FROM PRINCIPLES TO PRACTICES:

REALISING THE VALUE OF CIRCULAR ECONOMY IN REAL ESTATE

ARUP

ELLEN MACARTHUR FOUNDATION

CONTENTS

1 Finsbury Avenue, London

ABOUT THIS PROJECT

From Principles to Practices is a two-phase collaborative project led by Arup and the Ellen MacArthur Foundation that aims to translate the principles of a circular economy into everyday built environment practices.

Phase 1 of the project established our vision for a circular built environment and identified the key barriers, opportunities and enablers of implementing circular economy practices. It also informed proposals for who needs to lead the change and what their first steps might be. The key outputs from Phase 1 were published in a report titled, *First Steps Towards a Circular Built Environment*, released in July 2018.

The second phase of the project, described in this report, aims to demonstrate the value and process of implementing circular economy principles in the built environment to real estate investors and construction clients. We have focused on these two stakeholder groups because our Phase 1 work highlighted they are best placed to lead the transition to a circular built environment, since they have the greatest capacity to influence decision-making, set direction and catalyse action throughout the value chain. Policy makers were also identified as possible first movers, yet in our interviews in Phase 1, policy makers made it clear they needed an evidence base of the benefits of a circular economy to be developed by investors and construction clients. Our research also revealed that value and the way in which it is created from real estate assets is set by investors and construction clients through investment requirements, tenure models and design briefs (developed within the confines of the policy environment in which they operate). Despite this, the business case for implementing circular economy principles has not yet been explicitly articulated to investors or construction clients to incentivise a change in this direction. The aim of this project is, therefore, to signpost the business case.

FOREWORD

The built environment sector faces a desperate need to become more sustainable. The environmental and ethical cases to adapt have never been stronger. Less well articulated is the business case.

Our own research shows us that a business' customers and prospective employees increasingly expect it to act in a socially and environmentally responsible manner. But what are the financial benefits of doing so? Making the investment case is vital to turbocharging the adoption of circular economy principles, helping the sector tackle its environmental footprint and create better places for people to live and work. So too is practicality. What tangible changes could real estate investors and businesses make to tap into these benefits?

With these questions in mind, we welcome both the findings of the research, and the cross-industry collaboration that has supported the work of Arup and the Ellen MacArthur Foundation. Indeed, I am pleased that RICS has been able to help develop the five circular economy real estate business models outlined in this report.

The research doesn't just demonstrate that circular economy practices can be built into existing real estate business models, it highlights the benefits of doing so, whether creating new value from an asset, keeping an asset at its highest value, or eliminating waste.

At their core, the five business models developed support the optimal use of resources across a real estate asset's life cycle, rather than simply at the design stage. This will mean RICS professionals will be uniquely placed to realise circular economy practices. Among the other built environment professions, it is our profession alone that is engaged at every stage of an asset's lifespan.

The successful adoption of circular economy practices will be heavily dependent on the buy-in of investors, so the importance of investors' risk perception and appetite, as well as their understanding of an asset's financing, can't be overlooked. Valuation standards are integral to building investors' trust; applied by trusted professionals, they aid transparency and give investors confidence in the underlying valuation.

Adapting to circular economy practices, and the techniques this will require, will drive broader adoption of new tools among RICS professionals. The profession is already closely involved with several innovations identified within this report, such as buildings passports and digital twins; blockchain, to assure the provenance of materials, will also become part of the toolkit. Throughout this, RICS will continue to advance the future of the profession, providing it with the guidance and resources that will be required to match the needs of the evolving landscape in which they work.

As a global industry, and for the benefit of future generations, we have to deliver the sustainable cities that a growing global population requires. Working together, we can pioneer better built environments at the same time as meeting the challenges that rapid urbanisation brings.

This means embracing innovation. It's often all too easy to see change as a threat, rather than an opportunity. But as this research shows, those who are bold enough to blaze a trail will ultimately deliver greater value for their clients and gain competitive edge.

Sean Tompkins | Global Chief Executive Officer | RICS

February 2020

Bosco Verticale, Milan

ENDORSEMENTS

"Many actors in the real estate sector recognise the need to move from a linear to a circular approach, but struggle with building the financial business case due to lack of evidence and examples. This report gives validity to several clear business cases to apply circular principles to asset management and development and should be an invitation to investors, financiers, construction companies and service providers to put these principles into practice to promote a virtuous circle of further evidence, more innovation and greater adoption."

Clemens Brenninkmeijer | Head of Sustainable Business Operations | Redevco B.V.

"This report clearly showcases the many ways public and private real estate investors can realise value in the circular economy. The transition it calls for must happen fast. Lejerbo has taken an important first step to demonstrate that circular construction is feasible for social housing through the Circle House project, which will see 60 homes built in line with circular economy principles by 2023. Building better homes within the constraints of our planetary and social boundaries is a key challenge for the coming decades; circular real estate investment plays a vital role in overcoming this challenge."

Jesper Kort Andersen | Project Lead Circle House | Lejerbo Housing Association

"We desperately need to rethink the whole building lifecycle and appreciate the resources our planet provides. Adopting one or more of the circular real estate business models in this report during the early stages of the development process can significantly decrease the need for raw materials by making use of existing building structures and materials. The key enabler is the idea of a material passport, which can help to unlock residual value that was unknown before, alongside the benefits of reduced waste creation and a lower carbon footprint."

Coen van Oostrom | Founder & CEO | EDGE

"This report provides practical steps towards a circular economy by identifying five ways companies in the real estate industry can adjust their business models. It is very useful in explaining the impact of the circular principles on the real estate sector and I am pleased JLL has been able to support the Ellen MacArthur Foundation and Arup by contributing to this report."

Guy Grainger | Chief Executive Officer, Europe, Middle East and Africa | JLL

"As this report makes clear, the shift towards circular economy needs to be viewed as a business strategy, not just a waste management or design strategy. Currently our industry has one foot firmly in the past, with the other stepping tentatively into the future. If we are to witness the kinds of productivity, efficiency, profitability and sustainability outcomes that are not only economically desirable but urgently required, and create places that are genuinely fit for the future, we need to take a bold leap forward and start deploying these strategies today."

Paul King | Managing Director Sustainability & Social Impact - Europe | Lendlease

"If we are to seriously reduce carbon emissions, it is necessary to get the construction industry involved. Realdania is currently investing in new circular economy projects to mature the market for circular construction in Denmark. We wholeheartedly welcome this important report which clearly shows the business potential of circular economy for real estate."

Simon Kofod-Svendsen | Project Director Sustainable Construction | Realdania

“This report brings a new focus on the economic impact of sustainable business models. There is an undeniable link between sustainable real estate investment decisions and financial performance. The positive results reported make a strong argument that the circular economy is more than the management of resources and waste in the real estate sector. It’s also clear that a change of behavior by all parties (i.e. landlords, tenants, asset / property managers) and a review of regulation (e.g. accounting standards) is required to support and incentivise the uptake of circular business models in the future.”

Alexander Piur | Head of Innovation & Sustainability, Real Estate | ING Wholesale Banking

“Ronan Group is hugely encouraged by the ‘Realising the value of circular economy in real estate’ report findings. The Ellen MacArthur Foundation and Arup led initiative provides clear and timely blueprints for the application of circular principles to the real estate sector. The United Nations estimates that the built environment accounts for 40% of global energy use and 30% of energy-related greenhouse gas emissions. Consequently, as real estate industry leaders we have an ethical responsibility to adopt socially and environmentally progressive solutions. The time for debate has passed – the time is now – and it is to be hoped that this report will provide the catalyst for action. We must lead by example, and we will.”

John Ronan Jnr | Director | Ronan Group Real Estate

“British Land is delighted to endorse the findings of this report. We recognise the importance of emerging circular economy thinking for the real estate sector, and acknowledge that the principles of a circular economy will play a key part in helping the UK’s transition to a net zero carbon economy.”

Nigel Webb | Head of Development | British Land

“Our society is at beginning of a profound shift towards a circular economy. The traditional linear economy model shaped our world, giving us the possibility to thrive throughout the last century, but this achievement has come with huge environmental consequences. The real estate sector is the largest carbon emitter and the largest waste producer. This report sets the basis for the real estate sector to identify the technical and financial challenges that our industry shall address to sustain our industry and the future of our generations.”

Stefano Corbella | Sustainability Officer | COIMA

“We believe that the only way forward for our industry is to go from a linear to a circular business model. H&M Group is currently in the process of defining and setting a strategy for circular built environment and the findings from this report will provide important input parameters for our future journey, especially considering the definitions of circular KPI’s and business models. Additionally, we are also welcoming the external collaboration behind this report since we believe that industry-wide collaboration is key to create long lasting change.”

Ulrika Nordvall Bardh | Circular Strategy Lead Non-Commercial Goods | H&M Group

London skyline

© Paul Carstairs / Arup

PROJECT TEAM

PROJECT LEADS

ARUP

Arup is an independent firm of designers, planners, engineers, consultants and technical specialists, working across every aspect of today's built environment. Together we help our clients solve their most complex challenges – turning exciting ideas into tangible reality as we strive to find a better way and shape a better world.

ELLEN MACARTHUR FOUNDATION

The Ellen MacArthur Foundation was launched in 2010 with the aim of accelerating the transition to the circular economy. Since its creation, the charity has emerged as a global thought leader, putting circular economy on the agenda of decision-makers across businesses, governments, and academia.

PROJECT PARTNERS

3XN GXN

3XN Architects and GXN Innovation create buildings that challenge conventions while advancing a Scandinavian tradition of functionality and beauty. GXN is driving design innovation in materials, behaviour and technology, and with projects such as 'Building a Circular Future' and 'Circle House', the company is taking a lead in the circular economy.

EXPERT ADVISORS

JLL

JLL is a leading international professional services firm that specialises in real estate and investment management operating in over 80 countries. JLL is passionate about sustainability and was one of the first companies in the UK to commit to net zero carbon by 2030.

RICS

As a globally recognised professional body, everything RICS does is designed to effect positive change in the built and natural environments. Through its respected global standards, leading professional progression and its trusted data and insight, RICS promotes and enforces the highest professional standards in the development and management of land, real estate, construction and infrastructure.

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We would also like to thank all our roundtable attendees and five testbed partners for supporting this project.

GRAPHICS

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DISCLAIMER

EXECUTIVE SUMMARY

Improved financial performance of up to 18% over 12 years is available to investors and construction clients who unlock the potential of underutilised space in their portfolios. This is one of five new business models for real estate presented in this report, each of which offers better returns than business-as-usual. They demonstrate the potential of circular economy principles to improve the resource productivity of real estate while contributing to the decarbonisation of the sector.

This report is timely. Global leaders in business, government and cities have acknowledged the ideas behind a circular economy offer the opportunity to add value and reduce waste. At the same time, a new generation of customers are highly aware of the environmental and social costs of business-as-usual. Circular economy thinking offers real estate investors a framework for achieving environmental and social goals while at the same time delivering better economic performance. Yet until now, consideration of circular economy principles in this sector has principally focussed on design strategies, which is only half the story. This report tells the other half; how do real estate business models also need to change if circular economy principles are to scale in this sector?

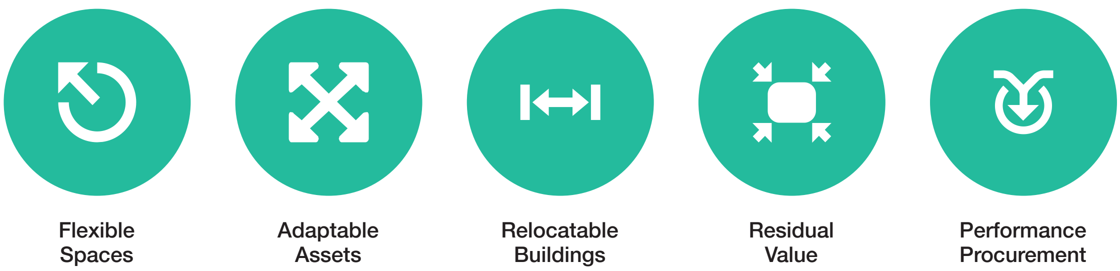
This report also comes at a time when the real estate sector is facing significant disruption, demanding a response from market players. A response to these trends based on linear ways of working will lock-in wasteful and polluting practices for the foreseeable future, just at the moment when the sector needs to eliminate waste and decarbonise. This report presents business models which work with these trends while also giving asset owners the ability to rapidly reposition assets if the worst happens.

The lost value endemic within the sector presents profit opportunities which our models exploit to deliver returns. This report explores the possibility that new circular real estate business models can deliver better returns on a reduced resource footprint.

Projects in diverse sectors and markets can benefit from these models. Feasibility studies using data from real projects in commercial, residential, retail and mixed-use markets and in five European cities demonstrate the models have relevance across typologies and markets.

THE FIVE MODELS

Significant amounts of space in buildings is wasted. The average office is 40-60% unoccupied during office hours, while the space in UK higher education is 72% underutilised. The first model, called **Flexible Spaces**, builds on the trend of co-working spaces to unlock the potential of underutilised space in buildings while balancing the risks normally associated with short tenure space. When explored on a tenanted office space in Milan, the potential additional revenue was found to be equivalent to 18% of the net present lease cost over 12 years.



Buildings are typically demolished before they reach the end of their technical life. A model based on **Adaptable Assets** considers the value of creating buildings which are resilient to both changing market conditions and social expectations by being able to adapt to alternative uses. This is tested on a residential development in Denmark and found to increase its internal rate of return by 3% over 50 years.

Meanwhile uses on otherwise vacant sites are an increasingly popular tactic for developers looking to create places and build a brand ahead of major regeneration schemes. Yet many existing building solutions for these temporary uses are architecturally constrained and can have poor operational performance. A business model based on **Relocatable Buildings** moving across several sites in Amsterdam could create an internal rate of return of up to 26% over 11 years without accounting for land costs.

Material depreciation in the built environment accounts for approximately €2.1tn of lost value each year. The **Residual Value** model envisages the creation of tradable futures contracts related to the value of building materials at deconstruction. During construction, clients can sell these futures contracts, which then could be traded while the building is operational, changing in value in response to local real estate and global commodity markets. Transfer of ownership and cash settlement takes place upon deconstruction after which the materials re-enter the market for reuse. This model reduced the whole life cost of ownership by over 5% across 10 years when tested on a retail fitout in Berlin.

Approximately 20-40% of building energy could be profitably conserved, with many buildings not performing as designed. One response to this is to pay for performance, not products, a key idea in product-as-a-service business models. Scaling this approach up to whole building systems creates the concept of **Performance Procurement**, which when tested for a build-to-rent development in London delivered up to a 3% improvement in internal rate of return over 30 years.

NEXT STEPS

The models demonstrate how circular economy principles can be operationalised to deliver improved financial performance to real estate investors and construction clients. To deliver their full value, these models will require new roles, relationships and requirements to be disseminated throughout the value chain. This report offers initial thoughts on what these roles, relationships and requirements might be.

It is also important to note the models are not exclusive – they are presented separately in this report for simplicity, yet it is likely that many projects will be able to realise even greater value by adopting several of the models, either in combination or for different elements of a single development.

Ultimately this report is a call to action directed at the real estate investment and construction client communities. It articulates how circular economy principles can be realised in practice by adopting real estate business models and demonstrates that they could deliver improved financial performance using discounted cash flow analysis. Moreover, it lays out what practical changes can be made on projects to make these models everyday industry practices.

What is needed now are commercial-scale pilot projects to demonstrate this potential is achievable.

The report concludes with four calls to action:

Action 1: Investor and construction client communities must lead the adoption of circular principles on scalable, commercial-scale real estate projects. This entails those communities evaluating the models presented in this report against their own specific needs and ambitions. Commercial directors should review their project strategies checking against the sources of lost value identified here. Investors and construction clients will need to challenge their commercial and sustainability professionals to adopt circular economy thinking to create and respond to new project briefs.

Action 2: Real estate professionals must drive this conversation. This report starts a conversation between those already driving change in the industry and those who are stuck in the linear, business-as-usual model. Communities of experts such as agents, insurers and accountants must be part of this conversation, and must be ready to over-turn long-standing conventions, framed entirely on linear economy thinking, to realise the opportunity presented by circular business models.

Action 3: Policy makers must be involved from the beginning of commercial-scale pilots. If private sector influencers lead on applying circular business models and reporting their benefits, they will create the evidence base that policy makers are requesting to ensure these approaches are adopted across the market and at all levels of the value chain. In some cases, policy changes will be needed for these models to be realised, for example, planning policies may need to adapt to facilitate widespread uptake of Relocatable Buildings. Requests to policy makers to support circular economy implementation are more likely to succeed if policy makers have seen for themselves the value unlocked by this approach.

Action 4: Evaluation tools which capture lost value must be developed. Value is lost because current evaluation models do not measure it. The resulting externalities are the climate emergency, the waste mountain and collapsing biodiversity. Real estate evaluation models that inform investors on projects that will make a positive contribution to restoring damaged natural systems are sorely needed.

CIRCULAR ECONOMY AS A BUSINESS STRATEGY

Circular economy approaches will only be adopted at scale if business models change. In other words, circular economy needs to be viewed as a business strategy, not just a waste management or a design strategy.

If a critical mass of investors and construction clients embraces this message and takes the actions above, we are confident the real estate sector can deliver significant returns while reducing its negative burden on the planet. Success in this will help meet financial, economic, social and environmental needs – making a positive impact, not just reducing negative ones – on a reduced resource footprint.

The procurement power held by investors and construction clients is immense. We are confident that the supply chain will respond to their lead, investing in new service offerings that deliver non-toxic, durable, reusable and repairable products as part of high-performance, user-focussed systems.

As this shift happens, the whole sector will move from discussing principles to changing practices, to create a more productive, more agile and less damaging real estate sector, accelerating the global transition to a circular built environment.

Futurium, Berlin

INTRODUCTION

THE OPPORTUNITY OF A CIRCULAR BUILT ENVIRONMENT

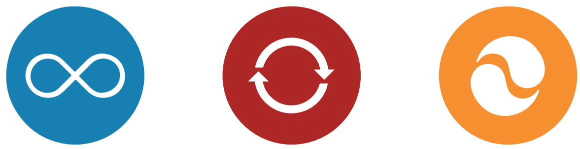
This report aims to demonstrate to real estate investors and construction clients the financial opportunity associated with applying circular economy business models to built environment assets.

The built environment - comprised of the man-made elements of our surroundings such as buildings and infrastructure – currently represents a major global consumer of natural resources and a significant contributor to global carbon emissions. This is because the built environment we live in today continues to be designed around the linear 'take-make-dispose' model, in which materials are sourced, used and then disposed of as waste. As a result, construction materials and the building sector are responsible for more than one-third of global resource consumption. Furthermore, current projections estimate that by 2060 across the world the equivalent of the city of Paris will be built each week.[1] With such trends, it is estimated that between now and 2050, carbon emissions from construction will be responsible for almost half of total new building emissions.[2]

The linear approach to current construction and building practices also results in significant structural waste (herein referred to as lost value): 40-60% of office space is unoccupied during working hours[3,4] and it is estimated that 20-40% of energy in existing buildings could be more profitably conserved.[5,6,7,8] Construction and demolition account for up to 40% of urban solid waste[9], and recovery of materials from buildings at end-of-life is often unattractive because the waste is hard to separate and contains toxic materials. These are all clear examples that the current linear system does not work and needs to change.

By contrast, a circular economy aims to decouple economic growth from the consumption of finite resources and build economic, natural, and social capital. Underpinned by a transition towards renewable energy sources and increasing use of renewable materials, the concept recognises the importance of the economy working effectively at all scales. This means it features active participation and collaboration between businesses both small and large, and from countries and cities to local communities and the people within them. Such a distributed, diverse, and inclusive economy will be better placed to create and share the benefits of a circular economy.

A circular economy approach employs three main principles:



DESIGNING OUT WASTE AND POLLUTION

KEEPING PRODUCTS AND MATERIALS IN USE

REGENERATING NATURAL SYSTEMS

Applying these principles to the built environment can create a sector that is resilient to volatile prices of raw materials, that maintains essential natural ecosystem services, and that creates urban areas that are more liveable, productive and convenient. Value is created by using design, technologies and business models to manage healthy, non-toxic materials and resources in loops that maintain them at their highest possible intrinsic value in every use. Our vision for a circular built environment (Appendix A), therefore embeds the principles of a circular economy across all its functions, establishing an urban system that is regenerative, accessible and abundant by design, thus supporting human well-being and natural systems.

Importantly, a transition to a circular built environment would also help to significantly reduce the carbon emissions associated with how we design, construct and use buildings. A recent report by the Ellen Macarthur Foundation titled ‘Completing the Picture: how the circular economy tackles climate change’, found that a circular scenario for the built environment could reduce global carbon emissions from building materials by 38% in 2050, due to a reduced demand for steel, aluminium, cement and plastic.[10] A report by C40 Cities (a network of the world’s megacities committed to addressing climate change), Arup and the University of Leeds exploring consumption-based emissions from 96 global cities found that material efficiency interventions for buildings and infrastructure has the highest emissions reduction impact, followed by enhancing building utilisation[11] - both circular economy strategies we explore further in this report.

Adopting circular economy approaches in a high-growth, high-waste sector like the built environment therefore presents a tremendous opportunity for investors and construction clients to minimise sources of lost value and thus improve return on investment from built environment assets, whilst also taking a fundamental step towards achieving carbon emissions targets.

IMPLEMENTING CIRCULAR ECONOMY IN THE BUILT ENVIRONMENT

Circular economy implementation can be considered at many different scales within the built environment, including component, building, city, national and global levels.[12] In order to realise the full opportunity of a circular built environment, new circular economy approaches will have to be implemented at all scales. However for this project, we have chosen to focus primarily on the building scale, exploring initiatives that influence the life cycle of a building as a whole. At the building scale, this will require the application of systems thinking and new approaches for the way stakeholders in the built environment develop, finance, procure, design, construct, operate, maintain, and repurpose building services and assets. Our research has identified two key approaches to implementing circular economy in the built environment - circular design and new business models.

CIRCULAR DESIGN

How buildings are designed is key to how they are used, the impact they have on their surroundings and how long they remain fit for purpose. Designing buildings in line with circular principles is therefore an important way of implementing circular economy in the built environment. Indeed, our analysis of over 100 built environment case studies showed that currently, the primary application of circular economy in the built environment is via design strategies for buildings, with a focus on reducing resource consumption and extending the life of materials and components.

Among the better known, but not yet widely adopted, circular design strategy is the shearing layers model. The concept of 'building in layers' was first proposed by architect Frank Duffy in the 1970s and developed by Stewart Brand in the 1990s.[13] Buildings, they said, are made of separate and interlinking layers, each with a different lifespan. Figure 1 shows Brand's model which includes six layers: Site, Structure, Skin, Services, Space Plan and Stuff.

Building in layers means elements with different lifespans can be separated and removed, allowing longer-lasting elements to be kept in use even if those with shorter lifespans require replacing. This facilitates reuse, remanufacture and recycling. For example, facades or heating systems may be designed and fitted as independent entities, integrated with other building systems but not entwined with the fabric of the building. This also avoids large scale wastage of assets, lowers resource use and other environmental impacts, and obviates the need to construct entirely new buildings and assets.

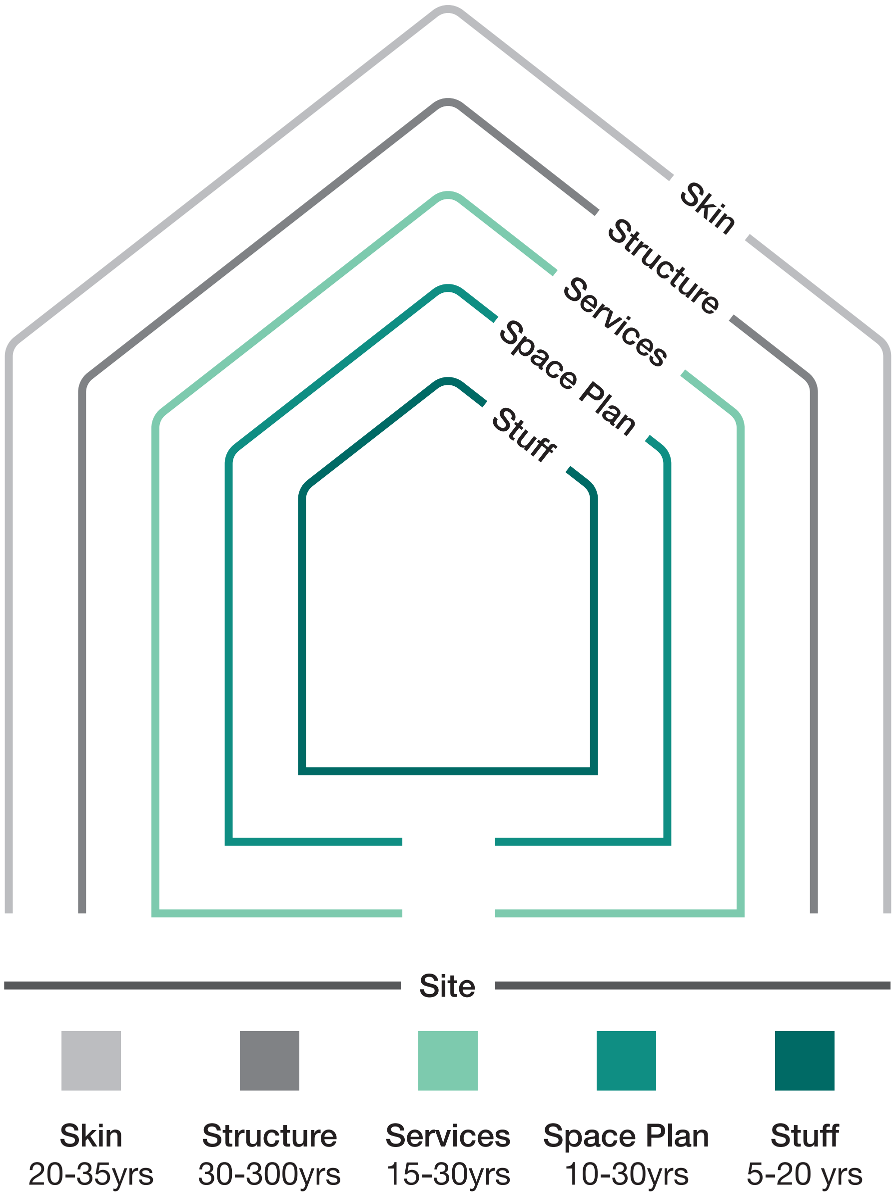
Building in separate layers with different lifespans also allows each element to be repaired, replaced, moved or adapted at different times without affecting the whole building or infrastructure asset. This reduces unnecessary obsolescence and increases flexibility of use and longevity over time. Design for deconstruction, design for ease of maintenance and report, design for flexibility, and design for adaptability are all examples of circular design that are supported by building in layers.

