convertibility. Interviewee C.4 noted that the belief in the long-term value of adaptivity influences decision-making, suggesting that investors who are committed for the long term may be more inclined to invest in convertible properties. This perspective suggests that long-term investors are more inclined to prioritise the inherent flexibility of convertible properties, viewing them as a strategic asset that can adapt to changing market conditions over time.

In contrast, other interviewees argued that value-add investors could be more likely to invest in convertible office buildings. Interviewee I.2 mentioned that these investors are often more comfortable with risk, viewing redevelopment as an opportunity for higher returns. For instance, value-add investors are typically more open to the uncertainties associated with converting properties, focusing on the potential for increased profitability when reselling the property rather than immediate market conditions.

Connecting this discussion back to the distinction between direct and indirect returns from real estate investments (see Chapter 4.1.1), long-term investors typically prioritise indirect returns, appreciating the flexibility and sustainability of convertible properties. Their investment decisions are based on the belief that these buildings can better withstand market fluctuations, leading to a more stable and reliable income stream over time. In contrast, value-add investors tend to focus on direct returns, viewing redevelopment opportunities as ways to achieve quick profits, even at higher risks. This focus on short-term gains may result in a limited view of the property's overall value. Additionally, the current economic environment can shape investor preferences; in uncertain times, there may be a stronger shift toward indirect returns, as the need for long-term stability becomes more critical.

However, the interviews also revealed a level of scepticism among certain interviewees regarding the marketability of convertible buildings. Interviewee I.3 expressed concerns about the valuation of convertibility within the context of office investments, suggesting that their focus is primarily on acquiring the highest-quality office properties without considering the potential for future conversions. This highlights a possible disconnection between the perceived advantages of convertible buildings and the current market sentiment.

From another perspective, the question arises as to whether these differing investor profiles truly impact the adoption of convertibility. If it is established that convertibility consistently offers more advantages, then the focus may need to shift toward informing and addressing all types of investors about these benefits.

7.1.1 Comparison literature and interviews

The following section compares the findings from the interviews with those from the literature. This comparison allows for an evaluation of the literature against practical perspectives, helping to identify potential differences or overlaps. Additionally, this comparison serves to validate the results obtained.

Design parameters

Although the design parameters that enable or hinder conversion were not direct components of the interview questions, they nonetheless emerged in most discussions. The parameters discussed by the interviewees should not be viewed as a definitive list. It is possible that these factors emerged during the conversations for various reasons, rather than being identified as the most important parameters. This suggests that other relevant factors may not have been mentioned or emphasised during the interviews.

One of the key takeaways from the interviews in relation to the design parameters of convertibility is that they confirm the underlying hypothesis of this research: converting office buildings to residential functions is the most feasible, and for the participants most interesting, functional conversion. A number of interviewees confirmed that the physical characteristics of office buildings are most suitable for residential conversion compared to other alternative functions, and that the market potential for such conversion also exists.

The table below, Table 14, illustrates the comparison between findings from the literature and the interviews conducted. It highlights the frequency with which specific design parameters are mentioned as critical for the convertibility of a building. The table differentiates among the structure, skin, services, and space plan layers of the building.

Upon reviewing this comparison, it becomes evident that the interview findings largely align with those from the literature. Both researchers and interviewees conclude that the most decisive factors for the convertibility of a building are as follows:

- Floor-to-floor height
- Plan depth
- Structural grid
- Surplus load bearing capacity
- Daylight admission
- Surplus of services and shaft capacity

While the literature emphasises the importance of the positioning of cores and entrances, this is not supported by the practical insights of the interviewees. The same applies to raised floors and the location of shafts. Conversely, interviewees identified the structural design of the building and the distribution of services as critical factors, which the literature considers only to a limited extent.

Interestingly, one new factor mentioned in the interviews that was not previously noted in the literature is the importance of being able to add balconies and outdoor space for future residential use.

The characteristics that make a building more adaptable for conversion are often interrelated. For instance, factors such as daylight admission, plan depth, and the positioning of the building's core are closely connected. A shallow plan depth enhances daylight admission, while strategic core placement can optimise natural light throughout the building.

Table 14: Comparison findings literature and interviews design parameters

	Design parameter	**Literature** (out of 12)	**Interviews** (out of 16)
Structure	Expandability	5	2
	Fire resistance structure	4	3
	Fire safety design	4	2
	Floor space size	5	3
	Floor-to-floor height	**9**	**8**
	Insulation	5	4
	Material durability	3	1
	Plan depth	**9**	**7**
	Position cores	**8**	5
	Position entrances	**7**	4
	Possibility of attaching interior walls to structure	3	3
	Separation of structure and infill	6	4
	Structural design	6	**7**
	Structural grid	**8**	**6**

	Surplus load bearing capacity	**7**	**8**
	Balconies and outdoor space	0	2
Skin	Daylight admission	**6**	**5**
	Façade grid	3	3
	Natural ventilation	2	2
	Possibility of attaching interior walls to façade	5	3
	Removable façade	**7**	4
Services	Accessibility of services	5	1
	Distribution of services	5	**5**
	Raised floors	**6**	4
	Shaft location	**6**	4
	Surplus of services and shaft capacity	**7**	**6**
	Suspended ceilings	4	4
Space plan	Adaptable interior walls	2	3
	Dismountable connection detailing interior walls	3	2
	Standardised components	2	1

Effects of convertibility on DCF model

A comparison of the findings from the literature and interviews regarding the costs and benefits, as well as their effect on the DCF model and thus on the financial feasibility of the investment, reveals significant differences. Table 15 below illustrates this comparison, with "Lit." representing literature and "Int." representing interviews.

Several factors mentioned in the interviews were not identified in the literature. These include sustainability premiums that can potentially influence both rental income and the terminal value of the building, potential rent losses due to less efficient space utilisation, potential changes in financing costs, the tax liabilities of the investor, and changes in the discount rate applied in the DCF calculation.

The factor that was not confirmed by the interviews is the reduced maintenance costs, which are identified in the literature as influencing both operating expenses and capital expenditures.

Table 15: Comparison findings literature and interviews costs and benefits of convertibility and effect on DCF determinants

Lit.	Int.	Costs and benefits convertibility	Effect on DCF determinant		Effect on NPV
x	x	• Increased design and planning costs	Initial investment	↑	–
	x	• Increased other professional fees (i.e. zoning)			
x	x	• Increased construction costs			
	x	• Sustainability premium on rent	Potential rent income	↑	+
	x	• Loss of usable floor space	Potential rent income	↓	–
	x	• Reduced space efficiency			
x	x	• Reduced long-term vacancy risk	Vacancy rate	↓	+
x		• Reduced maintenance costs	Operating expenses	↓	+
x		• Reduced maintenance costs	Capital expenditures	↓	+
x	x	• Shorter conversion time	Capital expenditures	↓	(+)
x	x	• Lower conversion construction costs			
	x	• Reduced long-term investment risk	Financing costs	↓	+
	x	• Potential tax concessions	Tax liability	↓	+
x	x	• Reduced long-term investment risk	Terminal value	↑	+
	x	• Sustainability premium on sale			
x	x	• Extended building lifespan	Holding period	↑	0
	x	• Reduced long-term investment risk	Discount rate	↓	+

7.1.2 Process

The research process faced several challenges, primarily due to the limited availability of quantitative data from existing convertible projects. As few such projects have been developed, the research was inherently exploratory, relying on qualitative insights rather than numerical evidence. Although the initial interviews were designed to gather specific information, they ultimately took on a more exploratory character. Their broader scope may have influenced the findings, but this iterative approach proved valuable in identifying key themes and unanticipated topics. These early insights from industry professionals shaped the research direction, enabling the refinement of questions and objectives to better align with current industry needs.

Interestingly, none of the interviewees questioned the use of the discounted cash flow (DCF) model; rather, they supported its application. Only one interviewee suggested that option theory could complement the DCF model in financial calculations. Previous research has critiqued the DCF model for its inability to adequately capture the value of adaptability in buildings (Carmichael & Taheriattar, 2018; Greden, 2005). These studies advocate for a lifecycle perspective in assessing adaptability, suggesting that existing valuation methods may fall short. Despite these theoretical critiques, practical applications of alternative valuation methods remain limited. Given that investors and property owners tend to prefer familiar and established calculation models, it is crucial to find ways to integrate the concept of preconfigured convertibility into the DCF framework. This could involve modifying the model to better account for the unique characteristics and potential benefits of convertible buildings, thereby enhancing its relevance for assessing their financial viability in an evolving market landscape.

7.2 Conclusion

The conclusion aims to give an answer to the main research question: *How does the design of a new office building for future residential conversion affect its financial feasibility?* By summarising and interpreting the findings of this research.

Overall, the design of a new office building for future residential conversion involves balancing immediate costs with potential future benefits.

One of the main challenges of the financial feasibility of convertible buildings is that convertible buildings typically require a higher initial investment. This can include costs for enhanced floor-to-floor height, increased load-bearing capacity, and other features that enable the future conversion of the building. Additionally, there may be increased design costs and professional fees. Further, the design for conversion can also lead to reduced space efficiency, which may decrease the usable floor area of the building and subsequently lower rental income. However, the significantly lower long-term vacancy risks associated with convertible buildings, on the other hand, allow for a reduced vacancy rate in calculations, thereby improving rental income. This reduced risk has further implications that enhance the financial feasibility of investing in convertible buildings. As a result, the lower risk associated with convertible buildings can potentially lead to lower financing costs, as investments with reduced risk profiles can secure financing at more favourable interest rates. Additionally, this lower risk contributes to a reduced discount rate applied in the DCF calculation.

Further, convertible buildings are often recognised for their sustainability benefits, as convertibility extends the useful lifespan of the property. Enhanced sustainability can influence financial feasibility in various ways, potentially yielding sustainability premiums that reward sustainable buildings with higher terminal values and increased rental income. Additionally, improved sustainability may lead to tax concessions, thereby reducing the investor's tax liabilities. However, the realisation of these premiums in practice remains debated. In contrast, it is widely accepted that the costs of conversion are significantly lower when convertibility is integrated into the building's design.

In Figure 19, the effects of the building's design for convertibility on its DCF calculation are additionally illustrated symbolically in a diagram. The elements shown in red represent the changes, while the standard elements of a DCF calculation are shown in grey as a direct comparison.

A critical factor that could generally negatively impact the financial feasibility of convertible buildings is the time value of money effect. While the benefits of convertible buildings are primarily realised in the long term, this effect implies that future expenses and income must be adjusted to present value. The further away a cash flow is in the future, the less it is valued today. However, as previously mentioned, convertible building design on the other hand allows for a reduction in the discount rate applied when adjusting future values to present value, resulting in less depreciation of future cash flows.

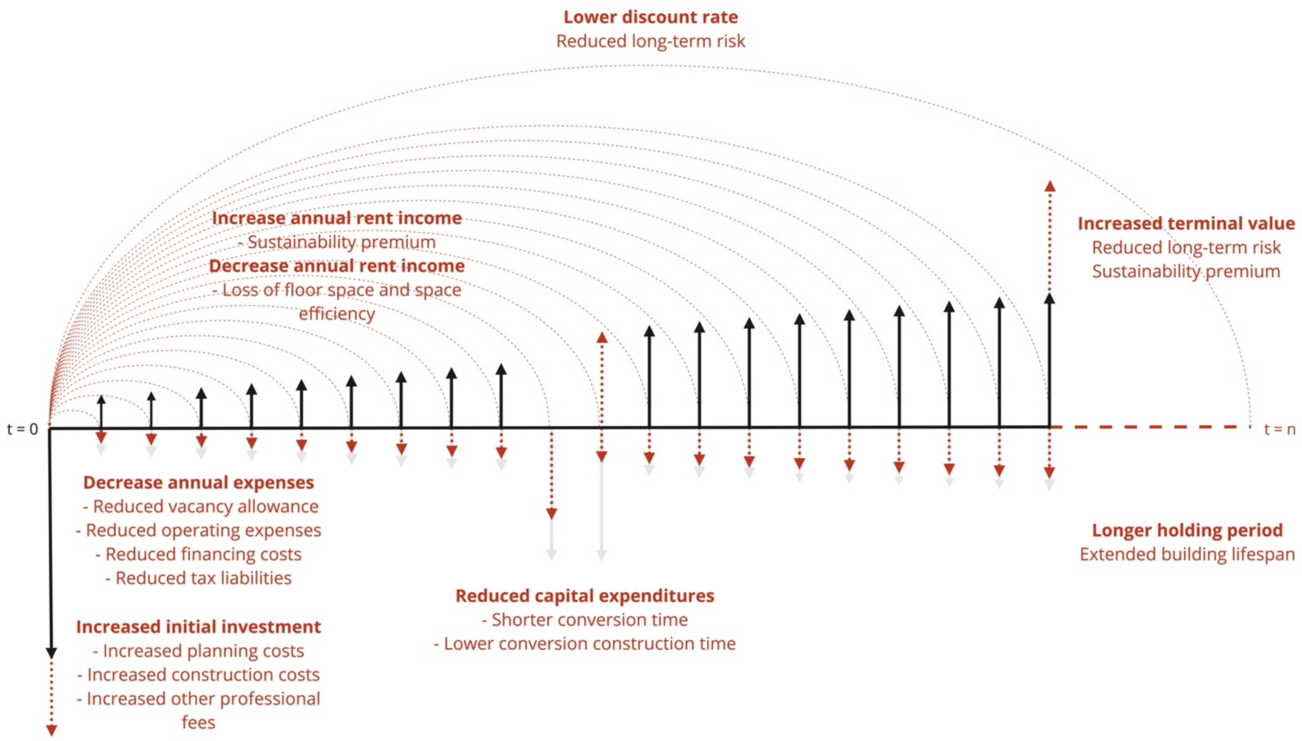

Figure 19: Overview effects of design for convertibility on DCF model

Table 16 provides an overview of the identified costs and benefits of the design of an office building for conversion, their effects on the determinants used in the DCF calculation, and ultimately on the NPV of the investment.

For example, increased design and planning costs that are incurred in convertible building designs, lead to a higher initial investment, which negatively impacts the NPV of the property. The effect of reduced conversion costs is indicated in brackets, as this benefit is only realised if the building is eventually converted. The extended holding period has no direct influence on the NPV. The points illustrated in grey are drawn from the literature and have not been confirmed through the interviews.

