To lease, or not to lease? A critical evaluation of Product-Service-System building components in rental housing

How Product-Service-System building components offer value to organizations specializing in the development and management of rental housing.

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MSc Thesis
Management in the Built Environment (MBE)
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July, 2021

Abstract

This research explores the value offered by Product-Service-Systems (PSSs), also known as Product-as-a-Service (PaaS), to organizations that develop, own and operate rental housing portfolios. The Dutch national government's ambition for a circular economy by 2050, combined with the demand for over 1 million sustainable new homes in the coming decades, provides grounds for increased PSS implementation in the housing sector. PSSs are touted as a critical tool to decouple environmentally harmful resource extraction from continued economic growth. However, for them to be implemented at scale, they must demonstrate clear value to decision makers who consider procuring them. As such, the value of PSSs in rental housing is theoretically explored and empirically studied through case studies to understand what drives housing providers to use PSSs within their developments and portfolios. The research reveals additional advantages perceived by housing providers, how housing providers analyze the use of a PSS, what challenges they encounter, and a preliminary review of how circular the studied cases inherently are. Five expert interviews are used to corroborate the findings from the case studies. Lastly, a financial simulation is conducted to understand the tax implications of using leased PSSs with zero-upfront investment.

Keywords: Rental Housing, Value, Product-Service-System (PSS), Product-as-a-Service (PaaS), Leasing, Circular Economy, Real Estate Management, Housing Management.

Preface

This master's thesis document represents the culmination of a 1-year research project as part of the Circular Business Models (CBMs) and Product-Service-Systems (PSSs) Graduation Lab within TU Delft's Management in the Built Environment Master of Science.

Throughout the year, many people have contributed to the research in various ways. First, I would like to thank my TU Delft supervisors, Tuuli, Gerard and Daan, who provided valuable feedback and guidance. Second, I would like to thank my ABN AMRO mentor, Rob, who gave me practical guidance and connected me with many interviewees. Third, I would like to thank my friends who helped keep spirits high and laugher rolling during this unprecedented and challenging time: Akshit, Carlos, Fabra, Maita, Manu, Alejandro, Rafa, Adriana, Daniel and Karl. And above all, I would like to thank my best friend and wife, Ashley, who provided unconditional support and always reminded me to "trust the process" when "the going got tough".

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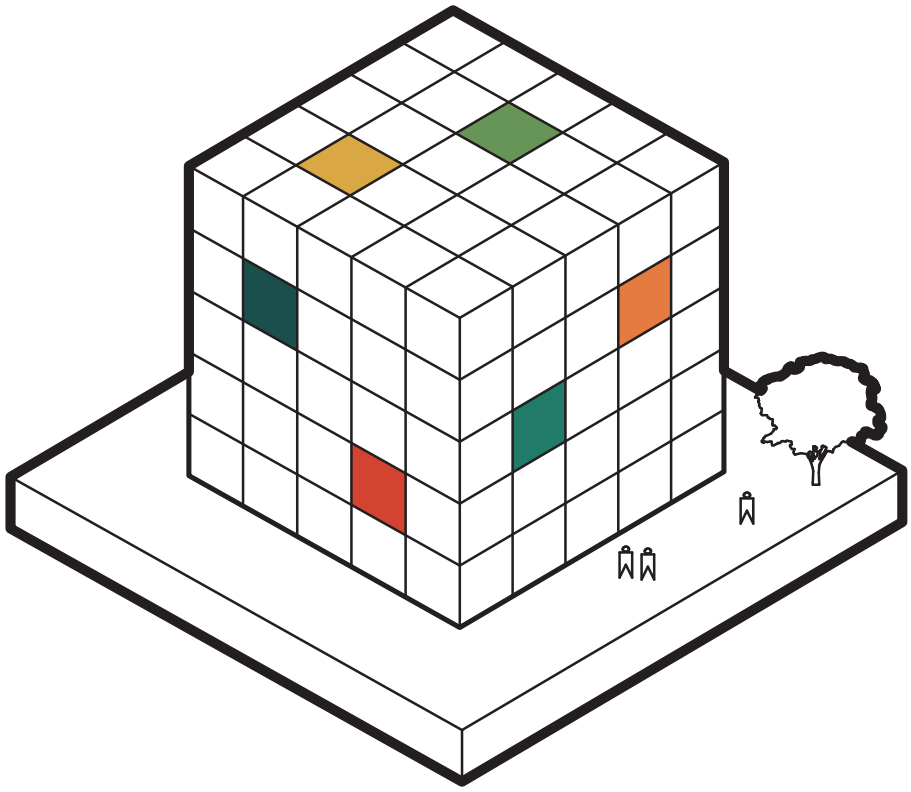
Executive Summary



1. Introduction

Of humanity's numerous environmentally-damaging activities, resource consumption is the underlying cause of greenhouse gas emissions and global warming (Satterthwaite, 2009). If no change is undertaken, resource consumption will intensify as the global population grows by an additional 41% by the end of the century (United Nations, 2019). This is especially concerning because, as of 2019, humanity already consumes natural resources 75% faster than nature replenishes them (Wackernagel et al., 2019). If resource extraction is not reduced, humanity will eventually deplete the world's biocapacity.

With much of the world's population moving to cities, an immense amount of urban housing construction is needed to keep pace with demand. The demand for residential construction unfortunately works in direct contradiction with reducing resource consumption, as housing "represents the largest resource and emissions footprint" among society's most crucial needs (Circle Economy, 2021).

To address such issues, the concept of the "circular economy" has been introduced as a means to reduce resource extraction and waste by keeping materials in perpetual use and using them to their fullest capacity. A circular economy requires the re-evaluation of current economic incentives which rely on continuous resource extraction to achieve economic growth. Product-Service-Systems (PSSs), commonly referred to as Product-as-a-Service (PaaS), have been identified as a business model with the potential to align increased economic growth with reduced resource consumption as they establish the possibility of **ownerless consumption** (Ellen MacArthur Foundation, 2013). When consumers do not purchase products, but instead lease them, manufacturers retain ownership of their raw materials and thus are incentivized to use them as efficiently as possible while reducing waste and the need for further resource extraction (van Ostaeyen et al., 2013).

Problem Statement

The Netherlands, like many countries globally, faces the aforementioned climate change and housing challenges. To help facilitate the realization of aggressive climate goals, the Dutch National Government intends to develop a circular economy by 2050, at which time, "raw materials will be used and reused efficiently without any harmful emissions into the environment" (Government of the Netherlands, 2016). In terms of housing production, when combining current shortages with forecasted population growth, roughly 1.2 million new homes must be constructed by 2050 (ABF Research, 2020; Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2019). Much of the housing will be built as dense multifamily housing in the cities of the region known as the Randstad (CBS, 2011) by housing providers (HPs) that develop and manage social-, mid- and high-income homes.

The required housing construction relies on resource extraction which unfortunately exacerbates current climate issues. If building components are **purchased** by housing providers (HPs), or organizations who develop and manage rental housing, it is unlikely that the raw materials will be reused in future products, as the materials will likely be discarded at the end of their initial use (van Ostaeyen et al., 2013). Thus, the value of PSSs, especially those that are **leased**, will be studied within the context of rental housing as an alternative procurement model which supports a circular economy.

Research Aims and Objectives

PSSs have been well-studied in applications such as car sharing (Catulli et al., 2021) and jet engines (Kühl et al., 2018), though the application of PSSs to real estate remains limited. The research that does exist primarily establishes a supply-oriented perspective which offers insights into the design and delivery of building-related PSSs (Azcarate-Aguerre et al., 2017; Coalition Circular Accounting, 2020). However, if PSSs are to be implemented at scale within the built environment, they must demonstrate clear value to decision makers who own and manage real estate. Thus, this research

explores the value of PSSs from a demand-oriented perspective, specifically that of a housing provider (HP), or an organization that owns and manages rental housing. The aim is to understand how HPs can benefit from the use of PSSs within their buildings and portfolios. With such information readily available, PSSs can potentially be used in greater abundance within the housing sector, thus serving as a demand-driven catalyst for enhanced circularity in the built environment.

Research Questions

This research builds on the existing body of PSS knowledge by answering the following main research question:

"How can Product-Service-Systems (PSSs) offer value to housing providers?"

In this research, the term "value" is defined by the "relative worth, utility, or importance" of something when compared with an alternative (Merriam-Webster, 2021). The value to be determined is that of PSS building components when compared with building components that are purchased, maintained and operated by the organization that owns them. In order to answer the main research question, the following sub-questions must also be answered:

1. *What is a PSS?*
2. *How can PSSs be applied in rental housing?*
3. *What are the drivers for housing providers to use PSSs?*
4. *What analysis do housing providers conduct before using PSSs?*
5. *What challenges do housing providers face when using PSSs?*
6. *What circular principles do market-implemented PSSs exhibit?*
7. *How does the use of PSSs impact a building's asset value?*

2. Methodology

The research is structured in four main sections: theoretical research, empirical research, financial simulation, and conclusions.

Theoretical Research

Theoretical research was conducted via a literature review of research databases, academic journals, books, and reports to understand the theoretical underpinnings of PSSs and how they can be applied in rental housing. Based on the findings, a theoretical framework was created to identify the theoretical value PSSs offer to housing providers (HPs).

Empirical Research

The research is divided in three main parts, as seen in figure II. First, case studies are conducted to understand what drives housing providers (HPs) to use PSSs, what secondary advantages PSSs offer, how HPs consider using PSSs, what challenges HPs face, and how inherently circular the PSSs are. The case studies also reveal contract details and payment structures of each PSS. Second, interviews are conducted with experts on the topics of Product-Service-Systems (PSSs) and circular business models (CBMs) within the built environment. These interviews are used to corroborate the findings from the case studies. Lastly, a financial simulation was conducted to understand the financial implications of leasing building components, and how a buildings tax liability and Internal Rate of Return (IRR) are impacted. The case studies, expert interviews, and financial simulation allow for triangulation which increases the validity of the research (Bryman, 2016).

<u>Case Studies</u>

The use of multiple case studies enables a deeper understanding of the value PSSs offer the housing providers that use them. The use of case studies allows for the investigation of "a contemporary phenomenon within its real-life context" (Yin, 2003). As such, this research investigates the contemporary

phenomenon of Product-Service-Systems in the real-life context of American and Dutch rental housing.

Across the 7 cases, as seen in figure I, all required criteria were met. Only in two cases were representatives from the housing provider not available for interviews. Of the four types of PSSs intended to be studied, only a performance-based PSS was not included in the study since a market-implemented performance-based PSS could not be identified. Based on the selection criteria, seven cases have been selected.

Case A – Input-based Elevator: located in New Hampshire, USA, Case A is the modernization of two existing elevators within a 78-apartment affordable (social) housing building.

Case B – Availability-based Kitchen: located in The Netherlands, Case B is the installation of 16 kitchens within the transformation of a historic (monument) office building to 16 market-rate apartments.

Case C – Availability-based Window: located in The Netherlands, Case C is installation of 130 windows within the transformation of an office building into 30 market-rate short-term rental apartments.

Case D – Availability-based Battery: located in The Netherlands, Case D is the installation of a battery storage system within a 50-apartment social (affordable) housing building.

Case E – Usage-based Elevator: located in The Netherlands, Case E is the installation of 14 elevators in a large new construction project comprised of 485 market-rate homes.

Case F – Usage-based Heat Pump: located in The Netherlands, Case F is the modernization of a heating plant within a 27-apartment social (affordable) housing building. The existing combined heat and power (CHP) gas boilers were replaced by new electric heat pumps.

Case G – Usage-based PV Panels: located in The Netherlands, Case G is the installation of solar panels on existing social (affordable) housing buildings.

		Cases						
	Criteria	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Required	1. A building component PSS has been procured a within the portfolio of a housing provider within the last 3 years.	X	X	X	X	X	X	X
	2. Representatives from either the housing provider or PSS provider are available for interview.	X	X	X	X	X	X	X
Desired	3. Representatives from both the housing provider and PSS provider are available for interview.	X	X	X	X	X	*HP unavailable*	
	4. If possible, select at least 1 case study of each PSS taxonomy: • Input-Based • Availability-based • Usage-based • Performance-Based	Input-based	Availability-based			Usage-based		

Fig. I
Match between case studies and selection criteria, own figure.

Demand + Supply Cases
In cases A-E, semi-structured interviews were conducted with housing provider representatives who procured PSSs within their buildings (demand-oriented), and PSS provider representatives who deliver the specific PSS (supply-oriented). Representatives were asked almost identical questions pertaining to why the housing provider used the PSS, how they analyzed using it, what challenges were faced when using it, and what principles of circularity are exhibited in the PSS. Cases also consider the proportion of service to product related costs during the duration of the contract.

Supply-Only Cases
In cases F and G, when HPs were unavailable for interview, PSSPs were interviewed using the same set of questions from the demand + supply study.

Analysis approach
Each case was studied individually before being compared across its type of case (Demand + supply vs supply-only), and lastly across all cases. The individual analysis of each case consists of the following parts: 1) case context, 2) propositions offered by the PSS provider, 3) drivers for the housing provider to use the PSS, 4) other advantages of using the PSS, 5) analysis of the PSS, 6) challenges faced, 7) circular principles exhibited, and 8) summary. The cross analyses aim to find characteristic patterns of each type of PSS (input-, availability-, usage). Based on these analyses, the theoretical framework will then be adjusted to reflect the findings. The use of multiple case studies minimizes errors and allows for more convincing results (Bryman, 2016).

Data Collection and Analysis
Cases are studied using a repetitive semi-structured interview protocol which enable better comparisons and conclusions to be drawn. Interview protocols are based on the findings from the theoretical framework and can be seen in Appendices A and B. Interviews were conducted during February and March of 2021 and analyzed in April. Each interview was 1-hour in duration, conducted over Zoom, and recorded for transcription. Data collected from the twelve case study interviews was transcribed using Otter.ai and analyzed using ATLAS.ti software. Using ATLAS.ti, interviewee responses were coded and labeled in connection to the concepts identified during the literature review and theoretical framework development (Bryman, 2016). Some codes pertain to those identified in the theoretical research, while others emerged based on new findings. An example of how interview data was coded is seen below.

Outsource Risk and Responsibilities

Accomplish (More) Scope without Capital

"Well, for me, the main thing is that it allows me to keep my business lean, so I don't want to expand the business in the sense of employing more people. So this is a very good way to outsource a big part of the technical responsibility while also being able to outsource the management over these assets and the financial investment on these assets. And that was the last point was especially important for this project, because transforming buildings is already very complex with many moving parts during the decision making process. And that's even worse in the case of old buildings, especially monuments where you have a lot of restrictions. So the PSS alternative to the kitchens came as a good way of releasing some pressure on the budget."

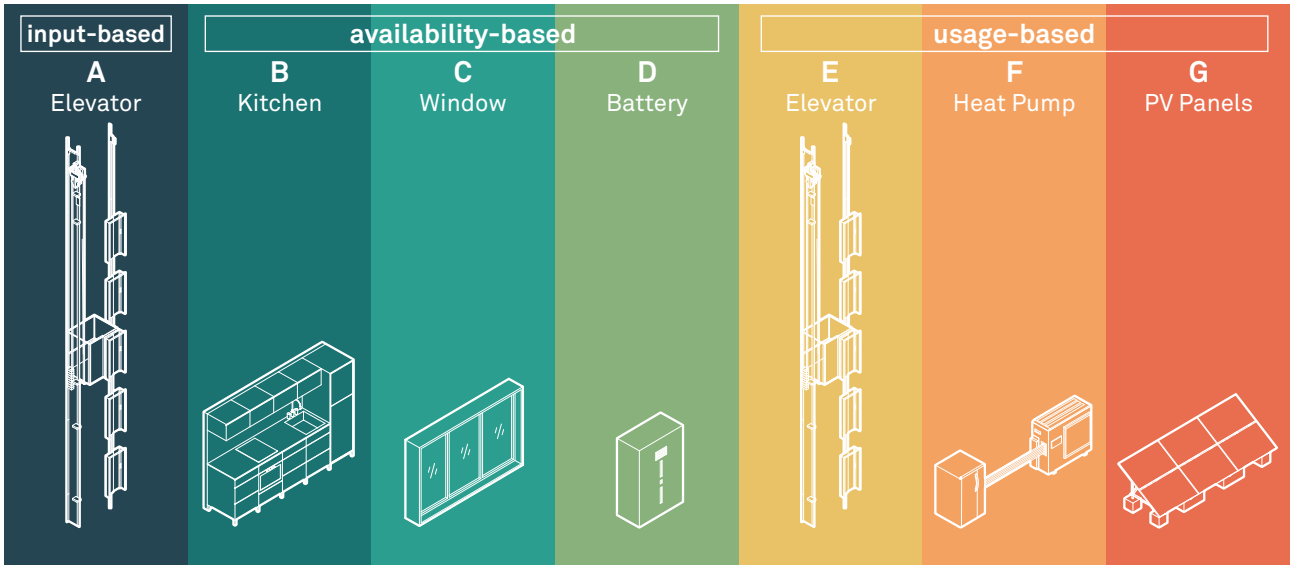
Each interview is analyzed individually, and then compared with other interviews to find recurring themes and reasoning for using the PSS. The codes used can be seen in figure 5.01 (Discussion and Recommendations).

Expert Interviews

The expert studies were used to corroborate the findings from the demand + supply and supply-only case studies. Semi-structured interviews were used to gather information regarding the potential drivers and advantages for real estate organizations who use PSSs. The expert interviews reveal the trends which have fueled the use of PSSs over the last decade, the barriers facing PSSs, the current market share of PSSs, and potential future for PSSs. The interviews help to understand the pervasiveness of CBMs and PSSs within the larger context of the real estate, design and construction, and the built environment in general. These interviews used the same data collection and analysis approach as the case studies.

Demand + Supply Cases | **Supply-Only Cases**

Purchased — Leased



Expert Interviews

Expert 1	*Expert 2*	*Expert 3*	*Expert 4*	*Expert 5*
(ABN AMRO)	**(TNO)**	**(Turntoo)**	**(Een Veilig Gevoel)**	**(Volantis)**
Rob van Willigen: Commercial Advisor Product-as-a-Service (PaaS).	**Mark van Ommen:** Business Developer of Circular Economy Buildings & Infrastructure.	**Sabine Oberhuber:** Co-founder of Turntoo, circular economy expert & innovator, speaker, and author.	**Rick Ruisch :** Founder & Shareholder of Security-as-a-Service Firm.	**Jeroen Reumkens:** Circular Innovation Consultant.

Financial Simulation

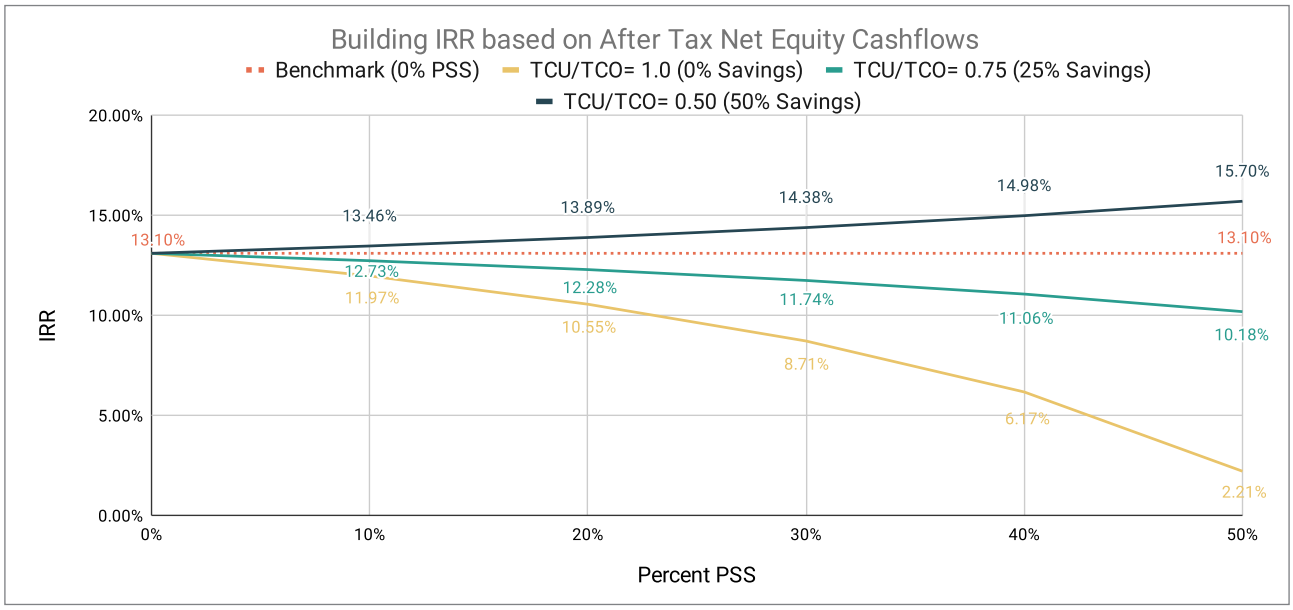


Fig. II
Empirical research components, own figure.

Financial Simulation

Based on finding from the case studies and expert interviews, a financial simulation was conducted to gain insights into the financial implications of leasing building components. The operational research utilizes a series of discounted cash flow models to simulate the impacts of leased PSSs on a building's tax liability, Internal Rate of Return (IRR), and Net Present Value (NPV). The indices and assumptions used in the model, as well as the model sheets themselves, can be found in Appendix G.

3. Findings

The main findings from the theoretical research, empirical research, and financial simulation are found below. Findings are presented in relation to relevant theory.

Q1) What is a Product-Service-System (PSS)?

A PSS, based on theory, is any combination of products and services that together deliver the user a desired solution (Mont, 2004). The ambition of delivering solutions over mere products and services is best illustrated by the quote "people do not need cars and washing machines, but mobility and clean clothes" (Meijkamp, 1998). PSSs in practice can take shape in various forms; the product can be sold in combination with supplemental services, or the product can be rented or leased to a user who utilizes it without becoming the owner (Tukker, 2004; van Ostaeyen et al., 2013).

Leased PSSs, or those in which products are not sold to customers but instead remain under the ownership of manufacturers or service providers, are considered to have the highest potential for circularity. When PSS providers (PSSPs) consider their products assets instead of goods, they are incentivized to minimize operational costs associated with parts and labor while simultaneously maximizing the lifespan of their products (van Ostaeyen et al., 2013). Additionally, PSSPs are incentivized to exploit the residual value of their assets, which often leads to the remanufacturing of used products so they may be used again. When configured properly, PSSs can thus decouple economic growth from continued resource consumption and assist the transition from a linear economy to one that is circular in nature (Ellen MacArthur Foundation, 2013; Lacy et al., 2014).

To think that all PSSs are inherently circular and environmentally beneficial is unfortunately not true (Blüher et al., 2020; Tukker & Tischner, 2006). If a PSS is not designed for disassembly, nor does it make use of circular inputs, it inherently relies on the continued extraction of raw material that must be extracted, transported, and manufactured - all of which has environmental consequences. A truly circular PSS relies on the cooperation of various supply-chain actors during production, use, and reverse logistics (Böhm et al., 2017; Windahl & Lakemond, 2006; Xing et al., 2013).

Q2) How can PSSs be applied in rental housing?

A housing provider (HP) can procure a PSS in one of four ways (input-, availability-, usage-, or performance-based), as either a purchased or leased PSS (van Ostaeyen et al., 2013). The PSS type is based on how the majority of payment value is delivered to the PSSP during the contract duration, meaning ownership does not necessarily determine the type of PSS (van Ostaeyen et al., 2013). First, HPs may use an input-based PSS contract to purchase a product with a supplemental service contract (ex: purchasing a heat pump with an annual inspection and maintenance contract). In input-based PSSs, the majority of payment is associated with the purchasing of the product. Second, they may use an availability-based PSS, typically in the form of a lease, to pay for the PSS to be available in their building (ex: leasing a kitchen and paying for it to be available, independent of how much it is used). Third, they may use a usage-based PSS, typically in the form of a lease, to pay per use of the PSS (ex: leasing an elevator and paying based on the total annual vertical distance traveled). And fourth, they may use a performance-based PSS, typically in the form of a lease, to pay for the PSS only when performance criteria are met (ex: lease an integrated solution of heating, cooling, ventilation, and building envelope, and paying

based on the amount of time a comfortable indoor environment is provided). Availability-, usage-, and performance-based PSSs can also be owned by the HP, although the majority of payment value must derive from service-rated costs. Each type of contract offers different payment structures and incentives for the PSS providers (PSSPs) to deliver quality service to the housing provider. In the order of input-, availability-, usage-, and performance-based, PSSs will increase in circularity (van Ostaeyen et al., 2013), increase in risk for the PSS provider (van Ostaeyen et al., 2013), increase in contract complexity (Reim et al., 2015), and decrease in contract standardization (Reim et al., 2015).

In theory, any product and complementary service can constitute a PSS, however there is an underlying logic regarding which products are most fitting for a PSS value proposition. Building components which require intensive maintenance or frequent replacement (Kim et al., 2016), and those that require recurring inspections or continuous monitoring (perhaps due to life-safety risks) (Raposo et al., 2013) are fitting for a PSS business model. Also, building components that are often replaced before they exceed their technical lifespan are fitting as a PSS (TU Delft, 2020). This is well illustrated by the fact that kitchens are often replaced far before the end of their useful life, simply because their outdated aesthetics reduce a building's ability to generate revenue. Findings from the empirical research also identified more criteria that may make some products more fitting than others as a PSS. Building components which are technologically innovative and require advanced expertise to achieve their promised operational efficiencies may lend themselves to a PSS value proposition. This is because housing providers (HPs) often outsource the expertise when it is not considered part of their core business (ex: operating a battery). Lastly, when CO2 taxes are established by governments, building components with exceptionally high CO2 footprints, and thus tax liabilities, may be good candidates for circular PSSs.

HPs should be aware of the legal concept of "accession", which states that components installed in a building become the property of the building owner when they cannot be removed without significantly damaging the rest of the building, or when the building would be considered incomplete without them. Due to accession, a building's structure cannot be procured as a leased PSS, as it cannot be removed without damaging the building. Other large building components, such as a façades, HVAC and kitchens, can be offered as leased PSSs when designed in a modular, demountable manner. In such cases, PSS providers (PSSPs) may opt for a pair of contracts to be used to circumnavigate the legal concept of accession so they may retain legal ownership of the PSS. First, the building owner (HP) will rent suspension points to the PSSP, and secondly, the PSSP will deliver a contract for the HP to use their PSS (Coalition Circular Accounting, 2020).

HPs considering the sale or purchase of buildings with preexisting long-term PSS contracts should also be aware of the legal concept of "chain liability" (ketenaansprakelijkheid) which enables businesses, such as property specific entities, to transfer or take over PSS contracts. Based on interviews with experts and PSSPs, buildings can easily be purchased and sold without disturbing such contracts.

Experts noted that PSSs currently comprise only a small portion of the overall products and services sold on the market. While their market share is limited, the number of PSSs has grown over the last few years due to companies which aim to be circular by nature, or more commonly, due to companies which strengthen their profit margins by integrating products with services. Once CO2 emission tax regulations are established, experts believe the pervasiveness of PSSs, especially those which embrace circular principles, will substantially increase.

Q3) What are the drivers for housing providers to use PSSs?

Based on empirical research, HPs use PSS for several reasons, as seen in figure III. Firstly, HPs use purchased and leased PSSs to achieve long-term cost savings, which is congruent with theory. Cost savings can be achieved by PSSs with higher than usual operational efficiencies (Case studies D, F, G; battery, heat pump, PV panels), or by those with longer than usual lifespans (Cases B, E; kitchen, elevator) (Blüher et al., 2020). Also consistent with theory, HPs use PSSs to outsource risk and unburden themselves of the maintenance and operational responsibilities associated with specific building component (van Ostaeyen et al., 2013). By doing so, HPs can maintain focus on their core business and avoid hiring additional expertise in-house. HPs also use leased PSSs to accomplish project scope without capital. Since many leased PSSs require minimal- or zero-upfront investments, HPs can accomplish more scope than they can afford to purchase, which is especially helpful considering evolving building energy performance requirements. Additionally, one HP (Case C) is using a circular PSS to prepare their organization for the inevitability of CO2 taxes. When CO2 taxes penalize transportation and raw material extraction, the HP can theoretically reduce their CO2 tax liability by using a locally based circular PSS. Other secondary advantages of using a PSS include establishing predictable costs and enhancing portfolio circularity.

Q4) What analysis do housing providers conduct before using a PSS?

HPs primarily conduct financial and risk analyses when considering the use of a PSS. Among leased PSSs, housing providers compare the Total Cost of Ownership (TCO) with the Total Cost of Use (TCU) for the specific building component during its lifespan, congruent with theory (Coalition Circular Accounting, 2020). Additionally, HPs consider the risk and responsibilities of ownership, and sometimes decide to use a leased PSS to diminish their risk profile, even when it is more financially beneficial to own the building component. When possible, HPs review the historic service performance of PSSPs. Lastly, and to a lesser extent, HPs consider the PSS's impact on resident service costs, impact on future building flexibility, and end-of-use- scenarios.

Q5) What challenges do housing providers face when using a PSS?

HP's often do not trust the PSSP's ability to deliver the promised value proposition pertaining to a leased PSS, as they find the combination of no initial investment and instant cost savings "too good to be true". HP's also faced challenges regarding the complexity of contracts when leasing building components for upwards of 40 years, which is consistent with theory (Reim et al., 2015). In several cases, HPs faced challenges regarding the unclear demarcation of what products and services are included in the PSS. HPs also faced challenges when serving as the contracting party for leased PSSs, as it results in negotiations to reduce the general contractor's scope and profit. One HP faced challenges regarding the inflexibility of a PSS to accommodate unique site conditions due to its very high degree of circularity. Lastly, the misalignment of incentives and lack of penalties for the PSSP in the Input-based PSS, due to the HP owning the product but the PSSP maintaining it, led to incomplete service coverage, unpredictable costs, and dissatisfactory service from the HPs perspective. Consistent with theory, input-based PSSs are those where the PSSP takes the least amount of risk, meaning the HP still has partial risk (van Ostaeyen et al., 2013).

Q6) What circular principles do market implemented PSSs exhibit?

Based on theory, the circular principles exhibited in each case should have increased in the order of input-, availability-, usage-, and performance-based PSSs (van Ostaeyen et al., 2013). However, this was not found to be true in practice, as the most circular cases were found to be availability- and usage-based PSSs, and the least circular cases were found to be input- and usage-based PSS. The cases studied displayed a wide range of circular principles, making clear that the circularity of each PSS must be studied individually. For a PSS to be circular, 1) the product must slow material loops by being

designed to maximize its lifespan and 2) the product must close material loops by being designed for disassembly. Additionally, 3) the business model must slow material loops by exploiting the product's residual value after its initial use, and 4) the business model must close material loops by making use of circular material inputs in its products (Bocken et al., 2016). All four circular principles were exhibited in the cases. Based on the seven cases, circular principles increase in the following order from least exhibited to most exhibited: 1) business model closing loops, 2) product closing loops, 3) business model slowing loops, and 4) product slowing loops. The findings are consistent with theory which states that PSSs are not automatically synonymous with sustainability and circularity (Blüher et al., 2020; Tukker & Tischner, 2006).