NEW BUSINESS MODELS

It is clear from Brand's model that circular economy design strategies have been around for some time. Yet we know that new circular products and approaches are not widespread in the built environment.[14] Why have they not scaled?

Our research shows that implementing circular economy in the built environment industry requires understanding of the whole building life cycle and the construction value chain, which involves high levels of collaboration and information exchange. In order to do this, new business models are needed that reimagine the currently fragmented value chain and facilitate more circular behaviour, for example by increasing asset use and fostering more use of reusable resources and components. New tools and incentives are required that enable investors to receive a financial return on decisions that affect not only the selling and leasing of properties and spaces, but also their end-of-use and repurposing.

There is therefore significant opportunity for stakeholders to extend their application of circular economy principles by implementing new business models. Businesses can take advantage of innovative ideas that harness both digital technologies and changing stakeholder behaviour to implement circular economy principles as well as encouraging smarter use of buildings. To ensure success, however, the enabling conditions also need to be right – potential and existing barriers to implementing circularity in the built environment need to be addressed. In particular, large-scale implementation of new business models that accelerate the shift to a circular built environment will only occur if key stakeholders can see how they add value.



Site is the fixed location of the building

Structure is the building's skeleton including the foundation and load-bearing elements

Skin is the façade and exterior

Services are the pipes, wires, energy and heating systems

Space Plan is the solid internal fit-out including walls and floors

Stuff is the rest of the internet fit-out including the furniture, lighting, and ICT

Figure 1. 6S building layers[13,15,16,17,18]

REALISING VALUE

Our research revealed that real estate investors and construction clients are fundamental to driving the transition to a circular built environment because they have the greatest capacity to set the direction and nature of their development strategies, ownership structures and operations models for each project across all stages of life cycles. We also heard from these stakeholders that uncertainty around how circular economy business models might work, and scepticism of whether the business case would stack up, contributed to a reluctance to implement circular business strategies.

We assert, therefore, that a crucial first step towards implementing scalable circular economy projects is the development of viable business models that help realise the added value of circular economy business models. If real estate investors and construction clients were to integrate circular economy as an inherent part of their overall business strategy, the building industry would begin to embed circular thinking in investment decisions, revenue models and the supply chain, moving beyond a singular focus on reduced resource consumption towards employing circular models that focus on realising maximum value from real estate assets.

To do this, we have developed five real estate business models based on circular economy principles that help to realise value from real estate assets in new ways, boosting their resource productivity. By testing the added financial value of these new circular business models using discounted cash flow analysis, we are in a position to deliver a message to the real estate investment community that adopting circular economy principles will deliver improved financial performance in their real estate portfolios.

To align the application of our models with market principles and professional practice we have, where appropriate, recognised and referred to International Valuation Standards (IVS), RICS Valuation - Global Standards, International Construction Measurement Standards (ICMS) and International Property Measurement Standards (IPMS).

We acknowledge that the circular economy is designed to create value beyond financial value, namely environmental, social and economic value. All value is important, yet we have set ourselves the challenge of demonstrating in the most direct sense the business case for adopting circular models; in other words, we want to prove these circular models deliver improved profitability in their own right.

STRUCTURE OF THIS REPORT

This report summarises the research and analysis carried out as part of this work and presents the overall conclusions from the *From Principles to Practices* project. We explore where value is being lost from the current, linear model of delivering real estate and key market trends that are influencing how buildings should be delivered. We then illustrate the opportunity that applying circular economy models creates to recover identified sources of lost value, and how such circular models can be applied using real world examples of different development types in five European cities. Finally, we evaluate the financial performance of the circular models, and consider some of the new relationships and requirements that might be needed to implement them. The outcome is a set of tangible models for realising circular value from real estate assets, referencing current professional standards and guidance, with financial estimates for the potential of these new approaches.

Circular Building, London

METHODOLOGY

The aim of this project is to convey a message to the real estate community that investing in circular economy development projects will deliver improved financial performance in their real estate portfolios.

We developed a four-stage methodology to substantiate that message with financial analyses based on real development projects. Each of these strands were delivered in parallel across five European cities: Aarhus, Amsterdam, Berlin, London and Milan.

We hope the response to this message will be invitations from real estate investors and construction clients to pilot these models on commercial scale projects, thereby creating the evidence base needed to scale this thinking across the industry.

1 IDENTIFYING SOURCES OF LOST VALUE AND MARKET TRENDS

Our first step was to hold semi-structured interviews and roundtables from long-standing real estate professionals. Participants included investors, construction clients, valuation professionals and consultants. The sessions captured insight to help shape the new circular real estate business models by interrogating what participants saw as the greatest sources of lost value in real estate assets and portfolios as well as the biggest trends affecting the future of the sector. We were supported by 3XN/GXN for the Danish interviews and roundtables.

2 DEVELOPING NEW CIRCULAR REAL ESTATE BUSINESS MODELS

We developed circular real estate business models inspired by circular economy principles to capture the lost value identified. These business models either build on existing business models and industry standards or are entirely new. This was a collaborative effort with input from 3XN/GXN, RICS and JLL. These models harness the trends bringing change to the real estate sector and are enabled by emerging digital technology.

BLOX, Copenhagen

3
TESTING THE FINANCIAL VALUE

We tested the impact of the models at feasibility level using data from real development projects (hereafter referred to as ‘testbed projects’), by comparing the investment value of the circular model to a business as usual, linear equivalent. Discounted cash flow analysis was used to estimate the investment performance in each case.

4
CONSIDERING NEW RELATIONSHIPS AND REQUIREMENTS

The models require new relationships to be established between value chain participants, and new requirements to define the dependencies in those relationships. The methodology concludes with consideration of how the models change relationships and requirements at each stage of the development life cycle, and which value chain participants they affect. The intention is that these considerations will be translated into project briefs, giving a set of tangible practices that capture how a built environment operating on circular economy principles will differ from today.

Macquarie University Incubator, North Ryde

STUDY ASSUMPTIONS AND LIMITATIONS

This study does not consider site location within the assessment of the financial performance of each circular business model. This is because the economics of site location will vary dramatically according to geography and market dynamics and is valued in a different way to the other building layers. We acknowledge that the site location will have impact the financial performance of any real estate and therefore should be taken into account when considering the application of any circular business model.

Attendees at the investor roundtable discussions emphasised that adopting circular business models will impact the wider ecosystem within which the built environment industry operates in. This ecosystem is the legal, financial, planning and insurance practices, specific to markets and changing with time, within which real estate assets are developed.

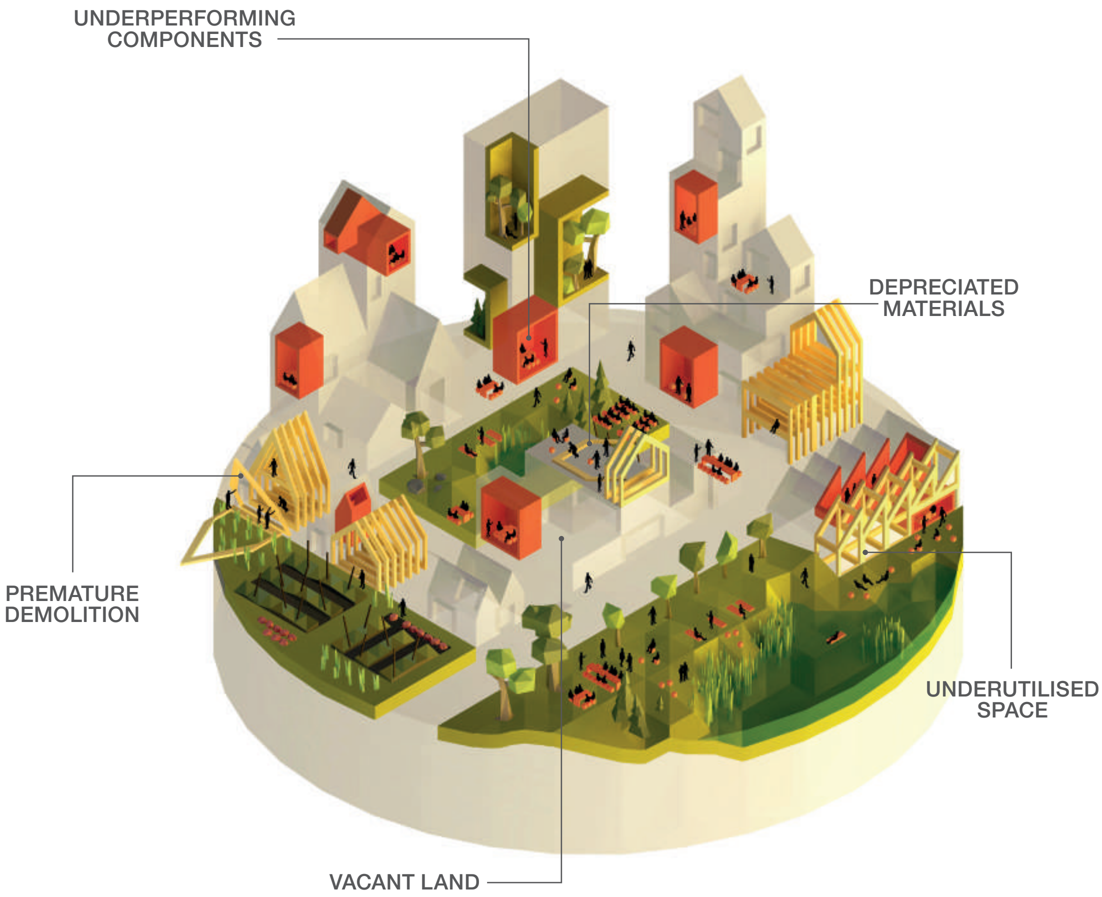
We have identified the following key factors which influence the wider ecosystem and could therefore affect the application of circular real estate business models:

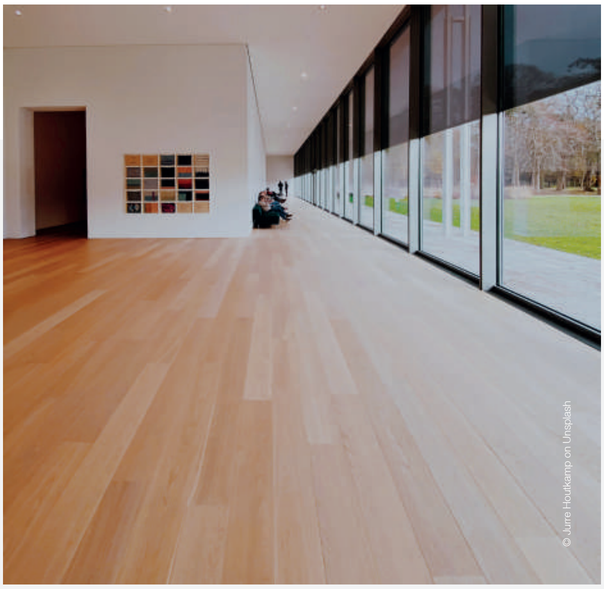
- Tax and capital allowances
- Supportive regulatory and policy changes
- Insurance requirements
- Financing
- Investor risk perception and appetite
- Applicable tenure type

It is outside the scope of this project to fully consider each of the above ecosystem factors. Further work is needed to consider their implications for the adoption of the models across the five study cities.

SOURCES OF LOST VALUE

Before developing effective value creation strategies, existing sources of lost or untapped value must be clearly identified. Roundtable discussions were held with real estate investors, clients and policymakers in each of the five study cities to explore sources of lost value in real estate. The five emerging sources arising from these discussions and their causes are provided in this section.





LOST VALUE 1. UNDERUTILISED SPACE

Description

Full revenue-generating potential of spaces is unrealised

Causes

- Commercial leases are designed to provide consistent rents to landlords irrespective of the tenant's headcount
- Commercial leases that prohibit subletting
- Tenant concerns about security and a reluctance to change living or working practices to make their spaces available to others outside their core hours of occupation
- Uncertain demand for space outside core hours of occupation

LOST VALUE 2. PREMATURE DEMOLITION

Description

Buildings are demolished even when they still provide usable spaces

Causes

- Demolition and divestment decisions are made based on the economic life (generic time period over which assets are depreciated to zero on company balance sheets) and opportunity cost (demolition and reconstruction is seen as a necessary investment to reduce liabilities and unlock the income generation potential of the site) rather than the technical life (the time period that a building and its structural materials could last)[19]
- Current spaces in buildings focus on a single use. Retrofits and refurbishments are likely to be constrained by the existing shell and core
- Refurbishments of unadaptable buildings are often not viable as they cannot add sufficient area to generate the necessary returns. In such cases, redevelopment is therefore only viable if significant area is added to the site, creating pressure for larger, denser development
- Changing planning and building regulations allow ongoing use of existing buildings but preclude significant retrofits or changes of use
- Split incentives between the original construction client who pays costs for adaptability and subsequent asset owners who benefits from owning an adaptable building

LOST VALUE 3. VACANT LAND

Description

Land not being used for any purpose or awaiting development

Causes

- The time taken to assemble plots and secure permission for new developments, particularly complex mixed-use developments on challenging urban brownfield sites
- Developers sitting on land without planning permission (also known as 'land banks') in anticipation of rising prices
- Many existing temporary building solutions do not provide an attractive option due to being architecturally limited and low-quality

LOST VALUE 4. DEPRECIATED MATERIALS

Description

Building materials lose market value

Causes

- Standard industry depreciation rates are used for accounting purposes; materials and components may lose value more quickly on paper than they actually do during use
- Buildings are not designed for deconstruction, which increases the cost of recovering reusable materials. These higher costs absorb the profit opportunity related to the price difference between virgin and scrap material
- Initial investors are not incentivised to absorb additional construction costs to ensure materials can be removed from buildings at their highest value; any value that does remain in the materials is normally captured by the demolition sector, long after the investor has moved on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LOST VALUE 5. UNDERPERFORMING COMPONENTS

Description

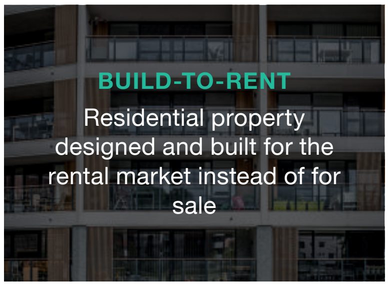
Buildings and their systems do not perform as they were designed or installed

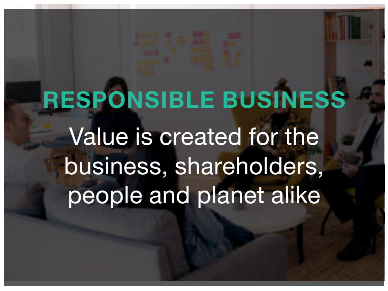
Causes

- The separation of capital and operational budgets disincentives life cycle thinking
- Capital budgets run low at the end of a project, just when resource is needed to commission building systems properly. This hits more complex energy efficient systems hardest, impacting building performance

MARKET TRENDS

To ensure that the value creation strategies are market relevant, the context in which they will operate should be considered. Six key trends facing the real estate sector, shaped by a combination of social needs, technological advances and regulatory changes, are described in this section. It is important that buildings are delivered in a way that responds to user preferences and requirements. The trends therefore provide important framing and context for the development of new business models in the real estate sector and should inform the way they are structured and implemented.





TREND 1. FLEXIBLE OFFICE SPACE

According to a recent report by Ernst & Young, four of the top ten reasons millennials - who will represent 75% of the global workforce by 2025 - have been found to quit their jobs relate to a lack of flexibility in how and where they can work.[20] Companies ranging from start-ups to corporations are increasingly seeking enhanced flexibility in the office space they occupy in response to their growing number of agile employees.

This has led to a rise in flexible office spaces, which aim to match office space supply with demand through lease agreements that vary in length from days to months (and sometimes years). As well as short lease lengths, rolling month-to-month contracts and shorter notice periods are common for flexible office spaces. The spaces are typically shared among several tenants in the form of serviced offices. Hot-desks might be used by several people throughout the day while communal areas serve multiple companies.

A global survey with over 7,300 office users by JLL found co-working spaces can support employee engagement more than other traditional work environments.[21] JLL also report that the flexible office space sector in Europe has more than doubled in size since 2014 and is set to grow up to 30% per year by 2023. Well-known players such as WeWork, The Instant Group, IWG, The Bureau and Work Club Global are already established in the sector. Additionally, a number of more traditional organisations are investing in flexible office spaces, including OVG (EDGE), L&G (Capsule), Tishman Speyer (Studio) and Landsec (Myo).

TREND 2. CO-LIVING

It is not just workspaces, but also living spaces that people are starting to share. Co-living providers offer private bedrooms with shared amenities such as kitchens, dining rooms, libraries, gyms, bars, restaurants and other social spaces. Tenants typically pay one monthly bill to cover everything, including utilities and taxes.

In PWC's survey on emerging trends in real estate for 2019, co-living ranked highest for investment and development prospects in the 'alternative' investment ranking.[22] Other subareas of co-living were also placed in the top ten, with retirement/assisted living coming in 3rd while student housing ranked 6th.

The demand for co-living is thought to result from increasing social isolation and excessive rent prices in prime accessible neighbourhoods. The Housing Anywhere European Rent Index shows that residential rental prices rose across Europe in 2018 compared to the previous year: 7.3% in Berlin, 3.4% in Milan, 3.3% in Amsterdam and 2.1% in London.[23] According to a Harvard report, social isolation has increased two-fold in the last 20 years.[24] This is linked to the age of the internet on millennials and the loss of contact with friends and family, decreased mobility, poor health, single living or limited income within the over-65 demographic.[25]

Recently, co-living developments aimed specifically at millennials have increased, with recent market entrants including Homy, Roam and Outsite. The Collective, the UK's largest co-living provider, has portfolio expansion plans for 4,500 co-living apartments across the UK, US and Germany.[26]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TREND 3. BUILD-TO-RENT

Difficulty in accessing mortgage finance and the experience economy has created 'Generation Rent', which has given rise to the 'build-to-rent' (or sometimes referred to as 'multifamily') model. Under build-to-rent, landlords focus on the provision of "services" such as high-speed internet, cleaning and laundry services, access to gyms and recreational space, and tastefully planned community events – much like co-living.

A market study by JLL in 2019 indicated that Germany had the largest build-to-rent market in Europe at €18.6bn, while the second largest is the UK at €6.8bn.[27] In the UK, Savills reported that the build-to-rent pipeline grew almost five-fold (478%) between 2013 and 2018. As of Q4 2019, there were just over 40,000 build-to-rent homes operational in the UK with 112,000 homes under planning or construction. The Netherlands and Denmark have slightly smaller market sizes than the UK at €5.6bn and €4.5bn, respectively.[28]

A report by CBRE 'The rise of investment in multifamily housing', published in June 2019, highlighted this growth, stating that multifamily has now become the second largest sector for real estate investments in Europe, tripling in size since 2007 and with cross-border investments more than doubling over the last four years.[29]


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TREND 4. E-COMMERCE

According to Statista, in 2019, retail e-commerce sales worldwide amounted to US $3.5tn and e-retail revenues are projected to grow to US $6.5tn in 2022.[30]

One challenge for retailers has become balancing high street presence with their e-commerce market; mixed-use environments with flexible spaces and a diverse service offering are increasingly seen as vital to the success of retail asset.[31] For example, some Uniqlo stores offer in-store events including yoga mornings and meditation classes. Selfridges has launched a live-theatre, integrating a space for events and even a skateboarding ramp into its London flagship store. Some established brands have taken a different approach and explored short-term retail pop up or concept stores. One example from clothes retailer COS is a modular installation in Milan from 2013 designed to be reconstructable in any shape or format, with the aspiration to relocate it in other cities in the future.[32] Dimension Data reports that 84% of companies who improve their in-store customer experience see a revenue increase.[33]

The increase in e-commerce will also see an increase in distribution and logistics centres. E-commerce operations require three times the amount of warehouse space that brick-and-mortar stores need to guarantee that inventory is on hand and returns can be processed in a timely manner.[34] The increased growth of e-commerce also drives demand for new, adaptable facilities, characterised by modular design and flexible semi-permanent structures, including small-scale micro-depots deployed to enable the decarbonisation of last-mile deliveries.[35] The European warehousing and logistics market is growing rapidly, with 1.3m sqm per year of new logistics and distribution assets in Central and Eastern Europe markets required until at least 2022.[36] Logistics facilities were ranked second in the 'alternative' investment category for investment and development prospects by PWC in their latest survey on emerging trends in real estate.[22]

TREND 5. SHORT LEASES OR OWNERSHIP

A PWC report acknowledges that asset needs are changing due to the latest accounting standards, which will likely affect asset managers' business models and service offerings.[37] Accounting standard IFRS16, which became effective 1 January 2019, requires a lessee to recognise assets and liabilities for all leases with a term of more than 12 months, unless the underlying asset is below a threshold value. The full term, therefore, of a lease obligation is now required to be shown on balance sheets, meaning long leases will show up as big liabilities on balance sheets. A Bloomberg report in 2017 estimated that companies had placed as much as US $3tn of operating lease obligations 'off balance sheet', demonstrating the scale of the transition.[38]

This is driving a trend in both short-term leasing and ownership over long-term leasing for commercial properties, increasing payment variability. The result would be increased risks. Asset managers might therefore focus on the acceleration of existing market developments in leasing and co-working, focussing mainly on services rather than on tangible assets. IFRS16 may well motivate large companies to consider co-working and more flexible leasing contracts to reduce the impact of financial leases on their balance sheets.

Conversely, it could eventually become more financially attractive for a company to purchase the building they are currently leasing. Some banking and financial institutions who have typically remained long-term tenants are already considering this. For example, Citigroup bought its 25 Canada Square skyscraper offices in London. "The purchase is in line with the Citi strategy of owning rather than renting our major premises in an effort to cut costs in the long term," said a spokesperson for the company.[39]

TREND 6. RESPONSIBLE BUSINESS

A responsible business is one that puts creation of shareholder value alongside making a positive long-term impact for wider stakeholders at the heart of their strategy. These wider stakeholders include customers, the community and wider society, the environment, and co-creators including staff and suppliers.

In a recent survey conducted by the World Economic Forum, almost 50% of millennials believe that climate change and sustainability issues should be a major concern of governments and institutions.[40] In late 2018, BlackRock CEO Larry Fink claimed that within the next five years, all investors will measure a company's impact on environmental, social and governance (ESG) factors to determine its worth.[41] An increasing number of investment funds are including ESG criteria into their decision-making process and more real estate managers are recognising the importance of including social and environmental factors in the long term.

Sustainable investments have grown 34% globally in the last two years, mainly as a response to climate change.[42] BNP Paribas had already dedicated €155bn to the energy transition and to the achievement of the United Nations Sustainable Development Goals by the end of 201743, Intesa Sanpaolo opened a credit ceiling of up to €5bn for innovative circular economy businesses in 2018[44] and BlackRock launched a circular economy fund with US$20m seed funding in 2019 to drive investment in businesses contributing to the transition to a circular economy.[45] Additionally, ABN AMRO has said it wants to finance at least €3bn worth of sustainable assets by 2020 of which €1bn will be in circular business assets.[46]

CIRCULAR REAL ESTATE BUSINESS MODELS

Lost value and market trends present themselves as business opportunities. This project proposes five new business models which capture each source of lost value and respond to the market trends using circular economy principles.

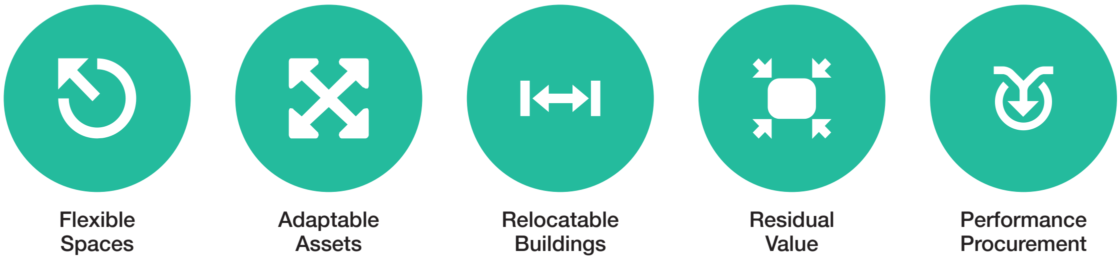


Figure 2. Five circular real estate business models

These models have been developed with input from 3XN/GXN, JLL and RICS. The models deliberately challenge conventional thinking and processes, but at the same time reflect activity from organisations leading the transition to a circular built environment. The models have similar elements to those created by the EIT Climate-KIC funded Reusable Buildings Pathfinder project, developed independently and in parallel to this work.[47] This highlights a growing consensus on how circular economy principles are best applied to real estate.