Table 16: Final framework effects of convertibility on DCF model

Costs and benefits convertibility	Effect on DCF determinant		Effect on NPV
• Increased design and planning costs	Initial investment	↑	–
• Increased other professional fees (i.e. zoning)			
• Increased construction costs			
• Sustainability premium on rent	Potential rent income	↑	+
• Loss of usable floor space	Potential rent income	↓	–
• Reduced space efficiency			
• Reduced long-term vacancy risk	Vacancy rate	↓	+
• Reduced maintenance costs	Operating expenses	↓	+

• Reduced maintenance costs	Capital expenditures	↓	+
• Shorter conversion time • Lower conversion construction costs	Capital expenditures	↓	(+)
• Reduced long-term investment risk	Financing costs	↓	+
• Potential tax concessions	Tax liability	↓	+
• Reduced long-term investment risk • Sustainability premium on sale	Terminal value	↑	+
• Extended building lifespan	Holding period	↑	0
• Reduced long-term investment risk	Discount rate	↓	+

While it is commonly believed that financial feasibility depends on whether the building is actually converted, the findings of this research suggest otherwise. As illustrated in Table 16, only the realisation of reduced conversion cost itself depends on whether the conversion actually takes place (indicated by the brackets). All other identified factors remain independent of the building's eventual conversion.

The sensitivity analysis of the IRR of a convertible office building compared to that of a standard office building yielded the following insights:

- The IRR of the converted convertible building is the same as that of a redeveloped standard building, demonstrating similar profitability. However, both converted and non-converted convertible buildings outperform standard buildings that are either maintained or converted, emphasising the possible financial advantages of adaptability.
- The initial investment costs of a convertible building could increase up to 108% before reaching the profitability threshold of a standard office building.
- Convertible buildings are more profitable than standard buildings in terms of their internal rate of return (IRR) when conversion costs remain below 25% of the initial investment costs.
- Considering convertible buildings, the applied gross exit yield (GEY) has a significant effect on the profitability of the investment.

It is important to note that all identified factors ultimately depend on the assumptions and interpretations of the respective analyst, as most factors are not definitively measurable and are subjectively determined.

The research findings indicate that the question of financial feasibility for convertible buildings cannot be answered universally; it depends on current market conditions, regional or local factors such as taxation or zoning regulations, and the expectations and profile of the assessing investor. However, it can be generally asserted that convertibility significantly reduces the long-term risk of the property, providing a flexible response to market developments.

7.3 Limitations

There are several limitations of this research that are outlined in the following chapter. These limitations are related to the chosen research design, data collection methods, and the scope of the research, all of which can affect the generalisability and validity of the findings.

First, the scope of this research can be understood to be relatively narrow as the findings are based on interviews with stakeholders in a limited geographic and market context, concentrating only on the Dutch market. As a result, the conclusions may not be fully generalisable to other markets with different regulatory environments, market dynamics, or real estate practices. This is particularly true because, as previously noted, real estate markets are not directly comparable to one another, as they are inherently local in nature.

Another limitation lies in the qualitative nature of the research. Even though the interviews provided in-depth insights into the perceived financial consequences of designing for conversion, qualitative data is inherently subjective and may reflect individual experiences or opinions rather than broader industry trends.

Moreover, the sample size of sixteen interviewees limits the representativeness of the findings. While the study gathered perspectives from a range of stakeholders, including architects, consultants, developers, investors, and municipal actors, the perspectives of other stakeholders in the market were not directly included. Understanding the perspective of for example valuators, who are a significant part of shaping the appraisal process of any real estate investment, would add to a more holistic answer to the research question. Additionally, although the backgrounds and perspectives of the interviewees were intentionally chosen to be as diverse as possible, only a few had direct experience with the construction or investment in convertible buildings. This is primarily due to the fact that there currently only exists a very limited number of convertible buildings on the market. However, several interviewees did have experience with the conversion of standard office buildings.

The interview findings underline the importance of legal preconditions, especially zoning regulations, in either enabling or limiting the design of convertible buildings. However, due to the time and scope limitations of this research, a comprehensive exploration of the broader legal and policy issues affecting the feasibility of convertible projects was not undertaken. Additionally, the study does not address potential tools that could facilitate such projects. On top of that, zoning regulations generally differ between regions and municipalities, which complicates the generalisation of these findings.

Although this research incorporates a sensitivity analysis using a discounted cash flow (DCF) model, the analysis is heavily reliant on assumptions. It does not account for the empirical data about the quantitative effects of design for conversion, primarily, again, as mentioned above, due to the limited number of existing convertible buildings. Case studies or empirical data on the financial performance of such buildings could have enhanced the qualitative findings, offering concrete evidence of the actual costs and benefits associated with these projects.

7.4 Further research

While this study has explored how the design of a new office building for future residential conversion affects its financial feasibility through qualitative interviews with different stakeholders, further research is needed to substantiate and complement these findings. Several main areas require additional research to fully understand the broader implications of the design of buildings for future conversion:

The primary area for future research is the quantitative evaluation of the financial impact of designing buildings for conversion. While this study provides qualitative insights into the perceptions and perspectives of stakeholders on the topic, further research is needed to substantiate these findings with quantitative data. A quantitative study using, for example, case studies could provide a more detailed understanding of the actual costs and benefits, financial returns, and long term value of convertible buildings. By analysing projects that have been designed for conversion, researchers could quantify the financial outcomes, offering more concrete data for investors and developers.

A significant finding from this study was the importance of legal preconditions, especially zoning regulations, in enabling or restricting the design of convertible buildings. Further research could focus on the role of zoning laws and urban planning policies in either facilitating or hindering the implementation of convertible building designs. Comparative studies in different areas or municipalities could provide insight into how flexible zoning regulations impact the feasibility of these projects. Research on policy frameworks that enable or encourage convertibility could also help policymakers.

This study also highlighted the limitations of current building valuation practices in terms of convertibility, which may not fully account for the added value of the design of new office buildings for future residential conversion. Existing valuation methods often don't recognise the potential future flexibility of buildings, which could lead to convertible properties in the market to be "undervalued". Future research could investigate how valuation practices could be adapted to reflect the long term benefits of convertible designs, including their potential to increase resale value. This area remains largely unexplored and could have significant implications for real estate investment strategies.

Another area for future research is the exploration on how different financial incentives could encourage investors to adopt more convertible building designs. Specifically, research could investigate whether convertibility can be integrated into sustainability certifications or green building rating systems, such as BREEAM or LEED. The inclusion of convertibility within these certifications could provide investors with additional financial incentives, as sustainability certifications often correlate with higher property values. By researching the potential for convertibility to be recognised within sustainability assessments, future studies could reveal alternatives for financially incentivising convertible building designs.

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Appendix

8. Appendix

A. Literature review history building convertibility
B. Literature review design parameters (quantitative)
C. DCF model calculations

A. Literature review history building convertibility

The following chapter gives a perspective on the historical development of building convertibility as a concept. Just as the conversion of buildings is not a new phenomenon, building convertibility as a concept is not new either (Schmidt III, 2014). The concept has developed over time. The most prominent strands of thought are illustrated in Figure 20. They can be categorised into spatial considerations and considerations regarding the building configuration.

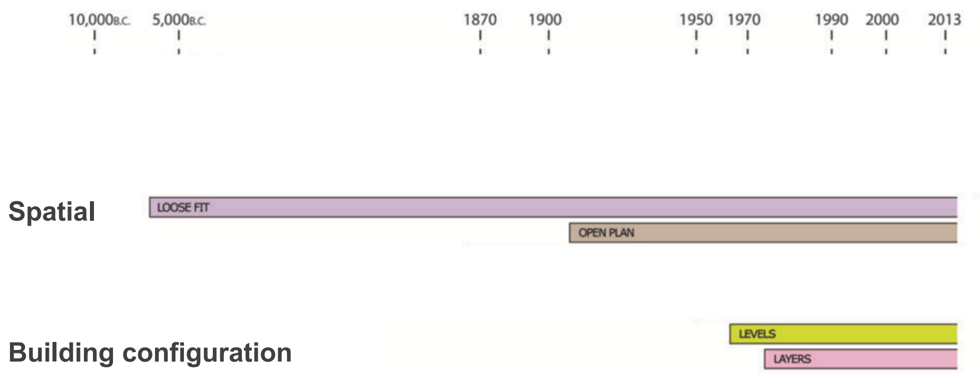

Figure 20: Strands of thought related to adaptability (Schmidt III & Austin, 2016)

Spatial

The first strand of thought is the loose fit approach. It focuses on the spatial configuration of the building, aiming to offer versatile space for various activities rather than imposing specific spatial standards for particular functions (Schmidt III & Austin, 2016). In other words, the idea behind the loose fit approach is to give users more choice by minimising the predetermination of space. The means to allow for adaptations to alternative uses in this approach are spacious dimensions and flexibility. However, the concern that arises are the costs for the additional space that is provided (Schmidt III & Austin, 2016).

The second strand of thought is the open plan approach. The first design to follow this idea is the Maison Domino designed by Le Corbusier in 1914, which is shown in Figure 21. The building is designed as a two-storey structure of concrete slabs, columns and stairs. This means that the structure and any other elements are completely divided and independent of each other, in an attempt to provide the user freedom in designing the space (Schmidt III & Austin, 2016). The division between load-bearing and non-load-bearing elements allows for a flexible positioning of the partitioning walls. The further development of the concept focussed on large spans between the load-bearing elements and flexibly designed interior spaces, with a division not only between load-bearing and non-load-bearing elements but also the building installations.

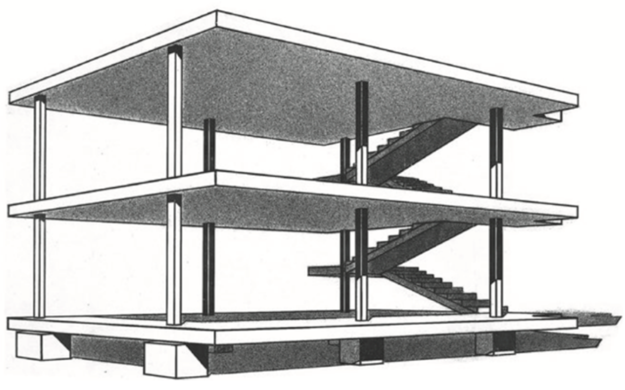

Figure 21: Maison Domino designed by Le Corbusier (Schmidt III & Austin, 2016)

Building configuration

The other category is the consideration of the building configuration in order to achieve adaptability. Spatial freedom plays less of a role here than the classification and separation of building elements. Both forms of this school of thought described here, the levels and the layers concept, categorise building elements in an effort to better understand the impact of change on the building over time (Schmidt III & Austin, 2016).

The idea was first put forward by Habraken in the 1960s as a level concept that divides the building into two levels: the load-bearing support level and the more flexible infill level (Habraken, 1961). As illustrated in Figure 22, while the support level with a long lifespan is determined by the community, the infill level has a shorter lifespan and is determined by the preferences of the residents (Geraedts et al., 2017; Manewa, 2012). In contrast to all other concepts, Habraken does not view convertibility primarily as a tool for prolonging the lifespan of the building, but rather as an opportunity for residents to influence the design (Remøy, 2010). The further development of this approach is the open building concept (not to be confused with the open plan approach).

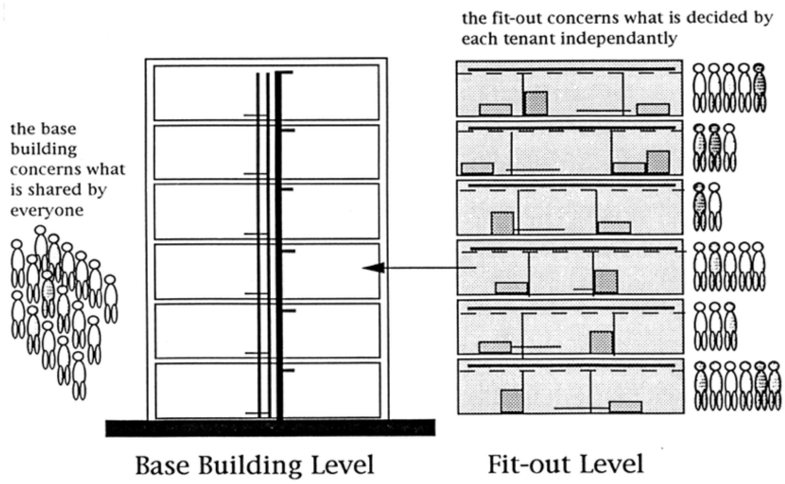

Figure 22: Building support level and infill level (Kendall, 2003)

Probably the most widely recognised approach is the layers approach, which has been significantly influenced by Duffy (1990) and Brand (1994) and is still being further developed in the literature today (Schmidt III, 2014). A fundamental idea in convertibility is to view a building as an assembly of layers as opposed to a single, solid structure (Moffatt & Russell, 2001; Ross, 2017; Slaughter, 2001; Watt et al., 2023).

The concept of viewing a building as a series of layers was initially put forward by Duffy in the 1970s and later developed further. Duffy (1990) focused on the ability of the building to adapt to the evolving needs of its users and thus based the categorisation of the building elements on their temporal dimensions rather than their material components (Watt et al., 2023). Building elements are grouped according to their expected lifecycle duration. Duffy (1990) distinguishes between three distinct building layers in office buildings: the shell, services layer and the scenery, illustrated in Figure 23. The scenery layer includes anything that can be changed without impairing the functionality of the shell or services (duration 5 years or less). The services include technical installations and building systems such as ventilation or elevators (duration over 15 years). The construction and the façade of the building are part of the buildings shell (duration 50 years). By dividing the building into layers, it is possible to adapt parts without affecting the function or technical viability of the building (Remøy, 2010). This concept is known as “shearing layers”. The shearing layers concept is developed further by Brand (1994) as the six “shearing layers of change”.

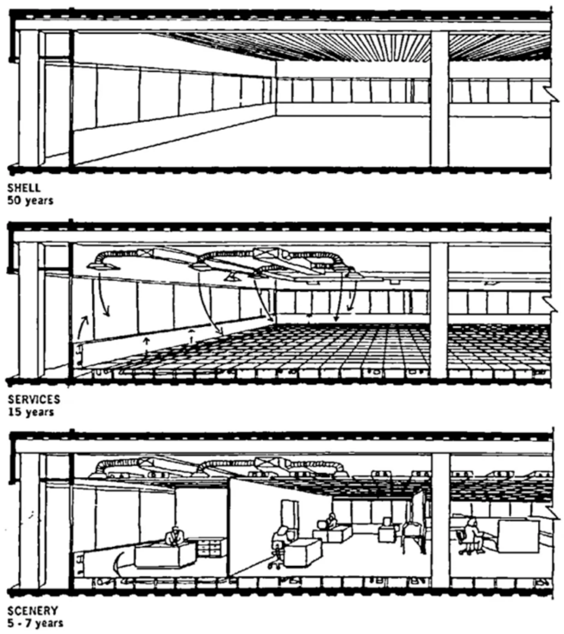

Figure 23: Layers shell, services and scenery (Duffy, 1990)

B. Literature review design parameters (quantitative)

A summary of the approximations to the values of the design parameters for convertible buildings is shown in Table 17 (Dutch Green Building Council, 2024; Geraedts, 2016; Manewa, 2012; Remøy, 2010; Remøy et al., 2011; Remøy & van der Voordt, 2014; Rijksoverheid, 2024a; Schmidt III & Austin, 2016).