Q7) How does the use of PSSs impact a building's asset value?

The impact of using PSSs on a building's value remains largely unknown. Theoretical research implies that PSSs will positively impact a building's value, as they foster effective preventative maintenance and gradual replacement of faulty parts during their lifespan (Gielingh et al., 2008). The expert study supported this theory, however the experts noted that it is still too early in the development of PSSs in buildings to understand their actual impact. Variables such as the specific product and the quality of the service make it very difficult to anticipate the financial impacts of PSSs. One expert noted that there will be tax implications when leasing building components, thus leased PSSs were studied through a simulated financial model. The model simulates a specific market-rate (non-social) rental housing building development in the Netherlands and is by no means representative of all housing developments. The simulation found that, due to the tax disadvantages of leasing, leased PSSs must achieve a TCU savings of 39% or more, when compared with TCO, to be financially advantageous for a HP. Put another way, based on the financial simulation, the first 39% of cost savings associated with a leased PSS are negated by the tax disadvantage of leasing. Additionally, the more a building is comprised of leased PSSs, the larger the impact on the building's asset value either positively or negatively. The simplified simulation does not consider other advantages of using a leased PSS, such as reducing risk or accomplishing other construction scope without capital, which are difficult to quantify. Nonetheless, the simulation implies that real estate owners will opt to remain the owner of majority of their buildings to achieve advantageous investment returns and may only lease building components with the highest associated risk, or when leasing is the only way to make projects viable. Such findings support the reasoning of the HP in Case B who used a 5-year lease-to-own financing structure to initially accomplish construction scope without capital, yet after 5 years of payments, have the kitchens on their balance sheet to capitalize on tax depreciation. The tax implications should be reevaluated when CO2 taxes are established by the national government and a circular low carbon PSS is used. In such a scenario, it is likely that a circular PSS will positively impact a building's value.

4. Conclusion

Main Question: "How can Product-Service-Systems (PSSs) offer value to housing providers?"

As the Netherlands national government aims for a circular economy by 2050, housing providers (HPs) simultaneously seek alternative procurement and maintenance methods to enhance the performance of their organizations, buildings, and portfolios. PSSs serve as a solution with the potential of increasing circularity in the built environment while offering value to HPs who procure them.

PSSs primarily offer HPs financial, risk management, and sustainability/circularity value. HPs can capture value by reducing their long-term costs and by outsourcing the risk, maintenance and operational responsibilities associated with specific building components. When leasing PSSs, housing providers can also outsource the financing of building components, enabling them to accomplish construction scope when

capital is unavailable. The use of PSSs also can establish predictable costs and enhance portfolio circularity.

However, the value offered by a PSS is largely depended on the type of PSS used. Based on the research, the value a PSS offers a HP increases in order of input-, availability-, usage-, and performance-based PSSs. This is particularly outstanding since the potential for circularity increases in the same order (van Ostaeyen et al., 2013), meaning the demand-oriented perspective for PSSs in rental housing supplements the realization of a circular economy. However, the volume of building components procurable by each contract type likely decreases in the same order, and not all building components are applicable to each contract type. Additionally, the value offered to HPs was found to increase as the proportion of service-related costs increase, assuming there are also penalties for the PSSP when dissatisfactory service is provided.

Although leased PSSs have higher circular potential than owned PSSs, Dutch commercial real estate tax incentivizes HPs to retain ownership of their building components while outsourcing the maintenance, operation, and risk. Thus, real estate owners will not procure entire buildings as leased PSSs since it is not financially feasible. Leased PSSs will likely remain a minority of how building components are procured, however they will become more commonplace as construction budgets are stressed by the energy transition, as technology advances, and as CO2 taxes are implemented. Leased PSSs contribute to achieving circularity in the built environment, with clear value from both supply + demand perspectives. To achieve circularity in the built environment, leased PSSs are part of the solution, however, building owners, in addition to PSS providers, must be incentivized to return materials to either technological or biological cycles. When CO2 taxes are established and reach their maturity, the leasing of circular PSSs with reduced tax liabilities may enhance the value of leasing PSSs. The value offered by each contract type is elaborated below.

While input-based PSSs have the tax advantages of ownership, they offer the least value to HPs. HPs using input-based PSSs still bear partial risk since they are the owner of the PSS and are liable for costs and risks not captured within the service agreement. Additionally, in input-based PSSs, PSSPs capture majority of their financial payments (50+%) at the moment of contracting and installation, meaning their financial incentive to deliver prolonged high-quality service is greatly diminished. If service penalties are not established, HPs may find it challenging to receive timely service when their products are not operational. Based on the research, input-based PSSs come with the shortest service contract durations of the four types, which reduce the risk undertaken by the PSSP and transfer it to the HP. When PSSPs can renegotiate terms every few years, HPs are not able to establish long-term cost predictability. Input-based PSSs have the lowest potential for cost-savings, as the PSSP does not exploit the product's residual value, meaning savings cannot be captured nor shared with the HP. Input-based contracts have the highest likelihood of existing on the market, as they bear the least risk for PSS providers. Input-based PSSs can be established by adding service contracts or simple warranties to products traditionally purchased by HPs.

Availability-based PSSs offer the second highest value to HPs. When leased, availability-based PSSs face tax disadvantages, however, they allow HPs to accomplish construction scope without investment capital. HPs can utilize leased availability-based PSSs to bring over-budget construction projects back into budget, or to expand the scope of on-budget projects, both of which are especially helpful as HPs grapple with the energy transition. When leased, availability-based PSSs establish predicable costs over their contract duration, which, based on the cases, can be upwards of 40 years. Since HPs pay for the product to simply be available, there may not be strong incentives for the PSSP to deliver exceptional service, unless service penalties for down-time are established in the contract. When PSSPs remain the owner of their products, they are incentivized to exploit residual value, thus they can offer larger long-term

PSSs in Rental Housing

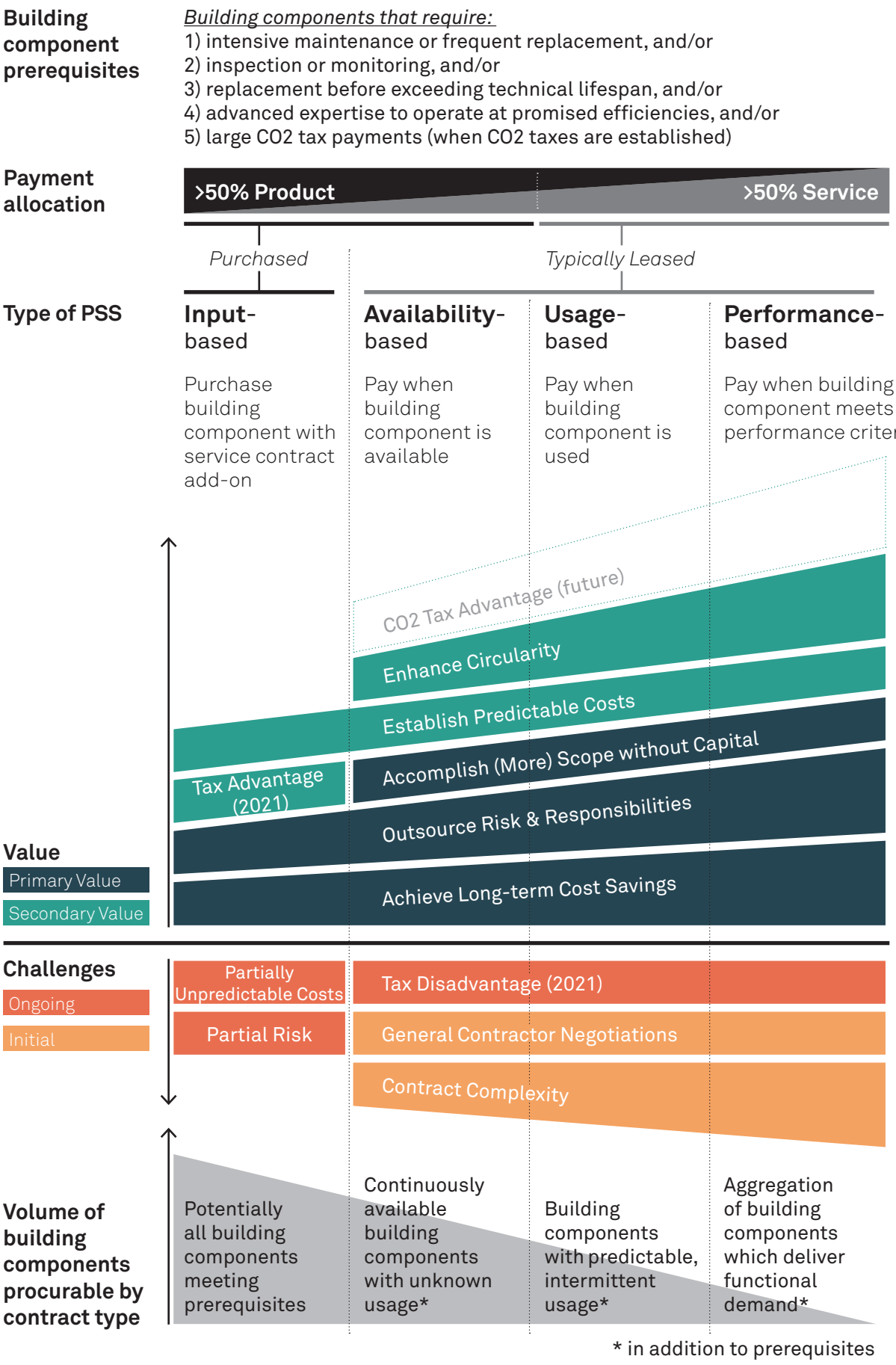


Fig. III
Framework illustrating PSSs in rental housing, own figure.

cost savings to HPs. When using leased PSS, HPs should be aware of initial challenges such as scope and profit negotiations with General Contractors, and contracts with increased complexity. HPs can alternatively choose to purchase or leasing-to-own an availability-based PSS to take advantage of tax deductions, however the PSSP will likely establish a right to reclaim or "take-back" the PSS at the end of the contract, and perhaps the PSSP's incentives to deliver exceptional service may be reduced since the PSS is no longer their asset. Availability-based PSSs have the second highest likelihood of existing on the market, as all building components, except structure and foundation, can in theory be offered as a leased product with majority of costs associated with service payments.

Usage-based PSSs offer the third highest value to HPs. Although they also face tax disadvantages when leased, usage-based PSSs establish strong incentives for the PSSP to deliver exceptional service. If the product is not able to be used, the PSSP cannot capture payment from the HP. Thus, the PSSP is incentivized to minimize downtime and always keep the product operational through the duration of the contract, which, based on the cases, can be upwards of 30 years. Of the cases studied, the difference in PSSP incentives is most evident between the input-based elevator PSS with no performance penalties (Case A), and the usage-based elevator PSS with performance penalties (Case E). In Case A, where the HP owns the elevator, the HP faced challenges regarding incomplete service coverage, unpredictable costs, and dissatisfactory service. However, in Case E, where the HP leases the functionality of the elevator, the HP can be confident about receiving satisfactory high-quality service since the PSSP will only be paid when the elevator is operational and will be financially penalized when the elevator is, on an annual basis, out of service more instances or more total time than the contract's agreed maximums. Usage-based PSSs, like availability-based PSSs, incentivize PSSPs to minimize operational costs and exploit residual value, thus increasing the likelihood of cost savings for the HP. Leased usage-based PSSs also enable HPs to accomplish construction scope when capital is unavailable and to establish predictable long-term costs. When leased, usage-based PSSs also face the potential initial challenges of profit negotiations with GCs and complex contracts. Usage-based PSSs can also be owned by an HP, offering them tax advantages. In such an arrangement, the HP pays the PSSP fees based on measured usage which are thus used as a reserve for service. When the HP is the owner of the product, they create a trade-off between increasing their risk profile and decreasing their tax liability. HPs of owned usage-based PSSs should be informed of which party (HP or PSSP) pays for service costs when they exceed the allotted reserve. Usage-based PSSs have the third highest likelihood of existing on the market, as they are only applied to building components with predictable and measurable intermittent usage.

Performance-based PSSs offer the highest value to HPs as they only pay when the expected result or function is delivered. However, performance-based PSSs may not be readily found in the market as they are the riskiest for PSSPs. To be offered, performance-based PSSPs need to integrate all aspects of performance into a single solution, which may only be possible through multiple iterations and the incorporation of new technologies. Performance-based PSSs also have the highest potential for circularity, as they put the PSSP in full control of delivering the desired outcome (van Ostaeyen et al., 2013), thus they have the highest potential for exploiting residual value and creating cost-savings for the HP. Case D, the availability-based window PSS, serves as a rudimentary version of what the PSSP aims to eventually offer as a performance-based integrated-façade PSS, complete with heating, cooling, and ventilation. The currently offered window PSS serves as an exploration in the contract, maintenance, and eventual takeback of a long-term leased product. Until performance-based PSSs are offered on the market, usage-based PSSs likely offer HPs the highest value.

5. Contributions of the Research

This research contributes to the arenas of real estate management, rental housing management, and Product-Service-Systems (PSSs) by establishing a link between the discrete concepts of PSSs and rental housing. The main contribution of the research is a consolidated demand-perspective on PSSs in the built environment. The research identifies the value PSSs offer HPs that use them, how HPs consider the use of a PSS, as well as what challenges they face when using PSSs.

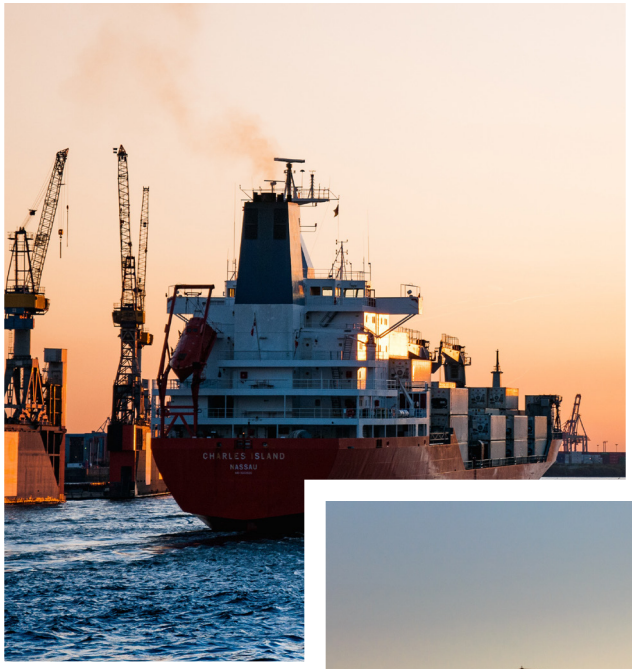
The research builds upon the van Ostaeyen's (2013) "Refined Typology" of PSSs framework, which is a refinement of Tukker's (2004) "Eight Types" of PSS, to establish the value of PSSs from a real estate owner perspective. The research establishes a framework of its own which shows increasing value for real estate owners in the order of input-, availability-, usage-, and performance-based PSSs. The research also establishes the correlation between PSSs increasing in potential for circularity and PSSs increasing in value for real estate owners that use them.

In a practical sense, 6 building components have been identified as market-implemented PSSs that HPs can immediately consider procuring. With such insights, HPs, and real estate owners at large may consider the use of PSSs within their organizations.

6. Recommendations for Future Research

Several topics were identified during the study that warrant future research, namely 1) the impact of PSSs on resident service costs, 2) the impact of leased PSSs on a general contractor's scope and profit, 3) insight into what specific details make a PSS contract especially complex, 4) quantitative life-cycle analyses of the studied PSSs cases to more definitively gauge their level of circularity, and 5) a more robust financial study of leasing vs owning building components that takes into account a variety of development financing scenarios. Lastly, a repeat of this study in the future (5 years+) with real estate owners who have a prolonged experience using PSSs would be valuable, as many of the studied cases were only installed within the last 2 years, meaning their performance history is rather limited.

01
Introduction



1. Introduction

1.1 Global relevance

Climate change, ravenous consumption and a growing global population

In 2007, at the United Nations Security Council debate, climate change was identified as the "number one threat to mankind" (United Nations, 2007), and in 2009, eighteen of the world's most respected scientific associations reached consensus that "the greenhouse gases emitted by human activities are the primary driver" of climate change (American Association For The Advancement Of Science (AAAS), 2009). Eleven years later, David Attenborough released "Life on Our Planet" (2020) as a grim reminder of the damage we, humans, have caused across the globe. Should we continue our global human activities as-is, we may cause the sixth mass extinction and render much of the planet uninhabitable (Attenborough, 2020). While frightening, there is still time to change how we as humans inhabit the planet.

The overarching theme of many solutions hinges on reducing our consumption of natural resources. By doing so, we can minimize our interference with the natural world, and in turn, allow natural ecosystems to thrive and sequester higher volumes of carbon (Attenborough, 2020). This is reinforced by research that states "the dominant underlying cause of global warming is the consumption of goods and services whose draw on resources for their fabrication, distribution (or provision), sale and use (and, for goods, disposal) causes the emission of GHGs" (Satterthwaite, 2009). The reduction of humanity's consumption of resources is not only in response to mitigating climate change, but also out of necessity. As of 2019, it was estimated that "humanity uses nature 75% faster than it renews" (Wackernagel et al., 2019). By 2050, the United Nations estimates that global resource consumption could double, totaling 186 billion tons of material usage per year (Ekins et al., 2017). At such pace, humankind will eventually deplete the biocapacity of nature.

To make matters worse, the global population is expected to increase 25% in the next 30 years, from 7.7 billion people today to 9.7 billion by 2050. By the turn of the century, the global population is expected to grow to 10.9 billion, marking a 41% increase from today (United Nations, 2019). With more people requiring resources, it is imperative that we fundamentally alter our consumption habits to ensure future generations can live prosperously.

Urbanization, housing shortages, and the construction industry

Since 2007, the world's population has been more urban than rural (Wimberley & Fulkerson, 2007), and by 2050, the United Nations estimates that 68% of the world's population will live in cities (United Nations, 2018), as "urban areas are expected to absorb virtually all of the future growth of the world's population" (United Nations, 2019). The growth of cities can be linked to their association with increased opportunity agglomeration economics, or the idea that "concentrations of people and economic activity generate knowledge, social transformation, innovations and new technologies" (Hoornweg et al., 2011).

With increased urbanization, the demand for housing has outpaced supply. In 2020, a United Nations expert on human rights and housing proclaimed that "the world is on an unsustainable path with increasing levels of homelessness worldwide especially in affluent countries, forced evictions carried out with impunity, and the cost of housing escalating at alarming rates making housing unaffordable even for the middle class" (United Nations, 2020). Much of this unaffordability can be linked to extreme levels of demand that drive housing prices out of reach for many.

To address demand, governments and construction industries are busy producing homes. While this helps address housing demand, current construction practices are still detrimental to climate change. As of 2019, "building construction and operations

accounted for the largest share of both global final energy use (36%) and energy-related CO2 emissions (39%)" (IEA and UNEP, 2019). Based on global society's seven most crucial needs, "the need that represents the largest resource and emissions footprint is for construction and maintenance of residential houses, especially in lower-income nations" (Circle Economy, 2021). To address both sustainability and housing demand challenges, sweeping changes within the construction industry must occur.

> ***"The need that represents the largest resource and emissions footprint [globally] is for construction and maintenance of residential houses, especially in lower-income nations."***
>
> (Circle Economy, 2021)

Transitioning from a linear economy to a circular economy

The climate predicament is a product of an outdated "linear economy", one that directly links economic growth with an increase of resource consumption. Sadly, the take-make-dispose way of operating works in direct contradiction with our global sustainability goals (Andrews, 2015). The economic world as we know it is built on a model of continuous expansion within a finite reservoir of resources, and therefore must be reconfigured.

The "circular economy" has emerged as a desirable alternative capable of aligning both economic and sustainability goals. In essence, the circular economy hinges upon the idea of eliminating the concept of "waste". It is "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes" (Kirchherr et al., 2017). It is a system that prioritizes the longevity of material usage; once a material has been sustainably harvested, the goal is to keep it in circulation for as long as possible and to use it to its fullest capacity (Ellen MacArthur Foundation, 2013). Put another way, the goal of the circular economy is to phase out and drastically reduce the need for landfills, as materials will continually stay in use. The circular economy, while still in its infancy, offers opportunities to redefine how our species interacts with the natural world.

New business models and Product-Service-Systems (PSSs)

As the circular economy is identified as an alternative economic system, it is no surprise that new innovative business models have been identified as critical enablers to its achievement (Brennan et al., 2015; Ellen MacArthur Foundation, 2013). Among those mentioned, Product-Service-Systems (PSSs) have been identified as a critical tool to align the reduction of resources with continued economic growth (Lacy et al., 2014).

Fundamentally, Product-Service-Systems (PSS), also commonly referred to as Product-as-a-Service (PaaS), is a reversal of traditional ownership. Instead of purchasing and owning a product outright, a consumer instead pays to access the product and the utility it delivers. Since the PSS provider remains the owner of the product, they are incentivized to reduce their costs by maximizing the usage of their materials, and by minimizing the energy it takes to offer their market solution (Halme et al., 2004). Constructed in the right way, PSSs have the potential to create win-win-win scenarios between the manufacturer, service provider, and customer (Coalition Circular Accounting, 2020), all while simultaneously assisting in the transition to a circular economy with

minimized material consumption. It should be noted, however, that the use of a PSS business model does not equate enhanced sustainability or circularity (Blüher et al., 2020; Tukker & Tischner, 2006), especially if the circular principles of slowing and closing loops are not pursued (Bocken et al., 2016).

1.2 Problem statement

The Netherlands, like many countries globally, faces the aforementioned climate change and housing challenges. To help facilitate the realization of aggressive climate goals, the Dutch National Government intends to develop a circular economy by 2050, at which time, "raw materials will be used and reused efficiently without any harmful emissions into the environment". In the interim, by 2030, the government aims to reduce the consumption of raw materials by 50% (Government of the Netherlands, 2016).

In terms of housing production, an estimated 882,000 homes will need to be built between now and 2050 to accommodate an expected growth in population of 1,240,000 people (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2019). In addition, as of 2019, the Netherlands already has a housing shortage of 315,000 homes (ABF Research, 2020), pushing the demand for new homes to roughly 1.2 million homes in total. Many of these homes will be constructed in the cities of the region known as the Randstad (CBS, 2011) in the form of dense multifamily housing. To address the massive demand, large housing developments are undertaken by social housing associations and market-rate developers.

The required housing construction relies on resource extraction which unfortunately only exacerbates current climate issues. If building components are **purchased** by housing providers (HPs), or organizations who develop and manage rental housing, it is unlikely that the raw materials will be reused in future products, as the materials will likely be discarded at the end of their initial use (van Ostaeyen et al., 2013). Thus, the value of PSSs, especially those that are **leased**, will be studied within the context of rental housing as an alternative procurement model which supports a circular economy.

1.3 Research aims and objectives

This research builds on the existing body of knowledge regarding PSSs. Firstly, this research aims to understand the current state of the art regarding PSSs. Secondly, the research identifies how PSSs might be applied within the system of rental housing. Thirdly, the research aims to understand, via case studies, why housing providers (HPs) choose to use PSSs, rather than purchase products outright and maintain them themselves. While exploring what drives a HP to use a PSS, the empirical research will also illuminate what other advantages HPs perceive of PSSs, how they evaluate using them, and what challenges were faced. Based on the individual cases studied, a preliminary review of the circularity of the PSSs will also be included. Lastly, the research includes a financial simulation to better understand housing leasing building components impacts a building's tax liability and Internal Rate of Return (IRR).

1.4 Relevance

Scientific Relevance

PSSs have been well-studied in applications such as car sharing (Catulli et al., 2021) and jet engines (Kühl et al., 2018), though the application of PSSs to real estate remains limited. The research that does exist primarily establishes a supply-oriented perspective which offers insights into the design and delivery of building-related PSSs (Azcarate-Aguerre et al., 2017; Coalition Circular Accounting, 2020). However, if PSSs are to be implemented at scale within the built environment, they must demonstrate clear value to decision makers who own and manage real estate. Thus, this research explores the value of PSSs from a demand-oriented perspective, specifically that of a housing provider (HP), or an organization that owns and manages rental housing. The aim is to understand how HPs can benefit from the use of PSSs within their buildings and portfolios. With such information readily available, PSSs can potentially be used in greater abundance within the housing sector, thus serving as a demand-driven catalyst for enhanced circularity in the built environment.

Societal Relevance

As housing comprises the largest global footprint concerning resource consumption and emissions (Circle Economy, 2021), and has a growing global demand, the research aims to offer housing providers and real estate owners at-large valuable information regarding potential alternative procurement methods that may enhance the circularity and performance of their portfolios. The use of PSSs has the potential to change the way real estate portfolios are procured, managed, and maintained. Additionally, the research provides insights for manufacturers, investors, and other service providers who are considering the development of built environment PSSs.

1.5 Research questions

As previously described, within the Netherlands there is great demand to construct new homes and achieve a circular economy by 2050. PSS business models are touted as a way to align suppliers and consumers around the concept of resource efficiency without sacrificing value or performance. Thus, the main research question to be answered is:

"How can Product-Service-Systems (PSSs) offer value to housing providers?"

In this research, the term "value" is defined by the "relative worth, utility, or importance" of something when compared with an alternative (Merriam-Webster, 2021). The value to be determined is that of PSS building components when compared with building components that are purchased, maintained and operated by the organization that owns them. In order to answer the main research question, the following sub-questions must also be answered:

1. What is a PSS?
This question clarifies what constitutes a PSS. It illuminates the history and development of the concept, as well as how PSSs have the potential to deliver environmental benefits.

2. How can PSSs be applied in rental housing?
This question draws a connection between the discrete topics of PSSs and rental housing development and management.

3. What are the drivers for housing providers to use PSSs?
This question clarifies the primary drivers for a housing provider (HP) to use a PSS. It also aims to understand the other advantages of using a PSS.

4. What analysis do housing providers conduct before using PSSs?
This question clarifies how what information HPs analyze before deciding to use a PSS.

5. What challenges do housing providers face when using PSSs?
This question clarifies what challenges and issues arise when HPs use PSSs.

6. What circular principles do market implemented PSSs exhibit?
This question clarifies how inherently circular market-implemented PSSs actually are.

7. How does the use of PSSs impact a building's asset value?
This question was added retroactively, based on the findings from the empirical research. It clarifies the tax implications of using PSSs.

1.6 Conceptual model

Figure 1.01 illustrates the conceptual model to guide the research. It includes the PSS provider and housing provider as the primary stakeholders within the system. For a PSS to be incorporated in a rental housing building, the PSS provider (PSSP) must deliver a solution that satisfies the organizational demands of the housing provider (HP).

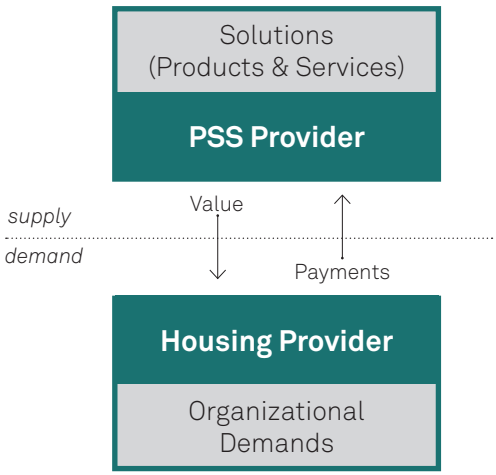


Fig. 1.01
Conceptual Model, own figure.

2. Methodology

2.1 Research design

To answer the main research question, this research will utilize an exploratory methodology to better understand the topic. Fundamentally, it aims to understand the merits of PSSs in the context of multifamily rental housing. As seen in figure 1.02, the research is structured in three main sections: theoretical research, empirical research and conclusions.

Theoretical research will be conducted via a literature review of research databases, academic journals, books, and reports. The databases of Scopus, Google Scholar, the TU Delft Library were searched using the search term “Product Service System”. Firstly, literature reviews on the subject were explored to find the most relevant papers which contribute to the current understanding of PSS. Boolean operators were used to find relevant literature reviews using the searches (“product service system” AND “state of the art”), and (“product service system” AND “literature review”). Specific papers from within the literature reviews were studied to understand the theoretical underpinnings of PSSs. Based on the findings, the concept of PSSs is applied to rental housing, and the potential value and challenges of PSSs for housing providers that use them is identified. Based on these findings, a theoretical framework was created to be tested and modified during the empirical research.

Empirical research was conducted via three parts: case studies, expert interviews, and a financial simulation. The case studies explore the real-life use of PSSs in rental housing through semi-structured interviews with both housing providers and PSS providers. By gathering data from both demand and supply perspectives, a more complete understanding of the cases can be established. Experts were interviewed to corroborate the findings from the case studies, and to understand PSSs within a larger context with a higher degree of abstraction. A financial simulation was used to understand how leasing PSSs impacts a building’s financial performance.

Mainly, the building's tax liability and Internal Rate of Return (IRR) were studied in various scenarios. The exercise uses a series of discounted-cash-flow financial models to illustrate the tax implications of leasing PSSs in market-rate rental housing (non-social) based on current-day Dutch corporate tax law. The findings from the three empirical research parts are used to refine the theoretical framework and derive conclusions.

Lastly, conclusions are drawn that clarify the main and sub research questions. The conclusions define what PSSs are, how they can be applied in rental housing, what drives housing providers to use them, what analysis housing providers conduct before using them, what challenges housing providers face when using them, how circular market-implemented PSSs are, how the use of PSSs impacts a building's asset value, and lastly, how PSSs can offer value to housing providers.

2.2 Research Output

The outcome of this research aims to paint a clear picture of how PSSs are applied and used within rental housing, and to illuminate why housing providers are opting for PSSs over traditional ownership. The main deliverables, in chronological order, are the following:

1. Theoretical framework explaining the value of PSSs from the perspective of a housing provider (literature review).

2. Realized drivers, advantages and challenges of using PSSs (case studies).

3. Understanding of how housing providers consider the use of PSSs (case studies).

4. Understanding of what circular principles market-implemented PSSs exhibit (case studies).

5. Simulation of tax implications of leasing PSSs (financial model).

6. Updated theoretical framework explaining how PSSs offer value to housing providers.

Dissemination and audiences

This research will be disseminated to housing associations and market developers, PSS providers, financiers, and consultants specializing in the circular economy.