For the purposes of illustration, each model is presented in isolation with the financial performance evaluated for one specific testbed project in one specific city to which the model has been applied. In reality, a development project could adopt more than one or even all five of the models. Early stage commitment from project leaders and a collaborative rather than a competitive approach from the supply chain will be required to identify which combination of models is best suited for each project.

In this section, each model is explored in detail and covers:

- **Overview:** A description of how the model works, how it relates to circular economy, enabling conditions and what might be required for the model to be applied at scale.
- **Modelling the testbed:** Information about the testbed project and how it has been modelled to evaluate the financial value created by the circular business model compared to a linear model equivalent using illustrative cash flow model diagrams.
- **Exploring the financial performance:** An assessment of the financial performance of the model in the context of a selected testbed project with sensitivity analysis on identified inputs.
- **New relationships and requirements:** A consideration of the relationships and requirements needed to implement the circular model, looking at the key activities and stakeholders involved across the life cycle of a development project.
- **Applications:** The building typologies and situations where the model could be adopted both now and in the future.

MODELLING APPROACH

Discounted Cash Flow (DCF) analysis is a widely used method for determining the Net Present Value (NPV) of a project (i.e. the value of a project in today's monetary terms) by discounting the project's estimated future cash flows using the time value of money concept.[48] By discounting estimated future cash flows for projects under consideration for investment to their NPV, the financial performance of these projects can be evaluated and compared against each other. A positive NPV indicates that the investment would be profitable whereas a negative NPV indicates that the investment would result in a loss.

The NPV formula is presented below:

$$\mathbf{NPV} = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \cdots + \frac{CF_n}{(1+r)^n}$$

NPV = net present value
CF = cash flow
r = discount or interest rate
n = the cash flow period

In order to evaluate the financial performance of the five circular real estate business models, DCF analysis has been undertaken to compare the cash flows of each of the circular models to a linear model equivalent. For this analysis, estimated future cash flows only at the earnings before interest, tax, depreciation and amortisation (EBITDA) level have been analysed given the financial information available for each testbed project.

To understand the difference in the type and timing of the cash flows between the linear and circular models, annual cash flows have been developed over a selected evaluation period. In this report, the annual cash flows are presented by simplified cash flow diagrams as illustrated in Figure 3. The green box indicates from which stakeholder's perspective the cash flow has been modelled. The horizontal line represents the time axis with the light grey text indicating the construction period and the dark grey text representing the operational period. The revenues and costs are shown separately for construction and operation. The length of the arrows are only indicative of the value they represent rather than scaled. Light green text and arrows in the circular model cash flow diagrams represent changes to the cash flow from the linear model. Further detail on the inputs and assumptions for each cash flow model is provided in Appendix B.

The financial information provided for each testbed has been reviewed with relevant inputs added to the DCF analysis. This has been supported by desktop research to develop missing inputs and other assumptions, where required, for both the linear and circular models. The financial performance has been calculated as either an Internal Rate of Return (IRR) or Net Present Cost (NPC). The IRR calculates what the discount rate would need to be for the NPV to equal zero. If the IRR exceeds the opportunity cost of capital (rate of return that can be earned elsewhere), the project should be accepted. The NPC is the sum of the present value of all costs over the evaluation period and has been calculated in cases where the testbed's revenue streams are not pertinent.

The findings have been presented in a manner which ensures that individual testbed projects are non-identifiable given the confidential nature of the information provided and does not take into account how any additional financial value achieved could be shared between the stakeholders involved in each model. Given the level of uncertainty with some of the assumptions, and to understand the key drivers in each of the circular real estate models, sensitivity analysis has been undertaken on selected inputs.

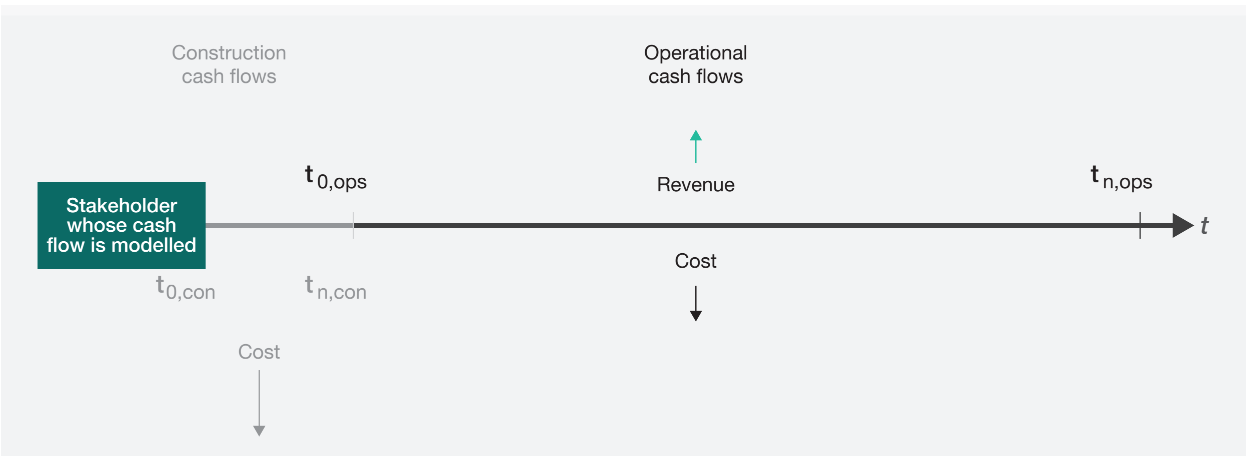


Figure 3. Format of illustrative cashflow diagrams

FLEXIBLE SPACES

Lost value captured: Underutilised space

Profit opportunity: Increased revenue from additional tenants

Supporting fact: According to CoreNet Global research published in 2012, traditional firms underutilise workspace by 40-50%.[3] A study by the British Council for offices published in 2018 found that workspaces are under-occupied by between 50-60% through the core working day.[4] It has been estimated that sharing and multi-purposing buildings could add €300–€450m to the Danish economy by 2035.[49]

OVERVIEW

The Flexible Spaces model seeks to list existing, underutilised building spaces for short-term use on online platforms. The spaces could be completely unused or in use but under-occupied. Depending on the lease agreements, either one of the following three parties could be responsible for arranging additional tenants to rent the space:

1. Landlord: The core tenant signs a lease which includes provisions allowing the landlord to advertise unused space through agreed processes. The landlord leads on finding additional tenants in parallel with the anchor tenant. The landlord controls who accesses the space.

2. Anchor tenant: An anchor tenant will sign a lease with a typical lease period, but with clauses that allow them to maximise the use of their spaces. The tenant leads on finding additional tenants and controls who accesses the space.

3. Third party operator: The anchor tenant and / or landlord work with a third party space sharing platform operator who run their business model on a portfolio of underutilised space. The third party leads on finding additional tenants and controls who accesses the space, with oversight from the anchor tenant and / or landlord.

The spaces can be listed on platforms in real time if a building is ‘smart,’ in that it can feed live information on space availability to the platform. The additional revenue generated (the upside) could be shared between the landlord and tenant by changing the fixed rent price or through a pain / gain share mechanism. The model offers the asset-utilisation-boosting capacity of the sharing economy without the risk and volatility that part of the flexible space market is currently facing.

The link to circular economy is clear: if existing spaces are used more smartly and to their full potential using new business models, the need to build new spaces and the resource use associated with that is avoided. The model gives people in need of short-term space the opportunity to access well-designed spaces. There are also potential benefits around bringing diversity of thought into the workplace and connecting different industries.

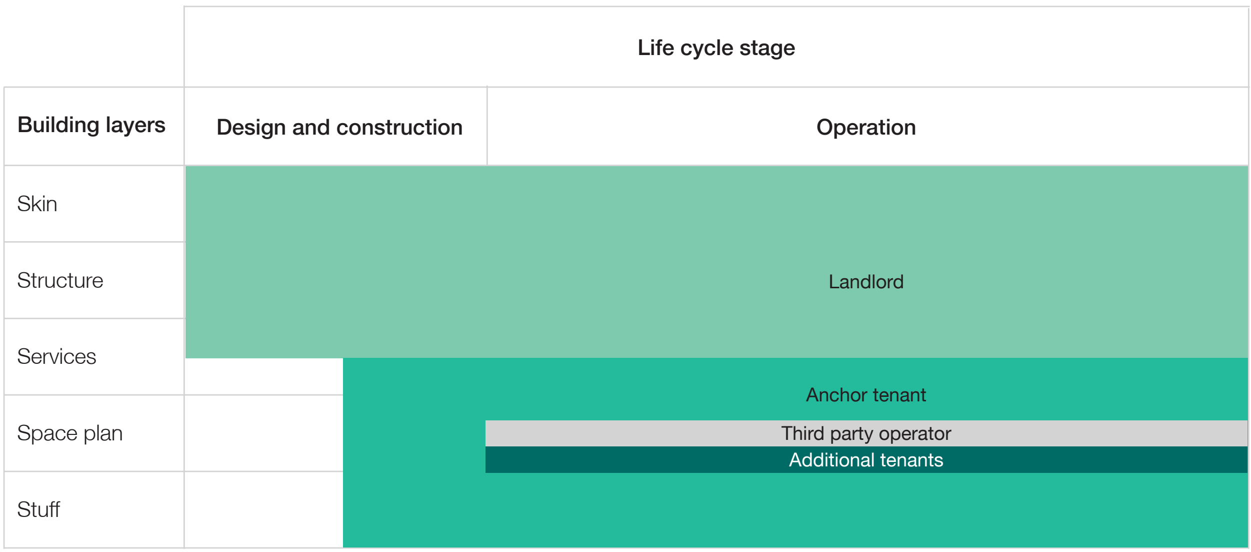


Figure 4. Key stakeholders by life cycle stage and building layer for Flexible Spaces

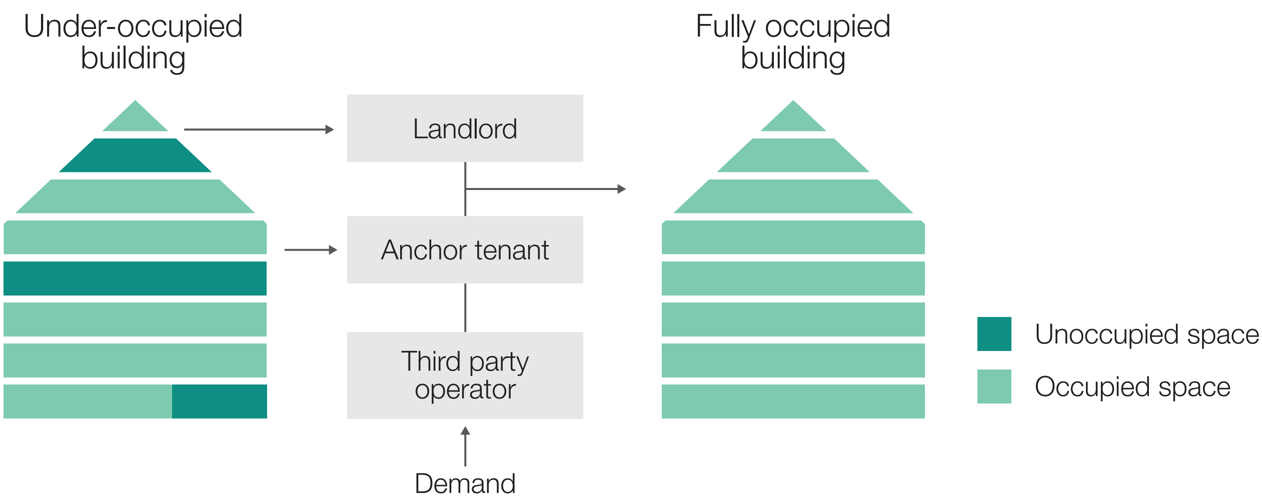


Figure 5. Schematic of Flexible Spaces during operation

Planning authorities will need to be as flexible as the building to support the model, for example, allow additional uses that may be considered non-compliant with the planning use class of the building.

For this model to succeed, a real focus is needed on changing behaviours. One of our investor roundtable attendees put it well; organisations need to "change how they operate before they change how they build." It is acknowledged that for some organisations, sharing space is not an option given the sensitivity of what they do. Yet, the growth of shared offices in the co-working market shows that, for many occupiers, sharing space is compatible with their operational and security needs. For participating existing offices, a new approach to desk allocation will also be needed, building on discussions around agile and flexible working.

Traditionally rigid tenure types like commercial leases will need to change to permit the use of underutilised space. The way in which repair costs are charged by the landlord will need to be reconsidered – irrespective of whether it is a full repairing and insuring lease, an internal repairing insuring lease or a new type of lease altogether. Insurance, whether held by the tenant or the landlord, will need to be appropriately priced for additional risks arising from more diverse and increased use of the building.

Architects and engineers will need to develop design approaches that move away from mono-functional spaces in favour of flexibility. This will be best delivered through open plan design, flexible fitout solutions, smart components and sensors, building services design that accommodates multiple uses, supportive building management systems and security design.[50] However, implementing flexibility into a space does not necessarily demand additional costs; it depends on the desired level of flexibility and the additional measures required to deliver it.

Elements of the technology needed to deliver this model are proven in the marketplace. In Amsterdam, space availability information is already available through a city scale pilot project called "Vacant Space Finding". Registered users of the platform can book and use those spaces for a fee, increasing space utilisation and boosting revenue for the building owners. Also in Amsterdam, The Edge building developed by OVG and occupied by Deloitte, has a smart building system that allocates space in the building each day to every employee based on their work schedule. Space sharing platforms like Hire Space in London mean that these spaces can be brought to market with bearable transaction costs, and the review systems and security offered by sharing economy applications like Airbnb could be used to give primary occupants the reassurance that they know who they are sharing their space with.

MODELLING THE TESTBED

The testbed chosen for the Flexible Spaces model is a tenanted office in Milan with the tenant organisation looking to expand into a 270m^2 extension to their existing office space. The tenant organisation decided to extend the office (with agreement from the landlord) in anticipation of future growth in headcount. The extension took one month to complete and was undertaken while the office remained operational. This testbed lends itself well to the model as, following expansion, there are several spaces within the office that can be listed on the platform, including desk space in the extension as well as open space and convertible meeting rooms in the original space.

Under the linear model, there remain significant areas of underutilised desk space during core working hours in the early years of the lease term. However, as the tenant organisation grows over the remaining 12 years of the lease term, there are fewer unoccupied desks as shown in Figure 6. The open space and convertible meeting rooms are only used by the tenant organisation during normal working hours.

The cash flows for the linear model are presented in Figure 7 (overleaf).

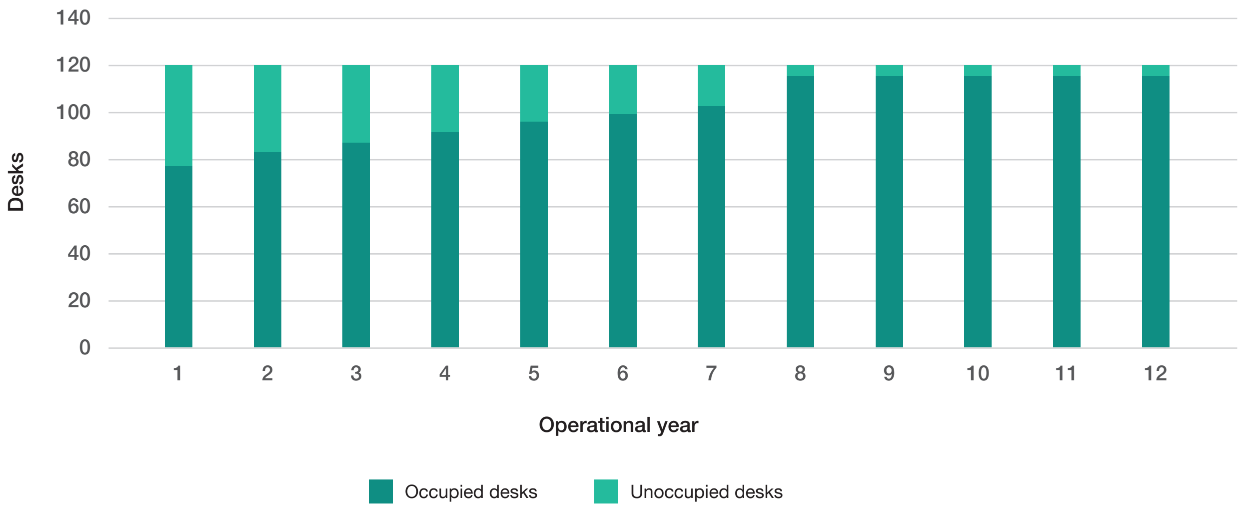


Figure 6. Occupied vs. Unoccupied desks under the linear model

The circular model allows for additional revenue streams to be created by renting out available desks during core working hours, as well as offering unused open spaces and meeting rooms for activities such as fitness classes and corporate meetings outside office hours. The model is based on a high-level market assessment undertaken by the testbed partner reflective of a moderate additional space use scenario.

In the analysis, the additional capital expenditure required to make the space flexible is not considered as the additional uses are accommodated by the existing design (this is considered further in the sensitivity analysis). Furthermore, it has been assumed that any additional net income (additional rental income minus additional operating costs) is earned by the tenant. In practice, this could be shared with the landlord depending on the commercial arrangements between the parties.

The cash flows for the circular model are presented in Figure 8. Like the linear model, the extension is indicated as a cost during the operational period as it took place while the rest of the office was still operational.

A summary of the key inputs and assumptions for the DCFs are presented in Appendix B.

7am–9am	No. of fitness classes	2 hours, twice a week
9am–6pm	Co-working occupancy of unused desks	75%
6pm–10pm	No. of fitness classes	2 hours, twice a week
	No. of night classes	3 hours, once a week
	No. of meetings or corporate events	15 per year

Table 1. Additional space use - moderate scenario

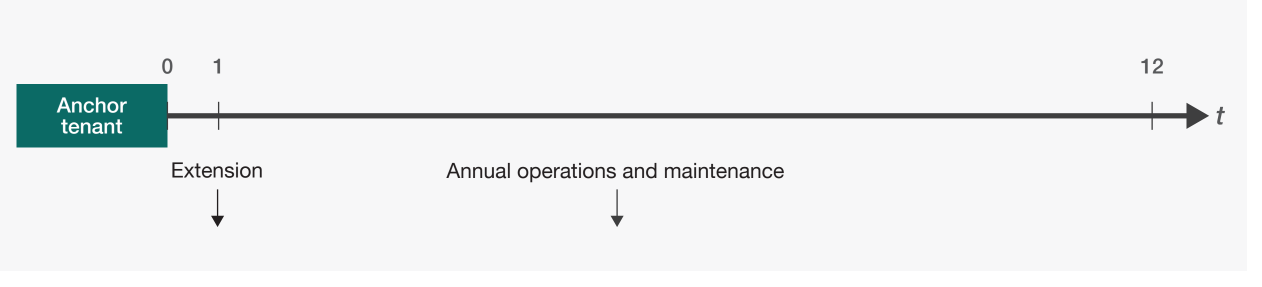


Figure 7. Illustrative cash flows modelled for the comparable linear model of Flexible Spaces

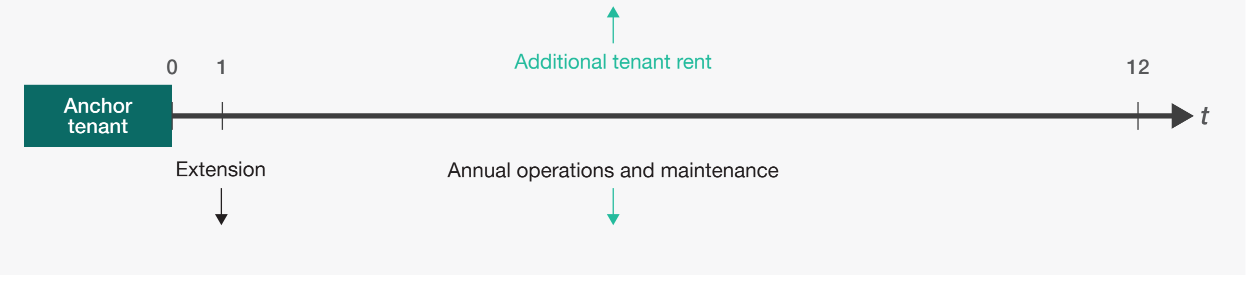


Figure 8. Illustrative cash flows modelled for Flexible Spaces

EXPLORING THE FINANCIAL PERFORMANCE

By applying the Flexible Spaces model to the testbed project, the additional net income earned equates to an NPC saving of 18% over the remaining 12-year lease term (circular base case) compared to the linear model.

A sensitivity analysis has been undertaken for:

1. the extent of additional space use
2. the additional cost of designing for flexibility

The additional tenant rent received remains the largest source of uncertainty. Optimistic and pessimistic additional space use scenarios have been developed to compare their financial performance with that calculated for the circular base case. The optimistic scenario considers a greater uptake of co-working from 75% to 90% of unoccupied desks, while the pessimistic scenario considers an uptake of 50%, as well as a reduction in out-of-hours activity. The three additional space use scenarios are presented in Table 2.

		Pessimistic	Moderate (circular base case)	Optimistic
7am–9am	No. of fitness classes	None	2 hours, twice a week	2 hours, twice a week
9am–6pm	Co-working occupancy of unused desks	50%	75%	90%
6pm–10pm	No. of fitness classes	None	2 hours, twice a week	2 hours, twice a week
	No. of night classes	None	3 hours, once a week	3 hours, once a week
	No. of meetings or corporate events	15 per year	15 per year	15 per year

Table 2. Additional space use – pessimistic, moderate and optimistic scenarios

The potential NPC savings that might be achieved over the lease term for all three additional space use scenarios is provided in Figure 9. These highlight that even under the pessimistic scenario there are still cost savings to be realised compared to the linear model.

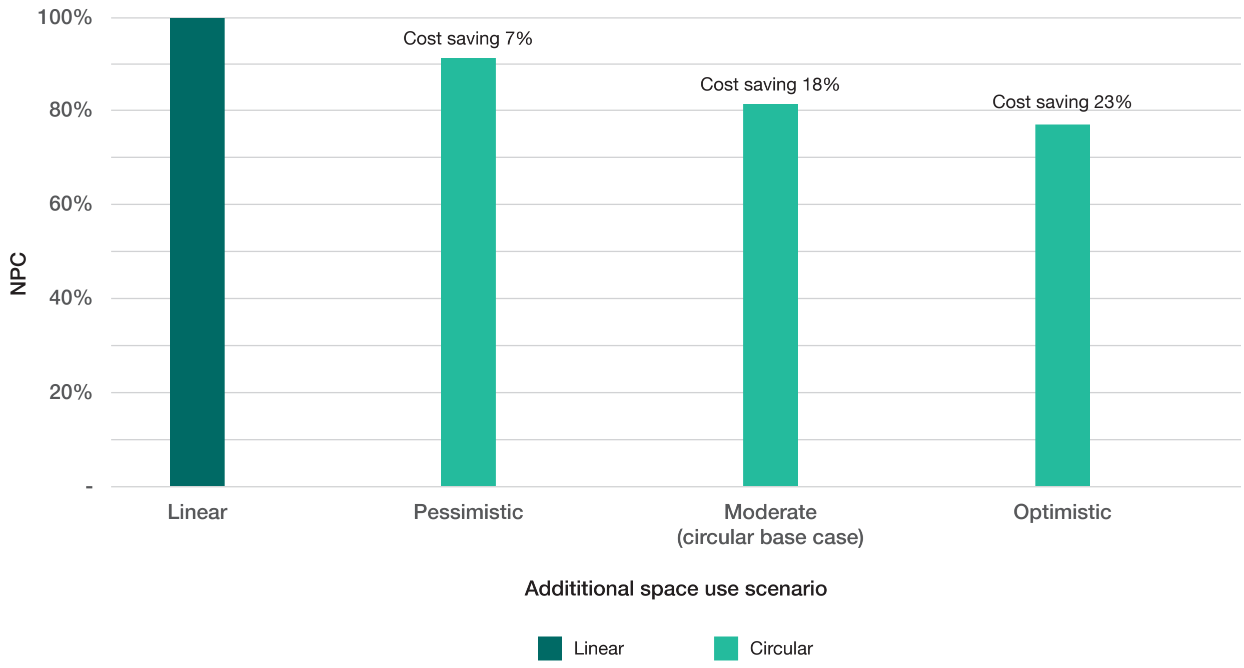


Figure 9. Sensitivity of NPC to different space use scenarios

For the circular base case, there was no additional cost assumed associated with designing for flexibility. As shown in Figure 10, the quantum of savings in the circular base case could support a 58% increase in extension costs associated with making the space more flexible to break-even with the linear model. In reality, the costs associated with making the space flexible is unlikely to be this high. It should be noted that if additional investment was made in making the testbed project more flexible, the extent of additional space use, and therefore revenue earned from it, would likely be greater.