Table 17: Overview design parameters for convertibility (quantitative)

Layer	Design parameter	Measure
Structure	Fire resistance structure	• 90 min for building heights < 7m • 120 min for building heights > 7m
	Floor-to-floor height	• 2.6 to 3.6m • 3.5m • At least 2.6m free ceiling height for housing (Dutch building code), inter-floor spacing 3m
	Insulation	• Acoustic insulation between units min. 20dB • Installation of additional acoustic insulation, including a suspended ceiling and a floating floor
	Plan depth	• >10m (5<10m one side lit, 5<20m two side lit) • Average 12-14m
	Position cores	• Not centrally placed • Building has one central and several decentred stairs/elevator cores per wing • Horizontal access directly by a central core in the building, or an external gallery • Elevator car 1.05m x 2.05m • Maximum distance to elevator = 90m
	Position entrances	• Central with access to vertical access • One centralised building entrance and different wings with separate entrances/cores
	Structural design	• Columns and free plans • Not too many columns, no prestressed concrete (makes it difficult to add vertical shafts)
	Structural grid	• 5.4 or 7.2m (>3.6m), large size structural grid • 5.4m grid (older buildings), 7.2m (modern buildings)
	Surplus load bearing capacity	• Floors of office buildings are typically designed to support heavier loads compared to those in residential structures (in offices, 300kg/m^2, in housing 175kg/m^2) • >3kN/m^2

Skin	Daylight admission	• 10% of floor surface • Daylight factor > 1/20
	Façade grid	• 1.8m • small size façade grid
	Natural ventilation	• Windows per planning grid size can be opened (>10%)
	Removable façade	• No cantilevering floors and a curtain wall façade • Connection points for interior walls
Services	Raised floors	• 0.2m
	Shaft location	• Not central • Distributed across the floor • Facility zones/shafts are located at central (building) level and at local (unit) level as well
	Surplus of facilities and shafts	• >10% to 20%
	Suspended ceilings	• -0.2m
Space plan	Dismountable connection detailing interior walls	• Dismountable, modular connection detailing

C. DCF model calculations

The conducted DCF model calculations are divided by the design of the building (standard or convertible) and the considered scenario (no conversion, conversion, demolition and redevelopment). The following combinations are calculated:

- Standard building design (scenario no conversion)
- Standard building design (scenario conversion)
- Standard building design (scenario demolition and redevelopment)
- Convertible building design (scenario no conversion)
- Convertible building design (scenario conversion)

Standard building design (scenario no conversion) – inputs

Property

Building size (standard)	4.500	m2 LFA
Building size (convertible)	4.400	m2 LFA
Number of parking lots	80	

Costs and income

Land costs	€ 3.000.000	paid at t=0, price level t=0
Initial investment	€ 14.000.000	paid at t=0, price level t=0
Additional initial investment	0,0%	of initial investment
Conversion costs	0,0%	of initial investment
Demolition costs	€ 0	price level t=0
Reconstruction costs	€ 2.100.000	price level t=0
Conversion/reconstruction time	0	years
Rent use 1 (offices - new built)	€ 250	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent use 2 (housing - new built)	€ 370	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent use 2 (housing - converted)	€ 350	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent parking lot	€ 200	received at end of the year; CPI indexed; price level t=0
Inflation (CPI)	2,0%	
Initial vacancy rate	15,0%	years 1 to 2
Friction vacancy rate	8,0%	years 3 to end of holding period
Repairs & maintenance	10,0%	of gross rent income, paid at end of the year
Property management	5,0%	of potential gross income, paid at end of the year
Gross exit yield (GEY)	9,0%	based on potential gross income (PGI)

Financing

Loan-to-Value (LTV) ratio	75,0%	
Interest rate on loan	5,0%	annually paid at end of year, assumption: second loan at present interest rate
Principal payments	1,8%	of loan amount, amortisation, first payment at t=1; paid at the end of the year

Tax liabilities

Annual depreciation	3%	of building value, linear depreciation of the building value; starting from t=1
Corporate tax rate	25,8%	

Required rate of return

Going-in IRR	7,0%	

Terminal property value

Potential gross income (PGI) at t=41	€ 2.533.726
Gross Exit Yield (GEY)	9,0%
Terminal value (at end of the holding period)	€ 28.152.506

Return analysis: expected rates of return

Investment return before-tax	6,46%
Equity return before-tax	7,78%
Equity return after-tax	6,88%

Net Present Value

NPV with required return as discount rate	-€ 159.616

Standard building design (scenario no conversion) – model part 1

	Construction			Use 1						
Period	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Vacancy rate %				15,0%	15,0%	8,0%	8,0%	8,0%	8,0%	8,0%
Operating income and expenses										
Potential gross income				1.193.859	1.217.736	1.242.091	1.266.933	1.292.271	1.318.117	1.344.479
Vacancy allowance				-179.079	-182.660	-99.367	-101.355	-103.382	-105.449	-107.558
Gross income				1.014.780	1.035.076	1.142.724	1.165.578	1.188.890	1.212.667	1.236.921
Other income										
Parking				14.432	14.721	16.252	16.577	16.909	17.247	17.592
Effective income				1.029.213	1.049.797	1.158.976	1.182.155	1.205.798	1.229.914	1.254.513
Operating expenses										
Repairs & maintenance				-101.478	-103.508	-114.272	-116.558	-118.889	-121.267	-123.692
Property management				-59.693	-60.887	-62.105	-63.347	-64.614	-65.906	-67.224
Net operating income				868.042	885.402	982.599	1.002.251	1.022.296	1.042.742	1.063.597
Investment										
Land costs	-3.000.000									
Purchase price (initial investment)	-14.000.000									
Demolition costs										
Reconstruction costs										
Conversion costs										
Re-sale price										
Investment	-17.000.000									
Debt (Loan 1 and 2)	12.750.000									
Equity investment	-4.250.000									
Debt services										
Interest payments		-637.500	-626.025	-614.550	-603.075	-591.600	-580.125	-568.650	-557.175	-545.700
Principal payments		-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500
Total debt service		-867.000	-855.525	-844.050	-832.575	-821.100	-809.625	-798.150	-786.675	-775.200
Income and capital gain tax										
Income tax		0	0	42.959	35.520	7.482	-548	-8.681	-16.916	-25.257
Capital gain tax										
Tax liability		0	0	42.959	35.520	7.482	-548	-8.681	-16.916	-25.257
Debt schedule: calculations (non-cash flows)										
Loan balance (Loan 1)	12.750.000	12.520.500	12.291.000	12.061.500	11.832.000	11.602.500	11.373.000	11.143.500	10.914.000	10.684.500
Principal payments (Loan 1)		229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500
Interest payments (Loan 1)		637.500	626.025	614.550	603.075	591.600	580.125	568.650	557.175	545.700
Loan balance (Loan 2)										
Prinicipal payments (Loan 2)										
Interest payments (Loan 2)										
Fiscal balance sheet (non-cash flows)										
Book value			17.000.000	16.580.000	16.160.000	15.740.000	15.320.000	14.900.000	14.480.000	14.060.000
Depreciation				420.000	420.000	420.000	420.000	420.000	420.000	420.000
Taxable income and tax liability calculation (non-cash flows)										
Operating cash flows										
Before-tax operating income				868.042	885.402	982.599	1.002.251	1.022.296	1.042.742	1.063.597
Total depreciation				-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000
Interest payments				-614.550	-603.075	-591.600	-580.125	-568.650	-557.175	-545.700
Taxable operating income				-166.508	-137.673	-29.001	2.126	33.646	65.567	97.897
Tax liability operating income				-42.959	-35.520	-7.482	548	8.681	16.916	25.257
Reversion cash flows										
Sale price property										
Reversion basis property										
Sale price land										
Capital gain										
Tax liability capital gain										
Net cash flows										
Investment cash flow before-tax	-17.000.000	0	0	868.042	885.402	982.599	1.002.251	1.022.296	1.042.742	1.063.597
Net equity cash flow before-tax	-4.250.000	-867.000	-855.525	23.992	52.827	161.499	192.626	224.146	256.067	288.397
Net equity cash flow after-tax	-4.250.000	-867.000	-855.525	66.951	88.347	168.981	192.077	215.465	239.150	263.139
Return analysis										
Net equity cash flow after-tax	-4.250.000	-867.000	-855.525	66.951	88.347	168.981	192.077	215.465	239.150	263.139
Present value net equity cash flow after-tax	-4.250.000	-810.280	-747.249	54.652	67.399	120.481	127.989	134.181	139.188	143.130

	Use 1										
Period	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Vacancy rate %	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%
Operating income and expenses											
Potential gross income	1.371.369	1.398.796	1.426.772	1.455.307	1.484.414	1.514.102	1.544.384	1.575.272	1.606.777	1.638.913	1.671.691
Vacancy allowance	-109.709	-111.904	-114.142	-116.425	-118.753	-121.128	-123.551	-126.022	-128.542	-131.113	-133.735
Gross income	1.261.659	1.286.892	1.312.630	1.338.883	1.365.661	1.392.974	1.420.833	1.449.250	1.478.235	1.507.800	1.537.956
Other income											
Parking	17.944	18.302	18.669	19.042	19.423	19.811	20.207	20.612	21.024	21.444	21.873
Effective income	1.279.603	1.305.195	1.331.299	1.357.925	1.385.083	1.412.785	1.441.041	1.469.861	1.499.259	1.529.244	1.559.829
Operating expenses											
Repairs & maintenance	-126.166	-128.689	-131.263	-133.888	-136.566	-139.297	-142.083	-144.925	-147.823	-150.780	-153.796
Property management	-68.568	-69.940	-71.339	-72.765	-74.221	-75.705	-77.219	-78.764	-80.339	-81.946	-83.585
Net operating income	1.084.868	1.106.566	1.128.697	1.151.271	1.174.297	1.197.782	1.221.738	1.246.173	1.271.096	1.296.518	1.322.449
Investment											
Land costs											
Purchase price (initial investment)											
Demolition costs											
Reconstruction costs											
Conversion costs											
Re-sale price											
Investment											
Debt (Loan 1 and 2)											
Equity investment											
Debt services											
Interest payments	-534.225	-522.750	-511.275	-499.800	-488.325	-476.850	-465.375	-453.900	-442.425	-430.950	-419.475
Principal payments	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500
Total debt service	-763.725	-752.250	-740.775	-729.300	-717.825	-706.350	-694.875	-683.400	-671.925	-660.450	-648.975
Income and capital gain tax											
Income tax	-33.706	-42.264	-50.935	-59.720	-68.621	-77.641	-86.782	-96.046	-105.437	-114.957	-124.607
Capital gain tax											
Tax liability	-33.706	-42.264	-50.935	-59.720	-68.621	-77.641	-86.782	-96.046	-105.437	-114.957	-124.607
Debt schedule: calculations (non-cash flows)											
Loan balance (Loan 1)	10.455.000	10.225.500	9.996.000	9.766.500	9.537.000	9.307.500	9.078.000	8.848.500	8.619.000	8.389.500	8.160.000
Principal payments (Loan 1)	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500
Interest payments (Loan 1)	534.225	522.750	511.275	499.800	488.325	476.850	465.375	453.900	442.425	430.950	419.475
Loan balance (Loan 2)											
Prinicipal payments (Loan 2)											
Interest payments (Loan 2)											
Fiscal balance sheet (non-cash flows)											
Book value	13.640.000	13.220.000	12.800.000	12.380.000	11.960.000	11.540.000	11.120.000	10.700.000	10.280.000	9.860.000	9.020.000
Depreciation	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000
Taxable income and tax liability calculation (non-cash flows)											
Operating cash flows											
Before-tax operating income	1.084.868	1.106.566	1.128.697	1.151.271	1.174.297	1.197.782	1.221.738	1.246.173	1.271.096	1.296.518	1.322.449
Total depreciation	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000
Interest payments	-534.225	-522.750	-511.275	-499.800	-488.325	-476.850	-465.375	-453.900	-442.425	-430.950	-419.475
Taxable operating income	130.643	163.816	197.422	231.471	265.972	300.932	336.363	372.273	408.671	445.568	482.974
Tax liability operating income	33.706	42.264	50.935	59.720	68.621	77.641	86.782	96.046	105.437	114.957	124.607
Reversion cash flows											
Sale price property											
Reversion basis property											
Sale price land											
Capital gain											
Tax liability capital gain											
Net cash flows											
Investment cash flow before-tax	1.084.868	1.106.566	1.128.697	1.151.271	1.174.297	1.197.782	1.221.738	1.246.173	1.271.096	1.296.518	1.322.449
Net equity cash flow before-tax	321.143	354.316	387.922	421.971	456.472	491.432	526.863	562.773	599.171	636.068	673.474
Net equity cash flow after-tax	287.437	312.051	336.987	362.252	387.851	413.792	440.081	466.726	493.734	521.112	548.866
Return analysis											
Net equity cash flow after-tax	287.437	312.051	336.987	362.252	387.851	413.792	440.081	466.726	493.734	521.112	548.866
Present value net equity cash flow after-tax	146.119	148.253	149.626	150.322	150.415	149.977	149.071	147.754	146.078	144.092	141.838