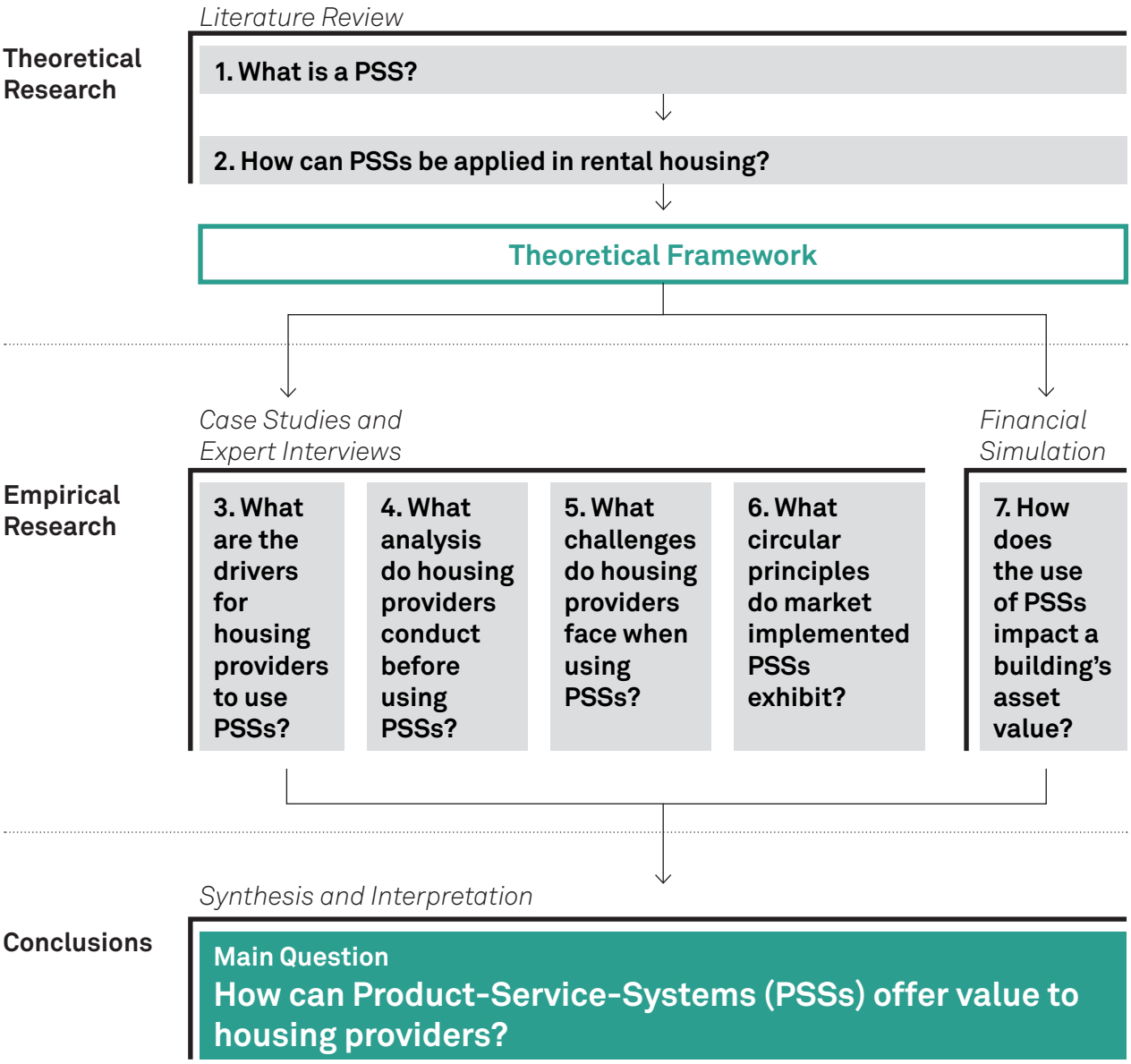
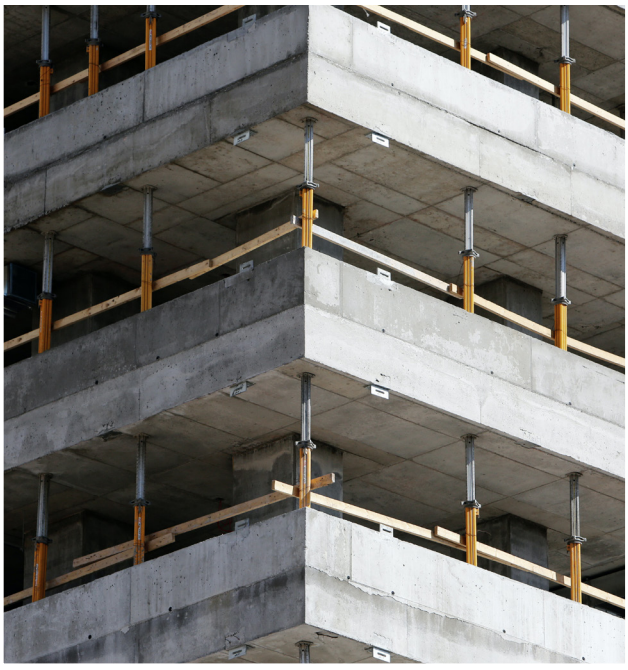


Fig. 1.02
Research design sequence; own figure.

02
Theoretical Framework



1. What is a Product-Service-System (PSS)?

1.1 PSS origins and context

In in the 1980's and 90's, several fields of research, including business, environmental sustainability, and economics were converging on what is today understood as a Product-Service-System (PSS). As seen in figure 2.01, businesses at the time were exploring ways to create and capture more value; environmentalists were exploring ways to decouple economic growth with resource extraction, and economists were exploring the fundamental reason people purchase goods. The historic underpinnings of PSSs are still highly relevant today, thus PSSs are being researched in growing numbers each year (Kowalkowski et al., 2017; Li et al., 2020)

The servitization of business

Businesses were looking for ways to expand into new markets, grow profits, and secure market shares, and increase competitiveness. Companies historically focused on the sale of products to their customers. However, some successful companies began utilizing "bundles" of products and services to better serve their customer's demands. This phenomenon became known as "servitization of businesses" (Vandermerwe & Rada, 1988).

Dematerialization

"Dematerialization" hinges on the idea of using fewer raw materials and total embodied energy to provide the same results to a consumer. Over time, many companies embraced the idea of dematerialization because it was seen as a way to reduce costs. Using less materials and generating less waste result in reduced production and disposal costs (Herman et al., 1990). Examples of dematerialization are automobiles and computers, which have over time decreased in mass while offering increased user functionality.

Eco-efficient services

The concept of "eco-efficient services" encompasses three previously disparate elements: 1) how products could be efficiently produced, 2) how efficiently products could perform during their use, and 3) how the user's consumption behavior could enhance sustainability (Meijkamp, 1998). The combination of these three elements shows that consumption efficiencies can be increased in both how the products are created, how they use other resources, and how they are consumed. Eco-efficient services aim to produce the same "unit of service" (what the customer demands), while reducing the environmental harm to do so. Eco-efficient services promote "sharing of use" as a way to serve the most amount of people with the least number of products. This allows a single product to serve multiple users, and thus reduces the amount of material needed to deliver the "units of service" that a consumer demand. Today, the phenomenon of eco-efficient services is often referred to as the "sharing economy".

The functional economy

Researchers and economists were exploring the reason consumers purchase products. One train of thought was based on the transactional value of the product, which is simply what a consumer is willing to pay for the product. This explanation did not answer the question 'why are they willing to pay such an amount?'. A competing, and more compelling view on the manner was that people purchase products to gain access to the product's functionality and the results that the product can deliver (Giarini & Stahel, 1990). This logic formed the underpinning of what became known as the "functional economy", which opened space to rethink the selling and purchasing of products. The functional economy, which was directly related and reinforced by the concept of eco-efficient services, "might be illustrated by the statement that people do not need cars and washing machines, but mobility and clean clothes." (Meijkamp, 1998).

The birth of Product-Service-Systems (PSSs)

In 1999, the concepts of servitization, dematerialization, eco-efficient services and the functional economy were combined into the singular term "Product-Service-Systems" (PSSs) (Goedkoop, 1999). Goedkoop's (1999) report, commissioned by the Dutch Ministries of Environment and Economic Affairs, stated that enhanced production practices alone cannot solve the world's sustainability challenges. Despite technological advancements that increase resource efficiency during a product's production and use, increases in population and consumption outweigh such progress and thus result in a net-negative impact on the environment. Consumption behavior is therefore a critical element of increased sustainability, and all actors, including producers and consumers, have a role to play.

> ***We have to find ways to increase the perceived value of all transactions without increasing the environmental load of products involved. The solution could be to dematerialize the economy. One strategy for this seems a shift from an economy based on production and consumption of physical products to a services-based economy.***
>
> (Goedkoop, 1999)

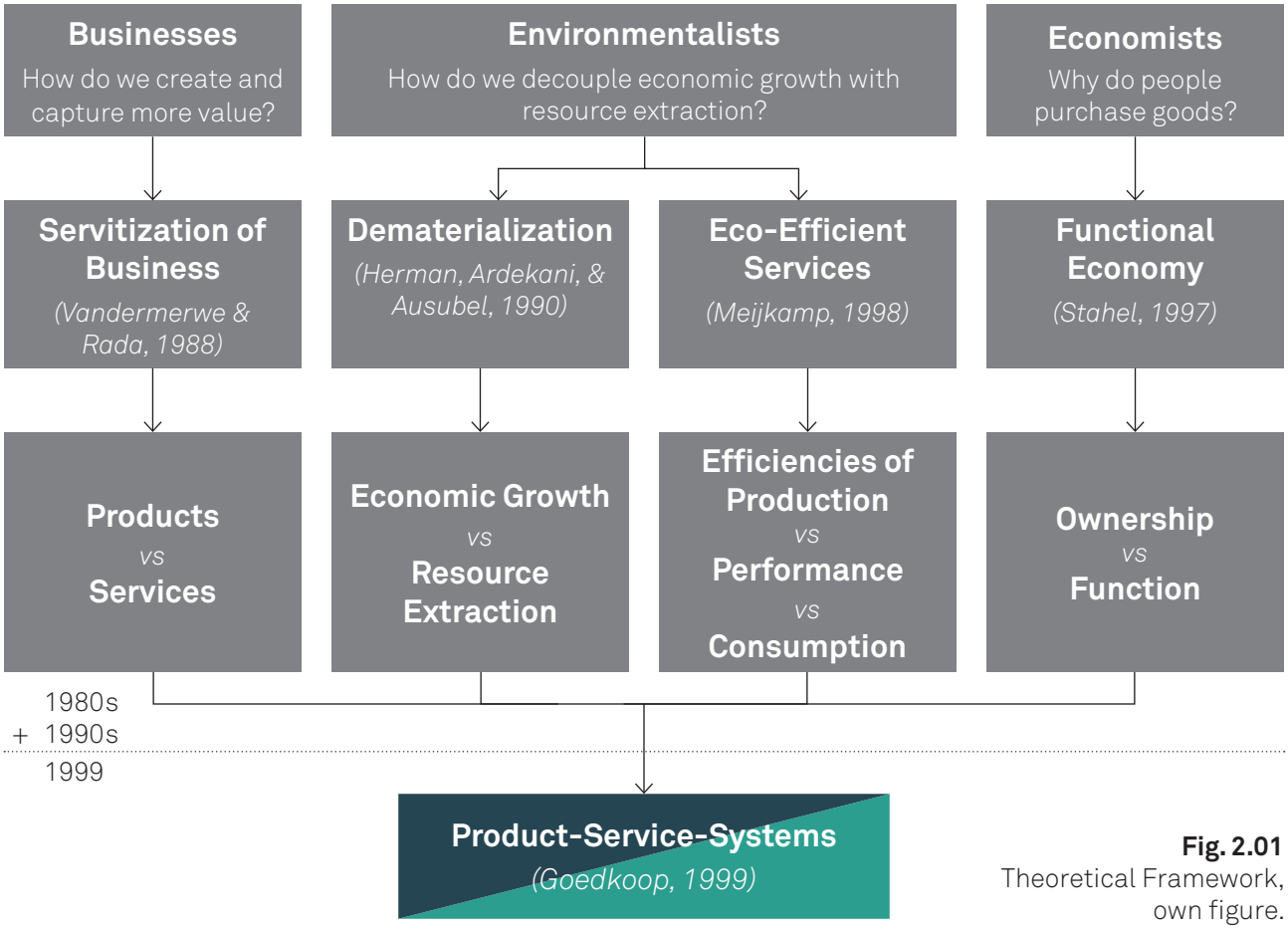


Fig. 2.01
Theoretical Framework, own figure.

1.2 An evolving definition

Product-Service-Systems (PSSs) have been studied in the five primary disciplines of "business and operations management, sustainability, marketing, service management, and technology and engineering" all of which use varied definitions (Li et al., 2020).

Many researchers view PSSs as a tool for the circular economy, as PSSs enable the decoupling of economic growth from environmentally harmful resource extraction (Baines et al., 2007; Rabetino et al., 2018). PSSs are also viewed as a means to strengthen a business's competitiveness by utilizing services to capture more value than products alone (Huikkola et al., 2016).

One way for a PSS to form is when a product-oriented company undergoes the "servitization of business" (Vandermerwe & Rada, 1988), as seen in figure 2.02. Examples of "servitization" include Xerox pay-per-print copy machines, Philips pay-per-lux LED lights, and Mitsubishi pay-per-use elevators that sell the functionality of their products, but not the products themselves.

In addition, PSSs can form when a service-oriented company undergoes the "productization of business" to capture additional value (Leoni, 2015). Examples of "productization" include Google and Amazon, which now sell physical SMART-home products in addition to their intangible services.

All of the examples above can be considered PSSs, as they offer an integrated solution that combines products and services to best meet the user's demands. The following definitions of PSSs have developed over time.

> ***"a system of products, services, networks of actors and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models"***
>
> (O. Mont, 2004)

> ***"a specific business concept that focuses primarily on customers' demands and is meant to provide them with all the product benefits (functionality, utility, self-esteem offered by brand) without necessary ownership, while being less harmful to the environment"***
>
> (Clegg et al., 2013)

Fig. 2.02
Servitization and Productization; own figure, based on Vandermerwe & Rada (1988), Tukker (2004), Leoni (2015).

1.3 System perspective on PSSs

PSSs, as seen in figure 2.03, can be viewed as a combination of components divided among elements, feasibility, and institutional framework (O. Mont, 2004).

PSS Elements

Product: something physical and tangible.

Service: an activity or work that a user is willing to pay for. The work can be completed by a human or by a machine. This includes all activities required to deliver function to the user (Tukker, 2004).

Infrastructure: something tangible or intangible that serves as the "enabler" for the products and services. For example, infrastructure can take form as a physical structure, as water or power connections, or as internet connection.

Actor networks: the consumer/user and the multiple stakeholders required to deliver the solution. PSS offerings are typically only made possible by several companies working in partnership throughout a supply chain (Windahl & Lakemond, 2006). PSSs can be offered to a consumer in various ways, such as a manufacturer that also offers services, by a service provider that also offers products, or by a third-party entity that bundles products with services.

PSS Feasibility

Customer/User needs, demands, and satisfaction: the fundamental reason that the PSS exists. In the words of Meijkamp (1998), "people do not need cars and washing machines, but mobility and clean clothes. This demonstrates that a PSS, by combining products and services, can rethink how solutions are delivered to customers. The quote illustrates that a consumer is interested in the utility a solution can provide, not necessarily the products or services that comprise the solution.

Reduced Environmental Impact: the key reason PSSs are studied in correlation to the concept of the circular economy. PSSs are viewed as a tool to decouple resource extraction from economic growth. Reduced environment impact is achieved through the remanufacturing of faulty parts and machines into "like-new" products. When manufacturers remain the owner of their products and lease them to customers, they are incentivized to maximize their product lifespans with as little maintenance and material input as possible. This means avoiding the need to purchase new materials, as well as avoiding the need to pay for disposal fees. Thus, they are incentivized to reduce costs, which simultaneously reduces environmental impact.

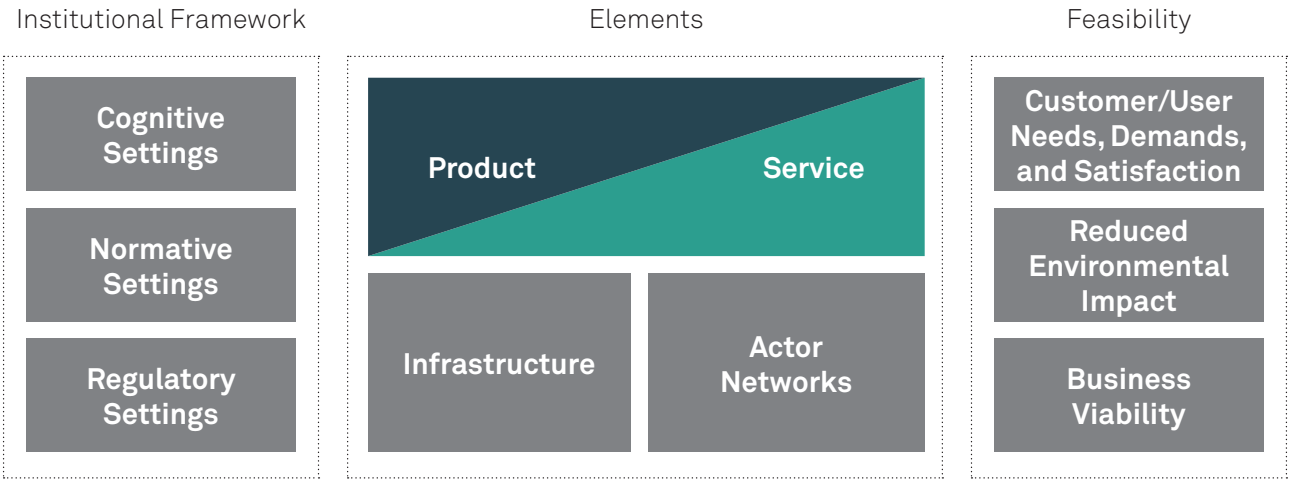


Fig. 2.03
PSS Framework; own figure, based on Mont (2004).

Business viability: if the PSS is not viable, it will not come to market. The business viability implies that the customer and the PSS provider are both able to capture value from the PSS.

PSS Institutional Framework

Cognitive settings: how society, organizations, and individuals are able to gather and evaluate information about the PSS in order to make decisions and solve problems. From a consumer perspective, this can be their ability to access, interpret, evaluate the PSS in comparison to the traditional ownership of a printer, and make a logical decision to use the PSS. Additionally, from a service provider perspective, this can be their ability to access data to further develop and improve their PSS.

Normative settings: how society, organizations, consumers and manufacturers behave and view the PSS. This can be thought of as the trends, popularity, or disapproval of a PSS.

Regulatory settings: these are the laws or regulations that may shape how a PSS is designed and used.

> ***"People do not need cars and washing machines, but mobility and clean clothes."***
>
> (Meijkamp, 1998)

1.4 PSSs and new economic incentives

To better understand the merits of PSSs, the traditional relationships and incentives of a linear economy must be compared with new circular approaches.

Current environmentally detrimental incentives within a linear economy

In the modern economy, due to current incentives, producers are typically rewarded by reducing costs via mass production, by providing standard non-exceptional quality, and by creating products with relatively short lifespans (Mont, 2002). Producers make profit when consumers rapidly purchase and thus are disincentivized from making long-lasting products. The longer the lifespan of their product, the less of the product they can sell, and therefore the less profit they can make. At a macro level, this activity depletes natural resources at staggering levels. Additionally, unless the market demands it or regulation enforces it, there is little incentive for manufacturers to enhance the performance efficiency of their products, since it is the customer that pays for the operation of the product once they purchase it. Once a product has been purchased by a consumer, with the exception of short-term limited warranties, the producer is typically no longer responsible for the product. After purchase it is the consumer's obligation to maintain the product and responsibly dispose of it at its end of life.

New circular incentives to avoid resource extraction

In relation to the circular economy, the goals of PSSs are 1) to create new incentives for manufacturers to capture value without extracting new resources, and 2) to offer consumers the same or greater levels of utility as they currently experience within the linear economy. Two simplified alternatives for manufacturers and consumers exist, both of which can be considered PSSs as they comprise a combination of products and services.

One option is to continue capturing value by selling products to consumers and offering additional maintenance and product take-back at the product's end of life. A familiar example is Apple's "AppleCare" and "Buy-Back" programs. Using AppleCare, which is essentially an extended warranty, consumers pay for unexpected maintenance during the coverage period. Using the Buy-Back program, Apple pays its customers (albeit a small amount) to return their old smartphones, tablets, and laptops when they are no longer functional. The benefit of this kind of PSS is that the producer is freed of the risks and capital requirements of retaining ownership of their products (Van Ostaeyen et al., 2013). In these scenarios, however, there is no guarantee that the products and their raw material are returned to the manufacturers at their end of life, as this decision remains in the hands of the consumer.

A more promising option to reduce resource extraction and environmental impact is one in which the producer retains ownership of their products and grants the customer access to the product (Van Ostaeyen et al., 2013). In such scenarios, the producer can guarantee they will get back the material since they never sell the product to their consumers. Xerox's "pay-per-print" office solution serves as a familiar example of such a value proposition. Xerox captures value by selling the functionality of their printer/copier, and the consumer captures value by being granted access to a fully operational printer/copier system without the headache of maintaining it nor ordering necessary supplies. In such an arrangement, the manufacturer retains ownership of their raw materials and is responsible for taking the product back at the end of its life. As their raw material is now an "asset", they are incentivized to recycle their material into the next version of their products in order to reduce costs and waste. Such a relationship between manufacturer and consumer illuminates how PSSs can create new economic incentives that decouple resource extraction from economic growth (Goedkoop, 1999; Mont, 2000, 2002).

1.4 Circular principles within PSS

To think that a PSS is synonymous with sustainability and circularity is unfortunately not true (Blüher et al., 2020; Tukker & Tischner, 2006). Thus, the PSSs must be assessed based on four circular economy principles to understand their inherent level of circularity (Bocken et al., 2016). The first principle is the product's ability to slow loops, which is associated with its ability to receive preventative maintenance that can extend its useful like as long as possible. The second principle is the product's ability to close loops, which is associated with its design for disassembly, and design for both technological or biological cycles, which allow for the components and raw material within the product to easily be used in a future process. The third principle is the business model's ability to slow loops, which is associated with the business model's exploitation of residual value which helps ensure that the raw materials will be used to their maximum in order to reduce unnecessary costs. Lastly, the fourth principle is the business model's ability to close loops, which is associated with the creation of new processes that use residual outputs, or what may now be considered as waste, as new circular inputs for future products.

1.5 Summary

The concept of a PSS was born out of the late 1980 and early 1990s, as an alternative business model which combined the agendas of businesses, environmentalists, and economists. The concept relies on delivering function and utility to a user via a combination of physical products and intangible services which can decouple economic growth from environmentally detrimental resource extraction (Goedkoop, 1999). PSSs can be studied through a framework comprising of elements, feasibility, and institutional framework (Mont, 2004). PSSs, through a reversal of ownership, create new incentives for manufacturers to reduce waste by keeping raw materials in use for as long as possible (Van Ostaeyen et al., 2013). However, to think that all PSSs are inherently circular is unfortunately not true (Blüher et al., 2020; Tukker & Tischner, 2006).

2. How can PSSs be applied in rental housing?

The application of PSSs in rental housing will be described based on Mont's (2004) framework and will take place from the perspective of a "housing provider", as "few stakeholders within a project, besides the client, have the ability to drive substantial innovation within a project, and to decide on alternative procurement measures" (Azcarate-Aguerre et al., 2017). In this research, real estate organizations that develop and/or own social (affordable) rental housing and/or market-rate rental housing are all considered housing providers (HPs). This definition is inclusive of short-term developers with no owned portfolios and long-term developers with owned portfolios.

2.1 Business Viability and PSS Types

Housing providers should be aware that companies offering PSSs are radically redefining the way they work internally and with their customers (Martinez et al., 2010). From the perspective of a housing provider, there are essentially four types of PSSs (figure 2.04), each with different payment structures and incentives for the PSS provider. In this research, a PSS will be defined as one of four types per van Ostaeyen's (2013) refined taxonomy, which is an evolved version of Tukker's (2004) eight types of PSSs.

Payment allocation	>50 %Product		>50% Service	
Type	**1. Input-based**	**2. Availability-based**	**3. Usage-based**	**4. Performance-based**
Majority of payments value (50+%)	Product-related payments	Service-related payments		
Payment Structure	At moment of purchase, & when service is completed	When building component is available	When building component is used	When performance criteria is met by building component
How function is accessed	Purchased	Typically Leased (purchasing is possible)		
Owner of product	Housing Provider	PSS Provider (typically)		
Maintainer and operator of product	PSS Provider	PSS Provider		

Fig. 2.04
Taxonomy of PSSs (4 Types); own figure, based on van Ostaeyen et al. (2013)

Type 1: Input-Based
Housing Provider is owner, and product is purchased.

In this type of PSS, the housing provider purchases a product, and pays additional service fees for any necessary services needed to keep the product functioning. These services can include "a maintenance contract, a financing scheme or the supply of consumables, but also a take-back agreement", as well as consultancy services to make sure the consumer uses the product to its highest potential and efficiency (Tukker, 2004). This reduces the work the housing provider must do themselves pertaining to the product they purchased (Baines et al., 2007). In input-based PSSs, the majority of payment value during the contract duration is associated with purchasing the product. An example of this PSS type is if the housing provider purchases a central heating boiler, as well as a service contract for annual maintenance and inspection, and the eventual take-back of the equipment at its end of life.

Type 2: Availability-based
PSS provider is typically owner, and product is typically leased.

In this type of PSS, the housing provider pays for the availability of the PSS, independent of how much they use it. This is typically arranged through a leasing-contract. The housing provider pays a fixed recurring fee which includes access to the product and any necessary repairs to keep the PSS operational. The PSS provider remains the owner and is responsible for all maintenance of the product. In such an arrangement, the consumer typically does not have to share the PSS with other users (Tukker, 2004). In this case, since the PSS provider retains ownership of the product, they take on additional risks and responsibilities such as long-term financing (Reim et al., 2015). In availability-based PSSs, the majority of payment is associated with servicing the PSS. An example of this PSS type is if the housing provider leases a kitchen that is owned and maintained by the PSS provider.

Type 3: Usage-based
PSS provider is typically owner, and product is typically leased.

In this type of PSS, the housing provider pays for the usage of the PSS, typically through a leasing contract. In usage-based PSSs, the majority of payment is associated with servicing the PSS. An example of this PSS type is if the housing provider leases an elevator and pays for it based on the distance the elevator travels when carrying passengers. The usage payment includes the servicing of the elevator by the PSS provider. By using the elevator more, the customer builds up a reserve for repairs by the service provider.

Type 4: Performance-Based
PSS provider is owner, and product is leased.

In this type of PSS, the PSS provider sells an agreed upon result to the housing provider, typically through a leasing contract. The housing provider pays a fee to the PSS provider only when the desired result is achieved. The PSS provider remains the owner of the products and services and decides how to best configure them to achieve the expected results. "Typical examples of this form of PSS are companies who offer to deliver a specified 'pleasant climate' in offices rather than gas or cooling equipment" (Tukker, 2004). In performance-based PSSs, the majority of payment is associated with servicing the PSS. Van Ostaeyen (2013) divides performance-based PSSs into three subgroups below better define the functional result offered by the PSS.

Solution-oriented performance based: the housing provider pays for the performance of the system itself, and not the effects it has on its surrounding environment. Ex: a radiator and the amount of heat it radiates.

Effect-oriented performance based: the housing provider pays for the performance of the PSS's effect on the surrounding environment. Ex: a radiator and the amount/percentage of time that the room is heated to a comfortable temperature.

Demand fulfillment-oriented performance based: the housing provider for the time that they are subjectively satisfied by the PSS. Ex: a radiator and the amount of time the users are satisfied with the level of thermal comfort in the room.

As seen in figure 2.04, there is a fundamental difference between type 1 (input based) and types 2-4 (availability-, usage-, and performance-based). In type 1, the product is purchased, and in types 2-4, the product is typically leased denoting a difference in which party (HP vs PSSP) owns the product.

PSS contracts

The contracts used define how the usage rights and liabilities are distributed between the PSS provider and the housing provider during the contract period. In such contracts it is important to clarify the "boundary" of the PSS, or what the PSS provider is responsible for, and how and where connections will be used to "mount" their PSS to the housing provider's building. The long-term nature of a PSS contract necessitates that the party carrying the most risk (either PSS provider or housing provider) is compensated.

As seen in figure 2.05, the amount of risk and responsibly the PSS provider takes on increases in the following order: product-oriented, availability based, usage based, and finally performance based, as does contract complexity. With increased risk comes increased risk premiums that the housing provider must pay to the PSS provider (Meier et al., 2010). In such contracts where the PSS provider is taking high risk, they may have clauses that mitigate against the housing provider or resident's poor behavior that can damage the PSS, and thus may reduce the coverage of the product's warranty if the agreed use-behavior is not met (Roy et al., 2009). The standardization of contracts will also decrease in the same order. Standardized contracts can likely be used in input-based PSSs, however in performance-based contracts the contract will need to be highly-customized to the housing provider's specific needs (Reim et al., 2015). Sometimes the contracts will be split into several agreements to reduce complexity (Roy et al., 2009).

In an input-based business model, the contract must define "the level of service delivery and outputs clearly. With a maintenance contract, this would mean agreeing on tasks to be included and the time frame for completing the task. It is also particularly important during the contract period to agree on payment details and how extra costs (e.g., for repair parts) will be added if unexpected events occur" (Reim et al., 2015)

In usage-based and availability-based PSSs, the contract will need to include terms regarding shared or exclusive access for the housing provider, pricing, responsibility for downtown and how the product is to be operated (Roy et al., 2009).

In performance-based contracts, HP's should be prepared for contracts that overly describe the various scenarios that could result in failure of the PSS (Gruneberg et al., 2007).

Since PSS systems often have monitoring equipment that measures usage or signals for maintenance, contracts often emphasize such requirements and are much more complex than simply selling a building product to a consumer. The contracts will likely include terms for how data will be shared and stored (Schuh et al., 2011).

More information on contracts can be found in the upcoming section 2.8 Regulation.

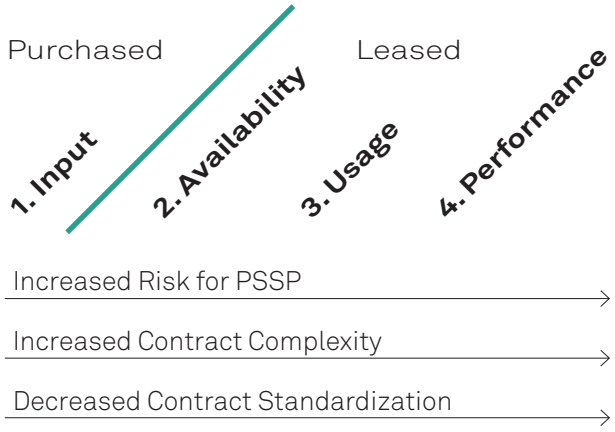


Fig. 2.05
PSS contracts; own figure.

2.2 Product

As PSSs contain a physical product, and rental housing buildings are themselves comprised of physical products, relating the two concepts via the "product" is a logical point of departure. However, to consider all the products within a building can be both overwhelming and unproductive. Thus, within the research topic of circular buildings, two frameworks are often used to reduce complexity while promoting circular concepts such as modularity, incremental replacement, and design for disassembly.