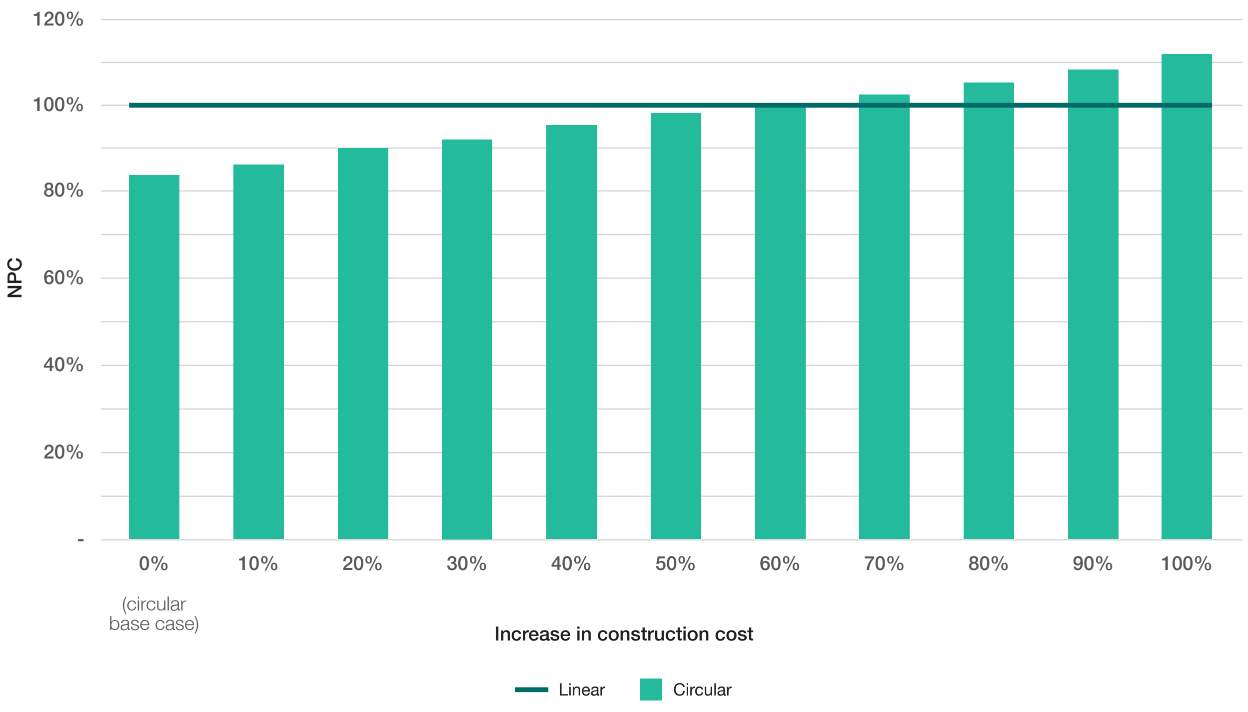


Figure 10. Sensitivity of NPC to additional upfront design for flexibility cost

NEW RELATIONSHIPS AND REQUIREMENTS

ACTIVITIES	STAKEHOLDERS
Preparation and Brief • Define possibilities for unused space, alternative uses for underutilised space and shared spaces	Construction client, Designers
• Liaise with the planning authority about flexible space use aspirations and agree on additional documentation requirements if needed	Policymaker, Construction client
• Discuss commercial arrangements related to who will lead on identifying additional tenants and how the additional rental income will be shared, if at all	Landlord, Anchor tenant, Third party operator
• Define additional tenant pricing structure e.g. m^2-hours, % sales revenue, internet data usage etc.	Landlord, Anchor tenant, Third party operator, Lawyer
• Develop flexible lease structures	Lawyer
Design and Construction • Develop flexible design solutions that consider factors including floorplate design, grid size, smart floors, dumb walls, building services provisions, core distribution, smart building technology, access and security	Designers, Contractors, Suppliers, Third party operator
• Plan for spatial variability and versatility e.g. work scenarios, multi-use functions, shared functions, amenities density etc.	Landlord, Anchor tenant, Third party operator, Designers
• Document flexible space use strategy including access and security components	Landlord, Anchor tenant, Third party operator, Designers
Operations and End-of-use • Define space specification for additional tenants	Landlord, Anchor tenant, Third party operator
• Use building data to match space supply with demand	Landlord, Anchor tenant, Third party operator
• Use building operations data to charge additional tenants	Landlord, Anchor tenant, Third party operator
• Monitor and measure space utilisation	Landlord, Anchor tenant, Third party operator
• Update flexible space use strategy, if required	Landlord, Anchor tenant, Third party operator

Ogden Centre for Fundamental Physics, Durham University

APPLICATIONS

Premises that have core operational hours or discrete opening times could adopt this model by making their spaces available out of hours. This could include offices, retail, government and leisure buildings, or even commercial kitchens.

Spaces in use but under-occupied, as well as completely unoccupied spaces (perhaps between leases) would also be well suited for this model. Under-occupied offices have already been mentioned on p36 but there is also data on higher education[51] and healthcare[52] in the UK that suggests these are opportunity areas. Further work is needed to identify under-occupied spaces to which this model could be applied.

ADAPTABLE ASSETS

Lost value captured: Buildings demolished prematurely

Profit opportunity: Delivering new uses demanded by the market at lower cost

Supporting facts: A study of UK residential buildings published in 2000 found 46% of demolished structures fell in the 11-32 year age class.[53] A study in Finland showed that out of the 50,818 buildings that were demolished between 2000 and 2012, residential buildings had an average age at the time of demolition of 58 years while non-residential was 43 years.[54]

OVERVIEW

Adaptable Assets are buildings that can accommodate more than one use during their lifetime through retrofit rather than demolition. The model operates through a new investment partnership; a long-term investor invests in the skin and structure (similar to what is often referred to as 'shell and core') acting as a chassis that can accommodate multiple functions, while a short-term investor rents the chassis to adapt it for a specific use. If the market changes so that a change in use is required, another short-term investor can cost effectively rent and adapt the chassis to reposition it on the market, installing the function-specific elements which are most exposed to market risk (falling rents, increasing vacancy rates). This division serves the purpose of separating the longer-term, lower-risk, lower-return skin and structure from the building layers which are function-specific, shorter-term, higher-risk and higher-return, namely the services, space plan and stuff.

This model incentivises a long-life, loose-fit design to ensure the opportunity cost of adaptation (or conversion) does not exceed demolition and reconstruction. The aim is to keep buildings in use for as long as possible at their highest value - one of the three principles of the circular economy.

A new player in the value chain is needed: the long-term investor in the adaptable skin and structure. At present, the benefit of an adaptable building is not recognised; often it is assumed by the client that their needs will not change significantly during the building's economic life, or any change is assumed to happen after the developer has made their return on the building. With organisational needs and market changes accelerating, these assumptions can be misguided.

The skin and structure of the building can account for over half the construction costs, so designing it for adaptability is an insurance policy against market risk for these high-cost elements. Suitable approaches borrowed from masterplanning, such as horizon scanning and scenario planning, can be adopted to manage the extent to which the building is designed for adaptability. These approaches consider several possible futures, or scenarios, identifying priorities and commonalities between them. This can be used to create an envelope of adaptability requirements pertinent to the more rigid parts of the building, such that a design team can effectively and efficiently make passive provision for future changes. Key design parameters to get right include:

- floor-to-floor height
- floor plate depth
- core positions and entrances
- riser sizing
- plant-room sizing and positioning

Masterplan design can be an enabler in itself. Specific plots are usually allocated to specific land uses. The masterplanner could identify which plots in a development might be mono-functional and which might be adaptable.

Building layers	Life cycle stage: Design and construction	Operation	Adapt	Operation
Skin	Shell and core contractor	Long-term investor		
Structure				
Services	Fit out contractor 1	Short-term investor 1	Fit out contractor 2	Short-term investor 2
Space plan				
Stuff		Tenant 1		Tenant 2

Figure 11. Key stakeholders by life cycle stage and building layer for Adaptable Assets

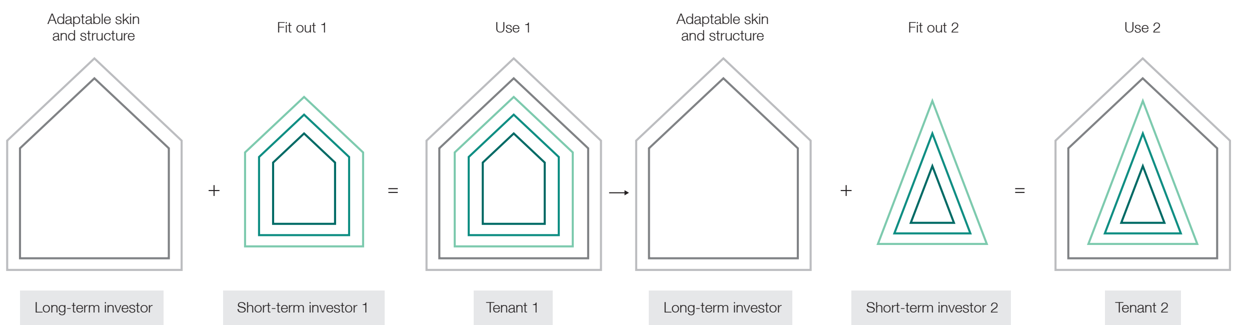


Figure 12. Schematic of Adaptable Assets over two operational life cycles

MODELLING THE TESTBED

The testbed chosen for the Adaptable Assets model is a five-floor, 15-unit residential block in Aarhus located within a larger masterplan. The baseline development has elements designed for adaptability, a particular challenge given the low floor-to-floor heights, low structural loading and constrained riser capacity typical of housing as a building typology.

A reasonable assumption for an investor is that demand for housing will remain steady, ensuring income from the 15 residential units over a 50-year operational period. If demand was expected to fall, the investment may not be viable.

The DCF has been developed assuming the steady-demand assumption was wrong and, due to economic and demographic changes, residents start moving out. The resulting vacancies warrant a change of use, one that would require an extensive engagement programme with any remaining residents.

A horizon scanning exercise for this location could have anticipated this change in demand, arising from the following site-specific emerging trends:

- decrease in population can create oversupply and lower prices
- increase in demand for local, last-mile logistics hubs or micro-depots, creating opportunity costs
- changing ideas of the most desirable mix of functions in development

The following scenario has been developed representative of a medium-term downturn as presented in Figure 13.

Under the linear model, it is assumed that the building is demolished when it reaches 60% vacancy (40% occupancy) in the face of falling residential demand, as shown in Figure 14. The investor (or construction client) evicts the remaining residents, demolishes the building and redevelops it into logistics use.

The cash flows under the linear model are presented in Figure 16.

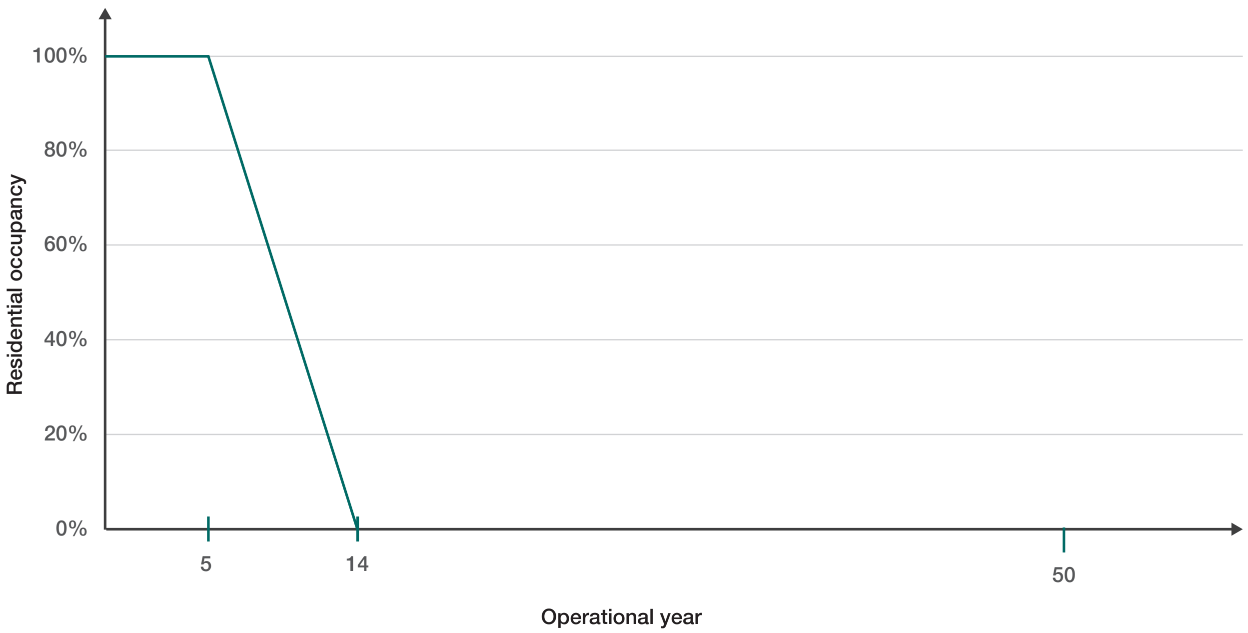


Figure 13. Medium-term market downturn assumption

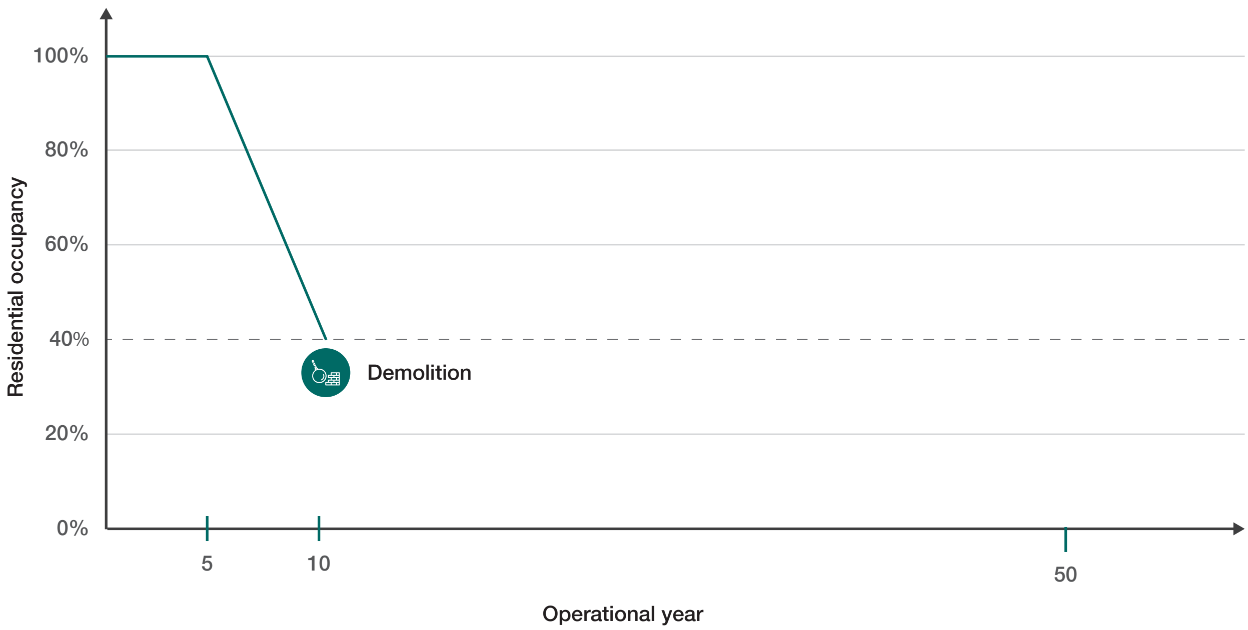


Figure 14. Demolition response to the market downturn under the linear model

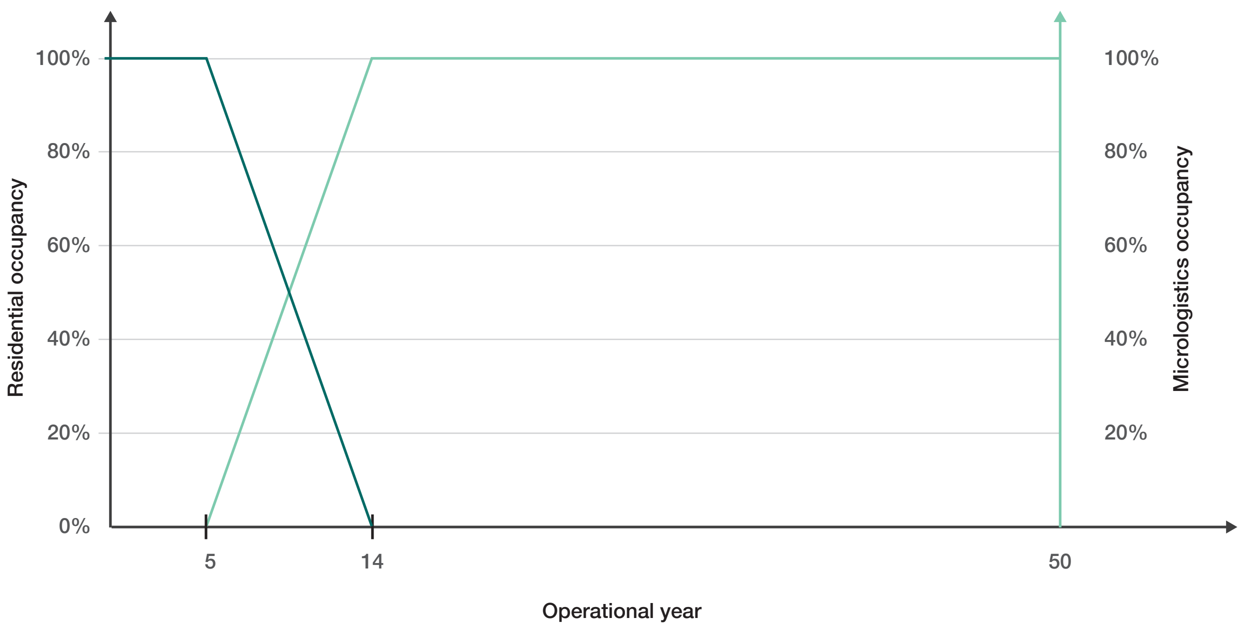


Figure 15. Assumed transition to micro-depot use under the circular model

In the circular model, the possibility of a downturn is acknowledged during brief development, and passive provision for this is provided in the design from the beginning. As the downturn takes effect and the vacancy increases, the building adapts the space to micrologistics use - a decentralised distribution centre located close to customers - as shown in Figure 15. This adaptation happens progressively, floor-by-floor, as occupancy gets consolidated and whole floors become unoccupied.

This adaptation process retains the foundations, structure and envelope of the building, while requiring changes to the building services and fit out. For example, the partition walls may be removed to create a single open space on each floor, with racking added to store parcels. An upgrade to the lift may be needed to allow larger or heavier items to move in and out of the building. As the cost of conversion is unknown, it is not considered directly for the circular base case but rather tested in the sensitivity analysis.

For the purposes of modelling, the cash flows of the long-term investor and short-term investor have been combined into a single cash flow model. Therefore, cash flows exchanged between them, such as the rent paid by the short-term investor to the long-term investor for use of the adaptable shell and core, is not accounted for. The cash flows under the circular model are presented in Figure 17.

A summary of the key assumptions for the modelling is presented below in Appendix B.

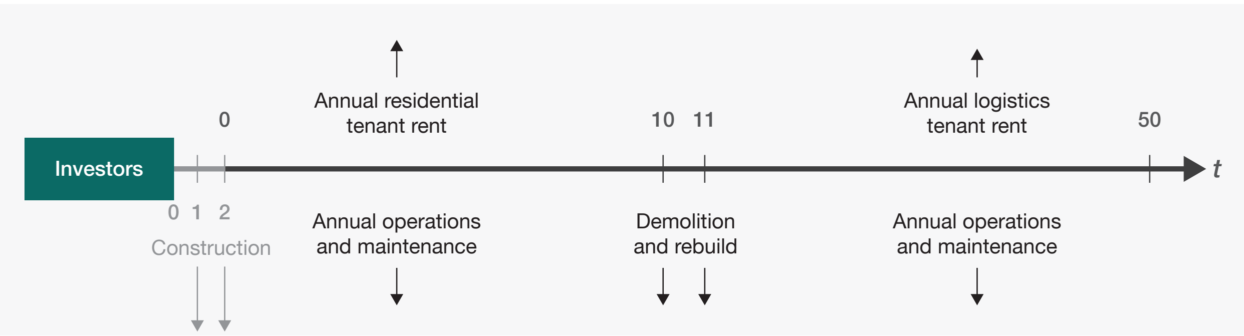


Figure 16. Illustrative cash flows modelled for the comparable linear model of Adaptable Assets

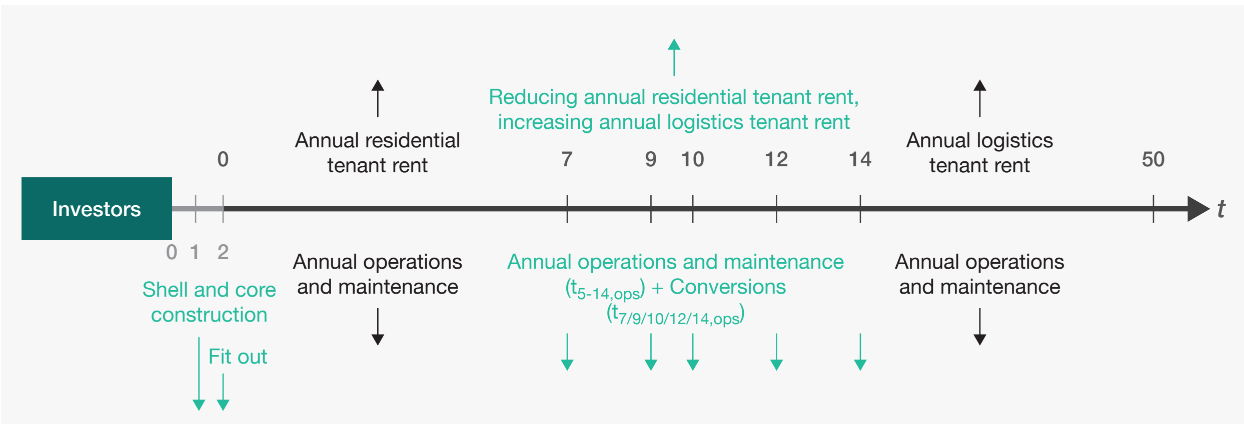


Figure 17. Illustrative cash flows modelled for Adaptable Assets

EXPLORING THE FINANCIAL PERFORMANCE

The starting assumption where residential income is maintained over the 50-year operational period gives an IRR of 3.7%. The linear model where the building would be demolished and rebuilt into a logistics centre gives an IRR of 0.3%. The circular model where each floor is progressively converted into micrologistics use gives an IRR of 3.6% (circular base case).

A sensitivity analysis has been undertaken for:

1. different market down-turn scenarios
2. the additional cost associated with design for adaptability
3. the cost of conversion
4. the annual rental income of the second use

Early-term and late-term downturn scenarios have been developed to compare against the medium-term downturn scenario assumed for the circular base case. The way in which each scenario affects residential and micrologistics occupancy is provided in Figure 18.

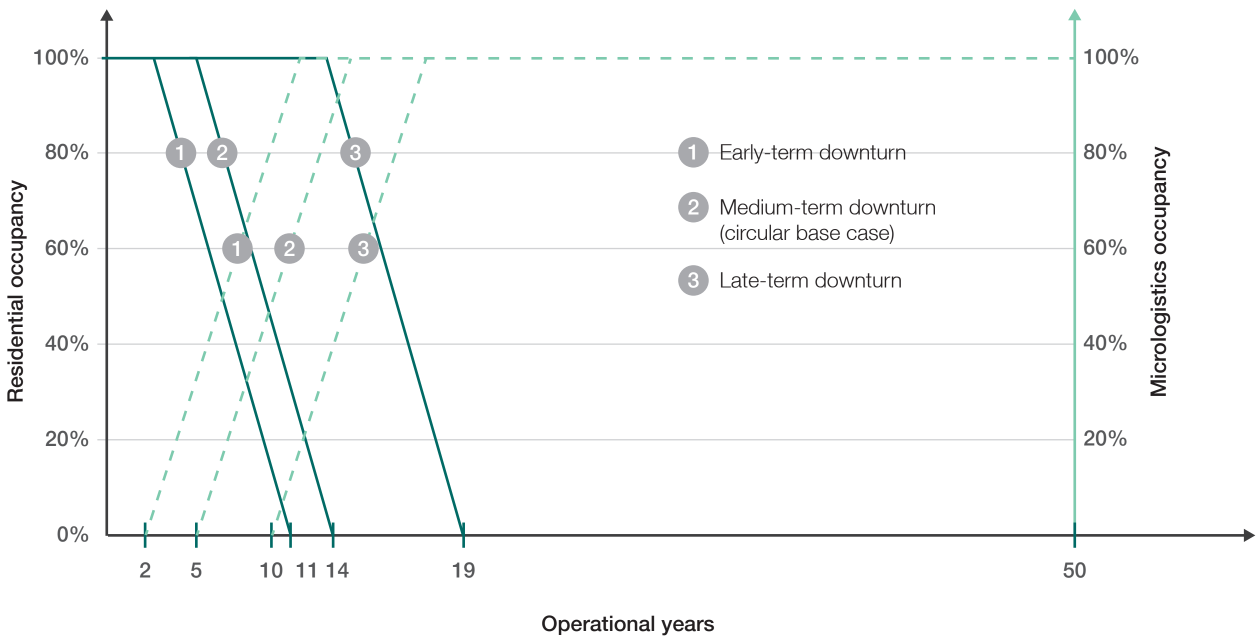


Figure 18. Assumed transition to micro-depot use under different market downturn scenarios

The IRRs for each of the market downturn scenarios are presented in Figure 19, showing the comparison in terms of IRR between the linear and circular models.

Given that in the circular base case, an additional upfront cost associated with design for adaptability was not assumed (the testbed project was designed already with some degree of adaptability), further analysis has been undertaken to assess the impact of additional upfront cost on the IRR. Figure 20 indicates that under the medium-term downturn scenario, the circular model hits the break-even point with the linear model with an additional 110% added to the construction cost.