Standard building design (scenario no conversion) – model part 2

				Renovation (in use)								Use 1							
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%	8,0%
1.705.125	1.739.227	1.774.012	1.809.492	1.845.682	1.882.595	1.920.247	1.958.652	1.997.825	2.037.782	2.078.537	2.120.108	2.162.510	2.205.761	2.249.876	2.294.873	2.340.771	2.387.586	2.435.338	2.484.045
-136.410	-139.138	-141.921	-144.759	-147.655	-150.608	-153.620	-156.692	-159.826	-163.023	-166.283	-169.609	-173.001	-176.461	-179.990	-183.590	-187.262	-191.007	-194.827	-198.724
1.568.715	1.600.089	1.632.091	1.664.733	1.698.027	1.731.988	1.766.628	1.801.960	1.837.999	1.874.759	1.912.254	1.950.500	1.989.510	2.029.300	2.069.886	2.111.283	2.153.509	2.196.579	2.240.511	2.285.321
22.311	22.757	23.212	23.676	24.150	24.633	25.125	25.628	26.140	26.663	27.197	27.740	28.295	28.861	29.438	30.027	30.628	31.240	31.865	32.502
1.591.025	1.622.846	1.655.303	1.688.409	1.722.177	1.756.620	1.791.753	1.827.588	1.864.140	1.901.422	1.939.451	1.978.240	2.017.805	2.058.161	2.099.324	2.141.311	2.184.137	2.227.819	2.272.376	2.317.823
-156.871	-160.009	-163.209	-166.473	-169.803	-173.199	-176.663	-180.196	-183.800	-187.476	-191.225	-195.050	-198.951	-202.930	-206.989	-211.128	-215.351	-219.658	-224.051	-228.532
-85.256	-86.961	-88.701	-90.475	-92.284	-94.130	-96.012	-97.933	-99.891	-101.889	-103.927	-106.005	-108.126	-110.288	-112.494	-114.744	-117.039	-119.379	-121.767	-124.202
1.348.898	1.375.876	1.403.393	1.431.461	1.460.090	1.489.292	1.519.078	1.549.459	1.580.448	1.612.057	1.644.299	1.677.185	1.710.728	1.744.943	1.779.842	1.815.439	1.851.747	1.888.782	1.926.558	1.965.089
				0															
				-3.445.273															
				0															
																			34.776.625
				-3.445.273															34.776.625
				2.583.954															-5.456.287
				-861.318															29.320.338
-408.000	-396.525	-385.050	-373.575	-362.100	-479.823	-466.022	-452.222	-438.421	-424.620	-410.820	-397.019	-383.219	-369.418	-355.618	-341.817	-328.017	-314.216	-300.415	-286.615
-229.500	-229.500	-229.500	-229.500	-229.500	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011
-637.500	-626.025	-614.550	-603.075	-591.600	-755.834	-742.033	-728.233	-714.432	-700.632	-686.831	-673.031	-659.230	-645.429	-631.629	-617.828	-604.028	-590.227	-576.427	-562.626
-134.392	-144.312	-154.373	-164.575	-174.921	-152.083	-163.328	-174.727	-186.283	-197.999	-209.878	-221.923	-234.137	-246.525	-259.090	-271.834	-284.763	-297.878	-311.185	-324.686
																			-8.031.889
-134.392	-144.312	-154.373	-164.575	-174.921	-152.083	-163.328	-174.727	-186.283	-197.999	-209.878	-221.923	-234.137	-246.525	-259.090	-271.834	-284.763	-297.878	-311.185	-8.356.575
7.930.500	7.701.000	7.471.500	7.242.000	7.012.500	6.783.000	6.553.500	6.324.000	6.094.500	5.865.000	5.635.500	5.406.000	5.176.500	4.947.000	4.717.500	4.488.000	4.258.500	4.029.000	3.799.500	3.570.000
229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500
408.000	396.525	385.050	373.575	362.100	350.625	339.150	327.675	316.200	304.725	293.250	281.775	270.300	258.825	247.350	235.875	224.400	212.925	201.450	189.975
				2.583.954	2.537.443	2.490.932	2.444.421	2.397.910	2.351.399	2.304.887	2.258.376	2.211.865	2.165.354	2.118.843	2.072.331	2.025.820	1.979.309	1.932.798	1.886.287
					46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511
					129.198	126.872	124.547	122.221	119.895	117.570	115.244	112.919	110.593	108.268	105.942	103.617	101.291	98.965	96.640
8.600.000	8.180.000	7.760.000	7.340.000	9.945.273	9.525.273	9.105.273	8.685.273	8.265.273	7.845.273	7.425.273	7.005.273	6.585.273	6.165.273	5.745.273	5.325.273	4.905.273	4.485.273	4.065.273	3.645.273
420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000
1.348.898	1.375.876	1.403.393	1.431.461	1.460.090	1.489.292	1.519.078	1.549.459	1.580.448	1.612.057	1.644.299	1.677.185	1.710.728	1.744.943	1.779.842	1.815.439	1.851.747	1.888.782	1.926.558	1.965.089
-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000
-408.000	-396.525	-385.050	-373.575	-362.100	-479.823	-466.022	-452.222	-438.421	-424.620	-410.820	-397.019	-383.219	-369.418	-355.618	-341.817	-328.017	-314.216	-300.415	-286.615
520.898	559.351	598.343	637.886	677.990	589.469	633.056	677.238	722.027	767.437	813.479	860.165	907.509	955.525	1.004.224	1.053.621	1.103.731	1.154.566	1.206.142	1.258.474
134.392	144.312	154.373	164.575	174.921	152.083	163.328	174.727	186.283	197.999	209.878	221.923	234.137	246.525	259.090	271.834	284.763	297.878	311.185	324.686
																			28.152.506
																			-3.645.273
																			6.624.119
																			31.131.352
																			8.031.889
1.348.898	1.375.876	1.403.393	1.431.461	-1.985.182	1.489.292	1.519.078	1.549.459	1.580.448	1.612.057	1.644.299	1.677.185	1.710.728	1.744.943	1.779.842	1.815.439	1.851.747	1.888.782	1.926.558	36.741.714
711.398	749.851	788.843	828.386	7.172	733.458	777.044	821.227	866.016	911.426	957.468	1.004.154	1.051.498	1.099.513	1.148.213	1.197.610	1.247.720	1.298.555	1.350.131	30.722.801
577.006	605.538	634.471	663.811	-167.749	581.375	613.716	646.499	679.733	713.427	747.590	782.231	817.361	852.988	889.123	925.776	962.957	1.000.677	1.038.947	22.366.226
577.006	605.538	634.471	663.811	-167.749	581.375	613.716	646.499	679.733	713.427	747.590	782.231	817.361	852.988	889.123	925.776	962.957	1.000.677	1.038.947	22.366.226
139.355	136.678	133.840	130.868	-30.908	100.110	98.766	97.235	95.545	93.721	91.784	89.754	87.649	85.486	83.278	81.038	78.778	76.509	74.238	1.493.625
																		NPV	-159.616

Standard building design (scenario conversion) – inputs

Property

Building size (standard)	4.500	m2 LFA
Building size (convertible)	4.400	m2 LFA
Number of parking lots	80	

Costs and income

Land costs	€ 3.000.000	paid at t=0, price level t=0
Initial investment	€ 14.000.000	paid at t=0, price level t=0
Additional initial investment	0,0%	of initial investment
Conversion costs	50,0%	of initial investment
Demolition costs	€ 0	price level t=0
Reconstruction costs	€ 0	price level t=0
Conversion/reconstruction time	2	years
Rent use 1 (offices - new built)	€ 250	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent use 2 (housing - new built)	€ 370	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent use 2 (housing - converted)	€ 350	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent parking lot	€ 200	received at end of the year; CPI indexed; price level t=0
Inflation (CPI)	2,0%	
Initial vacancy rate	15,0%	years 1 to 2
Friction vacancy rate	5,0%	years 3 to end of holding period
Repairs & maintenance	10,0%	of gross rent income, paid at end of the year
Property management	5,0%	of potential gross income, paid at end of the year
Gross exit yield (GEY)	9,0%	based on potential gross income (PGI)

Financing

Loan-to-Value (LTV) ratio	75,0%	
Interest rate on loan	5,0%	annually paid at end of year, assumption: second loan at present interest rate
Principal payments	1,8%	of loan amount, amortisation, first payment at t=1; paid at the end of the year

Tax liabilities

Annual depreciation	3%	of building value, linear depreciation of the building value; starting from t=1
Corporate tax rate	25,8%	

Required rate of return

Going-in IRR	7,0%	

Terminal property value

Potential gross income (PGI) at t=41	€ 3.547.216
Gross Exit Yield (GEY)	9,0%
Terminal value (at end of the holding period)	€ 39.413.508

Return analysis: expected rates of return

Investment return before-tax	6,55%
Equity return before-tax	7,98%
Equity return after-tax	6,79%

Net Present Value

NPV with required return as discount rate	-€ 285.000

Standard building design (scenario conversion) – model part 1

	Construction			Use 1																	
Period	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Vacancy rate %				15,0%	15,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%
Operating income and expenses																					
Potential gross income				1.193.859	1.217.736	1.242.091	1.266.933	1.292.271	1.318.117	1.344.479	1.371.369	1.398.796	1.426.772	1.455.307	1.484.414	1.514.102	1.544.384	1.575.272	1.606.777	1.638.913	1.671.691
Vacancy allowance				-179.079	-182.660	-62.105	-63.347	-64.614	-65.906	-67.224	-68.568	-69.940	-71.339	-72.765	-74.221	-75.705	-77.219	-78.764	-80.339	-81.946	-83.585
Gross income				1.014.780	1.035.076	1.179.986	1.203.586	1.227.658	1.252.211	1.277.255	1.302.800	1.328.856	1.355.433	1.382.542	1.410.193	1.438.397	1.467.165	1.496.508	1.526.438	1.556.967	1.588.106
Other income																					
Parking				14.432	14.721	16.782	17.118	17.460	17.809	18.165	18.529	18.899	19.277	19.663	20.056	20.457	20.866	21.284	21.709	22.144	22.586
Effective income				1.029.213	1.049.797	1.196.768	1.220.704	1.245.118	1.270.020	1.295.421	1.321.329	1.347.756	1.374.711	1.402.205	1.430.249	1.458.854	1.488.031	1.517.792	1.548.148	1.579.110	1.610.693
Operating expenses																					
Repairs & maintenance				-101.478	-103.508	-117.999	-120.359	-122.766	-125.221	-127.726	-130.280	-132.886	-135.543	-138.254	-141.019	-143.840	-146.716	-149.651	-152.644	-155.697	-158.811
Property management				-59.693	-60.887	-62.105	-63.347	-64.614	-65.906	-67.224	-68.568	-69.940	-71.339	-72.765	-74.221	-75.705	-77.219	-78.764	-80.339	-81.946	-83.585
Net operating income				868.042	885.402	1.016.665	1.036.999	1.057.738	1.078.893	1.100.471	1.122.481	1.144.930	1.167.829	1.191.185	1.215.009	1.239.309	1.264.095	1.289.377	1.315.165	1.341.468	1.368.298
Investment																					
Land costs	-3.000.000																				
Purchase price (initial investment)	-14.000.000																				
Demolition costs																					
Reconstruction costs																					
Conversion costs																					
Re-sale price																					
Investment	-17.000.000																				
Debt (Loan 1 and 2)	12.750.000																				
Equity investment	-4.250.000																				
Debt services																					
Interest payments		-637.500	-626.025	-614.550	-603.075	-591.600	-580.125	-568.650	-557.175	-545.700	-534.225	-522.750	-511.275	-499.800	-488.325	-476.850	-465.375	-453.900	-442.425	-430.950	-419.475
Principal payments		-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500
Total debt service		-867.000	-855.525	-844.050	-832.575	-821.100	-809.625	-798.150	-786.675	-775.200	-763.725	-752.250	-740.775	-729.300	-717.825	-706.350	-694.875	-683.400	-671.925	-660.450	-648.975
Income and capital gain tax																					
Income tax		0	0	42.959	35.520	-1.307	-9.513	-17.825	-26.243	-34.771	-43.410	-52.162	-61.031	-70.017	-79.124	-88.354	-97.710	-107.193	-116.807	-126.554	-136.436
Capital gain tax																					
Tax liability		0	0	42.959	35.520	-1.307	-9.513	-17.825	-26.243	-34.771	-43.410	-52.162	-61.031	-70.017	-79.124	-88.354	-97.710	-107.193	-116.807	-126.554	-136.436
Debt schedule: calculations (non-cash flows)																					
Loan balance (Loan 1)	12.750.000	12.520.500	12.291.000	12.061.500	11.832.000	11.602.500	11.373.000	11.143.500	10.914.000	10.684.500	10.455.000	10.225.500	9.996.000	9.766.500	9.537.000	9.307.500	9.078.000	8.848.500	8.619.000	8.389.500	8.160.000
Principal payments (Loan 1)		229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500
Interest payments (Loan 1)		637.500	626.025	614.550	603.075	591.600	580.125	568.650	557.175	545.700	534.225	522.750	511.275	499.800	488.325	476.850	465.375	453.900	442.425	430.950	419.475
Loan balance (Loan 2)																					
Prinicipal payments (Loan 2)																					
Interest payments (Loan 2)																					
Fiscal balance sheet (non-cash flows)																					
Book value			17.000.000	16.580.000	16.160.000	15.740.000	15.320.000	14.900.000	14.480.000	14.060.000	13.640.000	13.220.000	12.800.000	12.380.000	11.960.000	11.540.000	11.120.000	10.700.000	10.280.000	9.860.000	9.020.000
Depreciation				420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000
Taxable income and tax liability calculation (non-cash flows)																					
Operating cash flows																					
Before-tax operating income				868.042	885.402	1.016.665	1.036.999	1.057.738	1.078.893	1.100.471	1.122.481	1.144.930	1.167.829	1.191.185	1.215.009	1.239.309	1.264.095	1.289.377	1.315.165	1.341.468	1.368.298
Total depreciation				-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000
Interest payments				-614.550	-603.075	-591.600	-580.125	-568.650	-557.175	-545.700	-534.225	-522.750	-511.275	-499.800	-488.325	-476.850	-465.375	-453.900	-442.425	-430.950	-419.475
Taxable operating income				-166.508	-137.673	5.065	36.874	69.088	101.718	134.771	168.256	202.180	236.554	271.385	306.684	342.459	378.720	415.477	452.740	490.518	528.823
Tax liability operating income				-42.959	-35.520	1.307	9.513	17.825	26.243	34.771	43.410	52.162	61.031	70.017	79.124	88.354	97.710	107.193	116.807	126.554	136.436
Reversion cash flows																					
Sale price property																					
Reversion basis property																					
Sale price land																					
Capital gain																					
Tax liability capital gain																					
Net cash flows																					
Investment cash flow before-tax	-17.000.000	0	0	868.042	885.402	1.016.665	1.036.999	1.057.738	1.078.893	1.100.471	1.122.481	1.144.930	1.167.829	1.191.185	1.215.009	1.239.309	1.264.095	1.289.377	1.315.165	1.341.468	1.368.298
Net equity cash flow before-tax	-4.250.000	-867.000	-855.525	23.992	52.827	195.565	227.374	259.588	292.218	325.271	358.756	392.680	427.054	461.885	497.184	532.959	569.220	605.977	643.240	681.018	719.323
Net equity cash flow after-tax	-4.250.000	-867.000	-855.525	66.951	88.347	194.258	217.860	241.764	265.975	290.500	315.346	340.518	366.023	391.868	418.060	444.605	471.511	498.784	526.433	554.464	582.886
Return analysis																					
Net equity cash flow after-tax	-4.250.000	-867.000	-855.525	66.951	88.347	194.258	217.860	241.764	265.975	290.500	315.346	340.518	366.023	391.868	418.060	444.605	471.511	498.784	526.433	554.464	582.886
Present value net equity cash flow after-tax	-4.250.000	-810.280	-747.249	54.652	67.399	138.504	145.169	150.558	154.800	158.013	160.306	161.777	162.519	162.611	162.131	161.145	159.717	157.902	155.753	153.314	150.629