Circular building frameworks and their limitations

Brand's (1994) 6-layer approach (figure 2.06) divides a building into site, skin, structure, services, space plan and stuff. Each layer has its own lifespan and performs different functions for the users of the building. Conceptualizing a building in such a manner suggests the layers should be kept modular and independent of one another, so a building and its independent layers can be maintained or replaced over time without the necessity to demolish the entire building (Stewart Brand, 1994).
To supplement Brand's (1994) framework, the

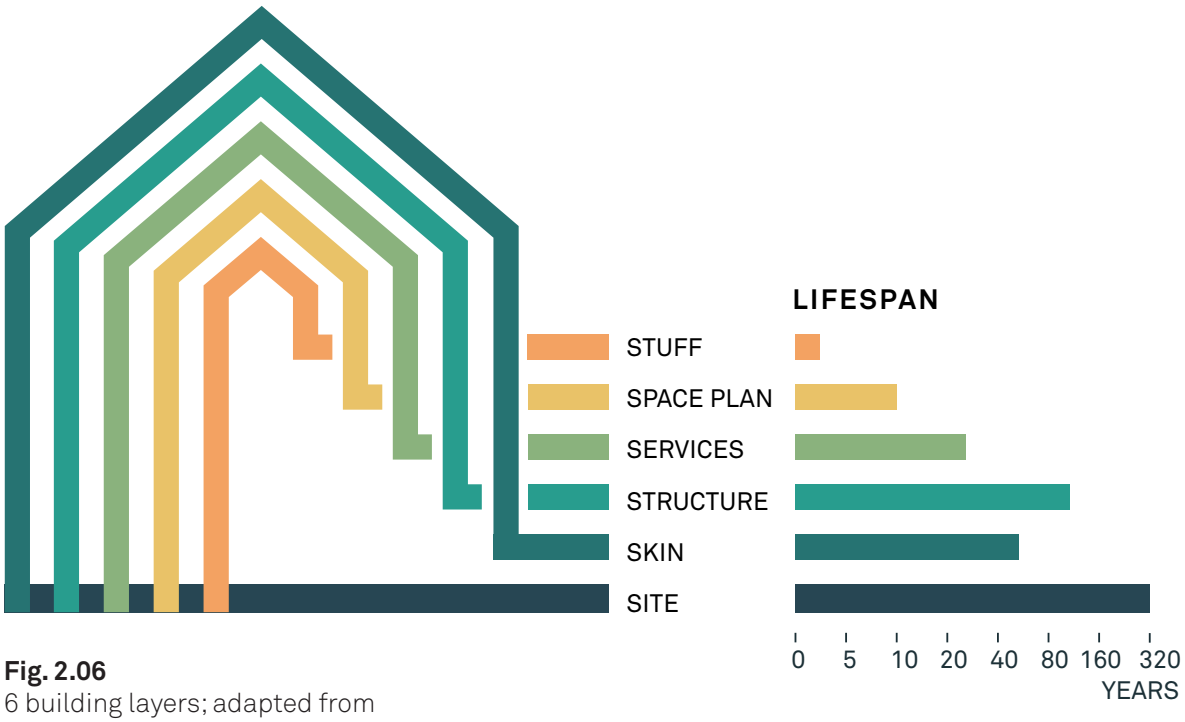
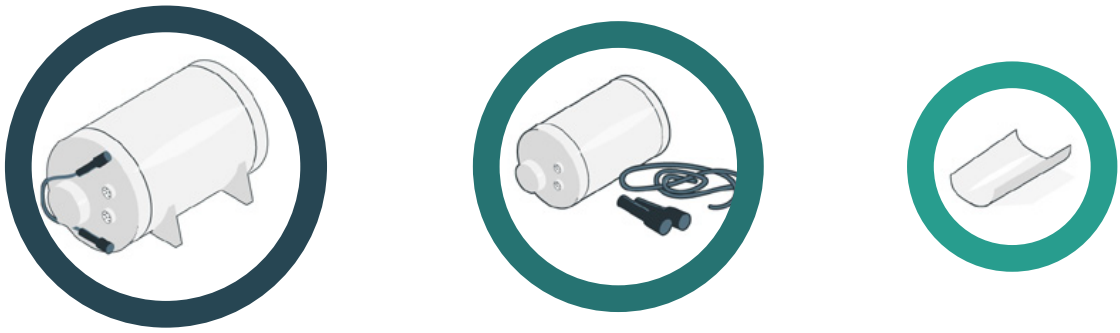


Fig. 2.06
6 building layers; adapted from Brand (1994) and Fischer (2019)



ELEMENT
boiler

PRODUCT
pipes & tank

MATERIAL
metal

Fig. 2.07
Elements, Products, Materials (EPMs); adapted from Achterberg et al. (2016) and Fischer (2019)

conceptual hierarchy of elements, products and materials (EPMs) (figure 2.07) is used to categorize smaller physical products within the six layers. An example of such is a water heater (element), it's pipes and tank (product), and the metal that comprise it (material) (Achterberg et al., 2016).

While the above two aforementioned frameworks promote the circular principles of ease of maintenance, upgrading, and re-use (Sundin & Bras, 2005), they can minimize the capabilities of a PSS. For example, a well-integrated PSS may compose multiple layers of a building into one system. Van Ostaeyen (2013) illustrates that a building's thermal comfort would best be delivered to the user if the building's skin and systems (heat, cooling, and ventilation) were combined in a single PSS offering.

Product and service integration

When conceptualizing the product within a PSS, it is key to view the product and the attached services as one integrated solution. Therefore, the services should not be viewed as an isolated or superfluous add-on to the product (Windahl & Lakemond, 2006). To achieve a high-level of integration, neither the product nor service should be able to deliver the intended results on its own (Xing et al., 2013) and the design of the PSS should developed both the product and the services simultaneously (Coreynen et al., 2017). Therefore, the service demands of a rental housing building must be identified, as focusing on the product aspect of a PSS alone does not result in a highly integrated PSS.

2.3 Service

Extending a building's lifespan

Buildings are comprised of a complex series of physical components, each with their own lifespan, maintenance requirements and eventual replacement timelines. The fundamental goal of maintenance or service is to extend a building's lifespan, which can be divided into three subsets: technical, functional/aesthetic, and economic. The technical lifespan refers to how long the building and its dwellings can exist physically while meeting performance and safety requirements. The functional/aesthetic lifespan refers to how long the building will fulfill the functional needs of its users/residents and appeal to their aesthetic preferences. The economic lifespan refers to how long the building is economically viable or generating more revenues than expenses (A. F. Thomsen & Straub, 2018). In combination, it is the shortest of the three lifespans that drives the need for large renovations or even the demolition of buildings. Often, a building's obsolesce is driven by its functional lifespan, or its inability to deliver the desired function to its users (A. Thomsen & der Flier, 2007).

Prerequisites for building component PSSs

Servitization, and therefore a PSS, is a more cost-efficient strategy when the goods involved require a high level of service (Kim et al., 2016). Therefore, it is helpful to think about housing-related PSSs in regard to which building components require intensive maintenance or frequent replacement (figure 2.08).

Building components that are required by regulation to undergo inspection or monitoring to ensure safe operation for the building's occupants, such as a HVAC systems, elevators/lifts and fire protection systems, may be good candidates for a PSS (Raposo et al., 2013).

Lastly, products that are typically disposed of before the end of their lifespans may be good

candidates for PSSs, as they contain a high residual value. This is well illustrated via the "circular kitchen", a concept being developed and brought to market by TU Delft and Bribus Kitchens. The circular kitchen was developed because kitchens on average are entirely disposed every 20 years due to their outdated aesthetics, even though the majority of the kitchen still technically performs well (TU Delft, 2020). Through modularity, the circular kitchen is designed to replace surface aesthetics every 20 years, functional components every 40 years, and the frame every 80 years. Thus, by using PSSs with mid-term (15-20 year) update cycles, such as the circular kitchen, HP's can keep their buildings aligned with evolving functional and aesthetic trends, thus mitigating against building obsolescence.

PSS building component prerequisites:

Those which require:

1. intensive maintenance or frequent replacement, and/or
2. inspection or monitoring, and/or
3. replacement before exceeding technical lifespan

Fig. 2.08
PSS building component prerequisites; own figure based on Raposo et al. (2013), Kim et al. (2016), (A. F. Thomsen & Straub (2018), TU Delft (2020).

What needs servicing?

Service can be thought of as any labor or material input needed after the building's original construction. Service can be divided into planned and unplanned maintenance/ replacement, as well as the continual provision of energy, and water. According to Preventative Maintenance for Multifamily Housing (2009), the exterior building elements which require the highest levels of service and maintenance include roofs, envelop/exterior walls, masonry, windows and doors. Interior elements with the highest service requirements include life safety (yearly fees to maintain fire alarm, elevator, HVAC, and fire protection systems), upgrades for accessibility, upgrades for building performance (HVAC, lighting, security, intercom, kitchen and bathroom, flooring), laundry rooms, water heaters, washing machines, trash rooms, and tenant change over (apartment cleaning and painting in between residents) (Preventive Maintenance for Multi-Family Housing, 2009).

While these items are helpful to identify, they do not allow for the creation of a hierarchy service requirements. To create such a hierarchy, a HP would need quantitative data to sort the service requirements by criteria such as annual costs or personnel hours spent servicing different elements of the building.

Quantitative service data

After extensive searching, quantitative data on maintenance and servicing in rental housing could not be found. As such, the rental housing building components which require the most service could not be identified.

A housing provider could gain access to quantitative service data by either gathering historic data from their portfolio/asset management department, or by forecasting future service demands by the use of a property management consultant (A. F. Thomsen & Straub, 2018). In either case, from the perspective of a HP, quantitative data is required to identify potential opportunities for a PSS, and to eventually compare the cost of a PSS with traditional ownership.

2.3 Infrastructure

The infrastructure for a PSS in rental housing can be comprised of anything that enables the PSS to exist. First, the land beneath a building, which is typically either purchased outright or offered as a land lease from the landowner to the land user, serves as infrastructure to a PSS by providing a place for a building to reside. Second, the structure of a building, which legally cannot be owned by a party other than the building owner (more information to be provided in the "regulation" section to come) also serves as the infrastructure of a PSS.

Beyond the land, structure, and physical space required, PSSs may rely on other connections to function correctly. For example, in an elevator PSS, the building's core and foundation, and electrical, telecommunication, and fire suppression systems must be in place to "host" the elevator. In the example of a kitchen PSS, a dedicated space with water, sewage, and electrical connections must be furnished to "host" the appliances, faucets, and sink. When using leased PSSs, the boundary of the PSS's product, which is provided by the PSS provider (PSSP), must be clearly defined in relationship to its required infrastructure, which is provided by the housing provider (HP). Only with a clear demarcation between product and infrastructure can the installation be properly coordinated (figure 2.09).

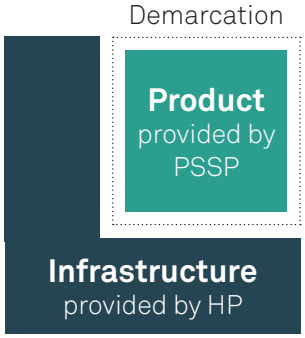


Fig. 2.09
Demarcation between product and infrastructure; own figure.

2.4 Actor networks

The housing provider (HP), PSS provider (PSSP) constitute the primary actors within the studied system (figure 2.10). In a simplified form, the PSSP delivers a solution to the housing provider. When applicable, an architect, general contractor and resident may be considered secondary actors.

Housing providers and value co-creation

In order to achieve successful outcomes, the PSS provider and housing provider must align their internal processes and work together to achieve "value co-creation". This requires activities such as increased dialogue, mutual access to information, risk sharing and increased transparency. If the housing provider is unable or unwilling to co-create value with the PSS provider, the PSS provider runs the risk of not being able to sufficiently deliver a satisfactory solution (Ng et al., 2010).

HPs may need to involve a wide range of personnel within their organization to effectively co-create value and find compelling solutions. Personnel specialized in operations, maintenance, personnel and supply chain management, asset management, financial and risk controlling, forecasting and planning, as well as policy guidelines and compliance may be relevant in the context of procuring PSSs within rental housing (Batista et al., 2017).

PSS Providers and their supply chain

When working with a PSS provider (PSSP), housing providers should be aware that PSSPs require an increased variety of competencies to deliver a PSS solution to market. At face-value, a PSS provider may appear to be one company, however they may actually be a partnership between separate product and service organizations (Windahl & Lakemond, 2006; Xing et al., 2013).

A PSS can be brought to market via a partnership between two companies, such as a manufacturer of heating equipment and a company specializing in HVAC maintenance, or via a consolidation of previously separate

companies that are now merged to fulfill the two kinds of business (product vs service) (Böhm et al., 2017). Also, a third-party dealer or leasing company may be the "face" of the PSS offering, and simply purchases the products from a manufacturer and provides the service aspect either in-house or by outsourcing to a service company. PSS providers may also have a contract with another company for reverse logistics, or the take-back, refurbishment or recycling of their products (Tukker, 2004). In any case, the housing provider should inquire the integral organization and supply chain of the PSS provider to best understand their core competencies.

Residents

In the context of rental housing, the resident is typically not involved in the contracting for specific building components, as the housing provider serves as the decision maker regarding the building. Also, in many business-to-business (B2B) PSSs, such as PSS provider to housing provider, the end-user, or resident, may not be aware that a PSS business model is even being used. However, if the housing provider grants permission to the residents, it is possible that a resident can directly contract with a PSS provider. Such a relationship will be explored in the empirical cases studies.

Procurement during construction/ renovation via contractor (and architect)

During the construction or renovation of a building, a housing provider will typically contract with hire an architect and general contractor, or a single entity that handles both design and construction (Chao-Duivis et al., 2013). In any case, the HP is contractually one-step removed from the suppliers and subcontractors who provide building products.

With this in mind, HPs may need to proactively engage with the PSS provider (PSSP) and bring them into early discussions about the building's design and operations. As mentioned before, the use of PSSs likely requires a higher degree of interaction and value co-creation than a HP may be accustomed to having with their general contractor's suppliers and subcontractors. This will require the PSSP to coordinate their work within a larger context of HP, General Contractor and Architect to establish the demarcation of the PSS and surrounding infrastructure.

When a leased PSS (types 2, 3, 4) is procured during construction or renovation, the HP will contract directly with the PSS provider, meaning the general contractor is no longer the contracting party for the product. This implies that the contractor will not be able to capture profit on the PSS product, but will still likely have to coordinate site logistics and other activities regarding the installation. When leased PSSs are procured during construction/renovation, HPs will likely need to communicate with their contractor and PSSP to find an appropriate solution (Lingegård, 2010).

Procurement during operation via facilities management

If a PSS is procured during the operations of a building, the HP and their facilities management department, either in-house or outsourced, will be in direct contact with the PSSP without a contractor as an intermediary. This may serve as a better starting point for the sharing of information between the HP and PSSP. If a PSS is utilized during the replacement of a previously owned product, the HP and facility manager can likely put a greater amount of energy (personnel hours) in co-creating a new solution, as the scopes complexity is reduced.

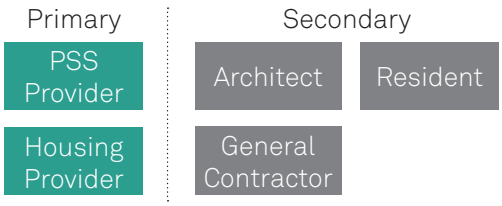


Fig. 2.10
Actor Network, own figure.

2.6 Housing provider demands

Within the context of rental housing there are two stakeholders who's demands must be met by the PSS: the housing provider (HP) that owns and operates the rental housing, and the resident which uses the homes. The demands of each stakeholder share little overlap, as the housing provider primarily captures value through the PSS by minimizing expenditures, and the resident captures value by maximizing functionality (Bertoni et al., 2017).

While for-profit and non-profit housing providers have fundamentally different organizational goals (profit vs social mission), both must remain financially viable if they are to exist over the long-term. At a portfolio level, this typical means controlling and minimizing costs and risks, and increasing resident satisfaction and market appeal. When considering the portfolio management KPI's (den Heijer, 2011) in rental housing, PSSs may have to ability to impact the following (figure 2.11):

Strategic

Enhance Market Appeal:
PSSs may serve to increase the market appeal of a building or portfolio since PSSs support the concept of the "Living Buildings", which are buildings that are ever-evolving, instead of static and complete (Gielingh et al., 2008). Additionally, since PSSs may not require initial investments, HPs may be able to install more expensive products than they could afford to purchase. By using products that residents are willing to pay premiums for, HPs can also enhance their building's market appeal.

Outsource Risk and Responsibilities:
Housing providers can reduce their operational risks and responsibilities since it is the PSS provider who is responsible for the functionality and maintenance of the product (van Ostaeyen, 2013). Therefore, housing providers may utilize PSSs in the most high-risk elements of their portfolios.

Functional

Enhance Resident Satisfaction:
Similar to market appeal, the continual refurbishment and replacement of products within a building enables as sense of "newness" from the perspective of a resident (Gielingh et al., 2008). Additionally, usage and performance-based PSSs incentivize a PSS provider to minimize the downtime of their PSSs, which in turn will reduce the potential for resident complaints.

Financial

Achieve Long-term Cost Savings:
Housing providers are motivated to reduce their costs for maintenance and replacement, utility consumption, and personnel (HR). Additionally, a PSS provider (PSSP), especially when using a usage- or performance-based contract, is incentivized to optimize the operation and maintenance of their PSS to maximize uptimes. Enhanced operational efficiencies combined with the residual value of the PSS have the potential to establish cost savings across the system, which the PSSP can in turn partially offer back to the HP (Blüher et al., 2020).

Accomplish (more) Scope without Capital: Leased PSSs (types 2, 3, 4), which typically require minimal initial investments of capital (CAPEX) (Azcarate-Aguerre et al., 2017), can enable a HP to use their limited capital elsewhere in their building or portfolio. HPs may choose to allocate investment capital where financial returns or mission-enhancement are greater, such as investing in the development of more homes, or enhancing the sustainability of the existing homes. HPs may use leased PSSs out of necessity simply to realign construction budgets, or to replace unexpectedly failed systems when capital reserves have not been allocated.

HPs may also make use of leased PSSs to address the "spit-incentive", which is a critical barrier to upgrading energy-intensive buildings (Elinder et al., 2017). The issue occurs when residents pay for

monthly utility (ex: heating) costs, but it is the HP that must investment in the system (ex: heating equipment). When such is the case, the landlord has no financial incentive to invest in sustainability upgrades for their properties, as it is the residents who will financial benefit from the reduced utility bills.

Stabilize Asset Value:
Similar to market appeal and resident satisfaction, the continual upgrading of building products keeps a building up to date, and therefore mitigates against asset depreciation (Gielingh et al., 2008).

Establish Predictable Costs:
By outsourcing the risk and maintenance responsibilities associated with a building component, HPs can establish long-term predictable costs during the contract duration (Pereira et al., 2019).

Physical

Enhance Circularity:
Housing providers who are under pressure to increase sustainability may consider using PSSs as they create new incentives for manufacturers themselves to utilize resources more efficiently.

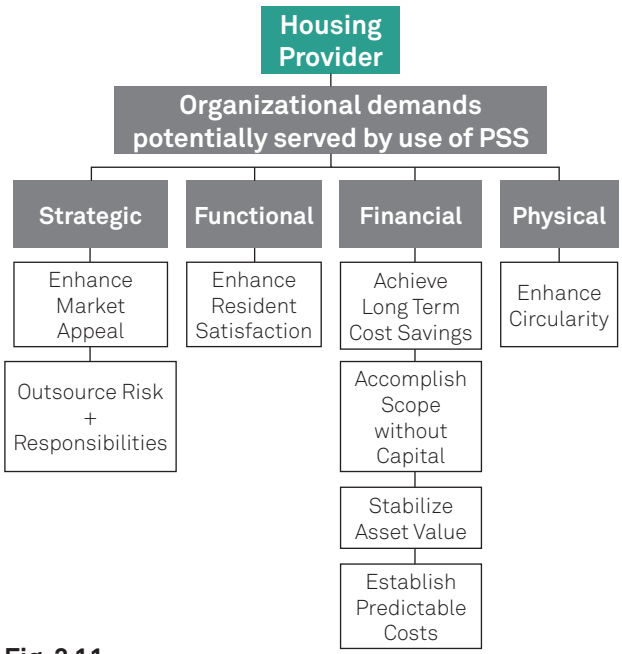


Fig. 2.11
Housing provider organizational demands potentially served by use of PSS, own figure based on Gielingh et al. (2008), den Heijer (2011), van Ostaeyen (2013), Azcarate-Aguerre et al. (2017), Pereira et al. (2019), Blüher et al. (2020).

Analyzing the use of a PSS

Based on the housing provider demands that may be benefited by the use of a PSS, HPs may analyze the use of a PSS in the following ways.

Financial comparison of Total Cost of Ownership (TCO) vs Total Cost of Use (TCU):
When a leased PSS is used (types 2, 3, 4) with minimal initial investment, the investment costs (CAPEX) are moved to operating costs (OPEX). While this can appear as a drastic increase in OPEX costs that should not be pursued, a more robust comparison must be undertaken to understand the difference between traditional procurement (purchasing and maintain the product in-house) and using a PSS. To do so, HPs should compare the total cost of ownership (TCO) with the total cost of use (TCU) (Coalition Circular Accounting, 2020). After discounting the TCO and TCU back to net-present values, whichever total is lower is the financially beneficial option for the HP. To establish the TCO, the HP must collect the following information by either reviewing historic portfolio data (ex-post), or by hiring a consulting company to forecast the cost of ownership (A. F. Thomsen & Straub, 2018): the initial investment cost (CAPEX), annual operational/ management costs (OPEX), annual maintenance costs (OPEX), and externalities such as insurance premiums (OPEX).

To establish the TCU, the HP must collect the following contract terms from the PSS provider: the initial investment cost (if any), installation costs (if any), annual operational costs (OPEX), duration of contract (in years), cost indexation, and take-back costs (if any).

When comparing TCO vs TCU, housing providers may also need to take into account equity vs debt financing, inflation rates, interest rates, depreciation, residual value, and tax liability.

Risk comparison of ownership vs leasing:
To supplement the financial comparison, housing providers likely review the inherent risks associated with traditional ownership in comparison to using a PSS. Even if a financial comparison reveals that a PSS is equal or higher costs over the long-term, a HP may use a PSS simply to reduce their risk profile.

2.7 Resident demands

Resident demands for a PSS are primarily related to function, as they are the ones who will use it on a daily basis. Van Ostaeyen (2013) divided a PSS user's demands into three levels of abstraction that together form a Functional Hierarchy Model (FHM). At the top of the FHM is the user's core demands and overall objective, which describe why the PSS exists in the first place. Next, the functional level describes what functions must be delivered to meet the demands. The bottom of the FHM, the structural level, describes the physical components that combine to deliver the expected functions within the functional level.

The following FHM depicts the structural, functional, and demands level of a resident of rental housing by building on the work of van Ostaeyen (2013) and including supplementary resident demands that may be delivered by a PSS. The "Activities of Daily Life" (Katz, 1983), while intended for the health care industry, identifies the following core demands that a home must provide for a resident: eating, dressing, personal hygiene and toileting, and sleeping. These demands typically manifest themselves in kitchens, wardrobes, bathrooms, and bedrooms, respectively. Additionally, residents also seeking accessibility and affordability in their homes, suggesting more core demands must be added to the FHM.

The FHM in figure 2.12 is not meant to be exhaustive, nor to cover all functional demands that as resident may have. Instead, it can be used to illustrate and conceptualize how physical products, either in isolation, or in combination, work to serve the demands of a resident. The purpose of mapping the resident's demands is to identify opportunities for innovation. Innovation can occur when inefficiencies can be found within a system and replaced with more efficient

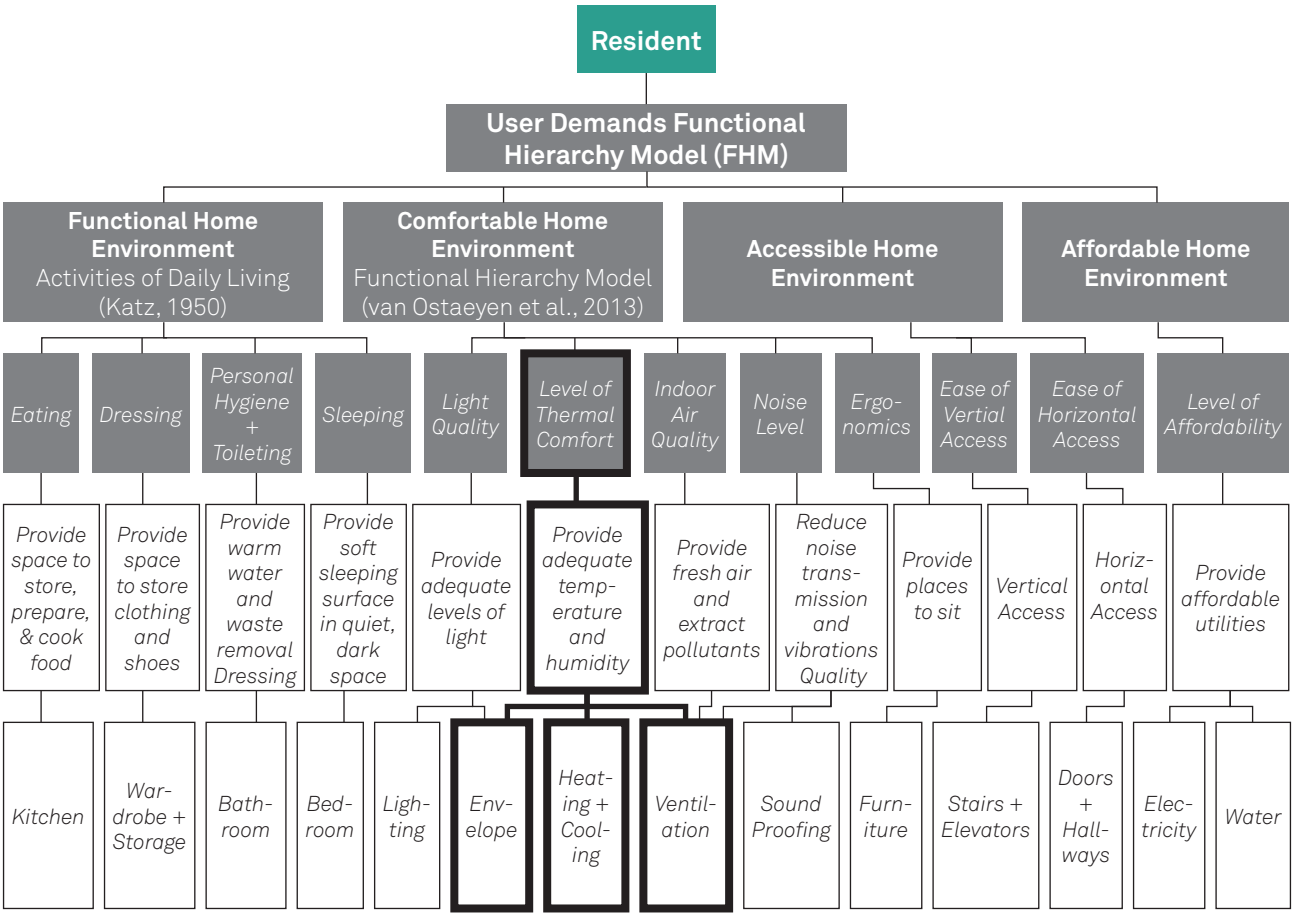


Fig. 2.12
Extrapolated Functional Hierarchy Model (FHM); own image, based on van Ostaeyen (2013) & Katz (1983).

ways to fulfill a demand.
For example, achieving thermal comfort is influenced by 1) the building's envelop, 2) the building's heating and cooling system, and 3) the building's ventilation system. This illustrates that thermal comfort could best be delivered to the resident by a PSS that combines all three systems into one (Van Ostaeyen et al., 2013). Additionally, the interaction between the building's envelop, heating and cooling, and ventilation, suggests that a PSSP would only offer a performance-based solution if they were able to control all the factors that influence a resident's thermal comfort. For instance, if they provide a performance-based contract ensuring that the resident will always be thermally comfortable and have a PSS solution that only integrates the building's envelop and heating and cooling system, the resident's thermal comfort can be disrupted by the heat recovery efficiency of the ventilation system (Van Ostaeyen et al., 2013).

2.8 Regulation

Structure

Based on Dutch Property law and the legal concept of "accession", a building's structure must be considered as infrastructure owned and provided by the building owner. Accession defines the following concept: if multiple objects add up to create a larger asset, and the multiple objects cannot be removed from one another without destroying the asset, then the combination of individual objects are legally viewed as one asset. Since the structure of a building cannot be removed without damaging or destroying the building itself, it is not suitable for a PSS, and should instead be considered infrastructure. Additionally, since the structure is an immovable good, it is viewed as part of the site and not permitted to be owned by another party besides the building owner (Coalition Circular Accounting, 2020).

Connections, rentals and service contracts

The issue of "accession" is relevant to other large building-related PSSs such as a facade/skin. To circumvent such issues, the Dutch Supreme Court recently approved a new rental legal structure (ECLI: NL: HR: 2018: 424, 2018) that overcomes the issue of accession in leased PSSs. The facade was designed in a modular, demountable way so that it can be installed and removed without damaging the larger building. In the context of a facade and a Facade Service Company (FSC), the leased facade PSS utilizes two contracts as follows (figure 2.13) (Coalition Circular Accounting, 2020):

1. "The FSC rents the suspension points for the facade from the owner of the building. To this end, the FSC enters into a rental agreement with the owner of the building or the property owners association (POA), in which the owner of the building or the property owners association makes the suspension points available to the FSC for use. This rental agreement includes the right of quiet enjoyment and the right to take back the product for the FSC. A periodic or a one-off fee may be agreed for this rental right."

2. "Subsequently, a separate contract - the actual service contract - regulates which services the service provider provides to the owner of the building or the property owners association with regard to the facade, such as installation, maintenance and technical updates. A separate periodic fee is paid for this."

The example of the facade can prove useful for the use of other PSSs that must be mounted to the surrounding building, such as kitchens or HVAC equipment. When necessary, the same legal approach of 1) the PSS provider renting the connection points from the housing provider, and 2) the housing provider paying for the use of the PSS, may prove useful.

Bankruptcies and Contract failures

The Dutch supreme court ruling (ECLI: NL: HR: 2018: 424, 2018) also clarified that if, during the contract period, the housing provider goes bankrupt or fails to make payments, the PSS provider may break the service lease and reclaim their PSS from the premise. On the other hand, if the PSS provider fails to deliver adequate service to the housing provider, the financiers of the PSS can replace the PSS provider with another provider who is able to fulfill the contract obligations. This is referred to as the "step-in-rights" of the PSS financier (Coalition Circular Accounting, 2020).