Similar to additional design for adaptability costs, the cost of converting an adaptable building from one use to another was not considered directly. Therefore, further analysis has been undertaken to assess the impact of conversion costs on the IRR. Figure 21 shows that under the medium-term downturn scenario, the cost of conversion would need to be 110% of the initial construction cost to break-even with the linear model.

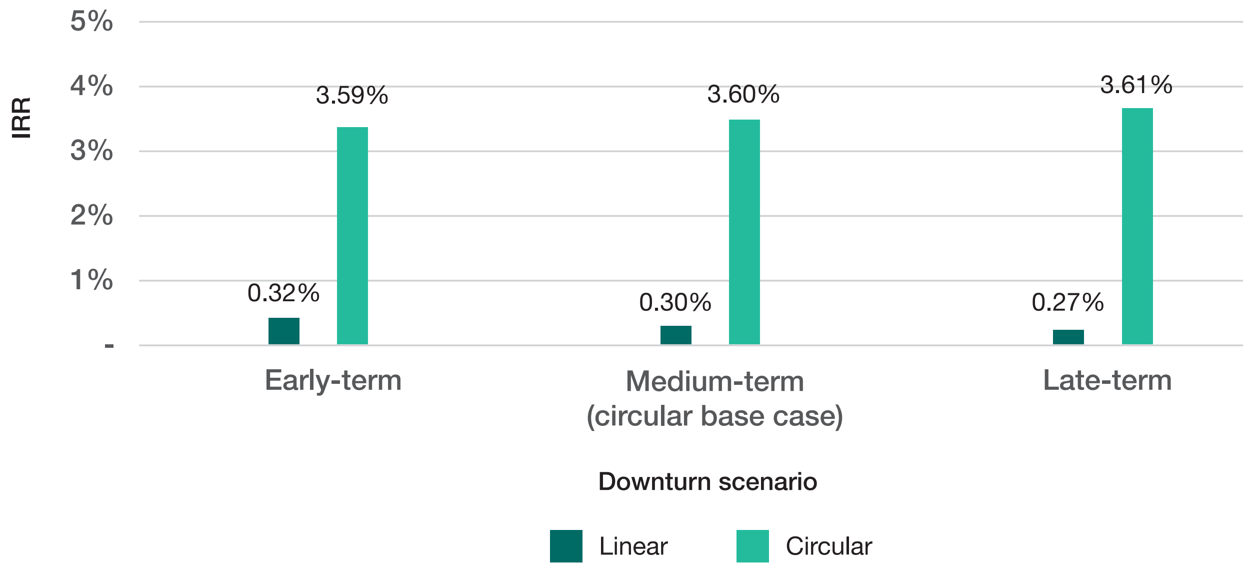


Figure 19. Sensitivity of IRR to different market downturn scenarios

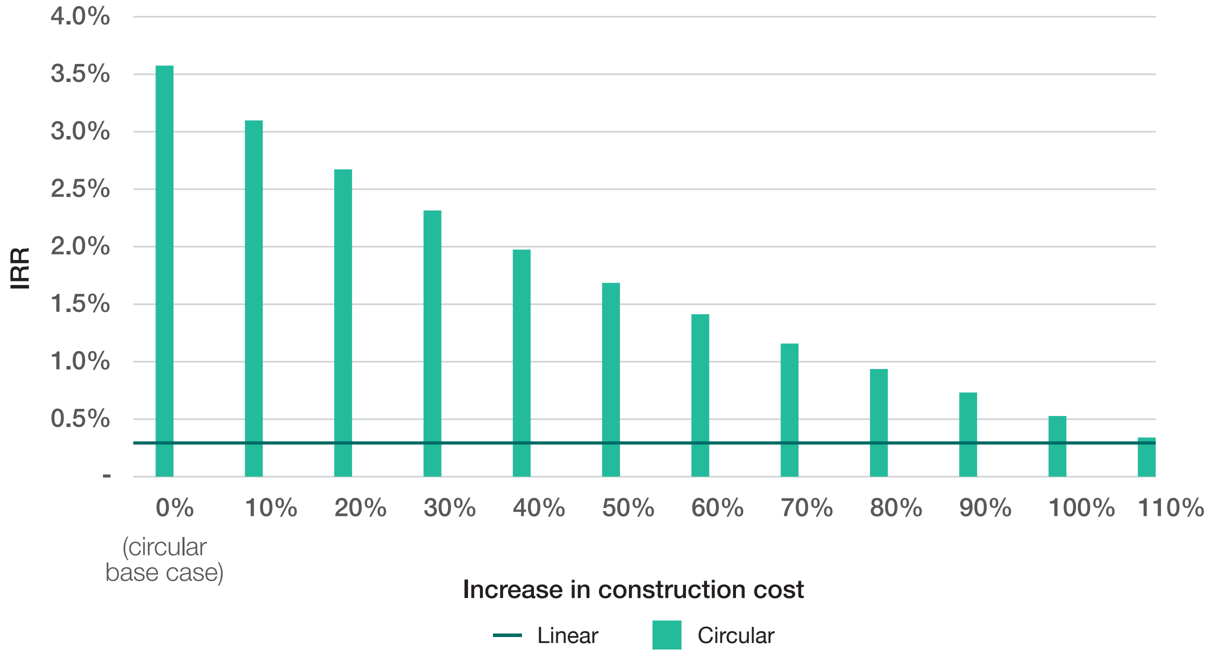


Figure 20. Sensitivity of IRR to additional upfront design for adaptability cost

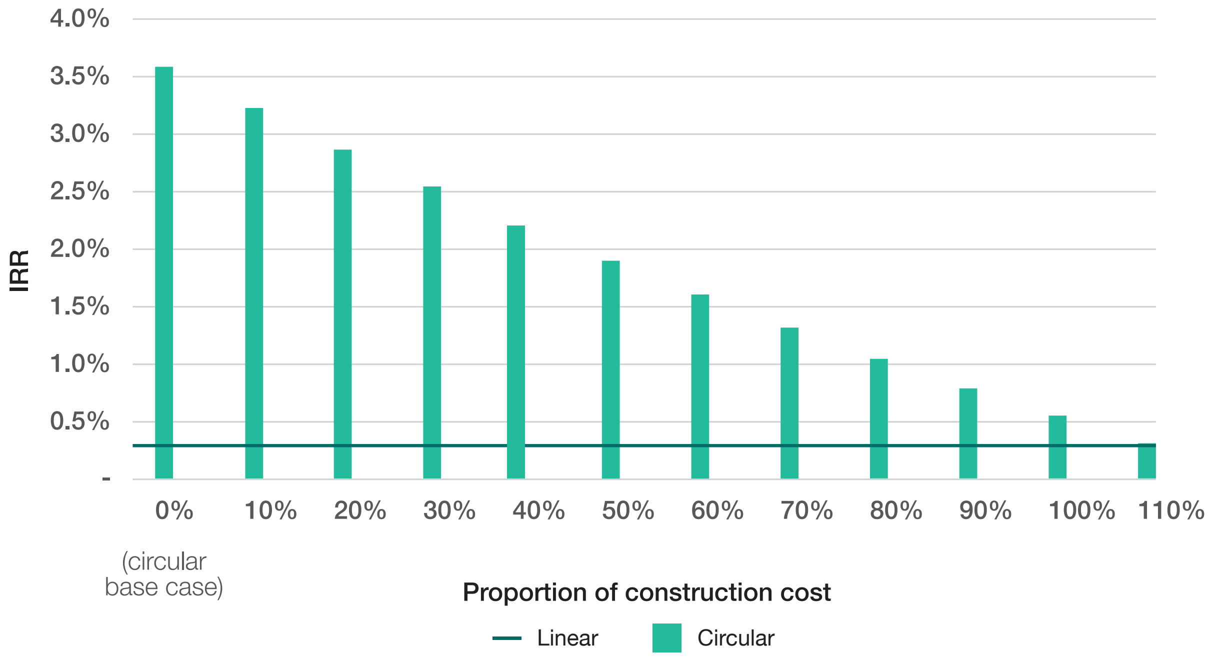


Figure 21. Sensitivity of IRR to cost of conversion into micrologistics use

Further sensitivity analysis has been undertaken under the medium-term downturn scenario to show the impact on the IRR to changes in the rental income from the second use. Figure 22 shows the change in IRR were the second use to command higher rents than the first use.

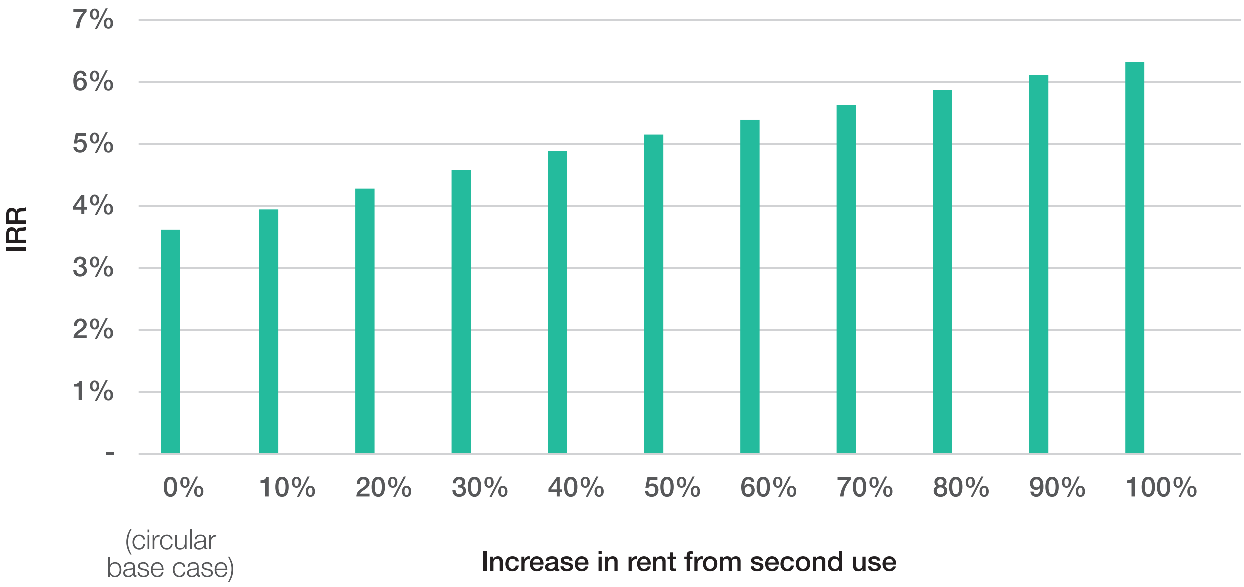


Figure 22. Sensitivity of IRR to changes in rental income of the second use

LocHal, Tilburg

NEW RELATIONSHIPS AND REQUIREMENTS

ACTIVITIES	STAKEHOLDERS
Preparation and Brief • Undertake horizon scanning and scenario planning to identify possible future uses for site	Long-term investor, Policymaker
• Liaise with the planning authority about adaptable asset aspirations and agree on additional documentation requirements	Long-term investor, Policymaker
• Undertake life cycle cost and life cycle assessment for the building to set targets	Long-term investor, Designers
• Identify short-term investor or developer for first use	Long-term investor, Short-term investor
• Define contract terms between long-term and short-term investors	Long-term investor, Short-term investor, Lawyer
• Define tender and procurement process for competing on quality and price	Long-term investor
Design and Construction • Plan for passive provision / redundancy in structure and systems	Long-term investor, Designers
• Define anticipated use lifetimes for each building layer	Long-term investor, Short-term investor, Designers, Suppliers
• Develop design response to possible future uses	Long-term investor, Short-term investor, Designers, Suppliers
• Design for deconstruction, modularity and standardised components	Designers, Suppliers, Contractors

• Document adaptability plan including:
  • building layer separation
  • accessible joints and connections
  • access strategies
  • structural loading allowances
  • sufficient floor-to-floor heights
  • core positioning
  • floor plate depths
  • passive provision in risers, cores and plant rooms
  • system upgrade or replacement strategies with focus on failure-critical elements
  • transfer floors (load and services)
  • specific consideration of features exposed to high risk of obsolescence
	Long-term investor, Designers, Suppliers, Contractors

• Develop digital twin and materials passport to facilitate changes in use	Long-term investor, Short-term investor, Designers, Suppliers, Contractors
Operations and End-of-use • Establish operations and maintenance contracts	Long-term investor, Short-term investor, Suppliers, Facilities manager
• Plan for documenting future building adaptations	Long-term investor, Short-term investor, Designers, Suppliers, Contractors
• Update digital twin and materials passport throughout operation and adaptation	Long-term investor, Short-term investor, Designers, Suppliers, Contractors, Facilities manager

Acne Studios, Seoul

© Annabel Elston / Acne Studios

APPLICATIONS

This model is particularly relevant in circumstances where market risk is significant. The retail sector is currently witnessing how digital technology can drive rapid obsolescence through a real estate asset class.[55,56] Out-of-town retail assets are typically designed for only one purpose and are now facing significant devaluations globally. Another example is car parks, where the anticipated adoption of autonomous vehicles is expected to make such structures obsolete in the next decade.

Office-to-residential conversions are relatively common in some markets where planning regulation facilitates it, for example, under Permitted Development Rights in the UK. However, the quality of conversion has come under scrutiny, suggesting that the market would benefit from the Adaptable Assets model.

Eventually, all buildings become unsuitable as a result of changed occupation practices, and thereby face being repositioned in the market. As Stewart Brand said in How Buildings Learn, "all buildings are predictions; all predictions are wrong." Whether the building responds through deconstruction or adaptation will depend on local market conditions and the location. Therefore, it may be more insightful to say that the Adaptable Assets model is best applied to types of location rather than types of buildings. For example, locations with low building turn-over yet uncertain future market performance could be cases where the planning system takes the lead in creating hybrid classifications for plots. This would have the implication that any proposed building on that site would need to demonstrate compliance with the requirements of more than one planning type.

RELOCATABLE BUILDINGS

Lost value captured: Vacant land

Profit opportunity: Revenue generation from short-term space use

Supporting facts: In 2015, UK housebuilders were sitting on 600,000 plots for houses with planning permission, yet delivered only one tenth of that.[57] The problem of land going undeveloped led to government changing policy, strengthening powers of compulsory purchase.

OVERVIEW

The Relocatable Buildings model sees an operator deploying a portfolio of relocatable buildings on unused sites to create short-term, or meanwhile, spaces. Relocatable Buildings are modular, designed for deconstruction and made of durable, high quality materials that create spaces with a permanent feel. The operator is responsible for identifying tenants to rent the space; this could be done in alliance with the landowner. The revenue generated from the rental income could be shared between the operator and landowner to incentivise the landowner to activate the vacant land. When the space is no longer needed on one site, the building is easily deconstructed and relocated to another site.

This model designs out waste by incentivising prefabricated and modular construction techniques, whilst ensuring materials are kept in use for as long as possible by designing buildings for deconstruction. The effect is to be able to relocate buildings from one vacant plot to another. Leaving sites empty is costly, especially in cities where land is at a premium. Making use of such sites by deploying the Relocatable Buildings model can support placemaking, offer affordable space to a range of different users, and allow operators and landowners to recover the lost value of vacant land.

The model seeks an improvement on traditional temporary building solutions, which can be architecturally constrained and often have an industrial look and feel, such as shipping containers, aluminium box framed structures or steel framed and clad structures. These types of temporary building solutions have limited appeal to higher value tenants, representing an opportunity for the supply chain to position itself to a new market segment by offering permanent-quality premises without the cost of new construction. Some solutions already emerging on the market include those by Bauhu, NUSSLI and ModCell.

Planning and licensing authorities will play key roles in scaling this model. They will need to look at how to allow greater flexibility over temporary planning applications and operating licenses, respectively, where risks associated with the temporary development are clearly low.[58] In the UK, for example, temporary planning applications are considered through the same process as permanent buildings; when the statutory determination period for validated planning application is eight weeks, this constitutes a considerable wait for short-term uses that might only have a life of a couple of months.

Local government has a supporting role to play by making information on unused greenfield and brownfield sites available to operators. This was behind the success of The Living Lots NYC pilot project by 596 Acres. This used data from the New York City OpenData portal and the Department of Citywide Administrative Services, among others, to transform 32 vacant lots in the city into community spaces.
As well as whole unused sites, unused space within development sites, especially those undergoing phased construction, should also be considered for deployment opportunities. The Queen Elizabeth Olympic Park, White City Campus South and Elephant Park developments in London have all successfully deployed temporary buildings in this way, putting in place a legacy strategy that considers how the temporary plots will be managed in the long term.

	Life cycle stage						
Relocatable building portfolio	Design	Transport and construction	Operation	Deconstruction, transport and reconstruction	Operation	Deconstruction, transport and reconstruction	Operation
Relocatable building 1	Relocatable building operator						
		Landowner 1		Landowner 2		Landowner 3	
			Tenant(s)		Tenant(s)		Tenant(s)
Relocatable building 2	Relocatable building operator						
		Landowner 4		Landowner 5		Landowner 6	
			Tenant(s)		Tenant(s)		Tenant(s)
Relocatable building 3	Relocatable building operator						
		Landowner 7		Landowner 8		Landowner 9	
			Tenant(s)		Tenant(s)		Tenant(s)

Figure 23. Key stakeholders by life cycle stage for Relocatable Buildings

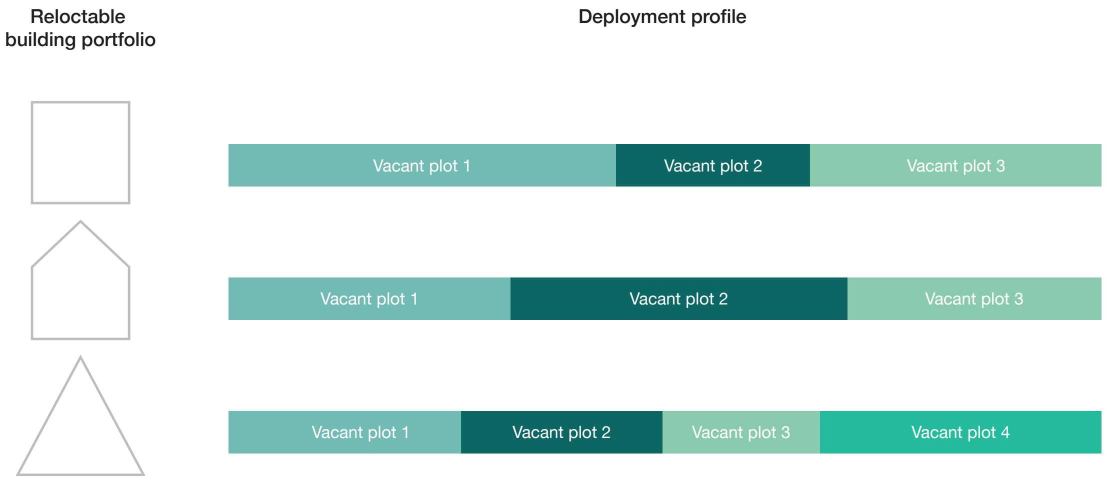


Figure 24. Schematic of the Relocatable Buildings model during operation

MODELLING THE TESTBED

The testbed chosen for this model is a 2,200m^2 mixed-use development in Amsterdam that has been designed for deconstruction. In theory, this could enable the building to adopt the relocatable building model by being deconstructed, relocated and reconstructed as required.

The Relocatable Buildings model is not directly comparable to an existing linear model. Temporary building providers like Neptunus, Springfield, Losberger and Maco Technology lease temporary buildings but are not responsible for identifying tenants to occupy the space. There are temporary building providers in the form of social enterprises who are responsible for identifying tenants but their goals and therefore financial performance cannot be compared like-for-like with this model. Therefore, a DCF for the linear model equivalent has not been developed for the Relocatable Buildings model.

Under the circular model, following an initial design and construction period lasting a year, it is assumed that the relocatable building would be erected and remain operational on the first site for five years. The specification of the building means that it can be leased close to market rental prices achieved by similar spaces provided by permanent buildings.

After five years, the relocatable building is deconstructed in a way that keeps the building materials in a reusable condition. They are then directly transported to a new vacant site; the building is reconstructed and remains operational for another five years.

For the purposes of modelling, only two operational phases have been considered. It is assumed that arrangements are made in such a way that the relocatable building is transported directly between the two sites so no intermediate storage is required. Planning costs associated with the relocation are assumed to be small as it is unlikely that an operator would choose a site that is particularly sensitive to development. Furthermore, the rent paid to the landlord and any profit share with the landlord has not been considered. Instead, the total potential financial value unlocked by the model is calculated (which could be shared between the landlord and relocatable building operator).

The cash flows for the circular model are presented in Figure 25.

A summary of the key inputs and assumptions for the DCF is presented in Appendix B.

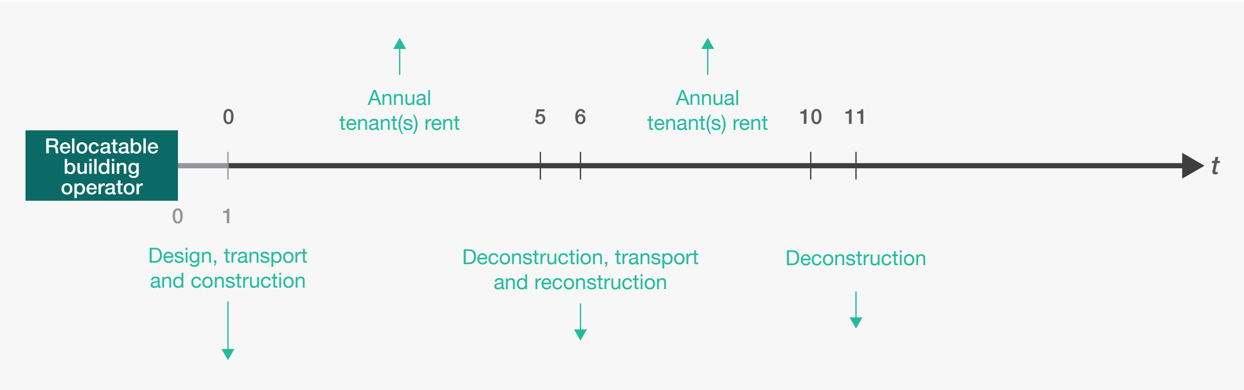


Figure 25. Illustrative cash flows modelled for Relocatable Buildings

EXPLORING THE FINANCIAL PERFORMANCE

An IRR of 26% has been calculated for the hypothetical relocatable building operator of the testbed project (circular base case). It should be noted that planning costs, landlord rent and any profit share with the landlord has not been modelled, which would lower the return for the relocatable building operator.

In reality, the initial design and construction cost (and the derived deconstruction and reconstruction cost) for a relocatable building is likely to be lower than the value used in the modelling, due to the testbed project being a bespoke construction project with limited prefabrication. This would improve the financial performance. The rental income remains an area of uncertainty in the analysis. A desk study suggests that rents charged to tenants for spaces created from temporary buildings are typically lower compared to the same for permanent buildings. However, this relocatable model is designed to offer permanent-quality business premises that could, arguably, attract close-to-market rental prices.

Therefore, a sensitivity analysis has been undertaken on:

1. the cost of design and construction
2. the rental income
3. the cost of deconstruction and reconstruction

Figure 26 indicates that changes to the rental income have greatest impact on the IRR followed by initial design and construction cost. Comparatively, the cost of deconstruction and reconstruction appears to have minimal impact on financial viability of the relocatable model when considering two relocations during the evaluation period. Even if deconstruction and reconstruction costs would double, an IRR of 24% would be maintained.

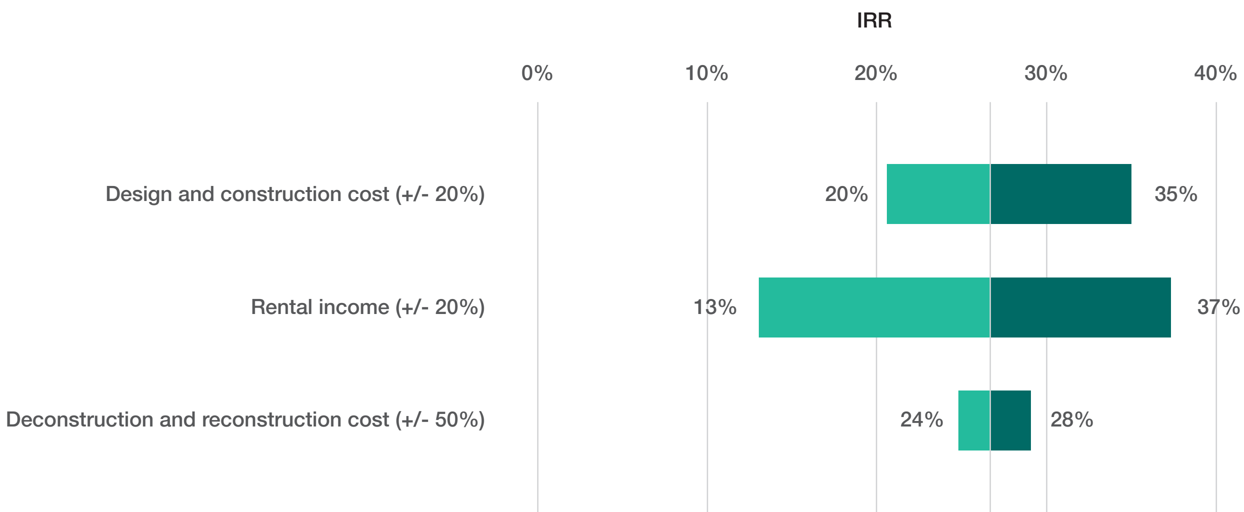


Figure 26. Sensitivity of IRR to the (1) cost of design and construction, (2) rental income and (3) cost of deconstruction and reconstruction

The impact of rental income has been further analysed in Figure 27. A monthly rental income of €226/m² would give a break-even scenario. This means in the circular base case, if planning and storage costs remained small, the landlord rent and any profit share with the landlord would need to be less than €124/m² each month for the relocatable building operator to stay in profit.