Standard building design (scenario conversion) – model part 2

				Conversion		Use 2													
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
5,0%	5,0%	5,0%	5,0%	100,0%	100,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%
1.705.125	1.739.227	1.774.012	1.809.492	0	0	2.688.346	2.742.113	2.796.955	2.852.894	2.909.952	2.968.151	3.027.514	3.088.065	3.149.826	3.212.823	3.277.079	3.342.621	3.409.473	3.477.662
-85.256	-86.961	-88.701	-90.475	0	0	-134.417	-137.106	-139.848	-142.645	-145.498	-148.408	-151.376	-154.403	-157.491	-160.641	-163.854	-167.131	-170.474	-173.883
1.619.868	1.652.266	1.685.311	1.719.017	0	0	2.553.929	2.605.007	2.657.108	2.710.250	2.764.455	2.819.744	2.876.139	2.933.662	2.992.335	3.052.181	3.113.225	3.175.490	3.238.999	3.303.779
23.038	23.499	23.969	24.448	0	0	25.945	26.464	26.993	27.533	28.083	28.645	29.218	29.802	30.398	31.006	31.626	32.259	32.904	33.562
1.642.907	1.675.765	1.709.280	1.743.466	0	0	2.579.874	2.631.471	2.684.100	2.737.782	2.792.538	2.848.389	2.905.357	2.963.464	3.022.733	3.083.188	3.144.851	3.207.749	3.271.903	3.337.342
-161.987	-165.227	-168.531	-171.902	0	0	-255.393	-260.501	-265.711	-271.025	-276.445	-281.974	-287.614	-293.366	-299.233	-305.218	-311.323	-317.549	-323.900	-330.378
-85.256	-86.961	-88.701	-90.475	0	0	-134.417	-137.106	-139.848	-142.645	-145.498	-148.408	-151.376	-154.403	-157.491	-160.641	-163.854	-167.131	-170.474	-173.883
1.395.663	1.423.577	1.452.048	1.481.089	0	0	2.190.063	2.233.865	2.278.542	2.324.113	2.370.595	2.418.007	2.466.367	2.515.694	2.566.008	2.617.328	2.669.675	2.723.069	2.777.530	2.833.080
				0															
				0															
				-11.484.242															
																			46.037.627
				-11.484.242															46.037.627
				8.613.181															-9.857.622
				-2.871.060															36.180.005
-408.000	-396.525	-385.050	-373.575	-362.100	-781.284	-762.057	-742.830	-723.603	-704.377	-685.150	-665.923	-646.696	-627.469	-608.242	-589.015	-569.789	-550.562	-531.335	-512.108
-229.500	-229.500	-229.500	-229.500	-229.500	-384.537	-384.537	-384.537	-384.537	-384.537	-384.537	-384.537	-384.537	-384.537	-384.537	-384.537	-384.537	-384.537	-384.537	-384.537
-637.500	-626.025	-614.550	-603.075	-591.600	-1.165.821	-1.146.594	-1.127.368	-1.108.141	-1.088.914	-1.069.687	-1.050.460	-1.031.233	-1.012.006	-992.780	-973.553	-954.326	-935.099	-915.872	-896.645
-146.457	-156.619	-166.926	-177.379	0	0	-260.066	-276.327	-292.814	-309.532	-326.485	-343.678	-361.115	-378.802	-396.744	-414.945	-541.771	-560.507	-579.518	-598.811
																			-11.877.708
-146.457	-156.619	-166.926	-177.379	0	0	-260.066	-276.327	-292.814	-309.532	-326.485	-343.678	-361.115	-378.802	-396.744	-414.945	-541.771	-560.507	-579.518	-12.476.519
7.930.500	7.701.000	7.471.500	7.242.000	7.012.500	6.783.000	6.553.500	6.324.000	6.094.500	5.865.000	5.635.500	5.406.000	5.176.500	4.947.000	4.717.500	4.488.000	4.258.500	4.029.000	3.799.500	3.570.000
229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500
408.000	396.525	385.050	373.575	362.100	350.625	339.150	327.675	316.200	304.725	293.250	281.775	270.300	258.825	247.350	235.875	224.400	212.925	201.450	189.975
				8.613.181	8.458.144	8.303.107	8.148.070	7.993.032	7.837.995	7.682.958	7.527.921	7.372.883	7.217.846	7.062.809	6.907.772	6.752.734	6.597.697	6.442.660	6.287.622
					155.037	155.037	155.037	155.037	155.037	155.037	155.037	155.037	155.037	155.037	155.037	155.037	155.037	155.037	155.037
					430.659	422.907	415.155	407.403	399.652	391.900	384.148	376.396	368.644	360.892	353.140	345.389	337.637	329.885	322.133
8.600.000	8.180.000	7.760.000	7.340.000	17.984.242	17.564.242	17.144.242	16.724.242	16.304.242	15.884.242	15.464.242	15.044.242	14.624.242	14.204.242	13.784.242	13.364.242	0	0	0	0
420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	0	0	0	0
1.395.663	1.423.577	1.452.048	1.481.089	0	0	2.190.063	2.233.865	2.278.542	2.324.113	2.370.595	2.418.007	2.466.367	2.515.694	2.566.008	2.617.328	2.669.675	2.723.069	2.777.530	2.833.080
-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	0	0	0	0
-408.000	-396.525	-385.050	-373.575	-362.100	-781.284	-762.057	-742.830	-723.603	-704.377	-685.150	-665.923	-646.696	-627.469	-608.242	-589.015	-569.789	-550.562	-531.335	-512.108
567.663	607.052	646.998	687.514	-782.100	-1.201.284	1.008.006	1.071.034	1.134.938	1.199.736	1.265.445	1.332.084	1.399.671	1.468.225	1.537.766	1.608.313	2.099.886	2.172.507	2.246.195	2.320.973
146.457	156.619	166.926	177.379	0	0	260.066	276.327	292.814	309.532	326.485	343.678	361.115	378.802	396.744	414.945	541.771	560.507	579.518	598.811
																			39.413.508
																			0
																			6.624.119
																			46.037.627
																			11.877.708
1.395.663	1.423.577	1.452.048	1.481.089	-11.484.242	0	2.190.063	2.233.865	2.278.542	2.324.113	2.370.595	2.418.007	2.466.367	2.515.694	2.566.008	2.617.328	2.669.675	2.723.069	2.777.530	48.870.707
758.163	797.552	837.498	878.014	-3.462.660	-1.165.821	1.043.469	1.106.497	1.170.401	1.235.199	1.300.908	1.367.547	1.435.134	1.503.688	1.573.229	1.643.776	1.715.349	1.787.970	1.861.658	38.116.440
611.706	640.932	670.573	700.636	-3.462.660	-1.165.821	783.403	830.170	877.587	925.667	974.423	1.023.869	1.074.019	1.124.886	1.176.485	1.228.831	1.173.578	1.227.463	1.282.139	25.639.921
611.706	640.932	670.573	700.636	-3.462.660	-1.165.821	783.403	830.170	877.587	925.667	974.423	1.023.869	1.074.019	1.124.886	1.176.485	1.228.831	1.173.578	1.227.463	1.282.139	25.639.921
147.735	144.667	141.455	138.128	-637.992	-200.749	126.073	124.859	123.356	121.602	119.633	117.480	115.172	112.735	110.193	107.566	96.009	93.848	91.615	1.712.244
																		NPV	-285.000

Standard building design (scenario demolition and redevelopment) – inputs

Property

Building size (standard)	4.500	m2 LFA
Building size (convertible)	4.400	m2 LFA
Number of parking lots	80	

Costs and income

Land costs	€ 3.000.000	paid at t=0, price level t=0
Initial investment	€ 14.000.000	paid at t=0, price level t=0
Additional initial investment	0,0%	of initial investment
Conversion costs	0,0%	of initial investment
Demolition costs	€ 500.000	price level t=0
Reconstruction costs	€ 10.000.000	price level t=0
Conversion/reconstruction time	3	years
Rent use 1 (offices - new built)	€ 250	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent use 2 (housing - new built)	€ 370	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent use 2 (housing - converted)	€ 350	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent parking lot	€ 200	received at end of the year; CPI indexed; price level t=0
Inflation (CPI)	2,0%	
Initial vacancy rate	15,0%	years 1 to 2
Friction vacancy rate	5,0%	years 3 to end of holding period
Repairs & maintenance	7,5%	of gross rent income, paid at end of the year
Property management	5,0%	of potential gross income, paid at end of the year
Gross exit yield (GEY)	6,5%	based on potential gross income (PGI)

Financing

Loan-to-Value (LTV) ratio	75,0%	
Interest rate on loan	5,0%	annually paid at end of year, assumption: second loan at present interest rate
Principal payments	1,8%	of loan amount, amortisation, first payment at t=1; paid at the end of the year

Tax liabilities

Annual depreciation	3%	of building value, linear depreciation of the building value; starting from t=1
Corporate tax rate	25,8%	

Required rate of return

Going-in IRR	7,0%	

Terminal property value

Potential gross income (PGI) at t=41	€ 3.749.914
Gross Exit Yield (GEY)	6,5%
Terminal value (at end of the holding period)	€ 57.690.981

Return analysis: expected rates of return

Investment return before-tax	6,70%
Equity return before-tax	8,24%
Equity return after-tax	7,16%

Net Present Value

NPV with required return as discount rate	€ 230.682

Standard building design (scenario demolition and redevelopment) – model part 1

	Construction			Use 1							
Period	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Vacancy rate %				15,0%	15,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%
Operating income and expenses											
Potential gross income				1.193.859	1.217.736	1.242.091	1.266.933	1.292.271	1.318.117	1.344.479	1.371.369
Vacancy allowance				-179.079	-182.660	-62.105	-63.347	-64.614	-65.906	-67.224	-68.568
Gross income				1.014.780	1.035.076	1.179.986	1.203.586	1.227.658	1.252.211	1.277.255	1.302.800
Other income											
Parking				14.432	14.721	16.782	17.118	17.460	17.809	18.165	18.529
Effective income				1.029.213	1.049.797	1.196.768	1.220.704	1.245.118	1.270.020	1.295.421	1.321.329
Operating expenses											
Repairs & maintenance				-76.109	-77.631	-88.499	-90.269	-92.074	-93.916	-95.794	-97.710
Property management				-59.693	-60.887	-62.105	-63.347	-64.614	-65.906	-67.224	-68.568
Net operating income				893.411	911.279	1.046.165	1.067.088	1.088.430	1.110.199	1.132.402	1.155.051
Investment											
Land costs	-3.000.000										
Purchase price (initial investment)	-14.000.000										
Demolition costs											
Reconstruction costs											
Conversion costs											
Re-sale price											
Investment	-17.000.000										
Debt (Loan 1 and 2)	12.750.000										
Equity investment	-4.250.000										
Debt services											
Interest payments		-637.500	-626.025	-614.550	-603.075	-591.600	-580.125	-568.650	-557.175	-545.700	-534.225
Principal payments		-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500
Total debt service		-867.000	-855.525	-844.050	-832.575	-821.100	-809.625	-798.150	-786.675	-775.200	-763.725
Income and capital gain tax											
Income tax		0	0	36.414	28.843	-8.918	-17.276	-25.743	-34.320	-43.009	-51.813
Capital gain tax											
Tax liability		0	0	36.414	28.843	-8.918	-17.276	-25.743	-34.320	-43.009	-51.813
Debt schedule: calculations (non-cash flows)											
Loan balance (Loan 1)	12.750.000	12.520.500	12.291.000	12.061.500	11.832.000	11.602.500	11.373.000	11.143.500	10.914.000	10.684.500	10.455.000
Principal payments (Loan 1)		229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500
Interest payments (Loan 1)		637.500	626.025	614.550	603.075	591.600	580.125	568.650	557.175	545.700	534.225
Loan balance (Loan 2)											
Prinicipal payments (Loan 2)											
Interest payments (Loan 2)											
Fiscal balance sheet (non-cash flows)											
Book value			17.000.000	16.580.000	16.160.000	15.740.000	15.320.000	14.900.000	14.480.000	14.060.000	13.640.000
Depreciation				420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000
Taxable income and tax liability calculation (non-cash flows)											
Operating cash flows											
Before-tax operating income				893.411	911.279	1.046.165	1.067.088	1.088.430	1.110.199	1.132.402	1.155.051
Total depreciation				-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000
Interest payments				-614.550	-603.075	-591.600	-580.125	-568.650	-557.175	-545.700	-534.225
Taxable operating income				-141.139	-111.796	34.565	66.963	99.780	133.024	166.702	200.826
Tax liability operating income				-36.414	-28.843	8.918	17.276	25.743	34.320	43.009	51.813
Reversion cash flows											
Sale price property											
Reversion basis property											
Sale price land											
Capital gain											
Tax liability capital gain											
Net cash flows											
Investment cash flow before-tax	-17.000.000	0	0	893.411	911.279	1.046.165	1.067.088	1.088.430	1.110.199	1.132.402	1.155.051
Net equity cash flow before-tax	-4.250.000	-867.000	-855.525	49.361	78.704	225.065	257.463	290.280	323.524	357.202	391.326
Net equity cash flow after-tax	-4.250.000	-867.000	-855.525	85.775	107.548	216.147	240.187	264.537	289.203	314.193	339.513
Return analysis											
Net equity cash flow after-tax	-4.250.000	-867.000	-855.525	85.775	107.548	216.147	240.187	264.537	289.203	314.193	339.513
Present value net equity cash flow after-tax	-4.250.000	-810.280	-747.249	70.018	82.048	154.110	160.047	164.740	168.319	170.900	172.591