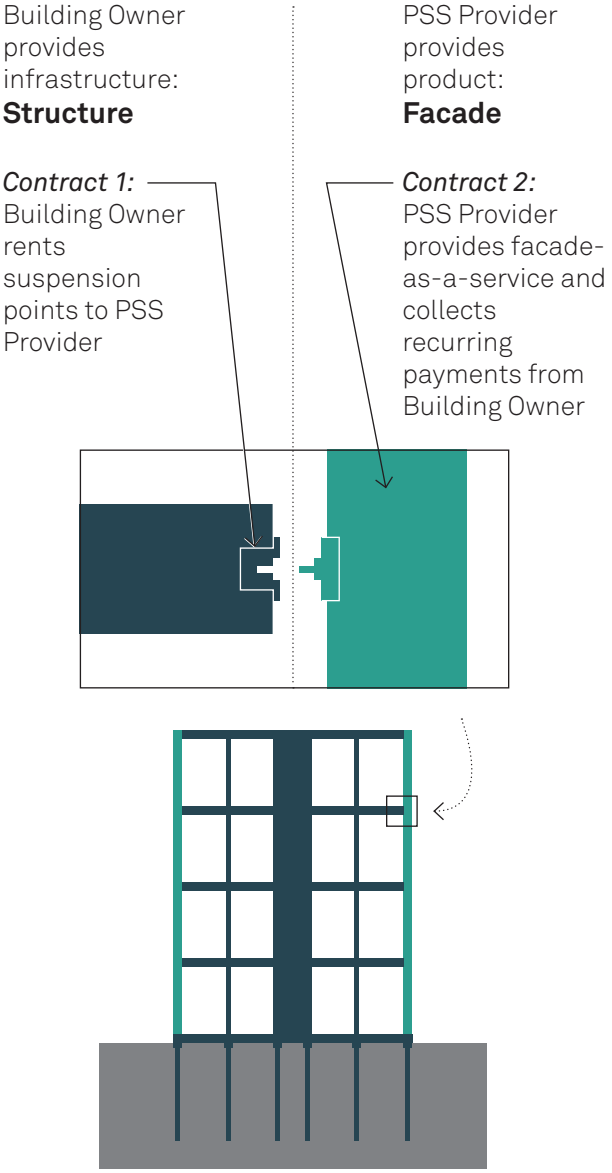


Fig. 2.13
Circumventing the legal concept of accession via two contracts; own figure based on Coalition Circular Accounting (2020).

2.9 Cognitive settings

Cognitive settings include the housing provider's knowledge of, or ability to learn about, PSSs and how they relate to their portfolio. The review of historic service data/ costs or forecasted service data/costs will largely enhance a HPs ability to recognize opportunities for PSS implementation. In the case of historic data, the HP's use of a robust portfolio management software will enable them to review, categorize, and sort large portfolio costs, enabling them to draw conclusions for possible service consolidation into a single PSS. PSSs will also likely be marketed as a way to reduce the responsibility, and "headache", of the housing provider within their portfolio. The zero or reduced initial costs for the PSS may also be marketed as a low barrier of entry, however housing providers must evaluate each PSS offering on a case-by-case basis.

Cognitive settings also include the PSS provider and their ability to clearly communicate with the HP. This implies that a PSS provider can concisely relay information such as pricing models, PSS demarcations, infrastructure requirements, leasing durations, contract renewals and terminations. For the housing provider to use a PSS, the PSS provider should be able to convey the long-term value they are offering, especially in comparison to the traditional purchasing of a product (Roy et al., 2009). The PSS provider will likely have varied PSS options with clear pricing that can be tailored to the housing provider's specific needs.

Lastly, the cognitive setting applies to the financiers of PSSs who must offer long-term lending to PSS providers. This is an underdeveloped field and requires financial institutions to develop new ways of calculating the product's value at its end of life. To do so, financial institutions have begun using "harvest value", instead of "residual value", to conceptualize the eventual reuse of raw material in future products, thus treating a PSS provider raw material as an asset itself. New ways of calculating risk are required to establish standardized financing mechanisms for PSSs (Coalition Circular Accounting, 2020).

2.10 Normative settings

Normative settings can be viewed as the HP's familiarity with PSSs and attitude towards using them. If the organization has historically used PSSs, or is aware of competitor organizations who use them, they may be more willing to consider and embrace the concept of ownerless consumption.

The same goes for manufacturers who are transitioning to the offering of PSSs. If they see competitors tapping into new sources of revenue and successfully avoiding the "service paradox" (Gebauer et al., 2005), or the stagnation of profits despite servitization, they may be more willing to evolve their business models.
As mentioned above, the financial industry is currently working to develop new ways to evaluate and finance PSS providers. When this becomes normalized, it will likely trigger a larger embracement of PSSs across many industries, including real estate and housing.

2.11 Reduced environmental impact

To think that the use of a PSS is automatically beneficial for the environment is unfortunately not true (Blüher et al., 2020; Tukker & Tischner, 2006). In the context of rental housing, a PSS's circularity can be attributed to many factors such as the resident's behavior, the PSS provider's (re)remanufacturing capabilities, and the contract form.

Resident behavior

Residents may abuse the products which comprise their home far more than if they owned the home themselves, resulting in increased maintenance and or refurbishment, and thus possibly reducing the environmental benefits of a PSS. IT should be noted that this is a common issue in rental housing, with or without the use of a PSS. On the other hand, the sharing or "pooling" of PSSs between multiple residents, for example shared laundry facilities, has beneficial environmental impacts since the products and materials are used to a higher intensity (Tukker, 2004).

Remanufacturing

If the PSS provider does not remanufacture their products at their end of their life, then the PSS largely still relies on harmful resource extraction. Remanufacturing, and not recycling, is viewed as a key component of reducing the environmental impact of PSSs. "Remanufacturing is a process of bringing used products to a "like-new" functional state with warranty to match. Its significance is that it can be both profitable and less harmful to the environment in comparison to conventional manufacturing." (Ijomah et al., 2007). Remanufacturing also implies that products, and the raw materials that embody them, are returned to their original manufacturers who have the expertise and capabilities of returning them to a "like-new" state.

The PSS provider may be motivated to increase their sustainability and re-use of raw material for legal or regularly reasons (Maxwell et al., 2006), for increased marketability to customers (Kriston et al.,

2010), or for cost-saving reasons, or for all three. In any case, housing providers concerned with the circularity of their portfolios should prioritize PSS providers with robust remanufacturing capabilities.

Contract types

The type of PSS, and hence the incentives for the PSS provider, also impact the likelihood that the PSS has beneficial environmental impacts. PSSs can be viewed from least to most sustainable in the following order: 1) input-based, 2) availability-based, 3) usage-based, and 4) performance-based (Van Ostaeyen et al., 2013).

The most promising are performance-based PSSs that enable the PSS provider full control of how to deliver the result. When given full control, the PSS can more readily minimize waste within their solution (Tukker, 2004). In performance-based / result-oriented PSS types, the "incentives for the provider to improve resource utilization are extremely high, because the operational savings will benefit the potential for the PSS provider to generate revenue" (Reim et al., 2015). Additionally, performance-based PSSs, by their lack of a prescribed solution, offer grounds for the highest levels of radial innovation (Tukker, 2004).

2.12 Summary

PSSs can be delivered to a HP in a variety of value propositions, all of which use different payment structure and create difference incentives for the PSSP. In the order of input-, availability-, usage-, and performance-based PSSs, contracts increase in complexity, increase in PSSP risk and responsibilities, increase in circularity/sustainability, and decrease in standardization. The four types can be divided into "purchased" PSSs (input-based), and "leased" PSSs (availability-, usage-, and performance-based). Besides a building's structure, which by law must be owned by the building's owner, all other building components can be offered as a leased PSS. However, based on theory, the applicability of a PSS business model to a product increases based on the product's service requirements. Thus, building components that require 1) intensive maintenance or frequent replacement, and/or 2) inspection or monitoring, and/or 3) replacement before exceeding technical lifespan may be most fitting for a PSS. PSSs depend on supportive infrastructure provided by housing providers in order to deliver the promised utility, such as water and electricity connections.

Housing providers will likely procure PSSs to satisfy own organizational demands and/or resident user demands. When procuring a PSS during new construction or large renovations, HPs will contract directly with PSSPs, in turn removing the general contractor (GC) as the contracting party. This will reduce the GC's scope and profit, which may necessitate additional conversations and negotiations. Lastly, when a leased PSS is used, Dutch property law and the legal concept of "accession" may require the use of two contracts between the HP and PSSP. In the first contract, the HP will rent connection points to the PSSP, and in the second contract, the PSSP will allow the HP to use the PSS.

3. Conclusion

PSSs can be delivered to a housing provider (HP) in a variety of value propositions, all of which use different payment structure and create difference incentives for the PSSP. The value offered by PSSs to HPs increases in the order of input-, availability-, usage-, and performance-based PSSs. In this order, contracts increase in the risk and responsibilities outsourced to the PSSP. In the same order, contracts also increase in the potential for circularity. Increased potential for circularity also creates an increased potential for long-term cost savings. When PSSPs exploit residual value, cost savings can theoretically be shared with housing providers. Leased PSSs can enable HPs to accomplish scope without capital, which can thus enable them to enhance the market value of their buildings. Based on enhanced maintenance and reduced downtimes, PSSs may enhance resident satisfaction. When they are maintained properly and replace faulty components, PSSs may have the ability to also stabilize asset value.

HPs may face growing challenges in the same order as contracts increase in complexity and decrease in standardization. When a leased PSS is used, Dutch property law and the legal concept of “accession” may require the use of two contracts between the HP and PSSP. In the first contract, the HP will rent connection points to the PSSP, and in the second contract, the PSSP will allow the HP to use the PSS. When procuring a leased PSS during new construction or large renovations, HPs will contract directly with PSSPs, in turn removing the general contractor (GC) as the contracting party. This will reduce the GC’s scope and profit, which may necessitate additional conversations and negotiations.

Besides a building’s structure, which by law must be owned by the building’s owner, all other building components can be offered as a leased PSS. However, based on theory, the applicability of a PSS business model to a product increases based on the product’s service requirements. Thus, building components that require 1) intensive maintenance or frequent replacement, and/or 2) inspection or monitoring, and/or 3 replacement before exceeding technical lifespan may be most fitting for a PSS. PSSs depend on supportive infrastructure provided by housing providers in order to deliver the promised utility, such as water and electricity connections.

PSSs in Rental Housing

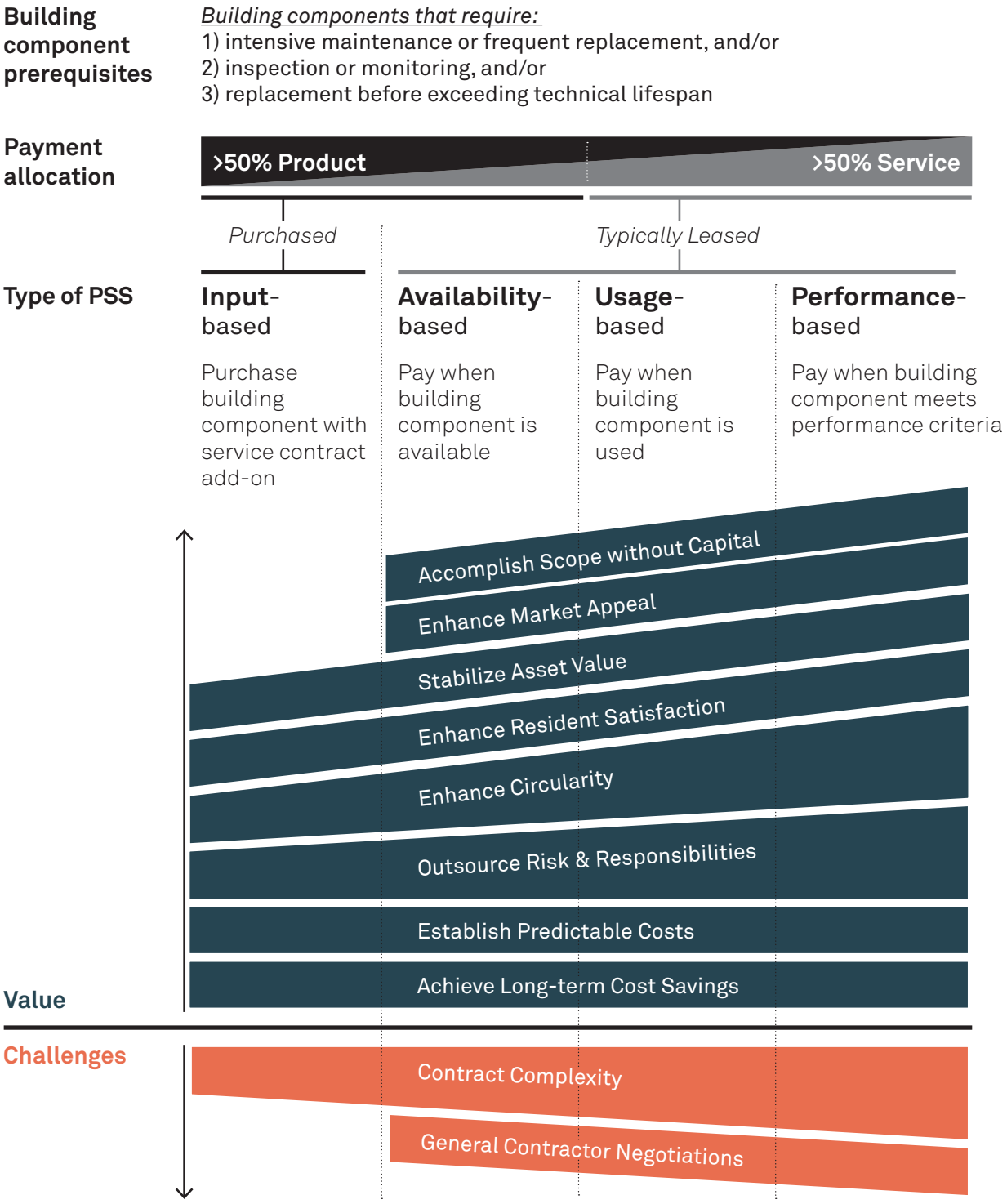


Fig. 2.14
Theoretical Framework, own figure.

03
Empirical Research Methodology

This chapter describes how the research methodology is organized in 5 parts: 1) empirical research parts, 2) case studies, 3) expert interviews, 4) financial simulations, and 5) data plan.

1. Empirical research parts

The purpose of the empirical research is to clarify, further explain, and modify the concepts described in the theoretical framework, and to answer the question:

"How can Product-Service-Systems (PSSs) offer value to housing providers?"

The research is divided in three main parts (figure 3.01). First, case studies are conducted to understand, from real examples of PSSs being used in rental housing, why housing providers are using them, how they considered using them, what challenges they faced, and how inherently circular the PSSs are. The case studies also reveal contract details and payment structures of each PSS. Second, interviews are conducted with experts on the topics of Product-Service-Systems (PSSs) and circular business models (CBMs) within the built environment. These interviews are used to corroborate the findings from the case studies. Lastly, a financial simulation was conducted to understand the financial implications of leasing building components, and how a buildings tax liability and Internal Rate of Return (IRR) are impacted. The case studies, expert interviews, and financial simulation allow for triangulation which increases the validity of the research (Bryman, 2016).

Fig. 3.01
Empirical research parts; own figure.

2. Case studies

Why Case Studies?

The use of multiple case studies enables a deeper understanding of the value PSSs offer the housing providers that use them. The use of case studies allows for the investigation of "a contemporary phenomenon within its real-life context" (Yin, 2003). As such, this research investigates the contemporary phenomenon of Product-Service-Systems in the real-life context of American and Dutch rental housing.

Case Study Selection Criteria

Case studies were selected based on criteria that allows for greater consistency in results. The criteria, as shown in figure 3.02, helps define the cases (Yin, 2003) and can be divided into required and desired criteria. As the research is exploratory in nature, the required criteria remain limited to allow more cases to be included.

	Criteria
Required	1. A building component PSS has been procured a within the portfolio of a housing provider within the last 3 years.
	2. Representatives from either the housing provider or PSS provider are available for interview.
Desired	3. Representatives from both the housing provider and PSS provider are available for interview.
	4. If possible, select at least 1 case study of each PSS taxonomy: • Input-Based • Availability-based • Usage-based • Performance-Based

Fig. 3.02
Case study selection criteria; own figure.

	Criteria	Cases						
		A	B	C	D	E	F	G
Required	1. A building component PSS has been procured a within the portfolio of a housing provider within the last 3 years.	X	X	X	X	X	X	X
	2. Representatives from either the housing provider or PSS provider are available for interview.	X	X	X	X	X	X	X
Desired	3. Representatives from both the housing provider and PSS provider are available for interview.	X	X	X	X	X	*HP unavailable*	
	4. If possible, select at least 1 case study of each PSS taxonomy: • Input-Based • Availability-based • Usage-based • Performance-Based	Input-based	Availability-based			Usage-based		

Fig. 3.03
Match between case studies and selection criteria, own figure.

Match between Criteria and Selected Cases

Across the 7 cases, as seen in figure 3.03, all required criteria were met. Only in two cases were representatives from the housing provider not available for interviews. Of the four types of PSSs intended to be studied, only a performance-based PSS was not included in the study since a market-implemented performance-based PSS could not be identified.

Introduction to Cases

Based on the selection criteria, seven cases have been selected.

Case A – Input-based Elevator:
located in New Hampshire, USA, Case A is the modernization of two existing elevators within a 78-apartment affordable (social) housing building.

Case B – Availability-based Kitchen:
located in The Netherlands, Case B is the installation of 16 kitchens within the transformation of a historic (monument) office building to 16 market-rate apartments.

Case C – Availability-based Window:
located in The Netherlands, Case C is installation of 130 windows within the transformation of an office building into 30 market-rate short-term rental apartments.

Case D – Availability-based Battery:
located in The Netherlands, Case D is the installation of a battery storage system within a 50-apartment social (affordable) housing building.

Case E – Usage-based Elevator:
located in The Netherlands, Case E is the installation of 14 elevators in a large new construction project comprised of 485 market-rate homes.

Case F – Usage-based Heat Pump PSS:
located in The Netherlands, Case F is the modernization of a heating plant within a 27-apartment social (affordable) housing building. The existing combined heat and power (CHP) gas boilers were replaced by new electric heat pumps.

Case G – Usage-based PV Panel PSS:
located in The Netherlands, Case G is the installation of solar panels on existing social (affordable) housing buildings.

Two types of case studies

Demand + Supply Cases
For cases A-E, an embedded multiple-case methodology (Yin, 2003) was utilized, as seen in the bottom right quadrant of figure 3.05. The cases are comprised of two units each: a representative from the housing provider, and a representative from the PSS provider.

Supply-Only Cases
For cases F and G, a holistic multiple-case methodology (Yin, 2003) was utilized, as seen in the top right quadrant of figure 3.05. The cases are comprised of one unit each, a representative of the PSS provider, as representatives from the housing provider were unavailable for interview.

Analysis approach

Each case was studied individually before being compared across its type of case (Demand + supply vs supply-only), and lastly across all cases. The individual analysis of each case consists of the following parts: 1) case context, 2) propositions offered by the PSS provider, 3) drivers for the housing provider to use the PSS, 4) other advantages of using the PSS, 5) analysis of the PSS, 6) challenges faced, 7) circular principles exhibited, and 8) summary.

The cross analyses aim to find characteristic patterns of each type of PSS (input-, availability-, usage). Based on these analyses, the theoretical framework will then be adjusted to reflect the findings (figure 3.06). The use of multiple case studies minimizes errors and allows for more convincing results (Bryman, 2016).

Data Collection and Analysis

Cases are studied using a repetitive semi-structured interview protocol which enable better comparisons and conclusions to be drawn. Interview protocols are based on the findings from the theoretical framework and can be seen in Appendices A and B. Interviews were conducted during February and March of 2021 and analyzed in April. Each interview was 1-hour in duration, conducted over Zoom, and recorded for transcription.

Data collected from the twelve case study interviews is transcribed using Otter.ai and analyzed using ATLAS.ti software. Using ATLAS.ti, interviewee responses were coded and labeled in connection to the concepts identified during the literature review and theoretical framework development (Bryman, 2016). Some codes pertain to those identified in the theoretical research, while others emerged based on new findings. An example of how interview data was coded is seen in figure 3.04.

Fig. 3.04
ATLAS.ti coding; own figure.

Each interview is analyzed individually, and then compared with other interviews to find recurring themes and reasoning for using the PSS. The codes used can be seen in figure 5.01 (Discussion and Recommendations).

3. Expert Interviews

Research Approach

The expert studies were used to corroborate the findings from the demand + supply and supply-only case studies. Semi-structured interviews were used to gather information regarding the potential drivers and advantages for real estate organizations who use PSSs. The expert interviews reveal

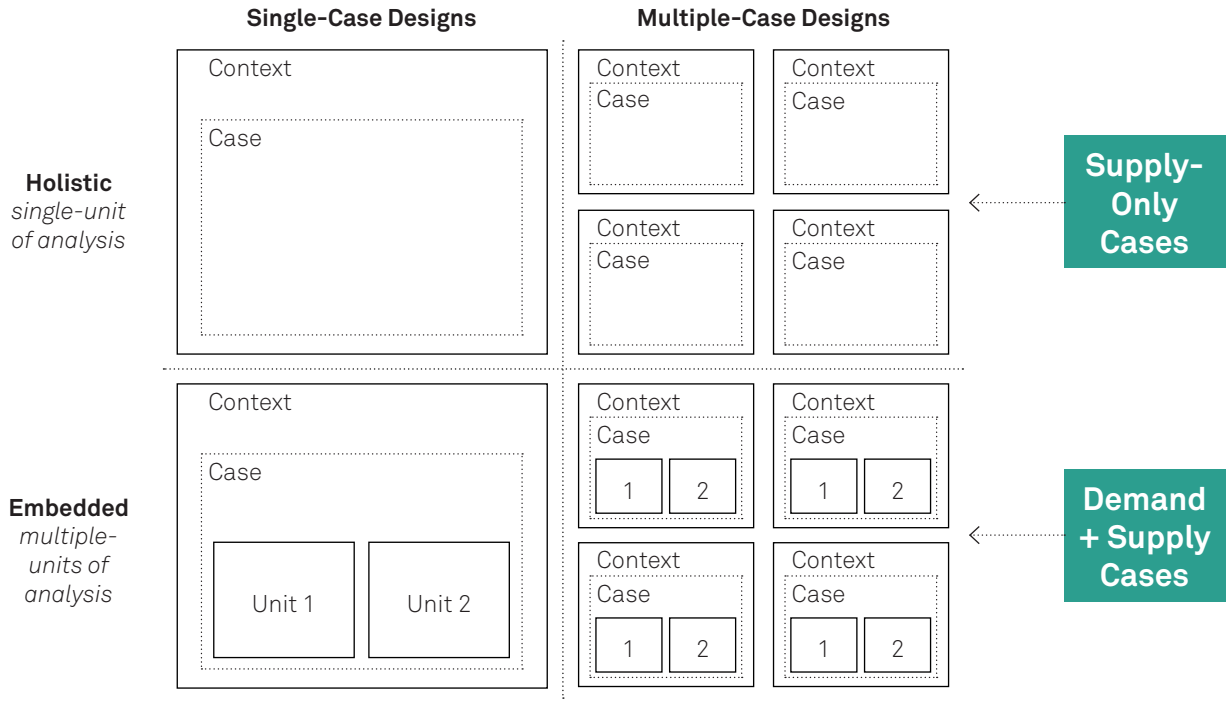


Fig. 3.05
Types of design for case studies; own figure based on Yin (2003).

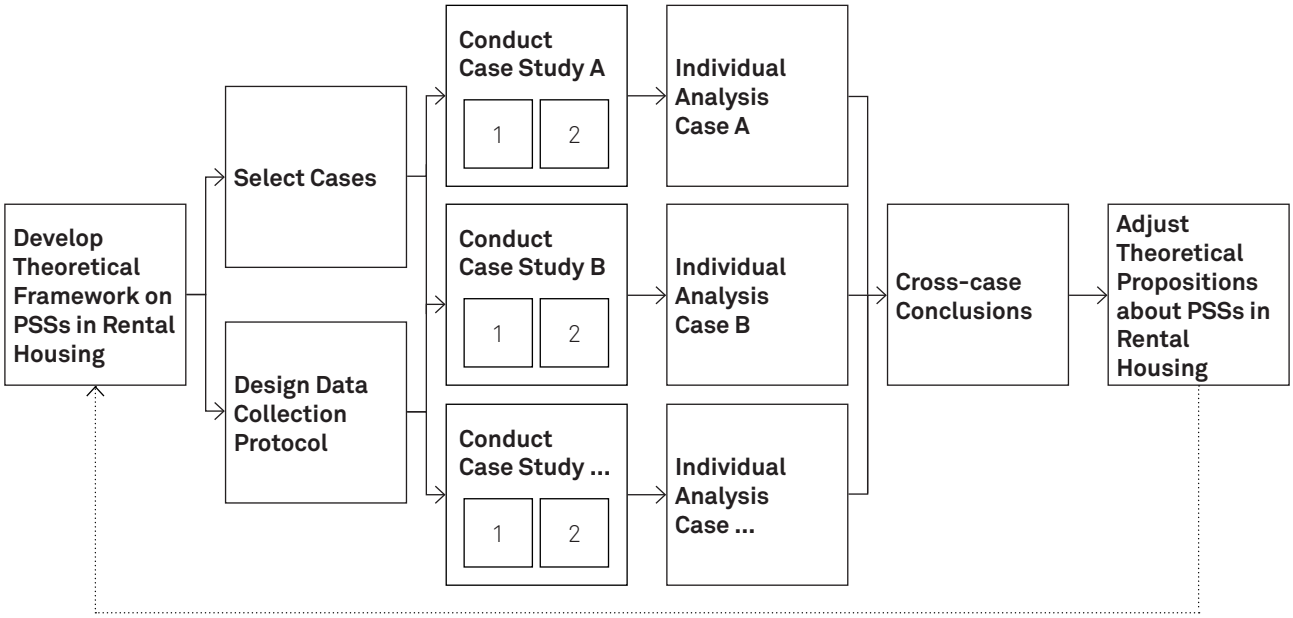


Fig. 3.06
Multiple-case procedure; own figure based on Yin (2003).

the trends which have fueled the use of PSSs over the last decade, the barriers facing PSSs, the current market share of PSSs, and potential future for PSSs. The interviews help to understand the pervasiveness of CBMs and PSSs within the larger context of the real estate, design and construction, and the built environment in general. These interviews used the same data collection and analysis approach as the case studies.

Introduction to Experts

A wide range of experts were selected based on their expertise regarding PSSs.

Expert 1 – Rob van Willigen (ABN AMRO):
Rob van Willigen is the Commercial Advisor Product-as-a-Service (PaaS). Rob has 32 years of commercial banking experience, of which, the last 2 years have been focused on PaaS.

Expert 2 – Mark van Ommen (TNO):
Mark van Ommen works as the Business Developer of Circular Economy Buildings & Infrastructure. Mark has 35 years of experience in construction and consulting, of which, the last 1.5 years have been focused on the circular economy.

Expert 3 – Sabine Oberhuber (Turntoo)**:**
Sabine Oberhuber is the co-founder of Turntoo. Sabine is a circular economy expert & innovator, speaker, and author. Sabine was a co-developer of the Phillips pay-per-lux model, and frequently collaborates with RAU Architects and Madaster Foundation. Sabine has 10 years of circularity experience.

Expert 4 – Rick Ruisch (Een Veilig Gevoel):
Rick Ruisch is the Founder & Shareholder of Een Veilig Gevoel, a Security-as-a-Service Firm. Rick has 10 years of experience operating an as-a-service company.

Expert 5 – Jeroen Reumkens (Volantis):
Jeroen Reumkens is a Circular Innovation Consultant with 2 years of experience in circular economy consultancy.

4. Financial Simulation

Based on finding from the case studies and expert interviews, a financial simulation was conducted to gain insights into the financial implications of leasing building components. The operational research utilizes a series of discounted cash flow models to simulate the impacts of leased PSSs on a building's tax liability, Internal Rate of Return (IRR), and Net Present Value (NPV). The indices and assumptions used in the model, as well as the model sheets themselves, can be found in Appendix G.

5. Data Plan

All data was be collected according to the GDPR (General Data Protection Regulation) requirements. Interviewees were given an Informed Form of Consent (IFC), as seen in Appendices D and E, to confirm their participation in the study and the intent of the research.

The IFC confirms that the participants volunteer in the data collection process voluntarily, that audio will be recorded during the interviews, that participants can remain anonymous if they choose, that select quotations may be used in the final report, and that the data collection will be published in TU Delft's online student thesis repository.

All interview audio files will be stored offline by the researcher and shall be deleted 12 months after graduation. The information will not be shared with anyone outside of the primary researcher/author, and the TU Delft advisors for the research. All personal information collected via interviews, including names and contact information will remain private and will also not be shared beyond the research team.

TU Delft's DMPonline tool will be used to create the data plan, and ensure compliance with the GDPR, as well as TU Delft's internal data policies. The data plan will be reviewed by TU Delft's Bouwkunde faculty data steward.

Lastly, the research will follow the FAIR (Findable, Accessible, Interoperable, Reusable) principles. The final report will be accessible via TU Delft's online education repository. Any datasets resulting from the research will be published using TU Delft's 4TU.ResearchData repository. All data published to the repository will be anonymized.

04
Empirical Research Results

This chapter consists of the following parts: 1) individual analysis of five demand + supply cases 2) a cross-case analysis of all five cases, 3) individual analysis of two supply-only cases, 4) cross case analysis of the two cases, 5) cross case analysis of all cases, 6) findings from the expert study, and 7) financial simulation.

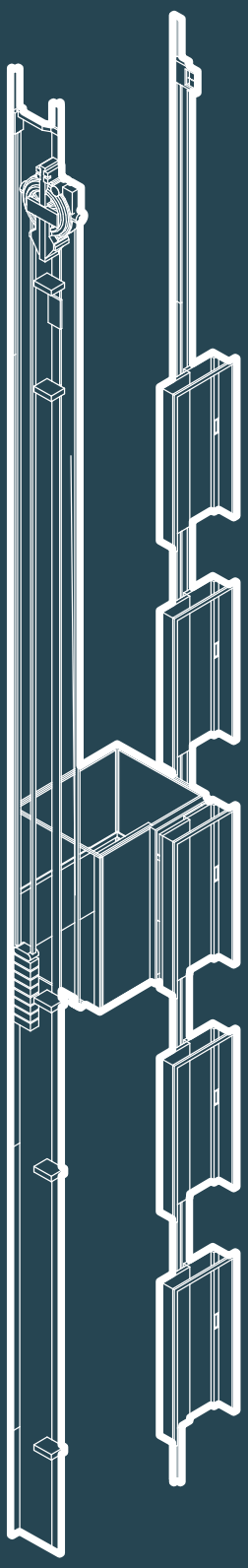
1. Individual Analysis of Demand + Supply Cases

The individual analysis of each case consists of the following parts: 1) case context, 2) propositions offered by the PSS provider, 3) primary drivers for the housing provider to use the PSS, 4) secondary advantages of using the PSS, 5) analysis of the PSS, 6) challenges faced, 7) future use of the PSS, 8) words of advice, 9) circular principles and 10) summary.