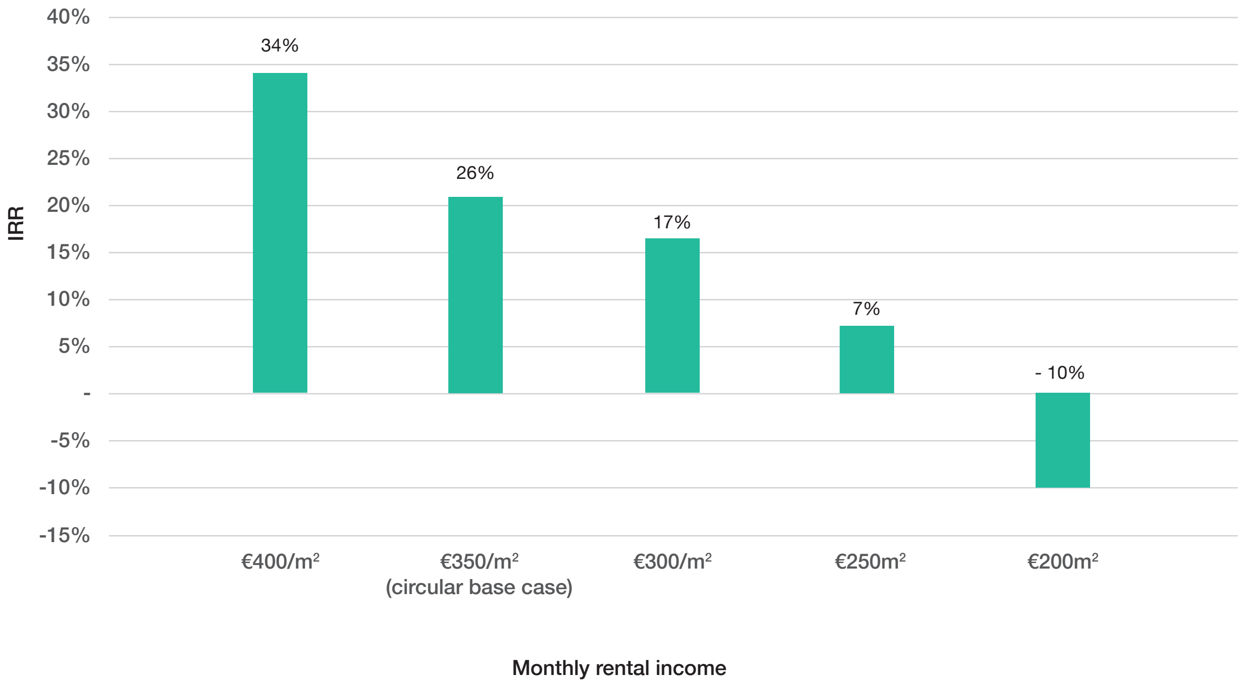


Figure 27. Sensitivity of IRR to monthly rental income

People's Pavilion, Eindhoven

NEW RELATIONSHIPS AND REQUIREMENTS

ACTIVITIES	STAKEHOLDERS
Preparation and Brief • Identify portfolio of vacant sites over the next five years and their respective landowners	Relocatable building operator, Policymakers, Landowners
• Engage landowners and municipalities on short-, mid- and long-term vision for the sites and surrounding areas	Relocatable building operator, Policymakers, Landowners
• Define meanwhile use(s), placemaking strategy, legacy strategy and how this fits with the vision for the site and surrounding areas	Relocatable building operator
• Agree contractual terms with the landowner	Relocatable building operator, Landowners, Lawyers
• Identify tenant(s) to take up meanwhile use(s) that meet(s) the rental income requirements	Relocatable building operator, Landowners, Tenants
• Discuss planning requirements with the municipality. Prepare and submit agreed documents to obtain planning permission	Relocatable building operator, Policymakers, Landowners
• Discuss operating license requirements with the municipality and other parties. Prepare and submit agreed documents to obtain operating licenses	Relocatable building operator, Policymakers
Design and Construction • Design portfolio of buildings for deconstruction by considering each building layer, reversible fittings, simple connections and temporary foundations	Relocatable building operator, Designers, Suppliers, Contractors
• Develop standard kit of parts for future modular expansion or contraction and flexible space use	Relocatable building operator, Designers, Suppliers, Contractors
• Select materials based on defined criteria including durability and environmental product declaration	Relocatable building operator, Designers, Suppliers, Contractors
• Tag materials and record standard kit of parts being used for each building to create a materials passport	Relocatable building operator, Suppliers, Contractors
• Design on- and off-grid mechanical, electrical and public health services to minimise environmental impact	Relocatable building operator, Designers, Suppliers, Contractors, Tenants
• Develop deconstruction and reconstruction plans that minimise plant and labour requirements	Relocatable building operator, Contractors
Operations and End-of-use • Develop and implement an operations and maintenance plan	Relocatable building operator, Tenants
• Prepare relocation plans and identify tenants for next meanwhile use	Relocatable building operator, Contractors, Landowners, Tenants
• Plan interim storage requirements if needed between deconstruction and reconstruction	Relocatable building operator
• Define weight and dimensions for transport between sites	Relocatable building operator, Contractors
• Repair and refurbish any materials that might have been damaged during deconstruction	Relocatable building operator, Suppliers

Deconstructed materials from the People's Pavilion, Eindhoven

© Jeroen van der Wielen

APPLICATIONS

The relocatable model could be suitable to several different types of stakeholders. Current temporary building suppliers are well placed to coordinate new relocatable building solutions in the supply chain. They also understand which site conditions have lower construction and deconstruction costs, so would be able to select cost effective sites.

Developers with large regeneration portfolios would be suit the model as they have oversight of the vacant and unused land in their portfolio. In such cases, the relocatable building operator and landlord could be the same entity. For some developers, deploying relocatable buildings might just be an extension of what they are already doing around meanwhile spaces. For others, it will require diversifying operations.

Municipalities are also a good candidate for adopting the business model as they too should have good oversight of the vacant and unused land they own or have mapped out. They could use the relocatable buildings to activate land and surrounding areas as part of a longer-term land use strategy.

RESIDUAL VALUE

Lost value captured: Depreciated building materials

Profit opportunity: Price received for reclaimed building materials are closer to (if not higher) than the cost of the original building materials

Supporting facts: Material depreciation in the built environment accounts for approximately €2.1tn of lost value each year.[59]

OVERVIEW

The Residual Value model involves the creation of a new contract, similar to a commodity futures contract. These contracts will be traded on a centralised exchange, their value tied to the estimated future of materials in a building when deconstructed. The futures contract, which contains detailed information about the recoverable materials (reusable when deconstructed) from the building, would first be placed on the market by the construction client after the building is constructed. The futures contract can then be traded while the building is operational and the building materials are in use. Buyers are expected to be anyone seeking to manage their position against increasingly volatile material prices such as contractors, suppliers and commodity traders. Whoever owns the futures contract at the time of deconstruction is the owner of the materials. In effect, the centralised exchange becomes a source of reusable building materials. For the original construction client, additional capital expenditure related to design for deconstruction or durable materials is covered by the sale of the futures contract.

The residual value model is designed to ensure that the true value of building materials is captured and recovered when they are removed from a building, thus creating an incentive to keep those materials in use at their highest value for as long as possible - one of the key principles of a circular economy.

The following have been identified as enablers of the model:

- Design for deconstruction, material selection and reversible construction techniques, for example, eliminating wet trades, using precast concrete over cast in-situ concrete and partition systems available from suppliers like DIRTT Environmental Solutions
- Building Information Modelling (BIM) allows detailed 3D models of buildings to be created with precise details on material content to create a materials passport for the building
- Sensors to monitor the performance of building materials, for example, smart lighting which records how long the bulbs have been used for
- Testing and recertification protocols for pre-used materials
- Blockchain technology to provide a transparent ledger of transactions to give all participants real-time information about a material's location, ownership and audit history

Reliable and accessible data on material provenance is critical to the success of this model; if the specifications of building materials are known, their historic uses are logged and their performance is tracked, their value can be estimated. Once their value is known, the materials can be traded on a future or forward basis and much like current commodity markets, this can be done without the materials moving or changing hands. An early indication that this could be viable is the success of Dutch organisation, Madaster. The platform uses a database of BIM models to create a materials bank and uses commodity markets to estimate the value of the materials in its database.

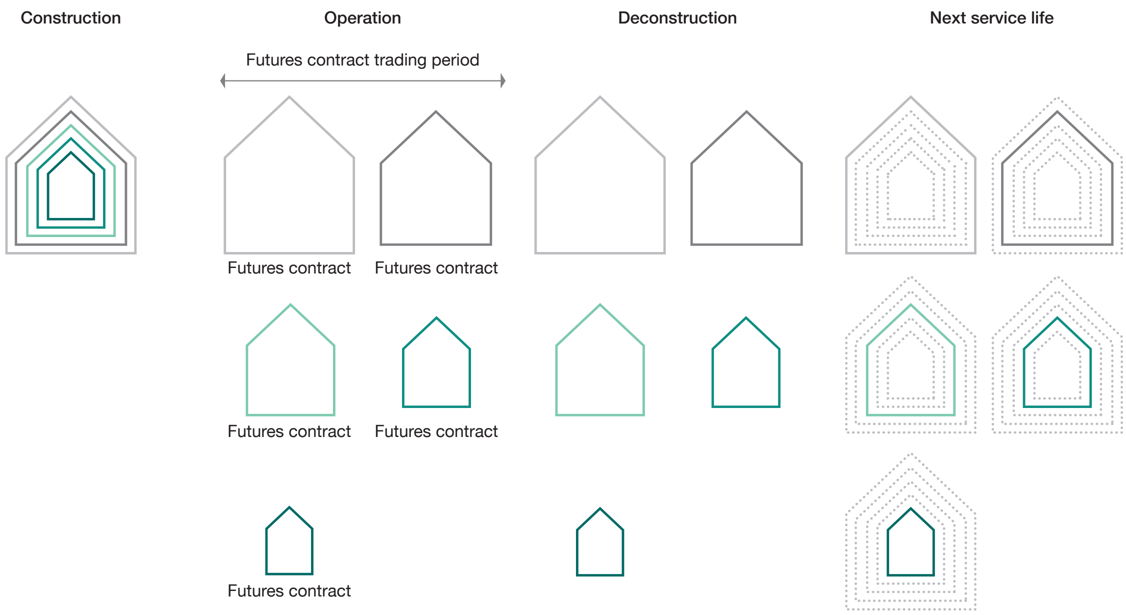


Figure 28. Schematic of the Residual Value model over a life cycle

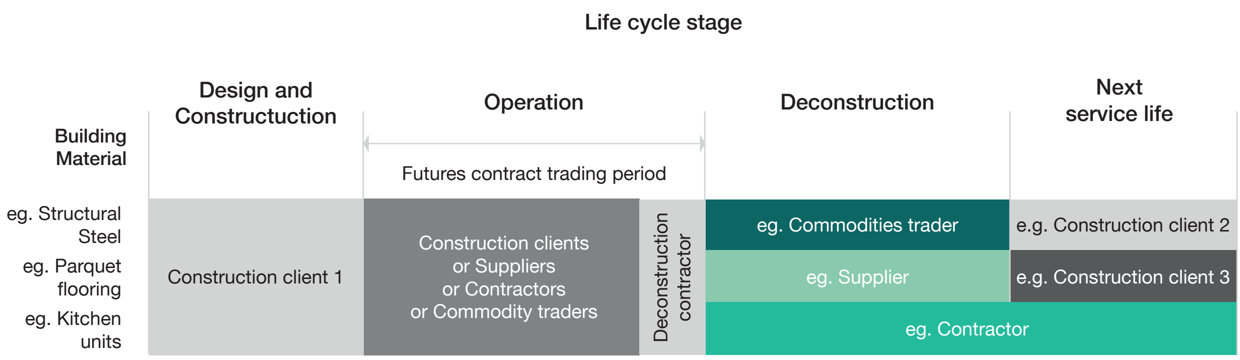


Figure 29. Example building material owners by life cycle stage for Residual Value

MODELLING THE TESTBED

The testbed chosen for the Residual Value model is an extension and refurbishment of a 1,000m^2 high-end retail store in Berlin with a sales area of 600m^2. This testbed was chosen as retail stores generally undergo more frequent refurbishment cycles compared to other typologies. This can be due to changing brand identities, changing interior design trends and upgrades to the customer experience.

Under the linear model, it takes one year to extend and refurbish the store using irrecoverable materials, fixtures and fittings. At the end of the lease following 10-years of operation, the retail tenant pays a contractor to strip out the retail store, with the materials managed as waste.

The cash flows for the linear model are presented in Figure 30.

For the circular model, it still takes one year to extend and refurbish the store, but this time the tenant adopts the principles of design for deconstruction and makes use of recoverable materials, fixtures and fittings where possible. A 5% increase in the construction cost is assumed to account for potential additional costs associated with design for deconstruction.

Based on information provided by the testbed partner, approximately 82% of building materials by spend (equivalent to 37% of the construction cost) used in the extension and refurbishment are potentially recoverable, meaning futures contracts associated with these materials can be sold on the exchange during the operational period. The cash settlement of the traded product occurs at the end of the lease following strip out. In the absence of detailed pricing models of the newly traded commodities product, the futures contract sale value is assumed to be 50% of the price that the building materials were originally bought.

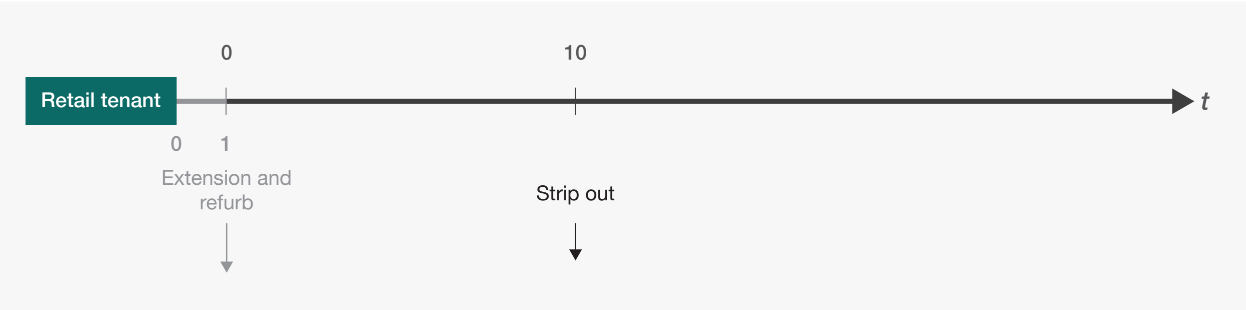


Figure 30. Illustrative cash flows modelled for the comparable linear model of Residual Value

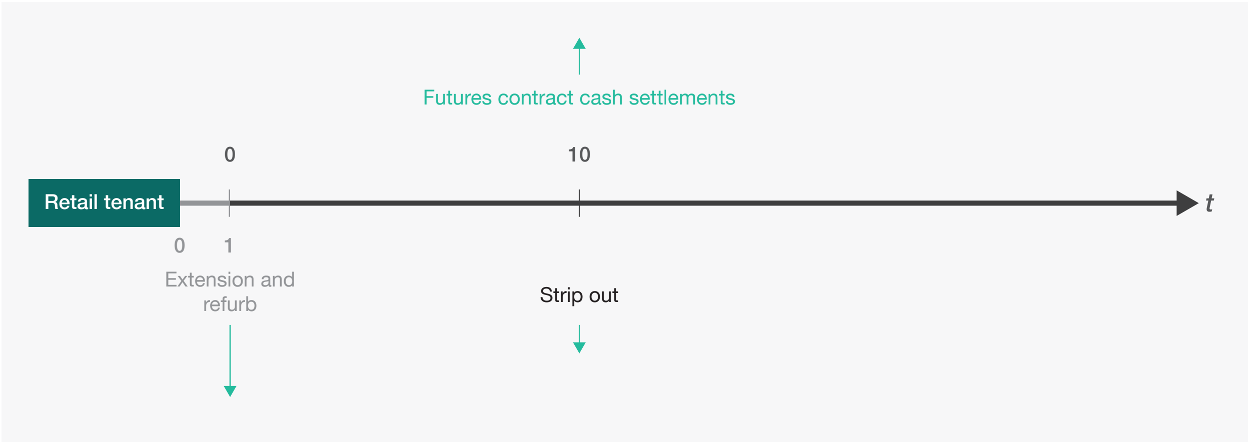


Figure 31. Illustrative cash flows modelled for Residual Value

The strip out is modelled to be cheaper than the linear model as the waste management cost to the strip out contractor will be reduced.

The cash flows for the circular model are presented in Figure 31.

A summary of the key inputs and assumptions for the DCFs are presented in Appendix B.

EXPLORING THE FINANCIAL PERFORMANCE

Based on the application of the Residual Value model to the testbed project, an NPC saving of 5% could be achieved (circular base case) when compared to the linear model. In order to understand the key drivers of the residual model, sensitivity analysis has been undertaken on:

1. the futures contract value
2. the additional cost of design for deconstruction
3. the recovery rate of materials

A summary of the sensitivity analysis on the future contract value and additional design for deconstruction cost is provided in Table 3.

SENSITIVITY	VALUE									
Futures contract value as % of original material cost	21%	25%	50%	75%	100%	125%	50%	50%	50%	50%
Additional design for deconstruction cost	5%	5%	5%	5%	5%	5%	7.5%	5%	2.5%	-
NPC saving	-	1%	5%	10%	15%	20%	3%	5%	8%	10%
			(circular base case)					(circular base case)		

Table 3. Sensitivity of NPC to the (1) futures contract value and (2) additional cost of design for deconstruction

The sensitivity analysis shows that the futures contract value (related to the original cost of the recoverable materials in the DCF) has greater impact on the NPC savings than does the additional cost related to design for deconstruction. Ultimately, it will be the market that dictates the futures contract value, while the cost of designing for deconstruction is likely to become cheaper as it becomes common design practice, and more solutions are developed by the industry. The analysis shows that without any additional deconstruction cost, the NPC savings could increase from the circular base case to 10%.

Figure 32 compares the NPC saving that could be achieved for different recovery rates of materials. A recovery rate above 82% represents a scenario where more materials than those identified as recoverable would be sold. A recovery rate below 82% represents cases where, for example, materials might be damaged during deconstruction. The sensitivity analysis indicates break-even occurs when approximately 33% of all materials by spend (equivalent to 15% of the construction cost) are sold.

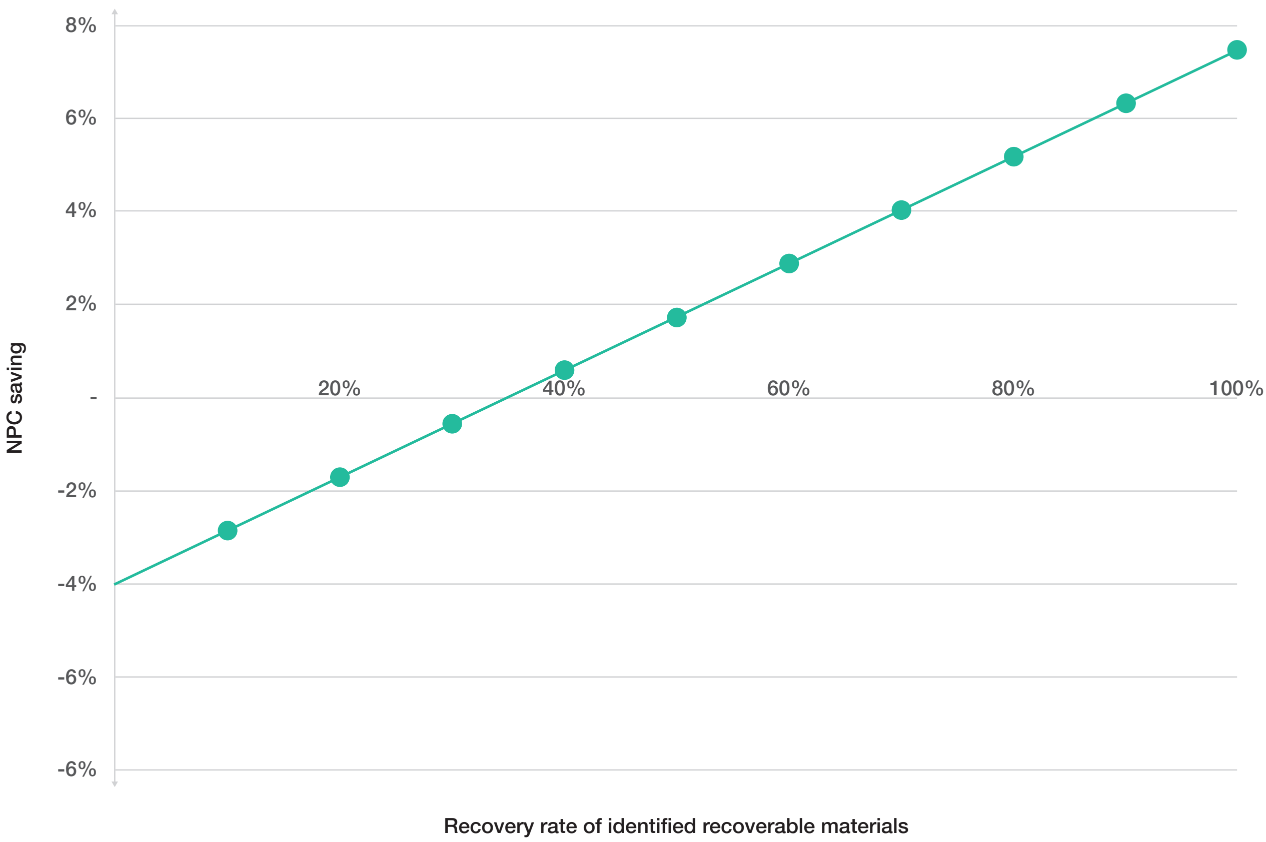
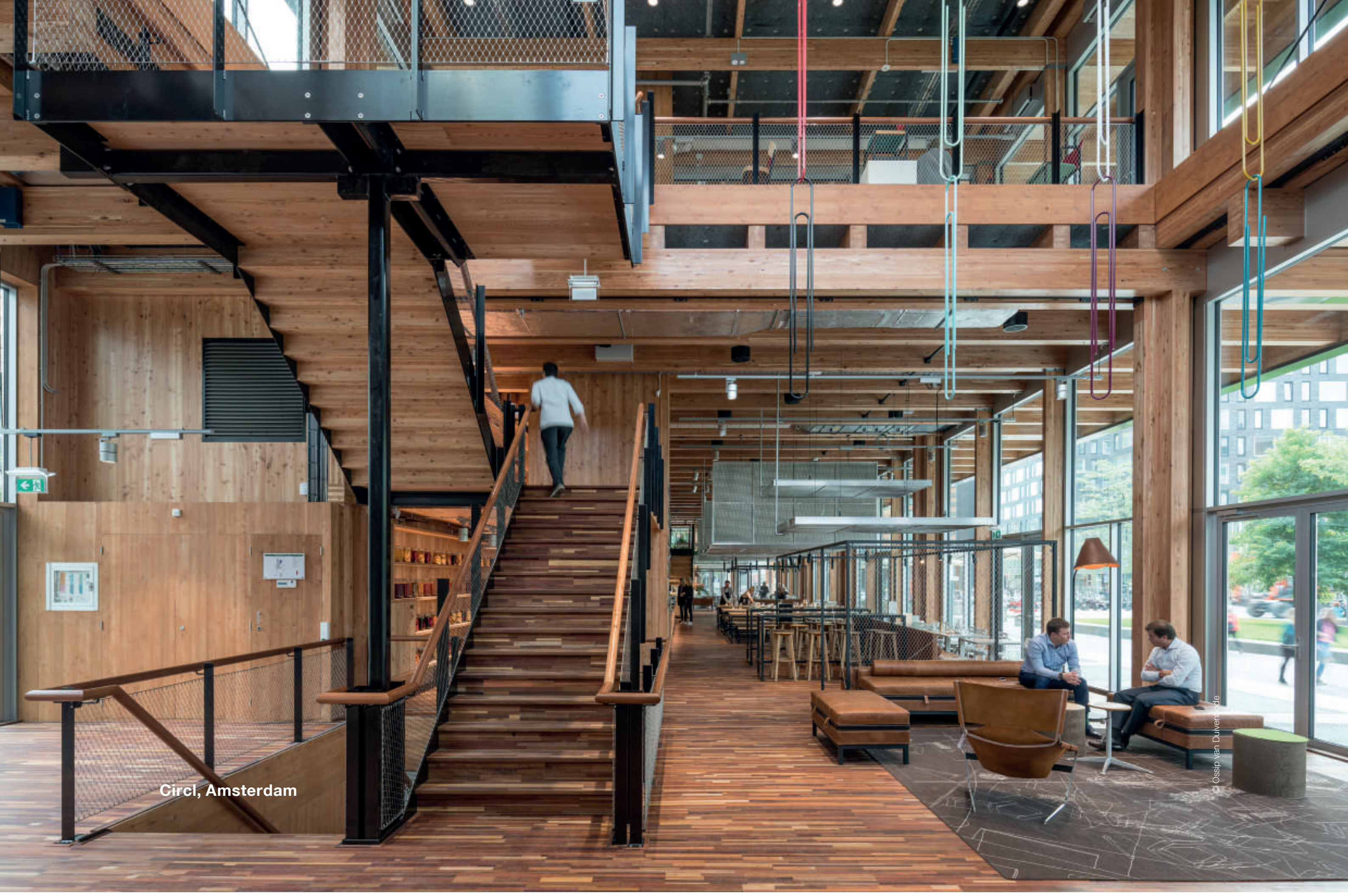


Figure 32. Sensitivity of NPC savings to the recovery rate of identified recoverable materials


Triodos Bank, Driebergen-Rijsenburg

NEW RELATIONSHIPS AND REQUIREMENTS

ACTIVITIES	STAKEHOLDERS
Preparation and Brief • Set out plan to maximise residual value by selling futures contracts on the centralised exchange* in the brief	Investor, Construction client
• Develop digital strategy to record, update and share material data with the market (BIM/materials passport/sensors/digital twin/ blockchain)	Construction client, Designers, Contractors, Facilities manager
Design and Construction • Design for deconstruction by considering for each building layer reversible fittings, simple connections and standardised components	Designers, Suppliers, Contractors
• Select materials based on defined criteria including durability and environmental product declarations	Designers, Suppliers, Contractors
• Develop operations and maintenance plan that maintains material value	Construction client, Designers, Suppliers, Contractors, Facilities manager
• Develop deconstruction plans that maximise recoverable materials	Designers, Suppliers, Contractors
• Establish list of recoverable materials and collate drawings and information required by the centralised exchange* for their sale	Construction client, Designers, Contractors
• Sell futures contracts of recoverable building materials on the centralised exchange* once the building is constructed	Investor, Construction client
Operations and End-of-use • Implement operations and maintenance plan	Tenant, Facilities management
• Update digital twin of building	Tenant, Facilities management
• Trade building material futures contracts	Construction clients, Suppliers, Contractors, Traders
• Identify and contract a suitable deconstruction contractor	Construction client, Contractors
• Notify market of deconstruction date	Investor, Construction client
• Undertake deconstruction and notify new building material owners of available date	Contractors
• Inspect and/or test material specification for reuse *assumes centralised exchange is already set up	Contractors



Circl, Amsterdam

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APPLICATIONS

As indicated by the testbed, retail lends itself well to this model due to the frequency of refurbishment. The reuse, refurbishment and resale of retail fit-out is a growing market, so barriers to entry could be lower than other sectors; Marks and Spencer (a multinational retailer) have a programme around reusing fit-out, Globechain (a reuse marketplace) have a retail catalogue and Fitout UK (a fit-out contractor) have a fit-out refurbishment business unit.