	Use 1									
Period	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Vacancy rate %	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%
Operating income and expenses										
Potential gross income	1.398.796	1.426.772	1.455.307	1.484.414	1.514.102	1.544.384	1.575.272	1.606.777	1.638.913	1.671.691
Vacancy allowance	-69.940	-71.339	-72.765	-74.221	-75.705	-77.219	-78.764	-80.339	-81.946	-83.585
Gross income	1.328.856	1.355.433	1.382.542	1.410.193	1.438.397	1.467.165	1.496.508	1.526.438	1.556.967	1.588.106
Other income										
Parking	18.899	19.277	19.663	20.056	20.457	20.866	21.284	21.709	22.144	22.586
Effective income	1.347.756	1.374.711	1.402.205	1.430.249	1.458.854	1.488.031	1.517.792	1.548.148	1.579.110	1.610.693
Operating expenses										
Repairs & maintenance	-99.664	-101.658	-103.691	-105.764	-107.880	-110.037	-112.238	-114.483	-116.773	-119.108
Property management	-69.940	-71.339	-72.765	-74.221	-75.705	-77.219	-78.764	-80.339	-81.946	-83.585
Net operating income	1.178.152	1.201.715	1.225.749	1.250.264	1.275.269	1.300.775	1.326.790	1.353.326	1.380.392	1.408.000
Investment										
Land costs										
Purchase price (initial investment)										
Demolition costs										
Reconstruction costs										
Conversion costs										
Re-sale price										
Investment										
Debt (Loan 1 and 2)										
Equity investment										
Debt services										
Interest payments	-522.750	-511.275	-499.800	-488.325	-476.850	-465.375	-453.900	-442.425	-430.950	-419.475
Principal payments	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500
Total debt service	-752.250	-740.775	-729.300	-717.825	-706.350	-694.875	-683.400	-671.925	-660.450	-648.975
Income and capital gain tax										
Income tax	-60.734	-69.773	-78.935	-88.220	-97.632	-107.173	-116.846	-126.652	-136.596	-146.679
Capital gain tax										
Tax liability	-60.734	-69.773	-78.935	-88.220	-97.632	-107.173	-116.846	-126.652	-136.596	-146.679
Debt schedule: calculations (non-cash flows)										
Loan balance (Loan 1)	10.225.500	9.996.000	9.766.500	9.537.000	9.307.500	9.078.000	8.848.500	8.619.000	8.389.500	8.160.000
Principal payments (Loan 1)	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500
Interest payments (Loan 1)	522.750	511.275	499.800	488.325	476.850	465.375	453.900	442.425	430.950	419.475
Loan balance (Loan 2)										
Prinicipal payments (Loan 2)										
Interest payments (Loan 2)										
Fiscal balance sheet (non-cash flows)										
Book value	13.220.000	12.800.000	12.380.000	11.960.000	11.540.000	11.120.000	10.700.000	10.280.000	9.860.000	9.020.000
Depreciation	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000
Taxable income and tax liability calculation (non-cash flows)										
Operating cash flows										
Before-tax operating income	1.178.152	1.201.715	1.225.749	1.250.264	1.275.269	1.300.775	1.326.790	1.353.326	1.380.392	1.408.000
Total depreciation	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000
Interest payments	-522.750	-511.275	-499.800	-488.325	-476.850	-465.375	-453.900	-442.425	-430.950	-419.475
Taxable operating income	235.402	270.440	305.949	341.939	378.419	415.400	452.890	490.901	529.442	568.525
Tax liability operating income	60.734	69.773	78.935	88.220	97.632	107.173	116.846	126.652	136.596	146.679
Reversion cash flows										
Sale price property										
Reversion basis property										
Sale price land										
Capital gain										
Tax liability capital gain										
Net cash flows										
Investment cash flow before-tax	1.178.152	1.201.715	1.225.749	1.250.264	1.275.269	1.300.775	1.326.790	1.353.326	1.380.392	1.408.000
Net equity cash flow before-tax	425.902	460.940	496.449	532.439	568.919	605.900	643.390	681.401	719.942	759.025
Net equity cash flow after-tax	365.168	391.166	417.514	444.219	471.287	498.726	526.544	554.748	583.346	612.346
Return analysis										
Net equity cash flow after-tax	365.168	391.166	417.514	444.219	471.287	498.726	526.544	554.748	583.346	612.346
Present value net equity cash flow after-tax	173.489	173.682	173.253	172.276	170.816	168.936	166.690	164.130	161.300	158.242

Standard building design (scenario demolition and redevelopment) – model part 2

				Redevelopment									Use 2						
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
5,0%	5,0%	5,0%	5,0%	100,0%	100,0%	100,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%
1.705.125	1.739.227	1.774.012	1.809.492	0	0	0	2.898.805	2.956.781	3.015.917	3.076.235	3.137.760	3.200.515	3.264.526	3.329.816	3.396.412	3.464.341	3.533.627	3.604.300	3.676.386
-85.256	-86.961	-88.701	-90.475	0	0	0	-144.940	-147.839	-150.796	-153.812	-156.888	-160.026	-163.226	-166.491	-169.821	-173.217	-176.681	-180.215	-183.819
1.619.868	1.652.266	1.685.311	1.719.017	0	0	0	2.753.865	2.808.942	2.865.121	2.922.424	2.980.872	3.040.490	3.101.299	3.163.325	3.226.592	3.291.124	3.356.946	3.424.085	3.492.567
23.038	23.499	23.969	24.448	0	0	0	26.464	26.993	27.533	28.083	28.645	29.218	29.802	30.398	31.006	31.626	32.259	32.904	33.562
1.642.907	1.675.765	1.709.280	1.743.466	0	0	0	2.780.329	2.835.935	2.892.654	2.950.507	3.009.517	3.069.707	3.131.102	3.193.724	3.257.598	3.322.750	3.389.205	3.456.989	3.526.129
-121.490	-123.920	-126.398	-128.926	0	0	0	-206.540	-210.671	-214.884	-219.182	-223.565	-228.037	-232.597	-237.249	-241.994	-246.834	-251.771	-256.806	-261.943
-85.256	-86.961	-88.701	-90.475	0	0	0	-144.940	-147.839	-150.796	-153.812	-156.888	-160.026	-163.226	-166.491	-169.821	-173.217	-176.681	-180.215	-183.819
1.436.160	1.464.883	1.494.181	1.524.065	0	0	0	2.428.848	2.477.425	2.526.974	2.577.513	2.629.064	2.681.645	2.735.278	2.789.983	2.845.783	2.902.699	2.960.753	3.019.968	3.080.367
				-820.303															
				-16.406.060															
				0															
																			64.315.100
				-17.226.363															64.315.100
				12.919.772															-13.001.434
				-4.306.591															51.313.666
-408.000	-396.525	-385.050	-373.575	-362.100	-996.614	-973.511	-950.408	-927.305	-904.202	-881.100	-857.997	-834.894	-811.791	-788.688	-765.586	-742.483	-719.380	-696.277	-673.174
-229.500	-229.500	-229.500	-229.500	-229.500	-462.056	-462.056	-462.056	-462.056	-462.056	-462.056	-462.056	-462.056	-462.056	-462.056	-462.056	-462.056	-462.056	-462.056	-462.056
-637.500	-626.025	-614.550	-603.075	-591.600	-1.458.670	-1.435.567	-1.412.464	-1.389.361	-1.366.258	-1.343.156	-1.320.053	-1.296.950	-1.273.847	-1.250.744	-1.227.642	-1.204.539	-1.181.436	-1.158.333	-1.135.230
-156.905	-167.276	-177.796	-188.466	0	0	0	-273.078	-291.571	-310.315	-329.315	-348.575	-368.102	-387.900	-407.974	-428.331	-448.976	-469.914	-491.152	-512.696
																			-12.097.294
-156.905	-167.276	-177.796	-188.466	0	0	0	-273.078	-291.571	-310.315	-329.315	-348.575	-368.102	-387.900	-407.974	-428.331	-448.976	-469.914	-491.152	-12.609.990
7.930.500	7.701.000	7.471.500	7.242.000	7.012.500	6.783.000	6.553.500	6.324.000	6.094.500	5.865.000	5.635.500	5.406.000	5.176.500	4.947.000	4.717.500	4.488.000	4.258.500	4.029.000	3.799.500	3.570.000
229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500
408.000	396.525	385.050	373.575	362.100	350.625	339.150	327.675	316.200	304.725	293.250	281.775	270.300	258.825	247.350	235.875	224.400	212.925	201.450	189.975
				12.919.772	12.687.216	12.454.660	12.222.105	11.989.549	11.756.993	11.524.437	11.291.881	11.059.325	10.826.769	10.594.213	10.361.657	10.129.101	9.896.546	9.663.990	9.431.434
					232.556	232.556	232.556	232.556	232.556	232.556	232.556	232.556	232.556	232.556	232.556	232.556	232.556	232.556	232.556
					645.989	634.361	622.733	611.105	599.477	587.850	576.222	564.594	552.966	541.338	529.711	518.083	506.455	494.827	483.199
8.600.000	8.180.000	7.760.000	7.340.000	23.726.363	23.306.363	22.886.363	22.466.363	22.046.363	21.626.363	21.206.363	20.786.363	20.366.363	19.946.363	19.526.363	19.106.363	18.686.363	18.266.363	17.846.363	17.426.363
420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000
1.436.160	1.464.883	1.494.181	1.524.065	0	0	0	2.428.848	2.477.425	2.526.974	2.577.513	2.629.064	2.681.645	2.735.278	2.789.983	2.845.783	2.902.699	2.960.753	3.019.968	3.080.367
-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000
-408.000	-396.525	-385.050	-373.575	-362.100	-996.614	-973.511	-950.408	-927.305	-904.202	-881.100	-857.997	-834.894	-811.791	-788.688	-765.586	-742.483	-719.380	-696.277	-673.174
608.160	648.358	689.131	730.490	-782.100	-1.416.614	-1.393.511	1.058.440	1.130.120	1.202.772	1.276.414	1.351.067	1.426.751	1.503.487	1.581.295	1.660.197	1.740.216	1.821.373	1.903.691	1.987.193
156.905	167.276	177.796	188.466	0	0	0	273.078	291.571	310.315	329.315	348.575	368.102	387.900	407.974	428.331	448.976	469.914	491.152	512.696
																			57.690.981
																			-17.426.363
																			6.624.119
																			46.888.737
																			12.097.294
1.436.160	1.464.883	1.494.181	1.524.065	-17.226.363	0	0	2.428.848	2.477.425	2.526.974	2.577.513	2.629.064	2.681.645	2.735.278	2.789.983	2.845.783	2.902.699	2.960.753	3.019.968	67.395.467
798.660	838.858	879.631	920.990	-4.898.191	-1.458.670	-1.435.567	1.016.385	1.088.064	1.160.716	1.234.358	1.309.011	1.384.695	1.461.431	1.539.239	1.618.142	1.698.160	1.779.317	1.861.635	53.258.803
641.755	671.582	701.835	732.523	-4.898.191	-1.458.670	-1.435.567	743.307	796.493	850.401	905.043	960.436	1.016.593	1.073.531	1.131.265	1.189.811	1.249.184	1.309.403	1.370.482	40.648.813
641.755	671.582	701.835	732.523	-4.898.191	-1.458.670	-1.435.567	743.307	796.493	850.401	905.043	960.436	1.016.593	1.073.531	1.131.265	1.189.811	1.249.184	1.309.403	1.370.482	40.648.813
154.992	151.585	148.050	144.414	-902.488	-251.176	-231.026	111.795	111.957	111.715	111.115	110.201	109.014	107.589	105.958	104.151	102.194	100.113	97.928	2.714.543
																		NPV	230.682

Convertible building design (scenario no conversion) – inputs

Property

Building size (standard)	4.500	m2 LFA
Building size (convertible)	4.400	m2 LFA
Number of parking lots	80	

Costs and income

Land costs	€ 3.000.000	paid at t=0, price level t=0
Initial investment	€ 14.000.000	paid at t=0, price level t=0
Additional initial investment	10,0%	of initial investment
Conversion costs	0,0%	of initial investment
Demolition costs	€ 0	price level t=0
Reconstruction costs	€ 2.100.000	price level t=0
Conversion/reconstruction time	0	years
Rent use 1 (offices - new built)	€ 250	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent use 2 (housing - new built)	€ 370	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent use 2 (housing - converted)	€ 350	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent parking lot	€ 200	received at end of the year; CPI indexed; price level t=0
Inflation (CPI)	2,0%	
Initial vacancy rate	15,0%	years 1 to 2
Friction vacancy rate	5,0%	years 3 to end of holding period
Repairs & maintenance	10,0%	of gross rent income, paid at end of the year
Property management	5,0%	of potential gross income, paid at end of the year
Gross exit yield (GEY)	8,0%	based on potential gross income (PGI)

Financing

Loan-to-Value (LTV) ratio	75,0%	
Interest rate on loan	4,9%	annually paid at end of year, assumption: second loan at present interest rate
Principal payments	1,8%	of loan amount, amortisation, first payment at t=1; paid at the end of the year

Tax liabilities

Annual depreciation	3%	of building value, linear depreciation of the building value; starting from t=1
Corporate tax rate	25,5%	

Required rate of return

Going-in IRR	7,0%	

Terminal property value

Potential gross income (PGI) at t=41	€ 2.477.421
Gross Exit Yield (GEY)	8,0%
Terminal value (at end of the holding period)	€ 30.967.756

Return analysis: expected rates of return

Investment return before-tax	6,57%
Equity return before-tax	8,05%
Equity return after-tax	7,14%