Case A

Elevator

input-based



Drivers for Housing Provider to use PSS

Strategic
+ Outsource Risk and Responsibilities
Financial
+ Achieve Long-term Cost Savings

PSS Design

Product
The product includes the majority of elevator equipment, with exceptions (see Infrastructure).

Service
Combination of pre-planned and dynamic IoT monitoring: Service includes all covered and maintainable parts and labor. Service does not include components that become obsolete, or infrastructure items (see below).

Infrastructure
Elevator core with mounting connections, as well as connections for fire safety, electricity, and telecommunications. Additionally, the HP must provide the elevator cab frame, rails, and jack cylinders.

Project Context

Installed During
System Replacement

United States of America

78
Affordable (Social) Apartments

Housing Provider Strategy

Long-term Ownership

PSS Business Model

34%
Service to Product Cost Ratio

✕
"as-a-Service" Business Model

Owner of Product

Housing Provider

PSS Contract

5
Year Service Contract (planning to be renewed 5x = 25 years)

na
Law of Accession "Work-Around"

Fig. 4.01
PSS Highlights
Case A, own figure.

Case A: Elevator

Context

- **Building:** located in New Hampshire, USA, Case A is the modernization of two existing elevators within a 78-apartment affordable (social) housing building.
- **Housing Provider:** the Housing Provider (HP), which has 50+ corporate employees, and 300+ property maintenance employees, has a long-term ownership strategy and considers sustainability a core value of their organization. They have a portfolio of over 10,000 affordable rental homes that they own and manage. They have been operational for 20 years and have used the PSS many times within their portfolio.
- **PSS Provider:** the PSS Provider (PSSP) has been operational for 20 years and installs 1.000s of elevators per year.

Propositions offered by PSS Provider

The following propositions were offered by the PSS provider. The housing provider chose those in bold:

Housing Provider is Owner of Product:

- 100% Investment (No Service Contract) (No Buyback Guarantee)
- **100% Investment with Service Contract (No Buyback Guarantee)**

Drivers for Housing Provider to use PSS

Fundamentally, the PSS was used by the Housing Provider for 2 reasons: to 1) outsource risk to the PSS (since elevators are a regulated piece of equipment that must comply with annual state-mandated inspection, it is an industry-standard/best-practice to outsource elevator maintenance and service to a PSSP), and to 2) achieve long-term cost savings.

> *1) "It's a critical component. And it's regulated, because you have annual inspections by the state. I don't think it's a requirement that you have one, but it's just a best practice."*
> *— Case A: HP Rep 2*

> *1) "As well as risk management. So, the first thing, if there's an injury, is the attorney will ask for service records. [...] You know, they bring up your service contract, and they bring up your preventative maintenance history and your inspection history. And if you're not good on any one of those, you're likely to have a poor outcome in the case. So, as an owner, I would certainly want to have a robust maintenance program to help protect against litigation." — Case A: PSSP*

> *2) "It's essentially cost savings. So, really, it's us as the provider incurring the risk of service calls, repairs, preventative maintenance. The onus is on us to ensure that we're properly maintaining the units to mitigate any unnecessary repairs." — Case A: PSSP*

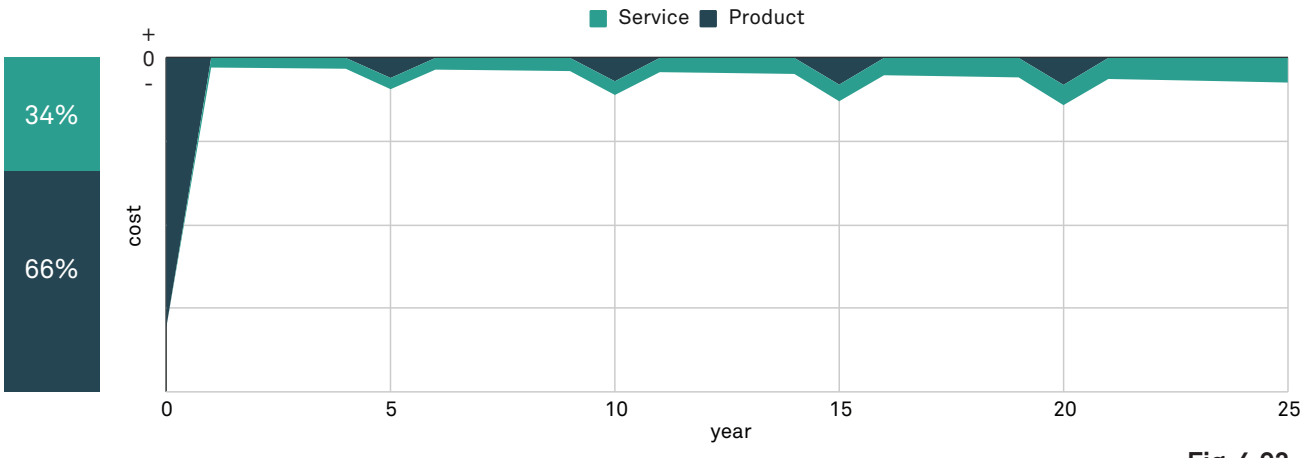


Fig. 4.02
Case A payment proportions over time; own figure .

Other Advantages for Housing Provider

Additional advantages for the HP include 1) predictable costs during the elevator's lifespan (for the most part, see challenges).

> *1) "Labor rates in the elevator business are higher than most other businesses. So, a single hour for a mechanic, no matter what company, is in excess of $300 an hour. So, in the example of [CASE A PROJECT], they're mid $two-hundreds per month. So, all they would need is one service call and that would exceed their monthly fee." — Case A: PSSP*

Analysis Performed by Housing Provider

The housing provider performed 1) a financial comparison of bids provided by several PSSPs. These included comparing initial investment costs in combination with service costs. The HP also 2) gave extra weight to the PSSP's historic record of performance.

> *1) "Part of the evaluation is not just the cost of the modernization, but we also say, "Hey, what would a service contract be for the service of this product after it's installed?". That's the time we can get some favorable rates to sweeten the deal with [PSS PROVIDER], and they would say, "Yeah, we'll continue to maintain this for a monthly rate of X." — Case A: HP Rep 2*

> *2) "Oftentimes we'll solicit bids from competitors. And there's an evaluation process, and always we're going to apply a value to an existing relationship that is favorable with positive response times and stuff. So, there's instances where we've solicited bids, and maybe [PSS PROVIDER] might not have been the low bidder, but because they have been doing a good job, we'll re-engage them." — Case A: HP Rep 2*

Challenges when using PSS

The HP faces several challenges when using the PSS. 1) Since the entirety of the elevator is not being replaced, the HP, with their limited knowledge of elevators, must determine the demarcation of the PSS, and thus the scope of the investment that will most extend the elevator's useful life. The HP has also received dissatisfactory service when replacement parts are not delivered in a timely manner, or when they have to convince the PSSP that service is indeed needed. 3) The largest challenge faced by the HP is the unexpected costs associated with gaps in the PSSP's service coverage.

1) "There's a general perception that at the end of the monetization you get a brand-new elevator, but that may not be the case. So, the risk for us is to make sure that the laundry list of items that they're changing out is adequate and buys you a restart to your lifecycle." — Case A: HP Rep 2

2) "And, unfortunately, because it isn't informed by necessary needs, they may manufacturer, certain parts based on the manufacturing operations, and not necessarily the service operations. So, we've had delays on parts that are [PSS PROVIDER] owned parts, and we're like, "Well, why the heck is that happening?" And this is this got explained to me. So, it's difficult to say that we have an advantage, because our service providers are familiar with the equipment, but in terms of parts, there really is not necessarily an advantage in terms of timely replacement. — Case A: HP Rep 2

*2) "Once we own the equipment, we have to chase them, we have to bother them, we have to do all this kind of effort to make sure that this works. And, you know, badger them and beat them down. It's a real pain in the ass, even though you're paying them."
— Case A: HP Rep 2*

3) "After a period of time, certain parts become subject to obsolescence. So, this is in the contracts that call out "yes, it was a covered item, but now it's obsolete. So, you have to pay for that, because it's obsolete." And this is this is where it really starts to get a little bit grinding between the relationship. So, when you think you've got everything covered in your budget for, "Okay, I'm going to spend X amount of dollars for my elevator maintenance, I might put in a contingency for whatever". But suddenly, this part comes up and they say, "Oh, it's obsolete." And you say, "Oh, wow, I didn't have 10,000 in my budget for the replacement of an obsolete component". — Case A: HP Rep 2

Future use of PSS by Housing Provider

When asked if the housing provider will continue working with the PSSP in future projects, they responded:

> *"We usually have them bid it, you know, in most cases recently we've gone with them. So, I think there's no reason to suggest why we wouldn't, but you know, if their service is not as good as it once was, we may consider changing it up. That's kind of the nature of this. You know, what they provide is not so good. It just happens to be the best of our experience at this point." — Case A: HP Rep 1*

Circular principles within PSS

The PSS embodies the following circular principles: 1) the product's slowing of loops by extending the elevator's useful life via preventative maintenance. Unfortunately, the PSS does not embody other circular principles. The product is not intentionally designed for disassembly or technological cycles, and the business case does not capture residual value, nor make use of circular inputs.

> *1) "They have the diagnostics, and they can support us in making the right decisions. And they can also know the equipment that we're replacing and parts that we're adding to make the useful life longer." — Case A: HP Rep 1*

> *"Mostly disposed of. Sometimes we'll save a motor for a spare, or have it reconditioned. You know, the motor shop, may purchase it and have a reconditioned. But for the most part, you know, unless there's specific components that are really hard to find, we may not retain a lot of the elevator that we remove." — Case A: PSSP*

Summary

In summary, the Housing Provider (HP) chose to contract with the PSS Provider (PSSP) for a 5-year contract that they anticipate renewing 5 times (25 years total). The HP decided to contract with the PSSP for 2 reasons: to 1) outsource risk on a building component that undergoes annual regulatory inspections and requires a high level of technical expertise to service, to 2) achieve long term costs savings.

Other advantages include 1) predicable costs (for the most part).

When analyzing the PSS, the HP compared 1) multiple financial bids. Additionally, the HP took into account 2) the PSSP's historic performance, which, to-date, has been better than the competition.

The HP faced challenges regarding 1) defining the demarcation between product and infrastructure based on their limited knowledge, 2) receiving dissatisfactory service due to the untimely replacement of parts, or when the HP has to convince the PSSP that service is needed, and 3) gaps in the PSSP's service coverage cause the HP to pay large, unexpected costs during the elevator's lifespan.

The PSS exhibits only the circular principle of 1) the product's slowing of loops by extending the product's useful life.

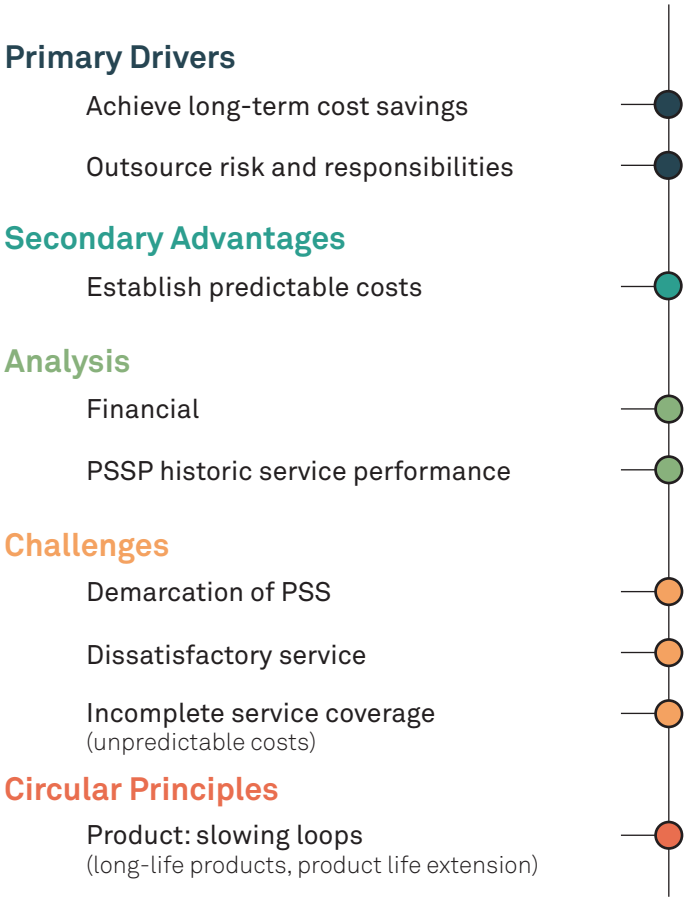


Fig. 4.03
Case A summary;
own figure .

Case B

Kitchen

availability-based

Drivers for Housing Provider to use PSS

Strategic
+ Outsource Risk and Responsibilities
Financial
+ Achieve Long-term Cost Savings
+ Accomplish (More) Scope without Capital

Project Context
Installed During **Building Transformation** from Office to Residential

The Netherlands

16 Market Rate Apartments

Housing Provider Strategy
Long-term Ownership

PSS Business Model
83% Service to Product Cost Ratio (15 Kitchens)

96% Service to Product Cost Ratio (1 Kitchen)

✓ "as-a-Service" Business Model

Owner of Product
Housing Provider (15 Kitchens)
PSS Provider (1 Kitchen)

PSS Contract
40 Year Service Contract

✓ Law of Accession "Work-Around" (1 Kitchen)

PSS Design

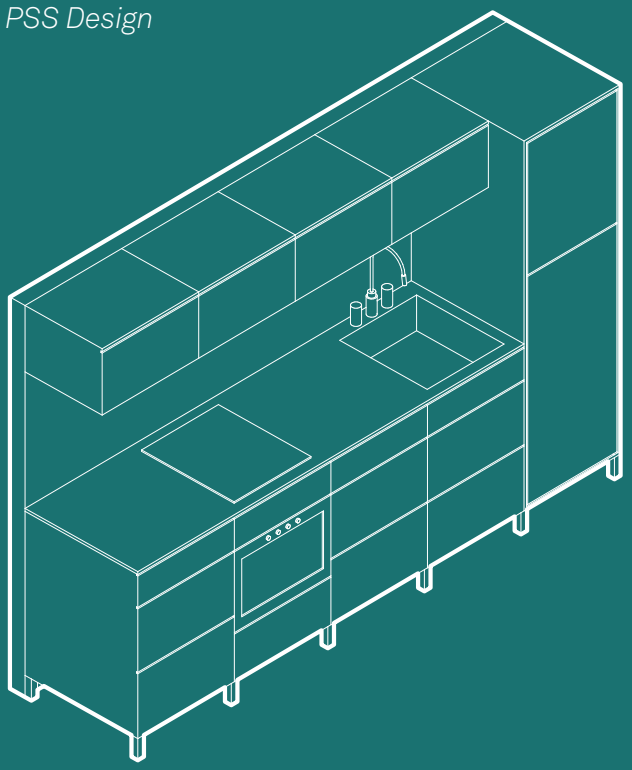


Fig. 4.04
PSS Highlights Case B, own figure.

Product
The product includes the cabinets, drawers, appliances, and sink and faucet, all of which are hung on a steel frame. The steel frame is expected to last for 60 years, and provides the basis for the product's residual value.

Service
In addition to financing, service includes pre-planned preventative maintenance: New Range-Hood Filters (2 Year Cycles), New Appliances (10 Year Cycles), New Countertop and Faceplates (20 Year Cycles), Replacement of Any Failures.

Infrastructure
Electrical, Water, and Sewage Connections.

Case B: Kitchen

Context

- **Building:** located in The Netherlands, Case B is the installation of 16 kitchens within the transformation of a historic (monument) office building to 16 market-rate apartments.
- **Housing Provider:** the Housing Provider (HP) is a one-person company with a long-term ownership strategy. They have a small portfolio of rental homes that they own, manage, and market as sustainable, low-carbon rental housing. They have been operational for 5 years, and this is their first use of the PSS.
- **PSS Provider:** the PSS Provider (PSSP) has been operational for 1 year and has, to date, installed 10 PSSs, with another 50 installations planned this spring.

Propositions offered by PSS Provider

The following propositions were offered by the PSS provider. The housing provider chose those in bold:

Housing Provider is Owner of Product:

- 100% Investment with Service Contract with Buyback Guarantee
- **Lease-to-Own with Service Contract with Buyback Guarantee (15 Kitchens)**

PSS Provider is Owner of Product:

- **No Down payment, Installation Fee, Recurring Service Payments (1 Kitchen)**
- Down Payment (Includes Installation Fee), Recurring Service Payment

Primary drivers for Housing Provider to use PSS

Fundamentally, the PSS was used by the housing provider for 3 reasons: 1) to outsource all kitchen maintenance and replacements in order to keep their organization lean, 2) to take pressure off their budget and accomplish scope without capital, and 3) to save costs over a 40-year period:

1) "Well, for me, the main thing is that it allows me to keep my business lean, so I don't want to expand the business in the sense of employing more people. So, this is a very good way to outsource a big part of the technical responsibility while also being able to outsource the management over these assets." — Case B: HP

2) "[...] because transforming buildings is already very complex with many moving parts during the decision-making process. And that's even worse in the case of old buildings, especially monuments where you have a lot of restrictions. So, the PSS alternative to the kitchens came as a good way of releasing some pressure on the budget"— Case B: HP

3) "I had a cost estimation firm make a long-term maintenance and management plan of the building. So, I knew that over the next 40 years, they had assigned about 240,000 euros for the fixing and replacement of appliances and replacement of kitchens at 20 years. So basically, I would have to replace the whole kitchens twice within 40 years. And then on the other hand, from [PSS PROVIDER], I got three different options." — Case B: HP

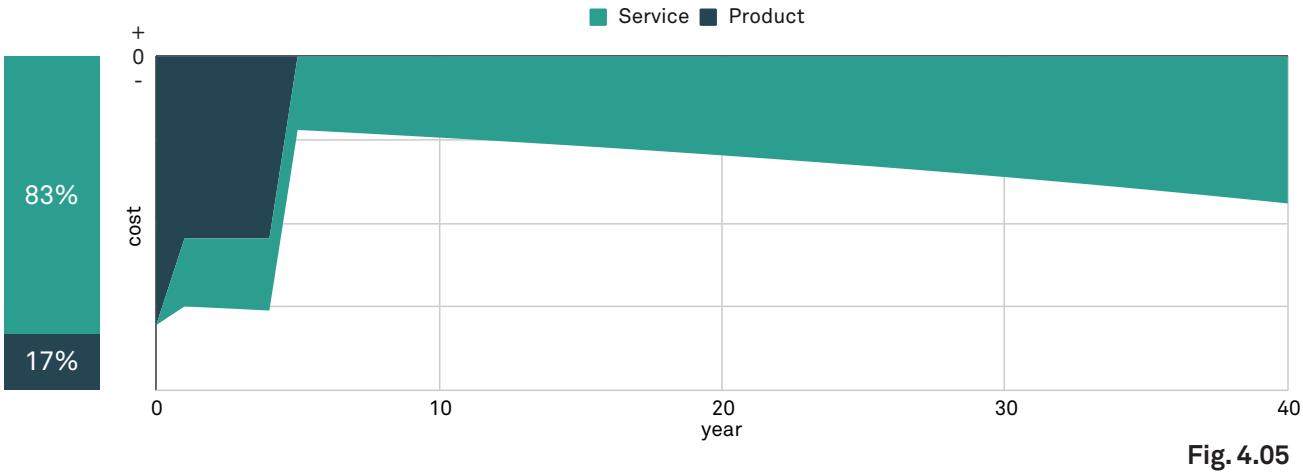


Fig. 4.05
Case B payment proportions over time (financial lease for 15 kitchens); own figure.

Secondary Advantages for Housing Provider

In addition to the reasoning listed above, the PSS also has several other advantages. Since the HP could accomplish scope without capital, they were able to get a getting a higher quality product than the housing provider could afford to purchase (ex: granite counter tops), which 1) increased their market appeal to residents. The PSS also 2) creates predicable costs for the HP, and 3) increases the circularity of the HP's portfolio.

1) "Well, I mean, on one side I think [PSS PROVIDER] does have a very good quality. So, for example, they can provide this granite countertop which normally, the 120,000 euros or so that I mentioned, would not have probably included a granite countertop. So also, within the same kind of price comparison, I can afford to get some things which tenants will actually value better, like for example, granite countertops." — Case B: HP

2) "I think one of the nicest things about our way of doing it is that, if you make a multiple-years-maintenance-plan, you can predict exactly what your kitchen would cost. So, it's very easy, it's predictable, it's calculable. And that is a huge advantage for any sort of investor" — Case B: PSSP

3) "It allows me to also fulfill my sustainability goals by replacing this equipment less often. And knowing that the appliance manufacturer will actually remanufacture it when the time comes to do so." — Case B: HP

Analysis Performed by Housing Provider

The housing provider performed a 1) financial comparison between Total Cost of Use (TCU) vs Total Cost of Ownership (TCO), as well as 2) reviewed the risks over the long-term period.

1) "I did a very simplified total cost of ownership over 20 years and over 40 years. So, for the baseline, the only thing I needed to use was my cost of capital. I had two options for the cost of capital, either to use the financing and interest rate from the renovation, which was very low, about 1.8% average. Or to use what I would make from a separate investment, so more the opportunity cost of capital. So, I used the latter one, which is closer to 5%. And then I have a pretty good idea of how much the 16 kitchens would cost to purchase and install. That was the 120,000 or so that I mentioned." — Case B: HP

2) "I mean, you could say that the concern of the company being around to deliver the services could be one. Yeah, but I'm not too worried because I mean, in the worst case, it would just become a linear kitchen." — Case B: HP

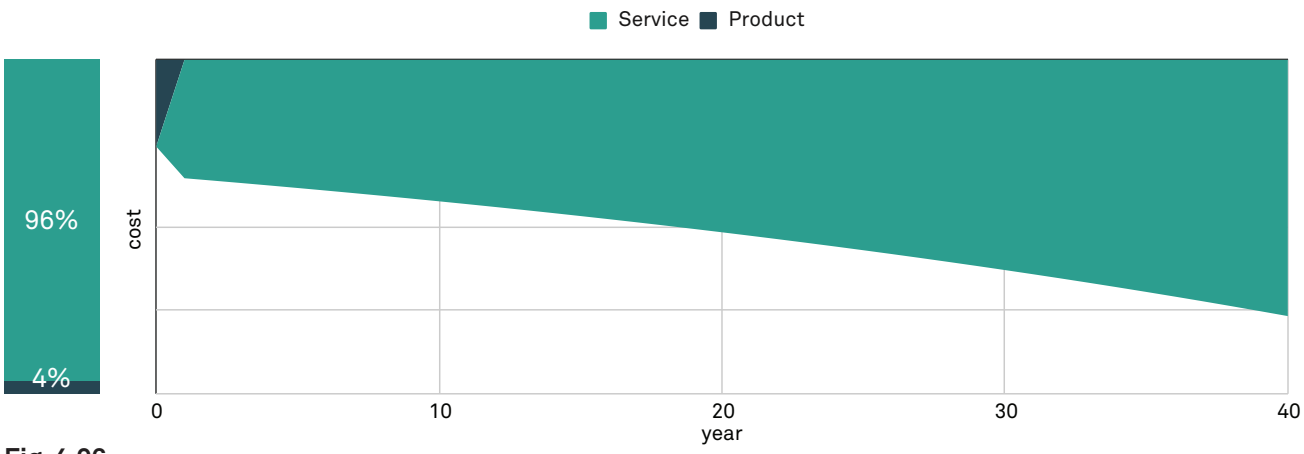


Fig. 4.06
Case B payment proportions over time (Kitchen-as-a-Service for 1 kitchen); own figure .

Challenges when using PSS

Challenges for the housing provider when using the PSS include 1) the kitchen not being as flexible as a traditional kitchen. Also, despite this not being a challenge for the specific HP, they noted that 2) the contract's complexity will likely be a challenge for individuals or organizations not familiar with the PSSP retaining ownership of their product.

> *1) "So, because [PSS PROVIDER] is circular and they want to only make modular components they can actually reuse easily at a high value, then they cannot really deal too much with specific shapes or connection points to other objects in the apartment."*
> *— Case B: HP*

> *2) "Because I know a lot about circular business models and product service systems already, then I didn't have to do the research into that. Otherwise, I can imagine, just understanding how the hell is it supposed to work, is probably very time consuming." — Case B: HP*

Future use of PSS by Housing Provider

When asked if the housing provider will continue the use of the PSS in future projects, they responded:

> *"When the other properties I have reach the end of the service life, I will surely replace the kitchens with the [PSS PROVIDER] offer, because I think it just makes much more sense to get rid of this trouble."— Case B: HP*

Words of Advice from Housing Provider

Additionally, when asked about words of advice to other housing providers who are considering the use of PSSs, they said:

> *"My word of advice is to find out and focus on what exactly it is that is their added value and their core business. I think very often, it will not be the management and maintenance of the hardware that they need to have in order to deliver the rental property to the tenant. And then I think once they do this, then they will start having an incentive to evaluate where their costs lie, and which actually makes sense for them to keep in house and which ones they should outsource. Therefore, they will probably start considering PSS as something that is worth their time, and worth their energy saved."*
> *— Case B: HP*

Circular principles within PSS

The PSS embodies the following circular principles: 1) the product's slowing of loops via extending the kitchens' lifespan, 2) the product's closing of loops via design for disassembly and technological cycles, 3) the business model's slowing of loops via the exploitation of residual value, and 4) the business model's closing of loops via the use of circular inputs.

> *1) "Every 10 years you get new appliances. So also at 20 years, if you decide to choose a second contractor, right? And then at 20 years, we change the fronts, the plate material, if needed. Of course, we don't know yet what the status of that kitchen will be. We don't know how intensely it will be used. If it's not used intensely, then the runners, and the drawers, and the hinges, they might be good for another five or 10 years. So, we change them at the next preventative maintenance opportunity. " — Case B: PSSP*

> *2) "You can tell from the design, that it's designed in a different way to a normal kitchen." — Case B: HP*

> *2) "For the appliances, indeed, it's all about companies, eventually taking back their product and using it in the highest value possible at that stage. That's either directly using it again, refurbishment, remanufacturing, and you go down the "R-ladder", in the end, recycle. And that's also something that we put in the contract, right. So, these are the steps you need to follow. And if that doesn't work, then you go to the next step. So we don't want you to go straight away to recycling. And we also*

have to see how that will pan out, really, when we start delivering back these components to these parties." — Case B: PSSP

3)" And [HOUSING PROVIDER] also wants to us to make a contract of 40 years, because we know that if the frame and the countertop can just stay on the location, then it will be way cheaper to put a second life kitchen in there." — Case B: PSSP

4) "So, the plate material is already 90% waste wood. So, it's already had its lifetime, had its use, and then it comes back, and they make new plate material out of it. So that's already circular input. For the steel, it's 25% circular inputs, so it's already old steel used there." — Case B: PSSP

Summary

In summary, the housing provider chose to contract with the PSS Provider for a 40-year contract. They decided to use the PSS for three reasons: 1) to keep their organization lean by outsourcing the risk and maintenance responsibilities to the PSSP, 2) to accomplish scope despite a lack of capital, and 3) to reduce the long-term costs of the kitchen over a 40-year period.

Other advantages include 1) increasing the market appeal of their rental homes, 2) creating predicable costs and 3) increasing the circularity of their kitchens, building, and portfolio.

When analyzing the PSS, the housing provider evaluated 1) the Total Cost of Ownership (TCO) vs the Total Cost of Use (TCO). For the analysis, they used the following information: investment costs from previous projects, cost of capital, leasing costs from the PSS provider, and lifecycle costs from a 3rd party cost estimation firm. They also 2) reviewed the risks associated with the PSSP going bankrupt during the contract period.

The HP faced challenges regarding 1) the inflexibility of the product, due to its high degree of circularity. While they have extensive circular business model knowledge, they noted that 2) the complexity of the contracts could very well be a challenge for those who are not familiar.

The PSS exhibits the circular principles of 1) the product's slowing of loops, 2) the product's closing of loops, 3) the business model's slowing of loops, and 4) the business model's closing of loops.

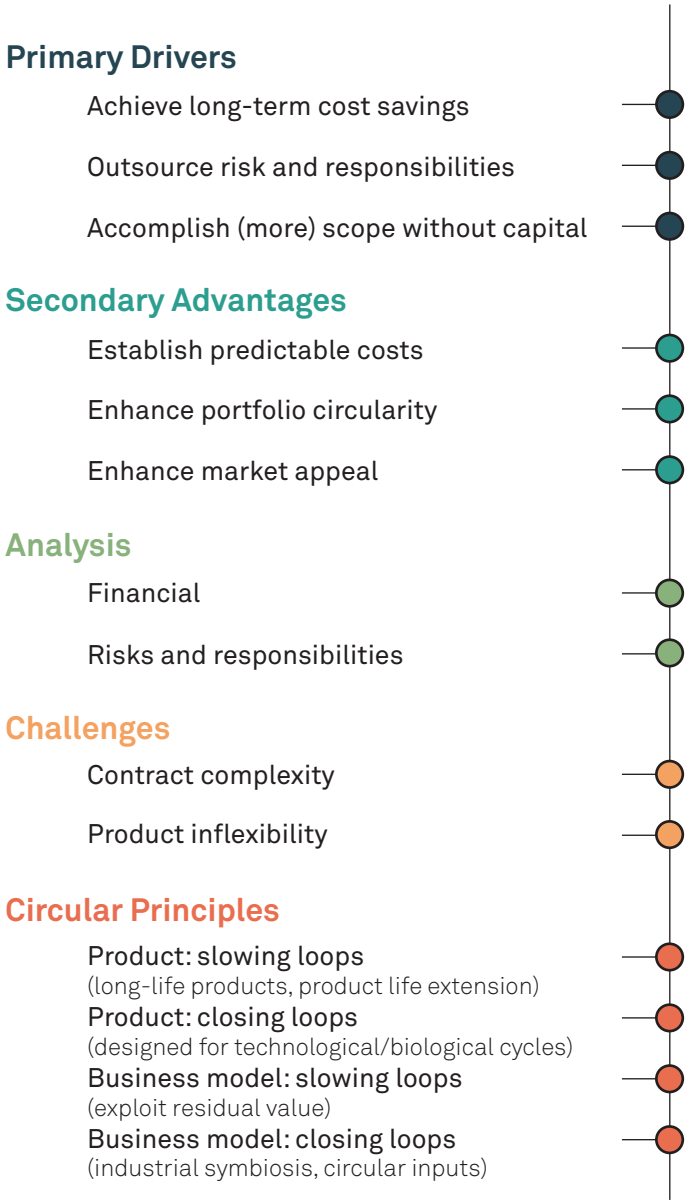


Fig. 4.07
Case B summary;
own figure .