Owners of single-storey steel portal frames could also be an early adopter, given these structures are easily deconstructable and reconstructable. Materials or components with standard dimensions are a good fit for this model as there is likely to be greater future demand for them.

Overall, a critical mass of users of the centralised exchange is needed to increase the supply, visibility and demand of building materials available at deconstruction. Information related to both new builds and existing building stocks will be required for this. City municipalities could provide the enabling conditions through the planning system.

PERFORMANCE PROCUREMENT

Lost value captured: Underperforming components

Profit opportunity: Subscription costs for access to building systems is less than the whole life cost of ownership of those services

Supporting facts: 20-40% of building energy use could be profitably conserved through retrofit.[5,6,7,8]

OVERVIEW

Performance Procurement extends the product-as-a-service model, currently seen in individual products such as lighting, to the building level. Under product-as-a-service procurement, rather than buying products from suppliers through capital budgets, construction clients and tenants buy subscriptions for services provided by those products through operational budgets. Following Brand's Layers model, the Performance Procurement model takes the concept to whole systems and assemblies within the skin, services and space plan layers (since skin and services determine the energy performance of a building and all three layers have economic lifetimes within reasonable investment to allow this model to offer a return). The subscription payments are linked to real-time performance, or key performance indicators, and include operations and maintenance costs. The supplier, now a service provider, retains ownership of the products themselves and is responsible for their maintenance, repair and upgrade.

The model changes incentives in two ways:

1. As the service providers are paid for performance over the technical life of assets, they are incentivised to use remote monitoring to deliver predictive maintenance to minimise downtime. This enables them to optimise the performance of the system, reduce running costs and give an improved occupant experience.
2. As the service providers retain ownership and therefore responsibility for repurposing or disposing of the products, they are incentivised to design products that can be easily repaired, remanufactured and reused, as well as to eliminate toxic, hard-to-dispose-of materials.

The link to circular economy is clear; this model incentivises service providers to create high performance systems that last.

Building layers	Life cycle stage: Design and construction	Operation	End-of-use
Skin	Skin service providers		
Structure	Construction client		Waste contractor
Services	Services service providers		
Space plan	Space plan service providers		
Stuff	Construction client or Tenant		Waste contractor

Figure 33. Key stakeholders by life cycle stage and building layer for Performance Procurement

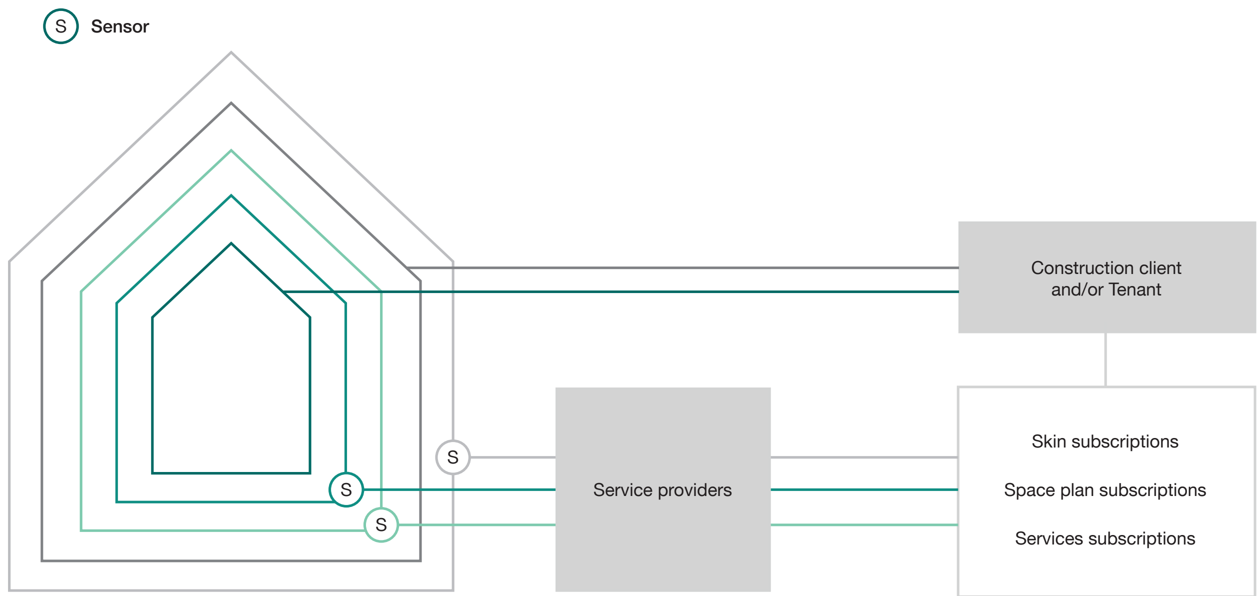

Figure 34. Schematic showing building layer ownership under Performance Procurement

Design, procurement, construction and operation processes will need to change. A new value chain member, the service provider, is needed. Service providers will be consortia of product manufacturers who are collectively able to provide whole systems, such as complete building envelopes or heating, ventilation and air conditioning systems, rather than individually providing products or sub-assemblies such as insulation panels or air-handling units. Construction clients and tenants may want to enter into framework relationships with service providers to secure economies of standardisation and contract management across their portfolios. The service providers will then work closely to coordinate with the client's design team to create highly-optimised, high-performance systems.

One reason these relationships are not currently entered into at an early stage is the risk of over-charging once a project is locked-in to a single supplier. In Performance Procurement, this risk is mitigated as replacement parts and maintenance costs are borne by the service provider and paid for by the pre-agreed subscription charge.

During construction, the main contractor will continue to coordinate trades and manage the overarching programme, while the service providers arrange the installation and commissioning of their systems. Following practical completion, the subscription contracts for the entire building could be managed by a facilities management company.

Existing and emerging product-as-a-service solutions include purchasing 'lux' rather than buying lighting systems (e.g. Signify), refrigeration-ton-hours rather than air conditioning units (e.g. Kaer), energy performance and user comfort rather than facade panels (e.g. pilot project at TU Delft), electrical distribution as a service (e.g. Engie), and office furniture services (e.g. Steelcase).

MODELLING THE TESTBED

The testbed chosen for the Performance Procurement model is a 150-unit residential build-to-rent development in London. Build-to-rent lends itself well to this model as the provision of more reliable and streamlined services for tenants is a source of competitive advantage over buy-to-let.

Under the linear model, the build-to-rent operator procures all building layers through capital budgets. The operator is also responsible for the annual operations and maintenance expenditure associated with common areas and associated services, building maintenance, and replacement of building systems including those within the skin, services and space plan layers. The operator receives an annual rental income from tenants, which excludes the utility costs paid directly by tenants.

The cash flows for the linear model are presented in Figure 35.

Under the circular model, the build-to-rent operator procures the skin, services and space plan building layers through annual subscriptions from service providers (representative of 45% of the construction cost). The remainder is procured through capital budgets as per the linear model. For the purposes of modelling, the subscription charge has been estimated by amortising the capital cost of each layer over its anticipated economic lifetime. The operator receives an annual rental income from tenants, including utility bills covering energy and water, to capture operations and maintenance efficiency gains from the higher performing systems.

The cash flows of the circular model are presented in Figure 36.

A summary of our key assumptions for the modelling is presented below in Appendix B.

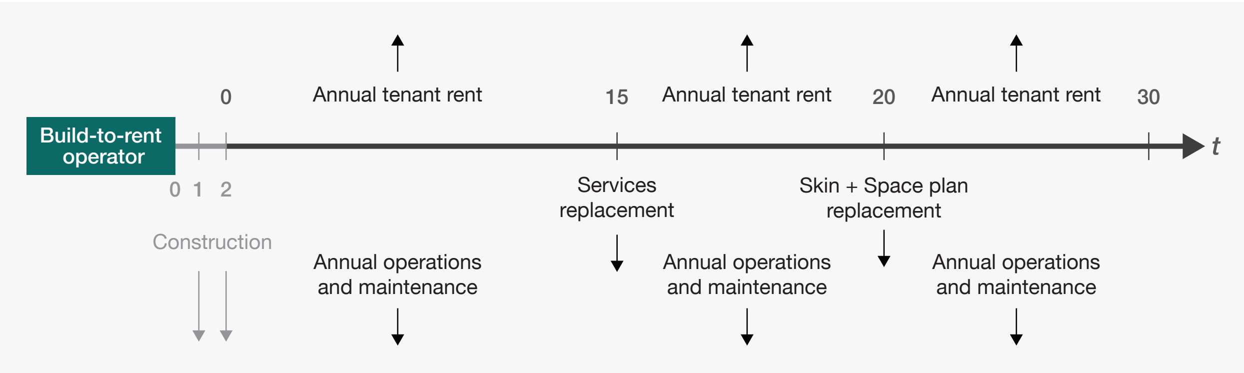

Figure 35. Illustrative cash flows modelled for the comparable linear model of Performance Procurement

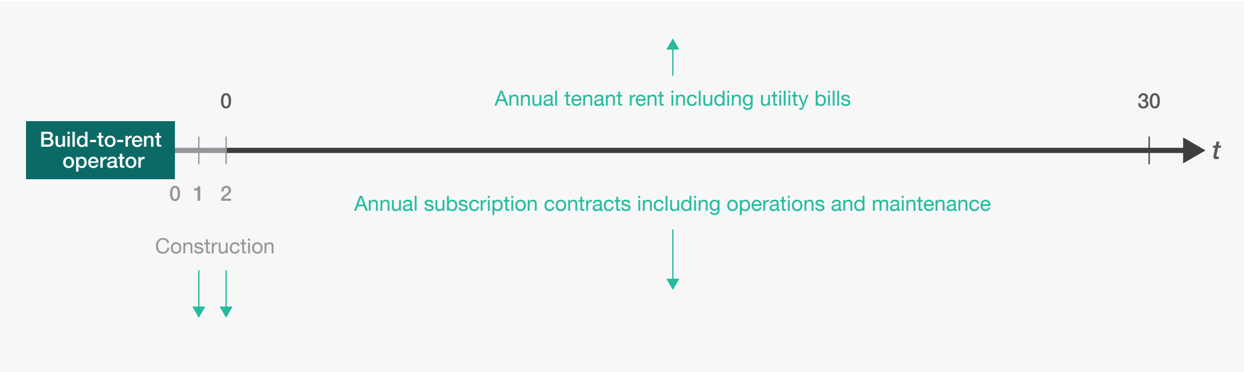

Figure 36. Illustrative cash flows modelled for Performance Procurement

EXPLORING THE FINANCIAL PERFORMANCE

Based on the analysis, the Performance Procurement model would see the build-to-rent operator achieve an IRR of 10.8% (circular base case) compared to 7.5% under the linear model.

Sensitivity analysis has been undertaken on:

1. the subscription charges
2. operations and maintenance costs
3. construction costs

In reality, the subscription charge will include financing costs, accounting for organisation- and system-specific considerations such as suppliers' financial position, design specifications and market maturity. The starting assumption for the subscription charge was to amortise the capital cost of each layer over its anticipated economic lifetime, excluding any financing costs. This established an upper bound on the achievable IRR. A lower bound is set by calculating the financing cost that would cause the circular model to deliver the same IRR as the linear model. Finance costs to the service provider are taken between these bounds to provide a sensitivity profile. Figure 37 shows that the IRR achieved by the operator is sensitive to financing costs.

The IRR achieved from the circular base case is most likely to be conservative since product-as-a-service models are structurally more profitable for service providers, as they are able to put products on the market over multiple use cycles. It would be expected that as the circular economy grows, suppliers who have adopted these approaches would offer more competitive pricing versus legacy linear businesses. Such a development would reduce costs for construction clients, creating a circular win-win.

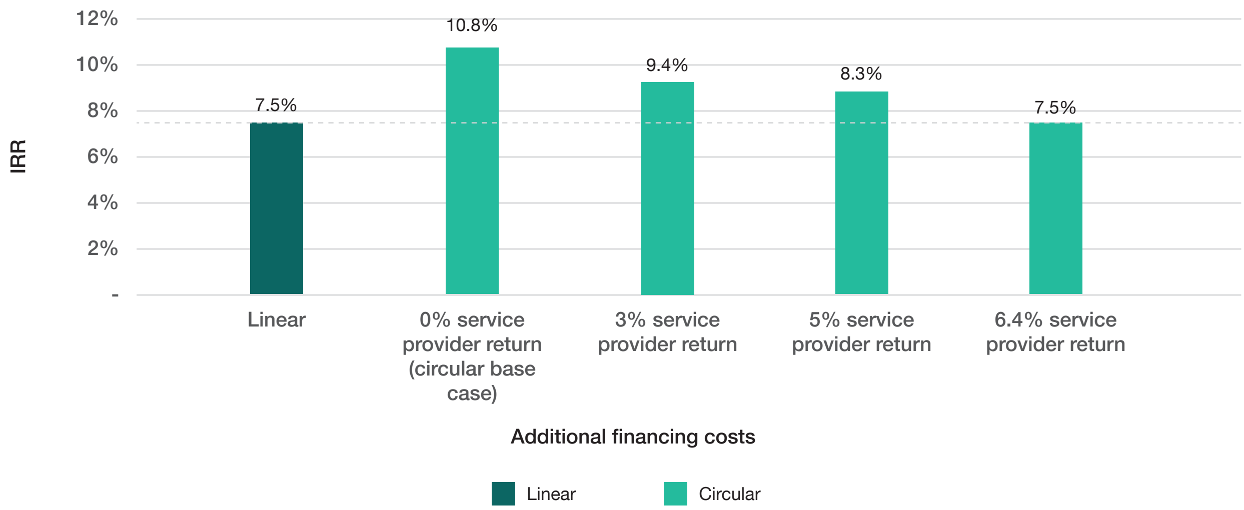

Figure 37. Sensitivity of IRR to financing costs

A sensitivity of +/- 10% of operational and maintenance costs against the circular base case results in little change of the IRR, as shown in Figure 38. This is a conservative allowance for the potential of Internet of Things (IoT) technology and durable products designed for long life to significantly increase performance and reduce operation and maintenance costs from buildings.

A sensitivity of +/- 10% of construction cost against the circular base case shows that the construction cost has much greater impact on the IRR when compared to operational and maintenance costs, as shown in Figure 38. This checks the potential impact of main contractors increasing cost in tender returns to account for not having worked in this way before.

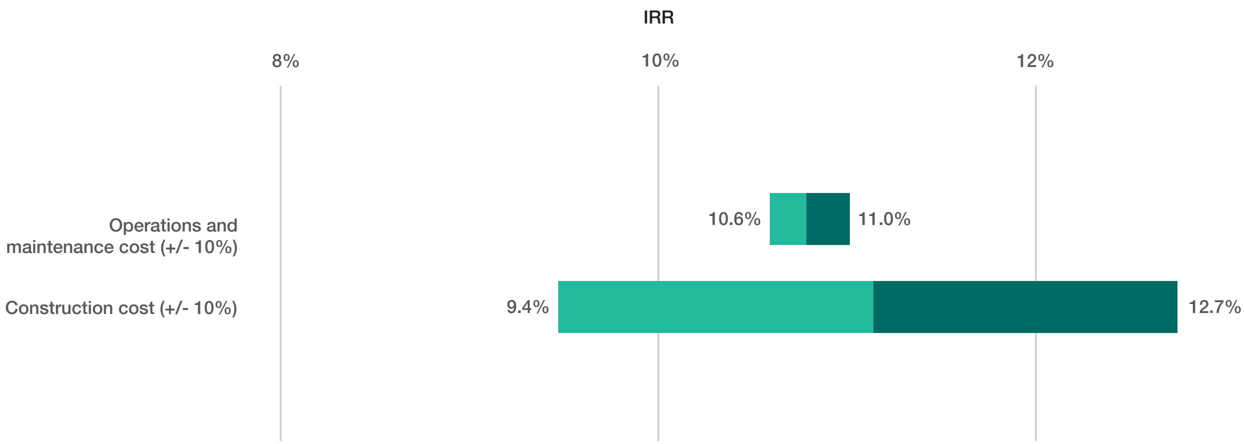

Figure 38. Sensitivity of IRR to (1) operations and maintenance costs and (2) construction costs

NEW RELATIONSHIPS AND REQUIREMENTS

ACTIVITIES	STAKEHOLDERS

Preparation and Brief
• Develop repairable, remanufacturable and reusable products with suitable subscription contracts for the market. Subscription contracts to consider:
  • lease and use rights
  • contract length
  • payment structure including options such as:
    • paying the same amount over the full contract duration
    • paying a higher price over an initial period followed by a lower price for the remainder
  • key performance indicators (e.g. occupant satisfaction, energy use, water use), including measurement, reporting and verification
  • interoperability standards to mitigate risk of lock-in
  • protocols for remote sensing and optimisation
  • data security standards and data ownership
  • methods for determining and sharing performance risk and reward
  • penalties due for poor performance
  • protocols and insurance requirements covering compensation events such as fire, theft and damage
  • maintenance plans
  • break-clauses
  • provisions for service provider insolvency
	Service providers

• Create consortia to develop complete systems aligned to building layers	Service providers
• Develop technology for remote monitoring, optimisation and predictive maintenance	Service providers
• Develop briefs based on performance (technical performance, reliability, target whole life cost, environmental impact)	Investor, Construction client, Designers
• Define possibilities for portfolio-wide subscription agreements	Investor, Construction client, Tenant, Service providers
Design and Construction • Design and specify systems that meet performance set out in brief	Construction client, Designers, Service providers
• Develop building-specific subscription plan including operations and maintenance strategy	Construction client, Service providers
• Coordinate overlapping trades, manage site logistics, security, welfare provision etc.	Contractors
• Align BIM strategy, operations and maintenance manual, subscription contracts and asset management plan	Investor, Construction client, Designers, Service providers
Operations and End-of-use • Record real-time performance data using IoT feedback system with which to inform charges to the client	Service providers
• Continuous commissioning using remote optimisation	Service providers
• Implement operations and maintenance strategy	Construction client, Service providers

Schiphol Airport, Amsterdam

APPLICATIONS

Beyond closing the performance gap, which is applicable to all buildings, the Performance Procurement model has particular relevance in two applications. The first is where tenant retention is central to the revenue model, and another where minimal disruption is of utmost importance. Tenant retention is central to the build-to-rent, co-living and co-working typologies. All buildings aspire for minimal disruption but buildings where the user experience really matters lend themselves well to subscription contracts. This includes:

- hospitals for patient comfort, health and safety
- hotels for guest comfort and experience
- airports for improved passenger flows and experience.

KEY FINDINGS

This report, *Realising the Value of Circular Economy in Real Estate,* represents one of the most advanced and sophisticated attempts to date to consider what applying circular economy business models to real estate might mean in practice. It has identified which actors in the real estate value chain are best placed to instigate a transition to circular practices in this sector, and it has explored new real estate business models which enable those actors to add value at all stages of an asset's life cycle.

Circular real estate business model	**Flexible Spaces**	**Adaptable Assets**	**Relocatable Buildings**	**Residual Value**	**Performance Procurement**
Financial returns	18% reduction in net present cost over 12 years	3% increase in internal rate of return over 50 years	26% increase in internal rate of return over 11 years	5% reduction in net present cost over 10 years	3% increase in internal rate of return over 30 years
Description	Additional tenants occupy underutilised space in buildings	Buildings that can adapt to alternative uses over time	Buildings that can be reused multiple times across multiple sites	Tradable futures contracts related to value of recoverable materials at deconstruction	Extension of the product-as-a-service model to the whole building level
Lost value captured	Underutilised space	Premature demolition	Vacant land	Depreciated materials	Underperforming components
Testbed location	Milan	Aarhus	Amsterdam	Berlin	London
Testbed project	Tenanted commercial	Tenanted residential	Tenanted mixed-use	Tenanted retail	Build-to-rent residential
Readiness	Now			New	Next

Figure 39. Summary of the financial returns of the five circular real estate business models

KEY FINDING 1: CIRCULAR ECONOMY PRINCIPLES OFFER IMPROVED FINANCIAL RETURNS

This report has found that applying circular economy principles to real estate business models improves the financial performance of assets. Five models have been developed that each capture a different source of lost value, creating five ways of applying circular principles in this sector.

The potential benefits likely exceed the numbers shown. A conservative approach is taken for the feasibility studies, and on real projects where open and direct conversations are possible, there will be opportunities for greater value capture and benefit sharing.

Additionally, the models are presented separately for clarity; many projects will benefit from applying the models in combination, meaning benefits will exceed those reported here. A holistic, blended approach to circular economy principles on a project will be the most effective way of maximising the benefits.

This improved performance offers investors and construction clients with the opportunity to improve their competitive position while at the same time strengthening their appeal among increasingly environmentally-aware and climate-conscious potential customers.

KEY FINDING 2: THESE FIVE MODELS OFFER VALUE ACROSS BUILDING TYPOLOGIES, TENURE TYPES, MARKETS AND TIMEFRAMES

The models developed were tested on real ('testbed') projects with different asset classes in different European cities (Aarhus, Amsterdam, Berlin, London and Milan). The circular model delivered improved performance versus the linear case across a range of typologies and tenures:

- tenanted commercial
- tenanted residential
- tenanted mixed-use
- tenanted retail
- build-to-rent residential

Study periods varied from 10 years (Residual Value) to 50 years (Adaptable Assets) showing returns can be realised within reasonable medium- and long-term horizons.

It should be noted that the models can be applied to other asset classes and tenure types, not only those tested. The real estate sector is a highly heterogeneous industry, meaning this versatility is important. It is also worth noting again that the five models presented here are not mutually exclusive; it is likely that many real estate investors and construction clients will be able to draw from all five to improve the financial and environmental performance of their projects. For example, a building operator may be forced to move in response to a population shift, and with a relocatable fit-out could move their operation from one adaptable asset to another, realising maximum residual value from the elements they are not able to reuse.

KEY FINDING 3: MANY OF THE TOOLS NEEDED TO ADOPT CIRCULAR THINKING IN REAL ESTATE ARE ALREADY HERE

The models deliberately challenge conventional thinking and processes, while simultaneously building on best practice from industry leaders. The readiness framework, 'Now, New, Next', gives an indication of maturity levels for each model, Figure 39. For example, Flexible Spaces addresses the trend towards fluid co-working environments. It is directly enabled by online platforms that drastically reduce transaction costs for finding tenants. IoT technology allows real-time monitoring of space utilisation and dynamic billing of users only for the space and time they have used.

Similarly, Adaptable Assets borrows from procurement approaches already prevalent in the infrastructure sector to ensure all value chain members, from investors through to operators, benefit from longer-term thinking and user-centric service provision.

Meanwhile use buildings are already being used as a tactic for regeneration schemes to bring life to otherwise derelict locations and to bring value to local communities earlier in the development process. Relocatable Buildings is a model that develops this further to encompass higher value spaces and more diverse uses.

The emergence of material passports, provenance standards, blockchains and digital twins make the concept behind Residual Value, namely a financial instrument priced against the future value of materials in buildings, a new possibility. Whether financial markets and institutions buy into this concept remains to be seen.

Finally, Performance Procurement, though technically feasible, will require careful testing of new relationships, requirements and contracts. This is best done through commercial-scale pilots led by leaders in the real estate asset classes and city markets considered in this report.