Net Present Value

NPV with required return as discount rate	€ 193.257

Convertible building design (scenario no conversion) – model part 1

	Construction			Use 1																	
Period	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Vacancy rate %				15,0%	15,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%
Operating income and expenses																					
Potential gross income				1.167.329	1.190.675	1.214.489	1.238.779	1.263.554	1.288.825	1.314.602	1.340.894	1.367.712	1.395.066	1.422.967	1.451.427	1.480.455	1.510.064	1.540.266	1.571.071	1.602.492	1.634.542
Vacancy allowance				-175.099	-178.601	-60.724	-61.939	-63.178	-64.441	-65.730	-67.045	-68.386	-69.753	-71.148	-72.571	-74.023	-75.503	-77.013	-78.554	-80.125	-81.727
Gross income				992.229	1.012.074	1.153.764	1.176.840	1.200.377	1.224.384	1.248.872	1.273.849	1.299.326	1.325.313	1.351.819	1.378.855	1.406.432	1.434.561	1.463.252	1.492.517	1.522.368	1.552.815
Other income																					
Parking				14.432	14.721	16.782	17.118	17.460	17.809	18.165	18.529	18.899	19.277	19.663	20.056	20.457	20.866	21.284	21.709	22.144	22.586
Effective income				1.006.662	1.026.795	1.170.546	1.193.957	1.217.837	1.242.193	1.267.037	1.292.378	1.318.225	1.344.590	1.371.482	1.398.911	1.426.890	1.455.427	1.484.536	1.514.227	1.544.511	1.575.401
Operating expenses																					
Repairs & maintenance				-99.223	-101.207	-115.376	-117.684	-120.038	-122.438	-124.887	-127.385	-129.933	-132.531	-135.182	-137.886	-140.643	-143.456	-146.325	-149.252	-152.237	-155.282
Property management				-58.366	-59.534	-60.724	-61.939	-63.178	-64.441	-65.730	-67.045	-68.386	-69.753	-71.148	-72.571	-74.023	-75.503	-77.013	-78.554	-80.125	-81.727
Net operating income				849.073	866.054	994.446	1.014.334	1.034.621	1.055.314	1.076.420	1.097.948	1.119.907	1.142.305	1.165.151	1.188.455	1.212.224	1.236.468	1.261.197	1.286.421	1.312.150	1.338.393
Investment																					
Land costs	-3.000.000																				
Purchase price (initial investment)	-14.000.000																				
Demolition costs																					
Reconstruction costs																					
Conversion costs																					
Re-sale price																					
Investment	-17.000.000																				
Debt (Loan 1 and 2)	12.750.000																				
Equity investment	-4.250.000																				
Debt services																					
Interest payments		-624.750	-613.505	-602.259	-591.014	-579.768	-568.523	-557.277	-546.032	-534.786	-523.541	-512.295	-501.050	-489.804	-478.559	-467.313	-456.068	-444.822	-433.577	-422.331	-411.086
Principal payments		-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500	-229.500
Total debt service		-854.250	-843.005	-831.759	-820.514	-809.268	-798.023	-786.777	-775.532	-764.286	-753.041	-741.795	-730.550	-719.304	-708.059	-696.813	-685.568	-674.322	-663.077	-651.831	-640.586
Income and capital gain tax																					
Income tax		0	0	44.163	36.965	1.357	-6.582	-14.623	-22.767	-31.017	-39.374	-47.841	-56.420	-65.114	-73.923	-82.852	-91.902	-101.076	-110.375	-119.804	-129.363
Capital gain tax																					
Tax liability		0	0	44.163	36.965	1.357	-6.582	-14.623	-22.767	-31.017	-39.374	-47.841	-56.420	-65.114	-73.923	-82.852	-91.902	-101.076	-110.375	-119.804	-129.363
Debt schedule: calculations (non-cash flows)																					
Loan balance (Loan 1)	12.750.000	12.520.500	12.291.000	12.061.500	11.832.000	11.602.500	11.373.000	11.143.500	10.914.000	10.684.500	10.455.000	10.225.500	9.996.000	9.766.500	9.537.000	9.307.500	9.078.000	8.848.500	8.619.000	8.389.500	8.160.000
Principal payments (Loan 1)		229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500
Interest payments (Loan 1)		624.750	613.505	602.259	591.014	579.768	568.523	557.277	546.032	534.786	523.541	512.295	501.050	489.804	478.559	467.313	456.068	444.822	433.577	422.331	411.086
Loan balance (Loan 2)																					
Prinicipal payments (Loan 2)																					
Interest payments (Loan 2)																					
Fiscal balance sheet (non-cash flows)																					
Book value			17.000.000	16.580.000	16.160.000	15.740.000	15.320.000	14.900.000	14.480.000	14.060.000	13.640.000	13.220.000	12.800.000	12.380.000	11.960.000	11.540.000	11.120.000	10.700.000	10.280.000	9.860.000	9.020.000
Depreciation				420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000
Taxable income and tax liability calculation (non-cash flows)																					
Operating cash flows																					
Before-tax operating income				849.073	866.054	994.446	1.014.334	1.034.621	1.055.314	1.076.420	1.097.948	1.119.907	1.142.305	1.165.151	1.188.455	1.212.224	1.236.468	1.261.197	1.286.421	1.312.150	1.338.393
Total depreciation				-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000
Interest payments				-602.259	-591.014	-579.768	-568.523	-557.277	-546.032	-534.786	-523.541	-512.295	-501.050	-489.804	-478.559	-467.313	-456.068	-444.822	-433.577	-422.331	-411.086
Taxable operating income				-173.186	-144.960	-5.322	25.812	57.344	89.282	121.634	154.408	187.612	221.256	255.347	289.896	324.911	360.401	396.375	432.845	469.819	507.307
Tax liability operating income				-44.163	-36.965	-1.357	6.582	14.623	22.767	31.017	39.374	47.841	56.420	65.114	73.923	82.852	91.902	101.076	110.375	119.804	129.363
Reversion cash flows																					
Sale price property																					
Reversion basis property																					
Sale price land																					
Capital gain																					
Tax liability capital gain																					
Net cash flows																					
Investment cash flow before-tax	-17.000.000	0	0	849.073	866.054	994.446	1.014.334	1.034.621	1.055.314	1.076.420	1.097.948	1.119.907	1.142.305	1.165.151	1.188.455	1.212.224	1.236.468	1.261.197	1.286.421	1.312.150	1.338.393
Net equity cash flow before-tax	-4.250.000	-854.250	-843.005	17.314	45.540	185.178	216.312	247.844	279.782	312.134	344.908	378.112	411.756	445.847	480.396	515.411	550.901	586.875	623.345	660.319	697.807
Net equity cash flow after-tax	-4.250.000	-854.250	-843.005	61.476	82.505	186.535	209.730	233.221	257.015	281.117	305.534	330.271	355.336	380.734	406.473	432.558	458.998	485.800	512.969	540.515	568.444
Return analysis																					
Net equity cash flow after-tax	-4.250.000	-854.250	-843.005	61.476	82.505	186.535	209.730	233.221	257.015	281.117	305.534	330.271	355.336	380.734	406.473	432.558	458.998	485.800	512.969	540.515	568.444
Present value net equity cash flow after-tax	-4.250.000	-798.364	-736.313	50.183	62.943	132.997	139.752	145.239	149.585	152.909	155.318	156.909	157.773	157.991	157.637	156.779	155.479	153.792	151.769	149.457	146.897

Convertible building design (scenario no conversion) – model part 2

				Renovation (in use)								Use 1							
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%
1.667.233	1.700.578	1.734.589	1.769.281	1.804.667	1.840.760	1.877.575	1.915.127	1.953.429	1.992.498	2.032.348	2.072.995	2.114.455	2.156.744	2.199.879	2.243.876	2.288.754	2.334.529	2.381.219	2.428.844
-83.362	-85.029	-86.729	-88.464	-90.233	-92.038	-93.879	-95.756	-97.671	-99.625	-101.617	-103.650	-105.723	-107.837	-109.994	-112.194	-114.438	-116.726	-119.061	-121.442
1.583.871	1.615.549	1.647.860	1.680.817	1.714.433	1.748.722	1.783.696	1.819.370	1.855.758	1.892.873	1.930.730	1.969.345	2.008.732	2.048.906	2.089.885	2.131.682	2.174.316	2.217.802	2.262.158	2.307.401
23.038	23.499	23.969	24.448	24.937	25.436	25.945	26.464	26.993	27.533	28.083	28.645	29.218	29.802	30.398	31.006	31.626	32.259	32.904	33.562
1.606.909	1.639.048	1.671.829	1.705.265	1.739.370	1.774.158	1.809.641	1.845.834	1.882.751	1.920.406	1.958.814	1.997.990	2.037.950	2.078.709	2.120.283	2.162.689	2.205.942	2.250.061	2.295.062	2.340.964
-158.387	-161.555	-164.786	-168.082	-171.443	-174.872	-178.370	-181.937	-185.576	-189.287	-193.073	-196.934	-200.873	-204.891	-208.988	-213.168	-217.432	-221.780	-226.216	-230.740
-83.362	-85.029	-86.729	-88.464	-90.233	-92.038	-93.879	-95.756	-97.671	-99.625	-101.617	-103.650	-105.723	-107.837	-109.994	-112.194	-114.438	-116.726	-119.061	-121.442
1.365.161	1.392.464	1.420.313	1.448.719	1.477.694	1.507.248	1.537.393	1.568.141	1.599.503	1.631.493	1.664.123	1.697.406	1.731.354	1.765.981	1.801.301	1.837.327	1.874.073	1.911.555	1.949.786	1.988.781
				0															
				-3.445.273															
				0															
																			37.591.875
				-3.445.273															37.591.875
				2.583.954															-5.456.287
				-861.318															32.135.589
-399.840	-388.595	-377.349	-366.104	-354.858	-470.226	-456.702	-443.177	-429.653	-416.128	-402.604	-389.079	-375.554	-362.030	-348.505	-334.981	-321.456	-307.932	-294.407	-280.883
-229.500	-229.500	-229.500	-229.500	-229.500	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011	-276.011
-629.340	-618.095	-606.849	-595.604	-584.358	-746.237	-732.713	-719.188	-705.664	-692.139	-678.615	-665.090	-651.566	-638.041	-624.517	-610.992	-597.467	-583.943	-570.418	-556.894
-139.057	-148.887	-158.856	-168.967	-179.223	-157.340	-168.476	-179.766	-191.212	-202.818	-214.588	-226.523	-238.629	-250.908	-263.363	-275.998	-288.817	-301.824	-315.022	-328.414
																			-8.656.384
-139.057	-148.887	-158.856	-168.967	-179.223	-157.340	-168.476	-179.766	-191.212	-202.818	-214.588	-226.523	-238.629	-250.908	-263.363	-275.998	-288.817	-301.824	-315.022	-8.984.798
7.930.500	7.701.000	7.471.500	7.242.000	7.012.500	6.783.000	6.553.500	6.324.000	6.094.500	5.865.000	5.635.500	5.406.000	5.176.500	4.947.000	4.717.500	4.488.000	4.258.500	4.029.000	3.799.500	3.570.000
229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500	229.500
399.840	388.595	377.349	366.104	354.858	343.613	332.367	321.122	309.876	298.631	287.385	276.140	264.894	253.649	242.403	231.158	219.912	208.667	197.421	186.176
				2.583.954	2.537.443	2.490.932	2.444.421	2.397.910	2.351.399	2.304.887	2.258.376	2.211.865	2.165.354	2.118.843	2.072.331	2.025.820	1.979.309	1.932.798	1.886.287
					46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511	46.511
					126.614	124.335	122.056	119.777	117.498	115.219	112.939	110.660	108.381	106.102	103.823	101.544	99.265	96.986	94.707
8.600.000	8.180.000	7.760.000	7.340.000	9.945.273	9.525.273	9.105.273	8.685.273	8.265.273	7.845.273	7.425.273	7.005.273	6.585.273	6.165.273	5.745.273	5.325.273	4.905.273	4.485.273	4.065.273	3.645.273
420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000
1.365.161	1.392.464	1.420.313	1.448.719	1.477.694	1.507.248	1.537.393	1.568.141	1.599.503	1.631.493	1.664.123	1.697.406	1.731.354	1.765.981	1.801.301	1.837.327	1.874.073	1.911.555	1.949.786	1.988.781
-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000
-399.840	-388.595	-377.349	-366.104	-354.858	-470.226	-456.702	-443.177	-429.653	-416.128	-402.604	-389.079	-375.554	-362.030	-348.505	-334.981	-321.456	-307.932	-294.407	-280.883
545.321	583.869	622.964	662.616	702.836	617.021	660.691	704.963	749.851	795.365	841.520	888.327	935.799	983.951	1.032.795	1.082.346	1.132.617	1.183.623	1.235.378	1.287.899
139.057	148.887	158.856	168.967	179.223	157.340	168.476	179.766	191.212	202.818	214.588	226.523	238.629	250.908	263.363	275.998	288.817	301.824	315.022	328.414
																			30.967.756
																			-3.645.273
																			6.624.119
																			33.946.603
																			8.656.384
1.365.161	1.392.464	1.420.313	1.448.719	-1.967.579	1.507.248	1.537.393	1.568.141	1.599.503	1.631.493	1.664.123	1.697.406	1.731.354	1.765.981	1.801.301	1.837.327	1.874.073	1.911.555	1.949.786	39.580.657
735.821	774.369	813.464	853.116	32.018	761.010	804.680	848.952	893.840	939.354	985.509	1.032.316	1.079.788	1.127.940	1.176.784	1.226.335	1.276.606	1.327.612	1.379.367	33.567.476
596.764	625.483	654.608	684.149	-147.205	603.670	636.204	669.187	702.628	736.536	770.921	805.792	841.159	877.032	913.421	950.336	987.788	1.025.788	1.064.346	24.582.678
596.764	625.483	654.608	684.149	-147.205	603.670	636.204	669.187	702.628	736.536	770.921	805.792	841.159	877.032	913.421	950.336	987.788	1.025.788	1.064.346	24.582.678
144.126	141.180	138.088	134.878	-27.122	103.949	102.384	100.647	98.763	96.757	94.648	92.458	90.201	87.896	85.554	83.188	80.810	78.429	76.053	1.641.641
																		NPV	193.257

Convertible building design (scenario conversion) – inputs

Property

Building size (standard)	4.500	m2 LFA
Building size (convertible)	4.400	m2 LFA
Number of parking lots	80	

Costs and income

Land costs	€ 3.000.000	paid at t=0, price level t=0
Initial investment	€ 14.000.000	paid at t=0, price level t=0
Additional initial investment	10,0%	of initial investment
Conversion costs	25%	of initial investment
Demolition costs	€ 0	price level t=0
Reconstruction costs	€ 0	price level t=0
Conversion/reconstruction time	1	year
Rent use 1 (offices - new built)	€ 250	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent use 2 (housing - new built)	€ 370	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent use 2 (housing - converted	€ 350	€/m2 LFA, received at end of the year; CPI indexed; price level t=0
Rent parking lot	€ 200	received at end of the year; CPI indexed; price level t=0
Inflation (CPI)	2,0%	
Initial vacancy rate	15,0%	years 1 to 2
Friction vacancy rate	5,0%	years 3 to end of holding period
Repairs & maintenance	10,0%	of gross rent income, paid at end of the year
Property management	5,0%	of potential gross income, paid at end of the year
Gross exit yield (GEY)	7,5%	based on potential gross income (PGI)

Financing

Loan-to-Value (LTV) ratio	75,0%	
Interest rate on loan	4,9%	annually paid at end of year, assumption: second loan at present interest rate
Principal payments	1,8%	of loan amount, amortisation, first payment at t=1; paid at the end of the year

Tax liabilities

Annual depreciation	3%	of building value, linear depreciation of the building value; starting from t=1
Corporate tax rate	25,5%	

Required rate of return

Going-in IRR	7,0%	

Terminal property value

Potential gross income (PGI) at t=41	€ 3.468.389
Gross Exit Yield (GEY)	7,5%
Terminal value (at end of the holding period)	€ 46.245.183

Return analysis: expected rates of return

Investment return before-tax	6,65%
Equity return before-tax	8,02%
Equity return after-tax	7,16%