Case C

Window

availability-based

Drivers for Housing Provider to use PSS

Strategic
+ Prepare for Changing Regulations
Financial
+ Achieve Long-term Cost Savings

Project Context
Installed During
Building Transformation
from Office to Residential

The Netherlands

30 Market Rate Apartments

Housing Provider Strategy

Long-term Ownership

PSS Business Model

100% Service to Product Cost Ratio

✓ "as-a-Service" Business Model

Owner of Product

PSS Provider

PSS Contract

30 Year Service Contract

✓ Law of Accession "Work-Around"

PSS Design

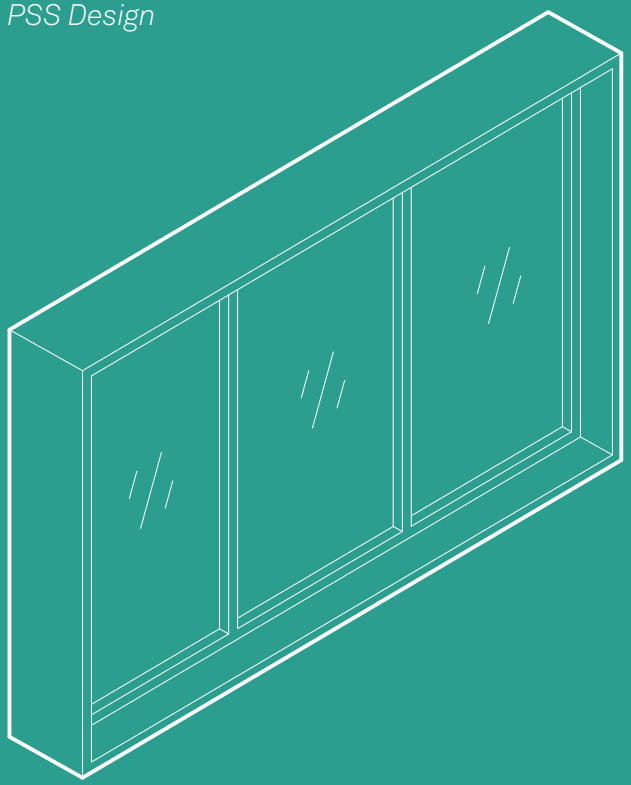


Fig. 4.08
PSS Highlights Case C, own figure.

Product
The product includes 130 aluminum frame windows with various operability.

Service
In addition to financing, service includes a combination of pre-planned and dynamic IoT monitoring: monitor how many times each window has been opened, and then perform dynamic maintenance to keep all doors and windows operable, based on maximum force to open and close windows. All washing and cleaning of the glass.

Infrastructure
Pre-fabricated facade from a 3rd Party Facade Fabricator, inclusive of structure, window rough opening, insulation, waterproofing, and cladding.

Case C: Window

Context

- **Building:** located in The Netherlands, Case C is installation of 130 windows within the transformation of an office building into 30 market-rate short-term rental apartments.
- **Housing Provider:** the Housing Provider (HP), which has 12 employees, has a long-term ownership strategy, . They have a portfolio of 10+ buildings that range in program type. The HP considers circularity to be a core value of their organization. They have been operational for 12 years and this is their first time using the PSS within their portfolio.
- **PSS Provider:** the PSS Provider has been selling their product for 30+ years, and this is their first time offering their product as-a-service to a customer.

Propositions offered by PSS Provider

The following propositions were offered by the PSS provider. The housing provider chose those in bold:

Housing Provider is Owner of Product:

- 100% Investment (No Service Contract) (No Buyback Guarantee)
- 100% Investment with Service Contract with Buyback Guarantee

PSS Provider is Owner of Product:

- **No Down Payment, No Installation Fee, Recurring Service Payments**

Primary drivers for Housing Provider to use PSS

Fundamentally, the PSS was used by the Housing Provider to 1) prepare their organization for new upcoming governmental tax regulations which will likely increase costs based on raw material extraction and CO2 emissions. When such taxations are implemented, the use of a circular PSS has the potential to 2) achieve cost savings via reduced raw material and CO2 tax liabilities. Thus, the HP is exploring how the use of a circular PSS impacts their processes and finances during the development and exploitation of a building.

> *1) "It's not really about the money in this project, but just exploring and see how the service will work and how the taxations, how to value of the facade together with the financial part. Yeah, just find out how this works, how this construction works, to probably do it later on a bigger scale in their projects." — Case C: PSSP*

> *2) "We have the vision on the long term by saying that, because it doesn't solve a problem, like for now, but in the future, this will become the problem, because the economy is going to end. So, in the future, all the things, like CO2 taxes, will come, and materials are going to be taxed higher. So, in the future, this model will work out better. Right now, it's not the perfect one, but we want to push this thinking." — Case C: HP*

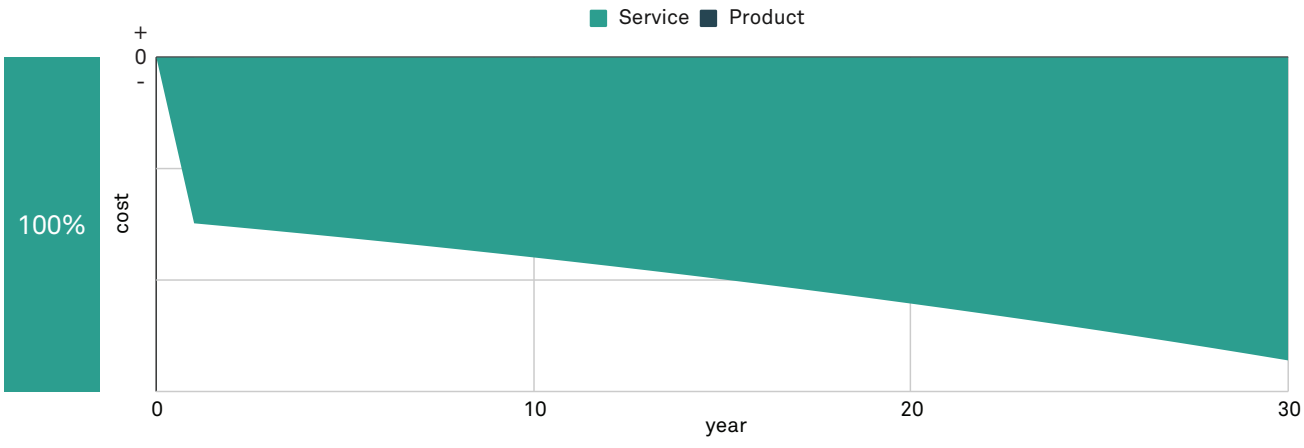


Fig. 4.09
Case C payment proportions over time; own figure.

Secondary advantages for Housing Provider

Additional advantages for the HP include 1) outsourcing the maintenance responsibilities to the PSSP, 2) increasing the flexibility of their building in the future to reduce the risk of obsolescence, and 3) increasing the circularity of their portfolio.

> *1) "And there are some other benefits, because if you are not the owner, for yourself of this part, like the window frames, then the maintenance is also not for our package."*
> *— Case C: HP*

> *2) "As an investor or a developer, we believe in multiple function buildings. So, it must be dynamic all the time, because it doesn't matter when, but the only thing you know for sure, is it's going to change one day, the use of the building. Previous it was an office. So right now, we're transforming an office to short term rental. And maybe in the future, it will be homes for living long term. Or maybe homes for living for elderly people. Could be all the things."*
> *— Case C: HP*

> *3) "It's one of the key things we say we are, we are circular. So, for me as the technical guy, it's the main focus to make this the next step towards circular economy." — Case C: HP*

Analysis Performed by Housing Provider

The housing provider reviewed 1) the proposal provided by the PSSP which included a comparison between leasing the facade (Total Cost of Use (TCU)) vs purchasing the facade (Total Cost of Ownership (TCO)), and 2) reviewing risks and responsibilities. Additionally, the HP was keen on 3) defining the take-back, or end-of-use, scenarios with the PSSP.

> *1) "What we basically do is we do the calculations for the TCO, total cost of ownership (TCO), total cost of use (TCU), and some components are included, like maintenance, insurance, managing and do the administration of the facade. That's all part of our concept. But at the end, there's one rental price, what they actually pay. And what's included in the price, that's a lot. It's not interesting to see it in detail, they're just interested in the rental price, because now they also know, in a traditional way, what a facade will cost in the next 30 years. You know, but then the risk is for them. And now the risk is for me, and I come to a to a certain rental price. That's what they have to pay."*
> *— Case C: PSSP*

> *2)" We have to verify for ourselves that it's not a stupid decision. When we found out, and we had some discussions, when we found out that this was a good decision, we just continued our thoughts to make it happen." — Case C: HP*

> *3) "We were having this discussion, and we were talking about the restrictions. Like what would be in the contract, we just say, give us something in return when we don't want the facade anymore, we want to have something in return. [...] A buyback guarantee, and within the first 10 years, I just say a term, I don't know it for sure, but in the first 10 years they buy it back for 30% of the investment costs, after 20 years, 20%, and after 30 years, 10%, for example. So that's the thing we discussed with [PSS PROVIDER]" — Case C: HP*

> *3) "Yea, kind of buy back. I don't know if we seriously buy it back. Or maybe for a little price, I don't know. That's maybe the day value of that moment of the facade. And then we need kind of notified bodies, to help us with saying what the value is, actually, because you need experts to help say, this is the value of the facade, the facade can still be 20 years be used. And then, based on that value, we probably can have a price on it. But I think, and also in the traditional way of doing this kind of projects, after 30 years, the facade is paid off. So, if we take it back, we make a lot of costs for disassembly, we make cost for transportation, we make cost for upgrades, remanufacturing. And that price, we have to pay it, you know,*

so if you find a new building where we can put it back, we have to make a lot of costs - doing a lot of investments. So, I think, in a financial way, buying back the product at that moment, is probably not really the case. Because we have to make costs to upgrade product."
— Case C: PSSP

Challenges when using PSS

The HP faced a challenge regarding 1) the PSS's impact on the general contractor's (GC's) processes and profit margin. Since the window package began in a "traditional" manner, the HP provided the GC payment so they could purchase the window package. When the window procurement changed from purchase to lease, the GC needed to return the funds to the HP, as they were no longer the contracting party. Also, since GCs typically calculate their profit as a % of the total construction costs, and the window PSS required no initial investment, the GC's profit was therefore reduced. Since the project was on a fast timeline, the HP decided to keep the GC's profit unchanged (thus overpaying) to avoid delays due to negotiations. The 2) contract complexity was also a challenge.

1) "Normally, when they deliver a product, they will get their provision over these products. So, that was one of the things we had to discuss with the contractor. So, we just said, alright, let's receive a proposal of the initial costs of these windows, then you can get your provision over these initial costs, but they don't really invest in these costs. [...] Like 10% extra. So that's the thing they don't get when we are the contract partner. So, we discussed with the contractor, to give this 10% margin or something based on the investment costs when you do it linear. So that's one thing which was hard. [...] So, they still get that 10%. [...] So, we discussed with the contractor that they will do it linear to get this on time. And that we buy it back, or we calculate at the end of the building construction, that we make it circular. So, if it's circular, they give us our money back or something."
— Case C: HP

2) "With [HOUSING PROVIDER] we needed some time to explain and how the contract works. And later on, we just dived into the financial calculations to get it understandable. And there's a certain point that they just can buy the product back. So how much is the amount then for it? And if they want to get it back earlier than we say in the contract that they need to pay a penalty, and what kind of penalty. Those are some points we had to go through."
— Case C: PSSP

Future use of PSS by Housing Provider

When asked if the housing provider will continue working with the PSSP in future projects, they responded:

> *"I assume that, if this building goes well, you'll start to develop perhaps a more long-term partnership with [PSS PROVIDER] for future buildings." — David Parker*

> *"Yeah, definitely." — Case C: HP*

Circular principles within PSS

The PSS embodies the following circular principles: 1) the product's slowing of loops via extending the lifespan of the windows through preventative maintenance, 2) the product's closing of loops via design for disassembly and technological cycles, 3) the business model's slowing of loops via the exploitation of residual value, and 4) the business model's closing of loops via the use of circular inputs.

> *1) "We have a long-term performance contract with them to keep the quality as high as possible so that we enlarge the lifespan of the materials." — Case C: PSSP*

> *2) "You push the manufacturer to think about their product, how is this going to be disassembled, how it is going to be brought back in the loop again." — Case C: HP*

> *3) "We don't know, there's no one who can say it to us. But our feeling and our believing in the circular economy is that we definitely can make a high residual value. But we don't use it in our calculations. We don't use a residual value in our calculations, not yet. Maybe later on." — Case C: PSSP*

> *4) "With this new entity we are setting up, 100% must be recycled and reused. You know. We when we set up the new brand, in the DNA is already embedded that we just reuse it till the end." — Case C: PSSP*

Summary

In summary, the housing provider chose to contract with the PSS Provider for a 30-year contract. The Housing Provider (HP) is using the PSS to 1) prepare for the Netherlands' eventual transition from a linear economy to a circular economy. Should such taxations be in place for raw material extraction and CO2 emissions, the use of a circular PSS will help the HP 2) achieve long term costs savings based on reduced tax liabilities. Thus, in the immediate term, the HP is using the PSS to explore the new procurement process, and better understand the PSS's impact on their processes and finances during the development and exploitation of a building.

Other advantages include 1) outsourcing the maintenance responsibilities to the PSSP, 2) having flexibility in their facade, should demands change in the future, and 3) increasing the circularity of their portfolio.

When analyzing the PSS, the HP compared 1) the Total Cost of Use (TCO) with the Total Cost of Ownership (TCO), 2) the risks and responsibilities associated with using the PSS, as well as 3) end-of-use scenarios pertaining to residual value. The end-of-life scenarios were loosely defined in the present and will be better defined in the future when the windows reach their end of use.

The HP faced challenges with 1) the PSS's impact on the general contractor's profit, and 2) the complexity of the contract.

The PSS exhibits the circular principles of 1) the product's slowing of loops, 2) the product's closing of loops, 3) the business model's slowing of loops, and 4) the business model's closing of loops.

Fig. 4.10
Case C summary;
own figure .

Case D

Battery

availability-based

Drivers for Housing Provider to use PSS

Strategic
+ Outsource Risk and Responsibilities
Financial
+ Achieve Long-term Cost Savings

Project Context

Installation of New Technology

The Netherlands

50 Social (Affordable) Apartments

Housing Provider Strategy

Long-term Ownership

PSS Business Model

97% Service to Product Cost Ratio

✓ "as-a-Service" Business Model

Owner of Product

PSS Provider

PSS Contract

10 Year Service Contract

✗ Law of Accession "Work-Around"

PSS Design

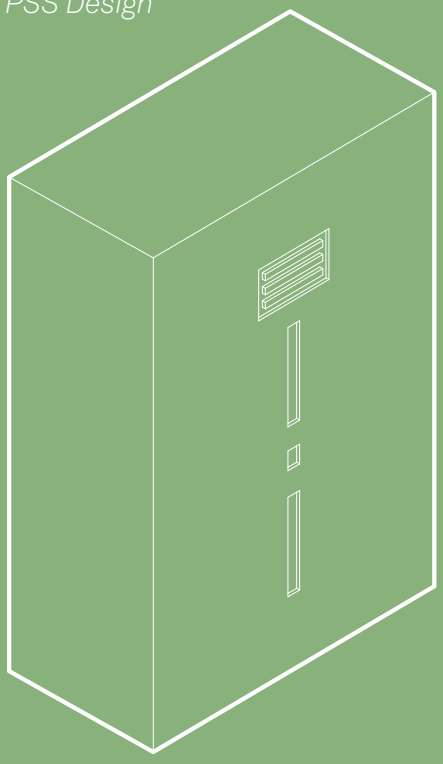


Fig. 4.11
PSS Highlights Case D, own figure.

Product
The product includes the battery and cabling to connect to building's master-meter.

Service
In addition to financing, service includes a combination of pre-planned and dynamic IoT monitoring to ensure no fire hazards. Monitoring also tracks performance of battery to ensure battery is providing the guaranteed minimum savings promised to the HP.

Infrastructure
Secure electrical closet in basement with adequate space for placing the battery. The HP must also contact the government to apply for, and receive, permission to reduce the size of their building's grid connection.

Case D: Battery

Context

- **Building:** located in The Netherlands, Case D is the installation of a battery storage system within a 50-apartment social (affordable) housing building.
- **Housing Provider:** the Housing Provider (HP), which has 100+ employees, has a long-term ownership strategy, and considers sustainability a core value of their organization. They have a portfolio of 16,000+ social rental homes buildings that they own and manage. They have been operational for 37 years and have used the PSS many times within their portfolio. The first use of the PSS was a purchased pilot project. Since then, they have decided to lease all additional batteries within their portfolio.
- **PSS Provider:** the PSS Provider (PSSP) has been selling and leasing their product for 2+ years and has installed 100+ batteries.

Propositions offered by PSS Provider

The following propositions were offered by the PSS provider. The housing provider chose those in bold:

Housing Provider is Owner of Product:

- 100% Investment with Service Contract with Buyback Guarantee

PSS Provider is Owner of Product:

- **No Down payment, Installation Fee, Recurring Service Payments**

Primary drivers for Housing Provider to use PSS

Fundamentally, the PSS was used by the Housing Provider to 1) achieve cost savings by reducing operating costs at their buildings, and to 2) outsource risk and responsibilities on a technologically advanced product, so they can maintain their focus on their core business.

> *1) "So, the main reason to choose for the battery is that it lowers the service costs of a building, so there is a benefit for the for the tenants. So that's the incentive. [...] It's quite an easy business case for [PSS PROVIDER], because only by reducing the grid capacity, they already have a business case." — Case D: HP*

> *2) "They choose to do it as-a-service because, a battery, it's a new technology, so there is risk involved. So, the degeneration of the battery, how will the components work over a lifetime of 10 years? All those risks [...] The housing company says, "okay, we are good in building houses and renting them, but we are not so involved in this completely new market." And the role of a housing company, especially a social housing company, is to have homes for the working class, or at least for people who don't have a lot of money. And this battery doesn't really fit in their own strategy, in their own value proposition." — Case D: HP*

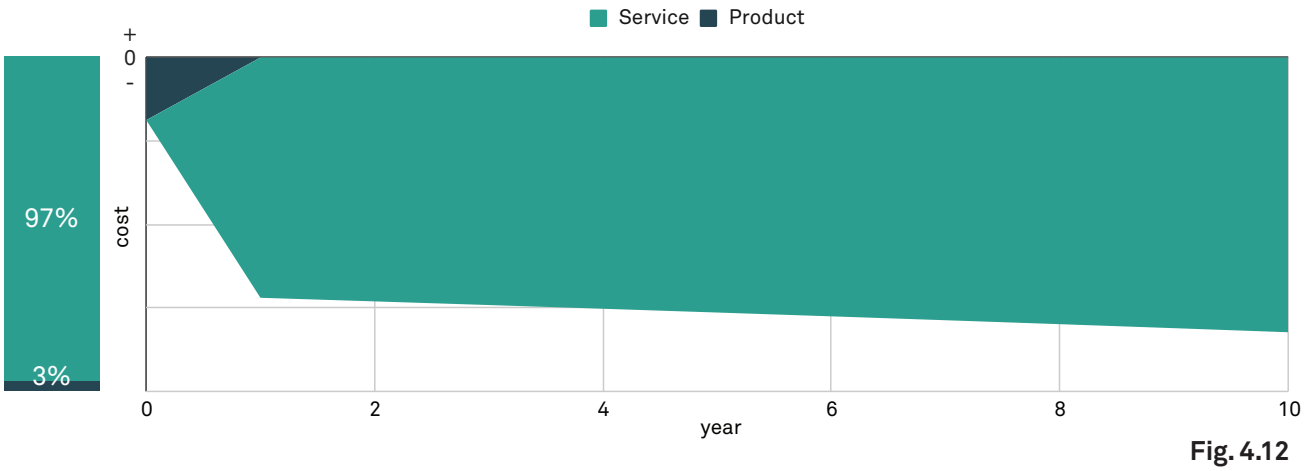


Fig. 4.12
Case D payment proportions over time; own figure.

Secondary advantages for Housing Provider

Additional advantages for the HP include 1) the increased market appeal of their property, 2) accomplishing scope without allocating capital, and 3) increasing the circularity of their portfolio.

> *1) "To the municipality, to other stakeholders involved, like, "okay, we are doing some very innovative things, and we have a virtual power plant running in our real estate."*
> *— Case D: HP*

> *2) "And at the housing corporation, it makes things much faster, because otherwise you need to write a plan for 12 batteries and do the whole decision-making process, which cost at least for four or five months. [...] It was way easier, because they don't have an investment to make." — Case D: HP*

> *3)" [HOUSING PROVIDER] was used to don't work with products as a service. But during that time the circular economy popped in." — Case D: HP*

Analysis Performed by Housing Provider

The housing provider reviewed 1) three financial scenarios, 2) a risk analysis associated with the financial scenarios, 3) the performance of a previous pilot project with the PSSP, and 4) a review of the PSS's impact on the building's future operations.

> *1)" It was a financial and risk analysis. [...] But it was mainly, of course, the business case was an important one. [...] So, three cases: What if we don't place a battery? What if we place a battery and we buy it ourselves? What are the benefits? What's the profit when you lease it? What's the profit when it's your own property? And what's the loss when you don't have any battery at all? And there is this quite a huge difference. I thought, for a building with 50 apartments, when you lease the battery, you have a profit of 300 to 400 euros, and if you buy the battery, it's really something like 600-1000. So, there is quite a difference between them, and still, the board said to me, "okay, the difference is not that much, when we see the risks which are involved." — Case D: HP*

> *2) "And at the end, it was kind of, not a SWOT analysis, but kind of what are the advantages when it is your own property? Or what are the advantages and disadvantages when you do the product as a surface version? And yeah, I valued both cases and asked different people in the organization, what's your opinion? And finally, there was kind of common sense that the product-as-a-service was a better solution" — Case D: HP*

> *3) "And now we could just say, "okay, we did the pilot, it went well." I made a memo, a short, short version of a report. And then the director said, "okay, we see the advantages, just do the lease" — Case D: HP*

> *4) "So, it's also important to have a more holistic view. Okay, what is the function of this battery in the whole system? And does it still fit within your strategy for the long term? So, if you have now the apartments are gas fired, but for example, in Amsterdam, they want some neighborhoods already within 10 years off the gas, all electric, so then it's quite illogical to now choose for a battery which reduces your grid capacity, while within 5 or 10 years, you have to enlarge your grid capacity. [...] In this case, [HOUSING PROVIDER] has a district heating, so city heating. So, they don't have to enlarge their grid capacity because they get a hot water pipe into buildings." — Case D: HP*

Challenges when using PSS

The HP faced challenges regarding 1) the contract and its demarcation of the PSS (where the product ends and the infrastructure begins), 2) the inflexibility of the PSSP's contract (pertaining to the HP's terms and conditions), and 3) the reluctance of the HP staff to trust in the PSSP's value proposition (the initial pilot project increased their confidence).

> *1) "If you place the battery further away from the grid connection, you need to have a longer AC cable. So, at a certain point, after 10 meters, it was not incorporated anymore. [...] So that cost was the kind of discussion. Yeah, is your responsibility? And what's the demarcation? For whom are those costs? It was now at [HOUSING PROVIDER]. But that was a kind of gray area." — Case D: HP*

> *2) "Yeah, the terms and conditions were quite challenging. Because the [HOUSING PROVIDER] wasn't used to have a product-as-a-service contract, [PSS PROVIDER] had a quite strict legal things with their financial company. So that didn't really fit. So, it was like, take it or leave it, because otherwise, from [PSS PROVIDER]'s point of view, they didn't get the financing closed. [...] For example, we want to have the general terms and conditions of [HOUSING PROVIDER] at the start. So that's the part of the contract where [PSS PROVIDER] said "that's impossible, we can only do our terms and conditions". And, for the procurement purchase department, that was quite an important part, because there are all the risks." — Case D: HP*

> *3)" One, of course, is that, if you tell somebody that they're going to instantly start saving money, they don't believe you. They say it's too good to be true. And then if you also tell them it's a battery, then they'll say, "no battery systems are not profitable in the Netherlands, you can't come with battery systems."*

Words of Advice from Housing Provider

When talking about PSSs pertaining to the energy transition, the HP stated that Housing Providers must be critical of how the PSS will impact the resident's service costs:

> *So, to make the business case feasible for a social housing company, it's easy to say "okay, just outsource the whole HVAC installation", but they often don't look to the housing costs for the tenant. It needs to be in balance. And now you see that you have a high rent, but also a high energy bill. And can you still call it then social housing?*
> *— Case D: HP*

Circular principles within PSS

The PSS embodies the following circular principles: 1) the business model's slowing of loops via the exploitation of residual value. Unfortunately, the PSS does not evidence other principles of circularity.

> *1) "After 10 years, it loses part of its capacity to instantly provide the power. So, after 10 years, we always take out the batteries and put in new batteries. And the old batteries we use in our smaller, even smaller system that we are developing for a home battery."*
> *— Case D: PSSP*

Summary

In summary, the housing provider chose to contract with the PSS Provider for a 10-year contract. The Housing Provider (HP) is using the PSS to 1) achieve long-term cost savings and 2) outsource the risk and responsibilities of a new and potentially volatile product.

Other advantages include 1) the increased market appeal, 2) accomplishing scope without allocating capital, and 3) increasing the circularity of their portfolio.

When analyzing the PSS, the HP reviewed 1) financial scenarios, 2) risks associated with each scenario, as well as 3) the PSS's impacts on the building's future operations.

The HP faced challenges regarding 1) an unclear demarcation of product and infrastructure, 2) the PSSP's inflexible contract, 3) the performance of a previous pilot project with the PSSP, and 4) a review of the PSS's impact on the building's future operations.

The PSS exhibits the circular principles of 1) the product's closing of loops via design for technological cycles, and 2) the business model's slowing of loops via the exploitation of residual value.

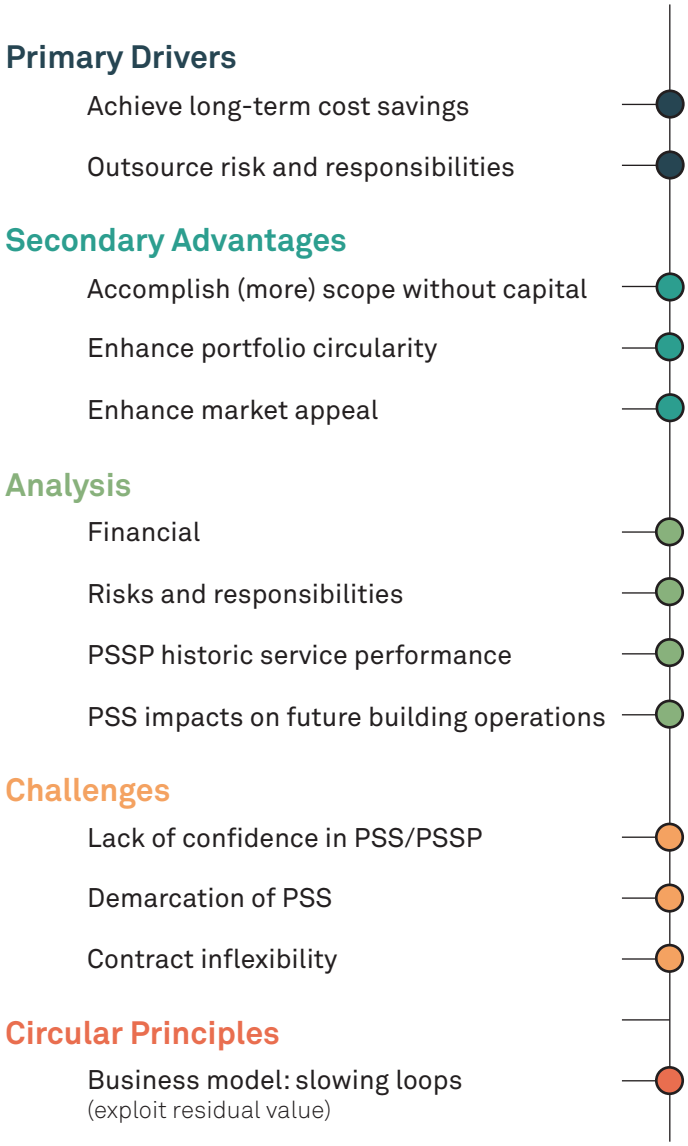
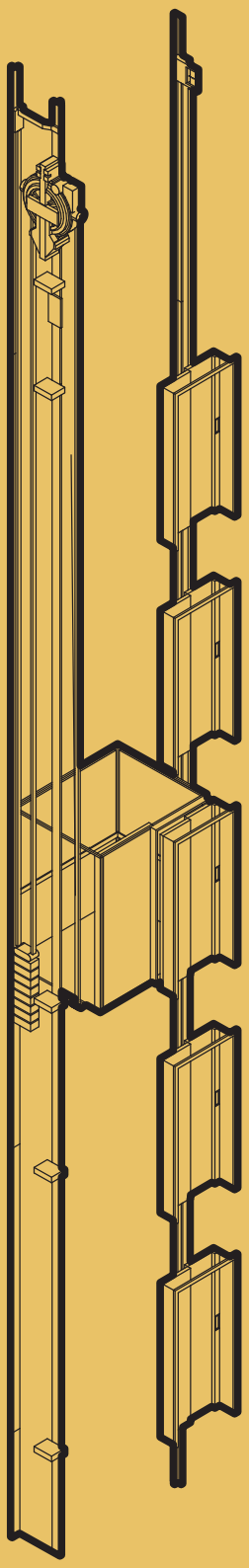


Fig. 4.13
Case D summary;
own figure .

Case E

Elevator

Usage-based



Drivers for Housing Provider to use PSS

Financial

+ Accomplish (More) Scope without Capital

PSS Design

Product
The product includes all required equipment (cab, rails, motor, doors at each floor, etc.) for 14 elevators.

Service
In addition to financing, service includes a combination of pre-planned and dynamic monitoring. PSSP guarantees 98% up-time annually, otherwise will pay penalty to HP.

Infrastructure
Elevator core with mounting connections, as well as connections for fire safety, electricity, and telecommunications.

Fig. 4.14
PSS Highlights
Case E, own figure.

Project Context

Installed During
New Construction

The Netherlands

485
Market Rate Homes

Housing Provider Strategy

Develop and Sell to Investor
(70% pre-sold before construction begins)

PSS Business Model

100%
Service to Product Cost Ratio

✓
"as-a-Service" Business Model

Owner of Product

PSS Provider

PSS Contract

30
Year Service Contract

na
Law of Accession "Work-Around"

Case E: Elevator

Context

- **Building:** located in The Netherlands, Case E is the installation of 14 elevators in a large new construction project comprised of 485 market-rate homes. 285 are being sold to consumers for homeownership, and the remaining 200 are being sold to an investor who will manage them as rental homes. A centralized homeowners association, which is funded by both the individual owners and the investor, serves as the contracting party for the PSS.
- **Housing Provider:** the Housing Provider (HP), which has 175+ employees, has a short-term development strategy. Only after 70% of the homes have been pre-sold does the HP begin construction. The HP has been operational for 19 years and this is their first time using the PSS within their portfolio.
- **PSS Provider:** the PSS Provider (PSSP) has been selling their product for 65+ years and began offering their product as-a- service in 2017. Since then, over 200 elevators have been procured via the Elevator-as-a-Service model.