KEY FINDING 4: NEW RELATIONSHIPS ARE NEEDED IN THE REAL ESTATE AND CONSTRUCTION VALUE CHAIN

Each of the models, particularly Residual Value, Relocatable Buildings and Performance Procurement, envisage the development of new relationships in the value chain. In the case of Residual Value, this means a new market for financial instruments linked to the future value of materials. For Relocatable Buildings and Performance Procurement, the value chain will change shape, with service providers offering integrated offerings around whole systems directly to construction clients, building operators and investors. Collaboration, entrepreneurship and investment are needed to drive these changes.

Exactly how these markets and value chains will develop is difficult to predict. For example, Flexible Spaces may provide space in abundance on a low resource footprint - one of the key outcomes of a circular economy. Yet there will be a natural limit to this abundance, not from limited supply but from limited demand. As more space becomes available, marginal rates will fall and the business case for making more space available will weaken. Conversely, a growing market will reduce the price of the technology needed to make spaces flexible, strengthening the business case. Value chain stakeholders will need to be as flexible as their spaces to manage these changes.

KEY FINDING 5: THESE FIVE MODELS CAN HELP REAL ESTATE ACTORS ACHIEVE THEIR NET ZERO CARBON TARGETS AS WELL AS BOOSTING ECONOMIC PERFORMANCE

While not explicitly quantified in this report, the five models presented improve the resource productivity of real estate and in turn will also serve to decarbonise the sector. Construction material manufacturing is a growing and hard-to-abate source of emissions. A recent report by C40 Cities with Arup and the University of Leeds identified five actions to cut 9.1Gt of greenhouse gas emissions associated with materials for buildings and infrastructure from the footprints of 96 global cities, using strategies linked to the models in this report. For example, two of the five actions are enhanced building utilisation, the focus of the Flexible Spaces and Adaptable Assets models, and the reuse of building components, enabled by Relocatable Buildings, Residual Value and Performance Procurement.

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NEXT STEPS

CALL TO ACTION

This report is a call to action directed at the real estate investment and construction client communities. It has articulated how circular economy principles can be realised in practice in real estate business models. It has used discounted cashflow analysis to demonstrate they have the potential to deliver improved financial performance. What is needed now are commercial-scale pilot projects to demonstrate this potential is achievable.

Action 1: Investor and construction client communities must lead the adoption of circular principles on scalable, commercial-scale real estate projects. This entails those communities evaluating the models presented in this report against their own specific needs and ambitions. Commercial directors should review their project strategies checking against the sources of lost value identified here. Investors and construction clients will need to challenge their commercial and sustainability professionals to adopt circular economy thinking to create and respond to new project briefs.

Action 2: Real estate professionals must drive this conversation. This report starts a conversation between those already driving change in the industry and those who are stuck in the linear business-as-usual. Communities of experts such as agents, insurers and accountants must be part of this conversation, and must be ready to over-turn long-standing conventions, framed entirely on linear economy thinking, to realise the opportunity presented by circular business models.

Action 3: Policy makers must be involved from the beginning of commercial-scale pilots. If private sector influencers lead on applying circular business models and reporting their benefits, they will create the evidence base that policy makers are requesting to ensure these approaches are adopted across the market and at all levels of the value chain. In some cases, policy changes will be needed for these models to be realised, for example, planning policies may need to change to facilitate widespread uptake of Relocatable Buildings. Requests to policy makers to support circular economy implementation are more likely to succeed if policy makers have seen for themselves the value unlocked by this approach.

Action 4: Evaluation tools which capture lost value must be developed. Value is lost because current evaluation models do not measure it. The resulting externalities are the climate emergency, the waste mountain and collapsing biodiversity. Real estate evaluation models are sorely needed which can inform investors which projects will make a positive contribution to restoring damaged natural systems.

CLOSING REMARKS

Circular economy approaches will only be adopted at scale if business models change. In other words, circular economy needs to be viewed as a business strategy, not just a waste management or a design strategy.

If a critical mass of investors and construction clients embrace this message and take the actions above, we are confident the real estate sector can deliver significant returns while reducing its negative burden on the planet. Success in this will help meet financial, economic, social and environmental needs – making a positive impact, not just reducing negative ones – on a reduced resource footprint.

We are also confident that the supply chain will respond to their lead, investing in new service offerings that deliver non-toxic, durable, reusable and repairable products as part of high-performance, user-focused systems.

As this shift happens, the whole sector will move from discussing principles to changing practices, to create a more productive, more agile and less damaging real estate sector, accelerating the global transition to a circular built environment.

HAUT, Amsterdam

FURTHER RESEARCH

This report provides a high-level illustration of the power of circular thinking in real estate. There remains more work to do to deliver these models in practice. The following are topics which struck the project team most strongly as needing additional consideration.

DEVELOPING PRICE STRUCTURES

This report has sought to quantify the net financial benefit associated with reducing sources of lost value. In reality, the added value will be shared across the value chain through pricing mechanisms. The price point of new cash flows, like the commodity futures contracts in Residual Value and subscription costs in Performance Procurement, have only been estimated. Although some sensitivity analysis has been carried out to test the impact of price on the financial performance, appropriate and industry-accepted pricing structures, likely in future to include carbon pricing, will be determined by the market.

DEMONSTRATING CO-BENEFITS

This report does not attempt to quantify the additional benefits that these models bring. All five models seek to reduce the climate impact of this sector through systemic change. In addition, the models offer other co-benefits. For example, Adaptable Assets reduces demolition activity, improving air quality from reduced dust and traffic. Relocatable Buildings could bring significant social benefits to communities impacted by blight from unoccupied sites. Further work is needed to demonstrate the benefits of these models beyond the improved financial performance demonstrated here.

THINKING BEYOND PROJECTS AND ACROSS PORTFOLIOS

Elements of each of the models require consideration beyond individual projects to incorporate whole real estate portfolios and realise their full potential value. For example, under Performance Procurement, service agreements may be best delivered through frameworks encompassing several buildings or an entire estate, while Relocatable Buildings envisages a portfolio of mobile buildings deployed across many sites at any given time. The business case of applying these models to portfolios needs to be estimated.

QUANTIFYING MARKET RISK MITIGATION

While not quantified in this report, the models help mitigate market risk. Flexible Spaces, Adaptable Assets, Relocatable Buildings and Residual Value all offer investors and construction clients greater options for an exit strategy in the event the market moves away from what they planned for. Further research is needed into how the proposed models offer greater benefit through improved business resilience, strengthened client relationships and better feedback on actual product performance.

CLOSING THE GAP BETWEEN TECHNICAL AND ECONOMIC LIFETIMES

Building design lives bear little relation to actual observed service lives; the latter being determined by by complex interactions of social, technical and economic drivers. Further research is needed into the reasons why buildings are demolished, to equip designers, construction clients and investors with the insight they need to anticipate and avoid premature demolition to the greatest possible degree.

L'Innesto - Milano Greco, Reinventing Cities, Milan

APPENDICES

APPENDIX A: VISION

How will a built environment operating on circular principles actually differ from the one we have today?

A circular built environment embeds the principles of a circular economy across all its functions, establishing an urban system that is regenerative, accessible and abundant by design.

Support human well-being and natural systems

Human living standards, health and well-being are improved, and natural systems are restored. Building occupants have improved outcomes in health and productivity. Material abundance comes without environmental degradation.

Guided by systems thinking

Decisions made across the built environment value chain are guided by feedback-rich and data-driven models that will account for interactions between buildings, infrastructure, users and the biosphere, as well as change over time. The models consider economic, environmental and social outcomes.

Leveraged by digital technology

Digital technologies provide accessible platforms to facilitate asset sharing and the management of buildings and materials. Smart apps and innovative practices virtualise many services currently rendered by the built environment as more people shop online and work from home.

Holistic urban planning

The overall design of space supports resilient and thriving communities with new business models to stimulate growth, and address congestion and pollution. Nature becomes part of urban areas, improving air quality, moderating extremes of temperature and supporting human well-being.

Continuous material cycles

Building occupants and infrastructure operators are responsible for tracking and returning construction materials (in the quantity and quality received) to suppliers for reuse. Use of looping, non-toxic materials reduces pollution and virgin material consumption.

Design for maintenance and deconstruction

Buildings are designed to enable maintenance, repair and reuse at all life cycle stages (including operation and end-of-service). Techniques such as modular construction minimise waste generation during construction and deconstruction stages.

Flexible productive buildings

Buildings meet their own energy and water needs while waste generation is dramatically reduced thanks to circular products. Internal utilisation rates increase thanks to shared, flexible and modular spaces.

Integrated infrastructure systems

Integrated water, energy and waste networks prioritise natural systems and can be used more intensively as smart management flattens peaks, making use of capacity available throughout the day.

Figure A1. A vision for a circular built environment

APPENDIX B: MODELLING INPUTS AND ASSUMPTIONS

FLEXIBLE SPACES

	VALUE	UNIT	SOURCE
GENERAL			
Evaluation period	12 (including 1 month fit out)	years	testbed
Inflation rate	0.5	% / annum	desk study[60]
Anchor tenant rent	60 - 80	€'000 / annum	testbed
Total desks	120	#	testbed
Occupancy post expansion	65	%	testbed
Anticipated employee growth rate	5	% / annum	project assumption
LINEAR MODEL			
Extension cost	200-250	€'000	testbed
CIRCULAR MODEL			
Additional design for flexibility cost	0	€'000	project assumption
Co-working occupancy of unused desks	75	%	project assumption
Co-working price	200	€ / month / desk	desk study - lower end of range used[61]
Co-working operating margin	20	%	project assumption
No. of fitness classes	4	/ week	testbed
No. of night classes	1	/ week	testbed
Recreational class price	90	€ / class	desk study - average used[62]
Open space operating margin	40	%	project assumption
No. of corporate meetings / events	15	/ annum	testbed assumption
Corporate meeting / event price	290	€ / meeting or event	desk study - average used[63]
Meeting space operating margin	40	%	project assumption

Table B1. Key inputs and assumptions for Flexible Spaces

ADAPTABLE ASSETS

	VALUE	UNIT	SOURCE
GENERAL			
Evaluation period	52 (2 years of construction and 50 years of operation)	years	project assumption
Inflation	0.5	% / annum	desk study[64]
Number of floors	5	#	testbed
Number of flats per floor	3	#	testbed
Average flat size	50	sqm	testbed
Total floor area	750	sqm	testbed
Construction cost	20,000 - 25,000	DKK'000	testbed
Residential rent	1.1	DKK'000 / sqm / annum	testbed
Logistics rent	1.1	DKK'000 / sqm / annum	testbed
Annual operations and maintenance cost	25	% of rent	project assumption
LINEAR MODEL			
Demolition and reconstruction cost	20,000 - 25,000	DKK'000	project assumption
Demolition and reconstruction period	2	years	project assumption
CIRCULAR MODEL			
Additional design for adaptability cost	negligible	-	unknown so included in sensitivity analysis
Conversion cost	negligible	-	unknown so included in sensitivity analysis
Conversion years	7, 9, 10, 12, 14	year of operation	project assumption

Table B2. Key inputs and assumptions for Adaptable Assets

RELOCATABLE BUILDINGS

	VALUE	UNIT	SOURCE
GENERAL			
Evaluation period	11 (9 months of design, 3 months of construction, 5 years of operation, 3 months of deconstruction, transport and reconstruction, 5 years of operation, and 1 month deconstruction and transport)	years	project assumption
Inflation rate	2.4	% / annum	desk study[65]
LINEAR MODEL			
-	-		
CIRCULAR MODEL			
Initial design and construction cost	6,000 - 7,000	€ / sqm	testbed
Deconstruction cost	15	% of initial construction cost	project assumption
Transport and reconstruction cost	30	% of initial construction cost	project assumption
Floor area	2,200	sqm	testbed
Leasable floor area	60	% of total floor area	project assumption
Average monthly rent	350	€ / sqm	desk study[66]
Operations and maintenance cost	17	% of initial construction cost	desk study[67]

Table B3. Key inputs and assumptions for Relocatable Buildings

RESIDUAL VALUE

	VALUE	UNIT	SOURCE
GENERAL			
Evaluation period	11 (1 year of construction and 10 years of operation)	years	project assumption
Inflation	1.5	% / annum	desk study[68]
LINEAR MODEL			
Construction cost	1,000 - 1,500	€'000	testbed
Recoverable materials identified	0	% of total materials	project assumption
Demolition year	10	year of operation	project assumption
Demolition cost	70 - 80	€'000	project assumption
CIRCULAR MODEL			
Additional design for deconstruction cost	5	% of linear model construction cost	desk study - a 7% increase in capital expenditure was found for a whole office building in Flanders. This testbed only considers fit out so a slightly lower increase in capital expenditure has been assumed[69]
Recoverable materials identified	37	% of construction cost	project assumption
Deconstruction year	10	year of operation	project assumption
Deconstruction cost	50 - 60	€'000	project assumption
Futures contract value	50	% of material cost in year of construction	project assumption
Futures contract settlement year	10	year of operation	project assumption

Table B4. Key inputs and assumptions for Residual Value

PERFORMANCE PROCUREMENT

	VALUE	UNIT	SOURCE
GENERAL			
Evaluation period	32 (2 for construction plus 30 for operation)	years	Construction period: Testbed Operational period: Project assumption
Inflation	2.0	% / annum	desk study[70]
Design and construction cost	35,000 - 45,000	GBP'000	testbed
Skin average useful life	20	years	project assumption
Services average useful life	15	years	project assumption
Space plan average useful life	20	years	project assumption
Skin construction cost	15	% of design and construction cost	testbed
Services construction cost	15	% of design and construction cost	testbed
Space plan construction cost	16	% of design and construction cost	testbed
Operational expenditure	350 - 400	GBP'000 / annum	testbed
CIRCULAR MODEL			
Service providers' financing cost	0	%	project assumption
Average annual utility bill	1,699	GBP / annum	desk study[71]
Component of energy bill with potential efficiency gains	83	%	desk study - includes heating, hot water and lights[72]
Component of water bill with potential efficiency gains	72	%	desk study - includes toilet, internal tap, bath and shower[73]
Utility bill reduction from efficiency gains	20	%	desk study[74,75,76]
Operations and maintenance cost savings for services	20	%	desk study[74,75,76]

Table B5. Key inputs and assumptions for Performance Procurement

PERFORMANCE PROCUREMENT END-OF-CONTRACT ASSUMPTIONS

At the end of the service agreement, the building operator has two options. The first is to renew the agreement for another period. This point in time is an opportunity to upgrade the system to meet the latest performance standards.

The second option is for the building operator to take ownership of the system. Subscription charges stop, in exchange for the building operator taking responsibility for maintenance and replacement costs.

In the first option, replacement costs are covered by the service provider and will be included in the subscription fee. In the second, replacement costs are borne by the building operator. In all cases modelled for this study, the first option is taken.

ABBREVIATIONS

Abbreviation	Definition
3XN/GXN	3XN Architects / GXN Innovation
BIM	Building information modelling
DCF	Discounted cash flow
EBITDA	Earnings before interest, tax, depreciation and amortisation
ESG	Environmental, social and governance
ICMS	International Construction Measurement Standards
IoT	Internet of Things
IPMS	International Property Measurement Standards
IRR	Internal rate of return
IVS	International Valuation Standards
NPC	Net present cost
NPV	Net present value
RICS	Royal Institution of Chartered Surveyors

White Collar Factory, London

REFERENCES

[1] International Energy Agency and the United Nations Environment Programme, *2018 Global Status Report: Towards a Zero Emission, Efficient and Resilient Buildings and Construction Sector*, 2018.

[2] Architecture 2030, *New Buildings: Embodied Carbon*, available at: https://architecture2030.org/new-buildings-embodied/, 2019.

[3] Norm G. Miller, *Workplace Trends in Office Space: Implications for Future Office Demand*, Journal of Corporate Real Estate, 2014.

[4] British Council for Offices, *Office Occupancy: Density and Utilisation*, 2018.

[5] International Energy Agency, *Energy Balances of Non-OECD Countries*, 2015.

[6] International Energy Agency, *Energy Statistics of Non-OECD Countries*, 2015.

[7] International Energy Agency, *Energy Statistics of OECD Countries*, 2015.

[8] United Nations, *Energy Statistics Yearbook*, 2016.

[9] World Bank, *What A Waste: A Global Review of Solid Waste Management*, 2012.

[10] Ellen MacArthur Foundation, *Completing the Picture: How the Circular Economy Tackles Climate Change*, 2019.

[11] Arup, C40 Cities and University of Leeds, *The Future of Urban Consumption in a 1.5°C World*, 2019.

[12] Arup, *Circular Economy in the Built Environment*, 2016.

[13] Stewart Brand, *How Buildings Learn: What Happens After They're Built*, 1994.

[14] Arup and Ellen MacArthur Foundation, *From Principles to Practices: First Steps to a Circular Built Environment*, 2018.

[15] Royal Institution of Chartered Surveyors, *Whole Life Carbon Assessment for the Built Environment*, 2017.

[16] Building Cost Information Service, *Life Expectancy of Building Components: A Practical Guide to Surveyors' Experiences of Buildings in Use*, 2006.

[17] Chartered Institution of Building Services Engineers, *CIBSE Guide M: Maintenance Engineering and Management*, 2008.

[18] Chris W. Scheuer, Gregory A. Keoleian and Peter Reppe, *Life Cycle Energy and Environmental Performance of a New University Building: Modeling Challenges and Design Implications*, Energy and Buildings, 2003.

[19] Jennifer O'Connor, *Survey on Actual Service Lives for North American Buildings*, 2004.

[20] EY, *Global Generations: A Global Study on Work-Life Challenges Across Generations, Detailed Findings*, 2015.

[21] JLL, *Disruption or Distraction: Is Flex Space Here for Good, or Just the Latest Real Estate Fashion?*, 2018.

[22] PwC and Urban Land Institute. *Emerging Trends in Real Estate: Europe 2019*, 2018.

[23] Housing Anywhere, *International Rent Index by City*, available at: https://housinganywhere.com/rent-index-by-city, 2020.

[24] Entrepeneur India, *6 Reasons Why 'Co-Living' is The New Trend Amongst Millennials*, available at: https://www.entrepreneur.com/article/320713, 2018.

[25] No Isolation, *What is the Prevalence of Social Isolation in Europe?*, available at: https://www.noisolation.com/global/research/the-prevalence-of-social-isolation-in-europe/, 2019.

[26] Forbes, *Exclusive: Britain's Co-Living King Has Raised $400m To Take On WeWork In America*, available at: https://www.forbes.com/sites/oliversmith/2018/03/27/exclusive-britains-co-living-king-has-raised-400m-to-take-on-wework-in-america/#47aa8cad9fca, 2018.

[27] JLL, *European Multifamily Investment Market Update*, 2019.

[28] Savills, *Five-Fold Growth Leaves Build to Rent Set to Become a Mainstream Asset Class*, available at: https://www.savills.co.uk/insight-and-opinion/savills-news/267907/five-fold-growth-leaves-build-to-rent-set-to-become-a-mainstream-asset-class, 2018.

[29] CBRE, *The Rise of Investment in Multifamily Housing*, 2019.

[30] Statista, *Retail E-Commerce Sales Worldwide From 2014 to 2023*, available at: https://www.statista.com/statistics/379046/worldwide-retail-e-commerce-sales/, 2019.

[31] Arup, *The Future of Retail*, 2017.

[32] The Dots, *COS Concept Store*, available at: https://the-dots.com/projects/cos-concept-store-88416.

[33] PR Newswire, *New Research from Dimension Data Reveals Uncomfortable CX Truths*, available at: https://www.prnewswire.com/news-releases/new-research-from-dimension-data-reveals-uncomfortable-cx-truths-300433878.html, 2017.

[34] The New York Times, *As Amazon Moves In, Demand for Warehouse Space Climbs*, available at: https://www.nytimes.com/2017/10/24/business/amazon-ecommerce-warehouse-demand.html, 2017.

[35] Deloitte, *The Shed of the Future, E-Commerce: Its Impact on Warehouses*, 2014.

[36] White & Case, *European Logistics and Warehousing: The outlook for 2019*, 2019.

[37] PwC, *IFRS 16: The Leases Standard is Changing, Are You Ready?*, 2016.

[38] Bloomberg, *Say Hello to $3 Trillion in Forgotten Debt*, available at: https://www.bloomberg.com/opinion/articles/2017-03-20/say-hello-to-3-trillion-in-forgotten-debt, 2017.

[39] Reuters, *Citigroup Splashes Out on London HQ*, available at: https://uk.reuters.com/article/citigroup-splashes-out-on-london-hq/citigroup-splashes-out-on-london-hq-idUKL8N21U4HO, 2019.

[40] World Economic Forum, *This is What Millennials Want in 2018*, available at: https://www.weforum.org/agenda/2018/01/this-is-what-millennials-want-in-2018/, 2018.

[41] BlackRock, *Larry Fink's 2018 Letter to CEOs: A Sense of Purpose*, available at: https://www.blackrock.com/corporate/investor-relations/2018-larry-fink-ceo-letter, 2018.

[42] The Energy Mix, *Sustainable Investments Grow 34% Over Two Years, with Climate as Prime Motivator*, available at: https://theenergymix.com/2019/04/03/sustainable-investment-grow-34-over-two-years-with-climate-as-prime-motivator/, 2019.

[43] BNP Paribas, *Energy Transition: BNP Paribas, The Number One Bank According to NGOs*, available at: https://group.bnpparibas/en/news/energy-transition-bnp-paribas-number-bank-ngos, 2018.

[44] Intesa Sanpaolo and Fondazione Cariplo, *Press Release: For a Future-Proof Development Model*, 2018.

[45] BlackRock, *BGF Circular Economy*, available at: https://www.blackrock.com/uk/intermediaries/products/310167/, 2020.

[46] ABN AMRO, *Circular Economy*, available at: https://www.abnamro.com/en/about-abnamro/in-society/sustainability/circular-economy/circular-economy.html.

[47] EIT Climate-KIC, *Re-usable Buildings Pathfinder Project*, 2018.

[48] DCF is defined and described within IVS 105, 50.

[49] Ellen MacArthur Foundation, *Potential for Denmark as a Circular Economy, A Case Study From: Delivering the Circular Economy – A Toolkit for Policy Makers*, 2015.

[50] Arup, *Living Workplace*, 2017.

[51] Association of University Directors of Estates, *Delivering Value from the Higher Education Estate*, 2015.

[52] The King's Fund, *NHS Buildings: Obstacle or Opportunity?*, 2013.

[53] UK Department of the Environment, Transport and the Regions, *Demolition and New Building on Local Authority Estates*, 2000.

[54] Satu Huuhka and Jukka Lahdensivu, *A Statistical and Geographical Study on Demolished Buildings*, Building Research and Information, 2006.

[55] The Times, *Retail Landlord Counts Cost of Devaluations*, available at: https://www.thetimes.co.uk/edition/business/retail-landlord-counts-cost-of-devaluations-0mjvvn3zv, 2019.

[56] Business News Australia, *Stockland Profits Smashed by Devaluations*, available at: https://www.businessnewsaus.com.au/articles/stockland-profits-smashed-by-devaluations.html, 2019.

[57] The Guardian, *Revealed: Housebuilders Sitting on 600,000 Plots of Land*, available at: https://www.theguardian.com/society/2015/dec/30/revealed-housebuilders-sitting-on-450000-plots-of-undeveloped-land, 2015.

[58] Centre for London, *Meanwhile, in London: Making Use of London's Empty Spaces*, 2018.

[59] Estimated based on data from p22-23 of the following report: Circle Economy, *The Circularity Gap Report*, 2019.

[60] Trading Economics, *Italy Inflation Rate*, available at: https://tradingeconomics.com/italy/inflation-cpi.

[61] What a Space, *Milan: Meeting Space*, available at: https://www.whataspace.it/, 2019.

[62] Immobiliare, *Rent: Milan Gym*, available at: https://www.immobiliare.it/, 2019.

[63] What a Space, *Milan: Event Location*, available at: https://www.whataspace.it/, 2019.

[64] Trading Economics, *Denmark Inflation Rate*, available at: https://tradingeconomics.com/denmark/inflation-cpi.

[65] Trading Economics, *Netherlands Inflation Rate*, available at: https://tradingeconomics.com/netherlands/inflation-cpi.

[66] Savills, *City Special: Amsterdam*, 2018.

[67] Graham Ive, *Re-Examining the Costs and Value Ratios of Owning and Occupying Buildings*, Building Research and Information, 2006.

[68] Trading Economics, *Germany Inflation Rate*, available at: https://tradingeconomics.com/germany/inflation-cpi.

[69] K Wang et al, *Why Invest in a Reversible Building Design?*, IOP Conference Series Earth and Environmental Science, 2019.

[70] Trading Economics, *United Kingdom Inflation Rate*, available at: https://tradingeconomics.com/united-kingdom/inflation-cpi.

[71] The Money Advice Service, *What is the Average Cost of Utility Bills Per Month?*, https://www.moneyadviceservice.org.uk/blog/what-is-the-average-cost-of-utility-bills-per-month, 2019.

[72] UK Department of Energy and Climate Change, *United Kingdom Housing Energy Fact File*, 2013.

[73] Market Transformation Programmee, *BNWAT28 Water Consumption in New and Existing Homes*, 2008.

[74] Philips, *Minimize Your Environmental Footprint and Create Instant Savings*, 2017.

[75] Ellen MacArthur Foundation, *Kaer: Air Conditioning as a Service Reduces Building Carbon Emissions*, available at: https://www.ellenmacarthurfoundation.org/case-studies/air-conditioning-as-a-service-reduces-building-carbon-emissions.

[76] European Waster Label, *Find a Product*, available at: http://www.europeanwaterlabel.eu/findaproduct.asp?country=GB&category=&rating=A&manufacturer=&order=, 2019.

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