Net Present Value

NPV with required return as discount rate	€ 269.838

Convertible building design (scenario conversion) – model part 1

	Construction			Use 1																	
Period	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Vacancy rate %				15,0%	15,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%
Operating income and expenses																					
Potential gross income				1.167.329	1.190.675	1.214.489	1.238.779	1.263.554	1.288.825	1.314.602	1.340.894	1.367.712	1.395.066	1.422.967	1.451.427	1.480.455	1.510.064	1.540.266	1.571.071	1.602.492	1.634.542
Vacancy allowance				-175.099	-178.601	-60.724	-61.939	-63.178	-64.441	-65.730	-67.045	-68.386	-69.753	-71.148	-72.571	-74.023	-75.503	-77.013	-78.554	-80.125	-81.727
Gross income				992.229	1.012.074	1.153.764	1.176.840	1.200.377	1.224.384	1.248.872	1.273.849	1.299.326	1.325.313	1.351.819	1.378.855	1.406.432	1.434.561	1.463.252	1.492.517	1.522.368	1.552.815
Other income																					
Parking				14.432	14.721	16.782	17.118	17.460	17.809	18.165	18.529	18.899	19.277	19.663	20.056	20.457	20.866	21.284	21.709	22.144	22.586
Effective income				1.006.662	1.026.795	1.170.546	1.193.957	1.217.837	1.242.193	1.267.037	1.292.378	1.318.225	1.344.590	1.371.482	1.398.911	1.426.890	1.455.427	1.484.536	1.514.227	1.544.511	1.575.401
Operating expenses																					
Repairs & maintenance				-99.223	-101.207	-115.376	-117.684	-120.038	-122.438	-124.887	-127.385	-129.933	-132.531	-135.182	-137.886	-140.643	-143.456	-146.325	-149.252	-152.237	-155.282
Property management				-58.366	-59.534	-60.724	-61.939	-63.178	-64.441	-65.730	-67.045	-68.386	-69.753	-71.148	-72.571	-74.023	-75.503	-77.013	-78.554	-80.125	-81.727
Net operating income				849.073	866.054	994.446	1.014.334	1.034.621	1.055.314	1.076.420	1.097.948	1.119.907	1.142.305	1.165.151	1.188.455	1.212.224	1.236.468	1.261.197	1.286.421	1.312.150	1.338.393
Investment																					
Land costs	-3.000.000																				
Purchase price (initial investment)	-15.400.000																				
Demolition costs																					
Reconstruction costs																					
Conversion costs																					
Re-sale price																					
Investment	-18.400.000																				
Debt (Loan 1 and 2)	13.800.000																				
Equity investment	-4.600.000																				
Debt services																					
Interest payments		-676.200	-664.028	-651.857	-639.685	-627.514	-615.342	-603.170	-590.999	-578.827	-566.656	-554.484	-542.312	-530.141	-517.969	-505.798	-493.626	-481.454	-469.283	-457.111	-444.940
Principal payments		-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400	-248.400
Total debt service		-924.600	-912.428	-900.257	-888.085	-875.914	-863.742	-851.570	-839.399	-827.227	-815.056	-802.884	-790.712	-778.541	-766.369	-754.198	-742.026	-729.854	-717.683	-705.511	-693.340
Income and capital gain tax																					
Income tax		0	0	56.810	49.376	13.532	5.357	-2.920	-11.300	-19.786	-28.380	-37.083	-45.898	-54.828	-63.874	-73.039	-82.325	-91.734	-101.270	-110.935	-120.731
Capital gain tax																					
Tax liability		0	0	56.810	49.376	13.532	5.357	-2.920	-11.300	-19.786	-28.380	-37.083	-45.898	-54.828	-63.874	-73.039	-82.325	-91.734	-101.270	-110.935	-120.731
Debt schedule: calculations (non-cash flows)																					
Loan balance (Loan 1)	13.800.000	13.551.600	13.303.200	13.054.800	12.806.400	12.558.000	12.309.600	12.061.200	11.812.800	11.564.400	11.316.000	11.067.600	10.819.200	10.570.800	10.322.400	10.074.000	9.825.600	9.577.200	9.328.800	9.080.400	8.832.000
Principal payments (Loan 1)		248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400
Interest payments (Loan 1)		676.200	664.028	651.857	639.685	627.514	615.342	603.170	590.999	578.827	566.656	554.484	542.312	530.141	517.969	505.798	493.626	481.454	469.283	457.111	444.940
Loan balance (Loan 2)																					
Prinicipal payments (Loan 2)																					
Interest payments (Loan 2)																					
Fiscal balance sheet (non-cash flows)																					
Book value			18.400.000	17.980.000	17.560.000	17.140.000	16.720.000	16.300.000	15.880.000	15.460.000	15.040.000	14.620.000	14.200.000	13.780.000	13.360.000	12.940.000	12.520.000	12.100.000	11.680.000	11.260.000	10.420.000
Depreciation				420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000
Taxable income and tax liability calculation (non-cash flows)																					
Operating cash flows																					
Before-tax operating income				849.073	866.054	994.446	1.014.334	1.034.621	1.055.314	1.076.420	1.097.948	1.119.907	1.142.305	1.165.151	1.188.455	1.212.224	1.236.468	1.261.197	1.286.421	1.312.150	1.338.393
Total depreciation				-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000
Interest payments				-651.857	-639.685	-627.514	-615.342	-603.170	-590.999	-578.827	-566.656	-554.484	-542.312	-530.141	-517.969	-505.798	-493.626	-481.454	-469.283	-457.111	-444.940
Taxable operating income				-222.784	-193.631	-53.068	-21.008	11.451	44.315	77.593	111.293	145.423	179.993	215.011	250.485	286.426	322.842	359.743	397.139	435.039	473.453
Tax liability operating income				-56.810	-49.376	-13.532	-5.357	2.920	11.300	19.786	28.380	37.083	45.898	54.828	63.874	73.039	82.325	91.734	101.270	110.935	120.731
Reversion cash flows																					
Sale price property																					
Reversion basis property																					
Sale price land																					
Capital gain																					
Tax liability capital gain																					
Net cash flows																					
Investment cash flow before-tax	-18.400.000	0	0	849.073	866.054	994.446	1.014.334	1.034.621	1.055.314	1.076.420	1.097.948	1.119.907	1.142.305	1.165.151	1.188.455	1.212.224	1.236.468	1.261.197	1.286.421	1.312.150	1.338.393
Net equity cash flow before-tax	-4.600.000	-924.600	-912.428	-51.184	-22.031	118.532	150.592	183.051	215.915	249.193	282.893	317.023	351.593	386.611	422.085	458.026	494.442	531.343	568.739	606.639	645.053
Net equity cash flow after-tax	-4.600.000	-924.600	-912.428	5.626	27.345	132.064	155.949	180.131	204.615	229.407	254.513	279.940	305.695	331.783	358.212	384.987	412.117	439.609	467.468	495.704	524.323
Return analysis																					
Net equity cash flow after-tax	-4.600.000	-924.600	-912.428	5.626	27.345	132.064	155.949	180.131	204.615	229.407	254.513	279.940	305.695	331.783	358.212	384.987	412.117	439.609	467.468	495.704	524.323
Present value net equity cash flow after-tax	-4.600.000	-864.112	-796.950	4.592	20.861	94.160	103.916	112.176	119.088	124.782	129.382	132.998	135.732	137.678	138.921	139.537	139.598	139.169	138.307	137.066	135.495

Convertible building design (scenario conversion) – model part 2

				Conversion								Use 2							
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
5,0%	5,0%	5,0%	5,0%	100,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%	5,0%
1.667.233	1.700.578	1.734.589	1.769.281	0	2.577.064	2.628.605	2.681.177	2.734.801	2.789.497	2.845.287	2.902.193	2.960.236	3.019.441	3.079.830	3.141.427	3.204.255	3.268.340	3.333.707	3.400.381
-83.362	-85.029	-86.729	-88.464	0	-128.853	-131.430	-134.059	-136.740	-139.475	-142.264	-145.110	-148.012	-150.972	-153.991	-157.071	-160.213	-163.417	-166.685	-170.019
1.583.871	1.615.549	1.647.860	1.680.817	0	2.448.211	2.497.175	2.547.118	2.598.061	2.650.022	2.703.022	2.757.083	2.812.225	2.868.469	2.925.838	2.984.355	3.044.042	3.104.923	3.167.022	3.230.362
23.038	23.499	23.969	24.448	0	25.436	25.945	26.464	26.993	27.533	28.083	28.645	29.218	29.802	30.398	31.006	31.626	32.259	32.904	33.562
1.606.909	1.639.048	1.671.829	1.705.265	0	2.473.647	2.523.120	2.573.582	2.625.054	2.677.555	2.731.106	2.785.728	2.841.442	2.898.271	2.956.237	3.015.361	3.075.669	3.137.182	3.199.926	3.263.924
-158.387	-161.555	-164.786	-168.082	0	-244.821	-249.717	-254.712	-259.806	-265.002	-270.302	-275.708	-281.222	-286.847	-292.584	-298.436	-304.404	-310.492	-316.702	-323.036
-83.362	-85.029	-86.729	-88.464	0	-128.853	-131.430	-134.059	-136.740	-139.475	-142.264	-145.110	-148.012	-150.972	-153.991	-157.071	-160.213	-163.417	-166.685	-170.019
1.365.161	1.392.464	1.420.313	1.448.719	0	2.099.972	2.141.972	2.184.811	2.228.508	2.273.078	2.318.539	2.364.910	2.412.208	2.460.452	2.509.661	2.559.855	2.611.052	2.663.273	2.716.538	2.770.869
				0															
				0															
				-5.742.121															
																			52.869.302
				-5.742.121															52.869.302
				4.306.591															-7.007.811
				-1.435.530															45.861.490
-432.768	-420.596	-408.425	-396.253	-384.082	-582.933	-566.963	-550.993	-535.023	-519.053	-503.083	-487.113	-471.143	-455.173	-439.203	-423.233	-407.263	-391.293	-375.323	-359.353
-248.400	-248.400	-248.400	-248.400	-248.400	-325.919	-325.919	-325.919	-325.919	-325.919	-325.919	-325.919	-325.919	-325.919	-325.919	-325.919	-325.919	-325.919	-325.919	-325.919
-681.168	-668.996	-656.825	-644.653	-632.482	-908.852	-892.882	-876.912	-860.942	-844.972	-829.002	-813.032	-797.061	-781.091	-765.121	-749.151	-733.181	-717.211	-701.241	-685.271
-130.660	-140.726	-150.932	-161.279	0	0	-294.527	-309.524	-324.739	-340.176	-355.841	-371.738	-387.872	-404.246	-420.867	-437.739	-454.866	-472.255	-489.910	-507.837
																			-11.609.431
-130.660	-140.726	-150.932	-161.279	0	0	-294.527	-309.524	-324.739	-340.176	-355.841	-371.738	-387.872	-404.246	-420.867	-437.739	-454.866	-472.255	-489.910	-12.117.268
8.583.600	8.335.200	8.086.800	7.838.400	7.590.000	7.341.600	7.093.200	6.844.800	6.596.400	6.348.000	6.099.600	5.851.200	5.602.800	5.354.400	5.106.000	4.857.600	4.609.200	4.360.800	4.112.400	3.864.000
248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400	248.400
432.768	420.596	408.425	396.253	384.082	371.910	359.738	347.567	335.395	323.224	311.052	298.880	286.709	274.537	262.366	250.194	238.022	225.851	213.679	201.508
				4.306.591	4.229.072	4.151.553	4.074.035	3.996.516	3.918.998	3.841.479	3.763.960	3.686.442	3.608.923	3.531.404	3.453.886	3.376.367	3.298.849	3.221.330	3.143.811
					77.519	77.519	77.519	77.519	77.519	77.519	77.519	77.519	77.519	77.519	77.519	77.519	77.519	77.519	77.519
					211.023	207.225	203.426	199.628	195.829	192.031	188.232	184.434	180.636	176.837	173.039	169.240	165.442	161.644	157.845
10.000.000	9.580.000	9.160.000	8.740.000	13.642.121	13.222.121	12.802.121	12.382.121	11.962.121	11.542.121	11.122.121	10.702.121	10.282.121	9.862.121	9.442.121	9.022.121	8.602.121	8.182.121	7.762.121	7.342.121
420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000	420.000
1.365.161	1.392.464	1.420.313	1.448.719	0	2.099.972	2.141.972	2.184.811	2.228.508	2.273.078	2.318.539	2.364.910	2.412.208	2.460.452	2.509.661	2.559.855	2.611.052	2.663.273	2.716.538	2.770.869
-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000	-420.000
-432.768	-420.596	-408.425	-396.253	-384.082	-582.933	-566.963	-550.993	-535.023	-519.053	-503.083	-487.113	-471.143	-455.173	-439.203	-423.233	-407.263	-391.293	-375.323	-359.353
512.393	551.867	591.888	632.466	-804.082	1.097.039	1.155.009	1.213.818	1.273.485	1.334.025	1.395.456	1.457.797	1.521.065	1.585.280	1.650.459	1.716.622	1.783.789	1.851.980	1.921.215	1.991.516
130.660	140.726	150.932	161.279	0	0	294.527	309.524	324.739	340.176	355.841	371.738	387.872	404.246	420.867	437.739	454.866	472.255	489.910	507.837
																			46.245.183
																			-7.342.121
																			6.624.119
																			45.527.181
																			11.609.431
1.365.161	1.392.464	1.420.313	1.448.719	-5.742.121	2.099.972	2.141.972	2.184.811	2.228.508	2.273.078	2.318.539	2.364.910	2.412.208	2.460.452	2.509.661	2.559.855	2.611.052	2.663.273	2.716.538	55.640.171
683.993	723.467	763.488	804.066	-2.068.012	1.191.121	1.249.090	1.307.900	1.367.566	1.428.106	1.489.538	1.551.878	1.615.147	1.679.361	1.744.540	1.810.703	1.877.870	1.946.061	2.015.297	47.947.088
553.333	582.741	612.557	642.787	-2.068.012	1.191.121	954.563	998.376	1.042.827	1.087.930	1.133.696	1.180.140	1.227.275	1.275.115	1.323.673	1.372.965	1.423.004	1.473.806	1.525.387	35.829.820
553.333	582.741	612.557	642.787	-2.068.012	1.191.121	954.563	998.376	1.042.827	1.087.930	1.133.696	1.180.140	1.227.275	1.275.115	1.323.673	1.372.965	1.423.004	1.473.806	1.525.387	35.829.820
133.637	131.532	129.217	126.723	-381.029	205.106	153.618	150.158	146.583	142.918	139.187	135.411	131.606	127.791	123.979	120.183	116.414	112.683	108.997	2.392.729
																		NPV	**269.838**