Propositions offered by PSS Provider

The following propositions were offered by the PSS provider. The housing provider chose those in bold:

Housing Provider is Owner of Product:
- 100% Investment with Service Contract (No Buyback Guarantee)

PSS Provider is Owner of Product:
- **No Down Payment, No Installation Fee, Recurring Service Payments**
- Down Payment (Includes Installation Fee), Recurring Service Payment

Primary drivers for Housing Provider to use PSS

Fundamentally, the PSS was used by the Housing Provider to 1) accomplish scope, and the project as whole, without the need for capital. By using the as-a-service model with no down payment, the project became viable.

> *1) "Well, for us the main reason to turn to [PSS PROVIDER] and the system of the PSS was the business case. It saved us a lot of money. That's mainly the only reason, that it saves us a lot of money, and otherwise we wouldn't have a good business case on the project. Normally we just buy the building from the contractor, and it's complete with all the elevators in it. And in this case, the elevators were amount in total of 5 million euros. And because of the as-a-service contract, we managed to get 4 million or four and a half million out of the contract with the contractor. And the costs of the maintenance and everything are for the people who are going to live there. So, it was mainly financial driven." — Case E: HP*

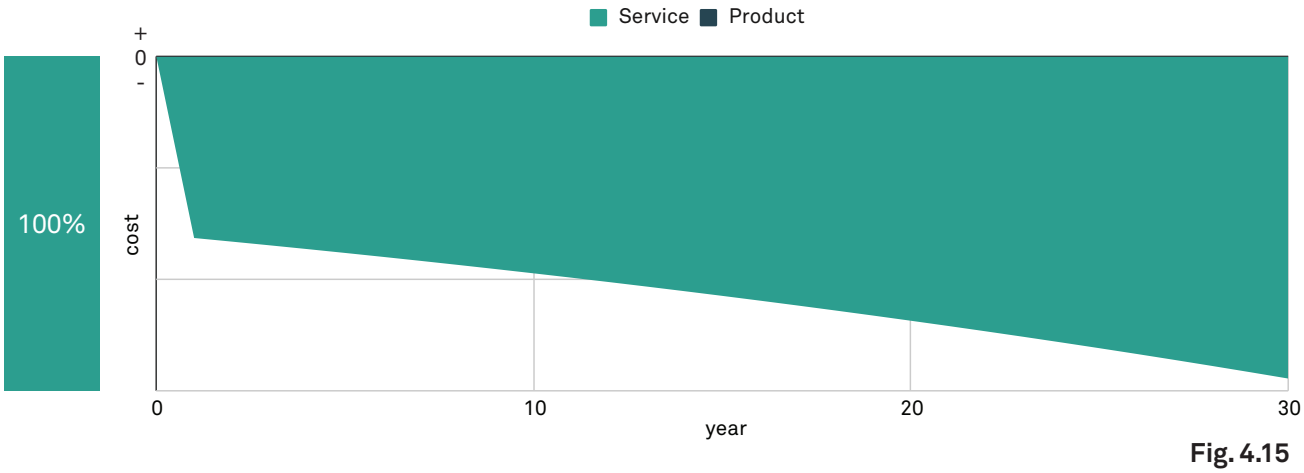


Fig. 4.15
Case E payment proportions over time; own figure.

Secondary advantages for Investor and Residents

Additional advantages for the investor and homeowners include 1) outsourcing the risk and responsibilities of maintaining the elevator, 2) achieving long term cost savings, and 3) creating predicable costs over the long term.

> *1) "If you have a building owner, the benefits for them when having a usage contract is to be sure that they have fixed fee, fixed costs, fixed margin, and no worries at all. And the elevator is almost always up and running. And it is guaranteed up and running against better service level than before in a traditional buying proposal."*
> *— Case E: PSSP*

> *2) "You have other kind of customers like real estate developers for housing, then you'll see often a consulting party calculating service costs per apartment. In these service costs, they have already also foreseen elevator costs for the direct costs, but also some costs for the long period maintenance or replacement costs, especially that. And that, they compare with [PSS NAME] contract. And more and more, you see that [PSS NAME] in the long term is approximately 20% lower in cost than traditional costs that come with some risk, without knowing if you achieve these kinds of figures." — Case E: PSSP*

> *3) "With [PSS NAME] you are guaranteed. So more often, you see that the real cost for the long period is higher than expected. And with [PSS NAME], you're sure that it's fixed."*
> *— Case E: PSSP*

Analysis Performed by Housing Provider

The housing provider reviewed 1) two financing alternatives regarding investing in the elevator in a traditional manner (TCO) vs procuring the elevator via an as-a-service model (TCU), as well as 2) the impact of the as-a-service model on resident service costs.

> *1) "We are very open and transparent in our contract. We are very open and transparent in the costs that we charge them, and also very open in comparison to traditional way and traditional costs. And that's not only by us, but it's also by having third parties, like these consulting parties who are delivering these kinds of real costs over elevators in the past. Combining that makes it a rather open and frank discussion. And you have to create trust and openness. It is the fundament of these kinds of contracts. Because you are going to have a contract for a very long period."*
> *— Case E: PSSP*

> *2) "If it's only 1, 2 or 3 euros per month, then it's explainable, because you get a higher quality, you get a higher percentage of availability. You are saving up for a new elevator in 40 years. So that's normal, that's acceptable. That's what we can explain. If it's 20, 30, 40 euros per month, then they're just not taking it. And then we have a bigger problem. [...] We have a large quantity of elevators; we have a lot of houses to divide the costs over. So, that's why it's only a few euros. Because you normally also pay for the maintenance. So, that's already in it. So, the only extra costs that you get is the main investment. And if you spread it out over 20 or 30 years, over 500 dwellings, then it's okay. It's a few euros. If you have the same system in an apartment complex of only 50 houses, then you are getting on a scale that it's not really affordable anymore."*
> *— Case E: HP*

Challenges when using PSS

The HP faced challenges regarding 1) the complexity of the contract required approval from multiple stakeholders within the development, additional input from the HP's legal team, and more time than a traditional contract, 2) the impact of the PSS on the general contract's profit, and 3) the HP's reluctance to have confidence in the PSS.

> *1) "Everything was new, and not only for us, but also for our investor, and also for [PSS PROVIDER], and also for the contractor. And all those parties had their say in the contracts. [...] So, I think there are four or five contracts. And there's also three-way contracts to manage all this. [...] So, our lawyers had a big job about it, just to manage everything because it was new. [...]. So, because we were the first, it was challenging. But yeah, that's one only one time." — Case E: HP*

> *2)" If you have the traditional way, then usually the construction company was our client. And they earn money buying elevators and having some margin on it. This product-as-a-service models create for them a lack of income. So, for them, it's rather difficult. But still because we are in contact with them and because we are talking about other aspects than the elevator, we are talking about building logistics, etc. We can create some margin for them in a building. So, although it's a new kind of income for them, we can make sure that they earned their money already." — Case E: PSSP*

> *3) "They're afraid of a long-term contract, because they think, "Ahh 20 years is a long period. Who knows what then? Do still exist as a company in 20 years?" These kinds of questions. And also, "If I'm not happy with you in the period between now and 20 years, how can we deal with that?" Etc. These kinds of questions." — Case E: PSSP*

Future use of PSS by Housing Provider

When asked if the housing provider will continue working with the PSSP in future projects, they responded:

> *"I think it depends on the project. As I said, this is a really big project with a lot of elevators, with a lot of houses, then it can be a solution. If it's getting too small, then you shouldn't do it because it's too much cost for your buyers. [...] But if you have a smaller project and you have an investor then maybe they say, "Oh, I think it's okay. Because I know for sure that the quality keeps high." So, I think that it's not going to be a standard for projects, but I think that we will see at which projects it's convenient and at which ones it's not." — Case E: HP*

Words of Advice from Housing Provider

Additionally, when asked about words of advice to other housing providers who are considering the use of PSSs, they said:

> *"Think about what it means for your buyers, think about how they will react to extra costs. So, it's not only your spreadsheet where you can cross out some costs. On the other side, you have your buyers and think about what is best for them. And I think that, it's okay with our project, it was a really big amount. But that's also why we could explain it to our buyers. So, I think that's the best advice. It's not always the best option." — Case E: HP*

Circular principles within PSS

The PSS embodies the following circular principles: 1) the product's slowing of loops via extending the lifespan of the elevator, 2) the product's closing of loops via design for disassembly and technological cycles, 3) the business model's slowing of loops via the exploitation of residual value, and 4) the business model's closing of loops via the use of circular inputs.

> *1) "We are achieving a lifespan expanding, because we use the model, and we use the products and components for a longer period. So, we lower the exploitation costs by having some intelligence in an elevator. And that will help us in the circular economy, that will help us extending the top of the value hill." — Case E: PSSP*

> *2 + 4) "We have LCA and also Cradle to Cradle document already fixed. And we can establish approximately 90% on reuse, and 10%, it's more on the electronical parts, it's hard to define the band materials, it's hard to define what's in it. So, that part, those 10%, we have to be honest, that it is today hardly not possible to create a take back and reuse of the electronic parts. For steel and that kind of parts, we can take it back, we can reuse it. Let's say if you have an elevator up and running in between guide rails, you can use these guide rails in another project, in form and material, as it is." — Case E: PSSP*

> *3) "And we are now just investigating how can we create a residual failure on these kinds of parts because in the past, it was only on weight, on how many kilograms of steel is in it, and now we are aiming to implement better residual value on these kinds of components to create also the reverse logistics on that. But it's, it's hard to come there. Because people are more and more looking at, "In 19 years, the material and raw material of metals are going in this way..." But I'm sure if you have a new future, if these materials are not available anymore, they will become more expensive." — Case E: PSSP*

Summary

In summary, the housing provider chose to contract with the PSS Provider for a 30-year contract. The Housing Provider (HP) is using the PSS to 1) reduce the amount of capital required for the initial investment in the project, and thus to make it viable, and likely preserve a profit margin for the developer.

Other advantages for the investor and homeowners include 1) outsourcing the risk and responsibilities of maintaining the elevator, 2) achieving long term cost savings, and 3) creating predicable costs over the long term.

When analyzing the PSS, the HP compared 1) the Total Cost of Use (TCO) with the Total Cost of Ownership (TCO), as well as 2) the impacts of the PSS on resident service fees.

In terms of challenges, the HP faced challenges regarding 1) the complexity of the contract, 2) PSS's impact on the general contractor's profit margin, and 3) the HP's hesitation to trust in a long-term contract.

The PSS embodies the following circular principles: 1) the product's slowing of loops via extending the lifespan of the elevator, 2) the product's closing of loops via design for technological cycles, and 3) the business model's slowing of loops via the exploitation of residual value.

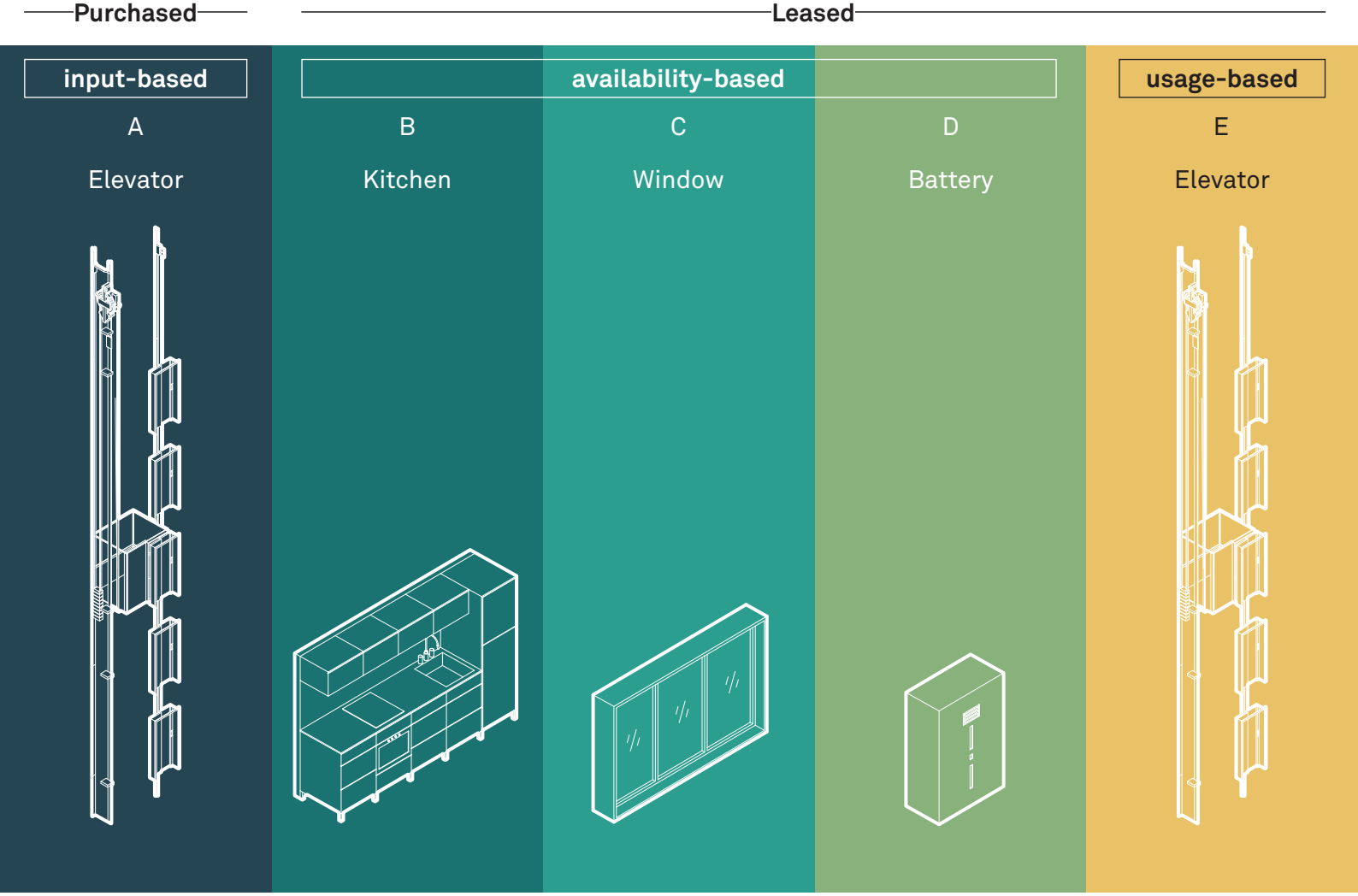
Fig. 4.16
Case E summary;
own figure .

2. Cross Analysis of Demand + Supply Cases

The cross-case analysis of the demand + supply studies compares the similarities and differences found within the individual cases studies and the themes explored therein.

Figure 4.17 shows the findings from the case studies and offers supportive reasoning for the cross-case analysis. Each dot represents a finding from an individual case, and the filled areas represent the accumulation of the findings across the cases.

The findings from the cross-case analysis can be grouped into the following categories: 1) Drivers to use a PSS, 2) Other advantages of using a PSS, 3) Analyzing the use of a PSS, 4) Challenges, 5) Circular principles within the PSSs, 6) Additional Observations, 7) Conclusions.



Primary Drivers
Secondary Advantages

- Achieve long-term cost savings
- Outsource risk and responsibilities
- Accomplish (more) scope without capital
- Prepare for changing regulations
- Establish predictable costs
- Enhance portfolio circularity
- Enhance market appeal
- Enhance building flexibility

Analysis

- Financial
- Risks and responsibilities
- PSSP historic service performance
- PSS impacts on resident service costs
- PSS impacts on future building operations
- End-of-use scenarios

Challenges

- Contract complexity
- Lack of confidence in PSS/PSSP
- PSS impact on General Contractor's profit
- Demarcation of PSS
- Product inflexibility
- Contract inflexibility
- Dissatisfactory service
- Incomplete service coverage (unpredictable costs)

Circular Principles

- Product: slowing loops (long-life products, product life extension)
- Product: closing loops (designed for technological/biological cycles)
- Business model: slowing loops (exploit residual value)
- Business model: closing loops (industrial symbiosis, circular inputs)

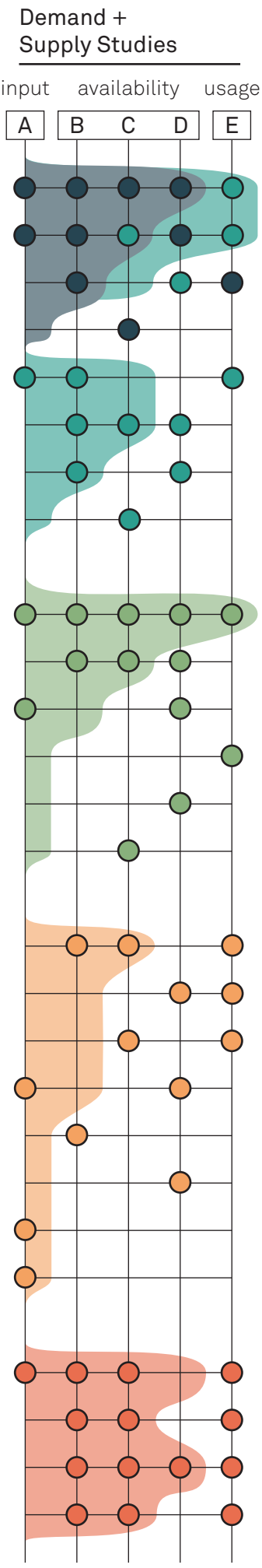


Fig. 4.17
Overview of cross analysis of demand + supply cases, own figure.

2.1 Primary drivers to use a PSS

Achieve long-term cost savings

Long-term cost savings was found to be the most important driver for the housing provider (HP) to use the PSS. Four of five cases noted this, and in the fifth, long-term cost savings was considered to be an advantage of the PSS. In Case B, the use of a long-term (40-year) maintenance plan made for an easy comparison of the PSS vs the traditional ways of owning, maintaining, and replacing kitchens. Cost savings are accomplished by both the design of the PSS (its increased efficiency as compared to what existed before), as well as the PSSP's preventative maintenance which extends the useful life of the product more than if the HP maintained it themselves. In one case, the long-term cost savings will not be captured until new carbon taxes are established by the government (see "prepare for changing regulations" below). In all cases, the cost savings are retained by the housing provider.

Outsource risk and responsibilities

In three cases, the outsourcing of risk and responsibilities to the PSSP was found to be a primary driver for the housing provider (HP) to use the PSS, and in two cases, it was considered an advantage. HPs are driven to outsource risk and responsibilities for several reasons. First, in cases A (elevator) and D (battery), the HP aims to reduce liability on technologies that pose a life-safety threat to residents. Second, in case D (battery), the HP also chose to lease the PSS to mitigate the risk of investing in a technology that depreciates in value faster than anticipated. Third, in cases B (kitchen) and D (battery), the HP is outsourcing risk and responsibility to avoid hiring additional in-house personnel to maintain and monitor the products.

Accomplish (more) scope without capital

In two of the cases, the HP was driven to use the PSS in order to accomplish scope despite a lack of capital. In case A (kitchen), the HP used the PSS to take pressure of their budget, and in case D (elevator), the HP used the PSS to ensure their project was viable and would in fact be constructed. In case D (battery), accomplishing scope without capital was considered an advantage because it eliminated the need for a drawn-out approval process, since no investment was needed.

Prepare for changing regulations

In one case, cost savings are not captured in the present, nor in the immediate future, but may be captured when new government regulations establish tax penalties for raw material extraction and CO2 emissions. Based on the possibility of evolving regulations, the HP is using the PSS to better understand how a circular PSS effects their internal processes and finances. If such regulations are put in place, the HP's familiarity with using circular PSSs will position them to achieve cost savings via reduced tax liabilities.

2.2 Secondary advantages of using a PSS

Establish predicable costs

In three cases (A, B, E), the PSS helps the HP establish predicable costs over the long term. No longer does the HP have to plan and estimate how much money to allocate when, as costs are predefined from the moment of contracting. However, in case A, which is an input-based PSS where the HP, as opposed to the PSSP, is the owner of the product, cost predictability is not guaranteed and also serves as a challenge of the PSS (see challenges: gaps in service coverage below).

Enhance portfolio circularity

In three cases (B, C, D), the HP considered the use of the PSS an advantageous as it increased the circularity of their portfolio, which they view as a core value within their organization. In cases B and C, the PSS has specifically designed to achieve a very high degree of circularity, however in case D, the PSS exhibits very low levels of circularity (see circular principles below).

Enhance market appeal

In two cases (B, D), the use of the PSS offered the HP additional market appeal. In Case B, the market appeal was associated with the kitchen's granite countertops, which the HP could not afford to purchase, yet prospective residents will likely value more. In case D, the increased market appeal was associated with the battery's "showcase" quality that appeals to the social housing association's local municipality and stakeholders.

Enhance flexibility

Only case C noted that the use of the PSS afforded them increased future building flexibility. Currently they are transforming an office building to residential use, and they believe that the building will likely change use again in the future. Thus, they believe that leasing the windows will allow for greater future flexibility and adaptability within the building's facade.

2.3 Analyzing the use of a PSS

Financial

The HPs in all five cases conducted financial analyses before contracting with the PSSP. In case A, which is input-based, the HP compared multiple bids for the purchase and continued servicing of an elevator. Thus, they compared multiple versions of Total Cost of Ownership (TCO). In cases B, C, D, and E, the HPs compared the TCO with the Total Cost of Use (TCU). In these cases, the financial comparison of owning vs leasing the product takes into account such aspects as the cost of capital, and the tax depreciation of the product. In some cases, such as monument buildings (case B) or social housing associations (case D), the HP can borrow money at a lower interest rate than the PSSP, meaning leasing may be financially disadvantageous since the PSSP's commercial finance rate will be embedded in the PSS financial structure. In case B, the HP, due to their lack of capital, opted for a lease-to-own contract in which they own the kitchens after five years of payment. The HP did this in order to get the asset value of the kitchens onto their balance sheet to capture the tax depreciation benefits of ownership. Otherwise, the tax depreciation would be associated with the PSSP's balance sheet, as the product's asset value can only be accounted for once.

Risks and responsibilities

Three of the cases (B, C, D) used a risk analysis to assist in their decision making. In these cases, the HP choose to use the PSS as it is the PSSP who takes almost all of the risk associated with the product. In these cases, the PSSP finances, installs, maintains, and eventually takes back the product at its end of use. In case D, the PSSP also operates and monitors the product during its useful life. While owning the battery offered the HP larger costs savings than leasing, the higher risks associated with ownership outweighed the financial benefit, which led them to lease the battery.

PSSP historic service performance

In two cases (A, D) the HP reviewed the PSSP's historic performance when considering the use of the PSS. In case A, the HP was renewing the service for another contract period, while in case D, the HP was initiating a lease, after a successful pilot project in which the HP purchased the product outright. In the other cases, the PSS is especially new, meaning there is almost no historic performance for the HP to consider.

PSS impacts on resident service costs

In case E, the HP analyzed the impact of the Elevator-as-a-Service on resident service costs. In the Netherlands it is commonplace for residents to pay monthly service costs for the maintenance of common areas within the building, such as hallway lighting, elevators, and lobby floor maintenance. Since the HP decided to lease the elevators with zero investment, it means that residents within the building will repay the value of the elevator to the PSSP over the 30-year contract period. Thus, when compared with other rental homes in which the elevator was paid for by the developer, the resident's monthly service costs will be proportionally higher. Since it was a very large building with over 400 homes, resident service costs increased less than 10 euros per month, which the HP deemed acceptable by prospective residents. If the building were smaller, and costs could be dived among less homes, the HP may have deemed that the service costs would increase to levels unacceptable to prospective renters, and thus would not have pursued the leasing of the elevators.

PSS impacts on future building operations

In contrast with case C, the HP in case D evaluated how the use of the PSS could actually reduce the flexibility of their building in the future. Since the battery's value proposition relies on reducing the size of building's electrical grid connection, the building is less capable of converting to all-electric heat pumps in the future, as these actually require a larger grid connection. This means in some of the HP's buildings, the use of the battery PSS was not suitable. However, in other buildings, where a district-wide heat net is in place, the battery, and the reduced grid connection, are an appropriate solution to increase sustainability and achieve costs savings.

End-of-use scenarios

In case C, the HP considered what will happen when the PSS reaches its end of use, as well as what happens if the HP wants to end the contract before the end of the contract term. The HP and PSSP discussed multiple scenarios that take into account a decreasing residual value over time. The HP noted that the PSSP would buy back the windows for a higher value at year 10, than at year 20, for example. Should the contract be renewed for another period, the PSSP noted that they would likely not pay the HP to take the windows back, as the transaction costs would be quite high to remove, remanufacture, and re-install the 2nd version of the windows. Thus, the end of use scenarios are loosely defined in the present, and will be further refined in the future.

2.4 Challenges

Complex contracts

Three cases (B, C, E) noted that the PSS leasing contract was more complex than a traditional contract to purchase the product. The complexity of the contract required additional time, and additional legal input, both from the PSSP and the HP. In case E, the HP noted that the first time they contract for the elevator-s-a-Service, it was a larger than usual task for their legal department, however, on subsequent projects, since the contract is already established, it is no extra work as the contract can easily be reused.

Lack of confidence in PSS/PSSP

Two cases identified that the HP's distrust and lack of confidence in the PSS and PSSP served as a challenge to be overcome. In case D, the HP did not believe that they could instantly start savings money without any upfront investment, and in case E, the HP was hesitant about signing a 20-year contract and was worried about what would happen if the PSSP were to go bankrupt during the contract period.

Demarcation of PSS

In cases A and D, the demarcation between product and infrastructure served as a challenge. In case D, the length of battery's AC cable was a topic of discussion, as it was not clear to the HP that the PSSP would only cover the cost of the first 10 meted of cable. Since that discussion the PSSP has updated their contract to make the demarcation clearer, thus, this challenge may not be relevant to future customers. In case A, however, the demarcation between product and infrastructure is variable on each installation of the elevator. Since it is a partial replacement of the elevator, the HP must make a decision as to what will be replaced, and what will remain. Thus, the demarcation is a recurring issue within the PSS.

PSS impact on General Contract Profit

In two cases (C, E), the use of a leasing model reduces the general contractor's (GC's) profit, as they are no longer the contracting party for the products. In case C, the HP decided to pay the GC their typical profit margin on the windows in order to avoid lengthy negotiations that could have delayed the project. This essentially means that they paid for the contracting of the windows twice, once to the GC, and once for the time it took their staff to manage the contract with the PSSP. In case E, the HP and PSSP noted that, while the GC's profit is reduced, so is their risk, as they are no longer responsible for the inspection of the elevators within the project. The PSSP in case E also noted that the GC can still capture some value due to their time spent on site logistics and coordination of the elevator PSS.

Product Inflexibility

In case A, the HP noted that the kitchen PSS, due to its especially high degree of circularity, is less flexible than a tradition kitchen. Since the PSSP needs to keep their kitchens as modular as possible, they are not able to accommodate unique site conditions such as custom millwork, or non-perpendicular walls, as these will likely result in wasted material at the end of the kitchens useful life.

Contract Inflexibility

In case D, due to the strict requirements of the PSSP's investor, the contract was not flexible. Typically, the HP, when contracting with parties, includes their own general terms and conditions at the front of all contracts. In this case, the investor would not allow the PSSP to alter the contract, which resulted in several rounds of lengthy negotiations. Eventually, the contracting inflexibility was solved with addendums that included the HP's general terms and conditions.

Dissatisfactory Service

In case A, the HP noted that they often have to call the PSSP several times and almost convince them that service is indeed needed at their building. Also, the HP noted that the PSSP often performs service as fast as possible to reduce their own costs, which they believe reduces the quality of the repair work.

Gaps in Service Coverage (unpredictable costs)

In case A, gaps in the service coverage create unpredictable costs for the HP. The evolution of computer hardware technologies sometimes makes the already-installed components within the elevator obsolete. When this occurs, the PSSP charges the HP for the replacement of "obsolete" technologies, which is often a large expense that the HP had not planned for. Additionally, since the PSSP does not take responsibility for all components of the elevator, due to parts of the elevator that are considered infrastructure (HP's responsibility) instead of product (PSSP's responsibility), the HP must cover these costs when they arise.

2.5 Circular principles within the PSSs

Product: slowing loops

The product's ability to slow loops is associated with its ability to receive preventative maintenance that can extend its useful like as long as possible (Bocken et al., 2016). In four of the five cases, the PSSP's preventative maintenance plan is intended to extend the product's lifespan. It was only the battery PSS that did not make note of preventative maintenance extending the product's lifespan. This may be due to the limitations of the technology and its relatively fast degradation.

Product: closing loops

The product's ability to close loops is associated with its design for disassembly, and design for both technological or biological cycles, which allow for the components and raw material within the product to easily be used in a future process (Bocken et al., 2016). In three of the cases, the product is specifically designed for disassembly. Only in cases A and D are the products not designed for disassembly from their conceptual phase.

Business model: slowing loops

The business model's ability to slow loops is associated with the exploitation of residual value, which helps ensure that the raw materials will be used to their maximum in order to reduce unnecessary costs (Bocken et al., 2016). In four of the cases, the PSSP, and the business model of the PSS, are specifically aware of the residual value within their product. While many of them cannot use the residual value of the products to their advantage today (based on the limitations of residual value calculations within the financial industry, as only the raw material can easily be calculated), the PSSPs do believe that their products retain significant residual value that they will, in the future, be able to use to their advantage when (re) financing their PSSs. Only in case A, which is input based, is the residual value of the elevator not accounted for.

Business model: closing loops

The business model's ability to close loops is associated with the business's use of residual outputs (waste) from either its own processes, or those of another organization, as new circular inputs for a new product (Bocken et al., 2016). Only in two of the cases (B, C) does the business model close material loops and intentionally use circular inputs. In case B, the kitchen uses residual output from other industries (recycles materials), and in case C, they plan to remanufacture 100% of their own material into the next version of the PSS.

2.6 PSSP incentives

There is a notable difference in the incentives for the PSSPs between the input-based elevator (case A) and the usage-based elevator (case E). In the input-based elevator, the PSSP is incentivized to continue the sales of their product, as 66% of their revenue is associated with the sale of the original elevator (50%), and replacement parts during its use (16%). Only 34% of the PSSP's revenues is generated by the service component of the PSS. Thus, their manufacturing department likely prioritizes the sale of elevators over the replacement of failed parts already in use. Additionally, the PSSP does not receive any penalties for elevator downtime or delays in repairs, meaning they may not be incentivized to respond quickly or ensure the elevator is always operational. In contrast, the PSSP of the use-age based elevator receives 100% of their revenue from the servicing of the elevator, as the HP pays no initial investment for the elevator to be installed. Additionally, the PSSP faces financial penalties if the elevator is down more than once per year or is down more than 0.002% of the year (18 hours), meaning they are incentivized to actively ensure the elevator is operational at all times, without prodding from the HP. While these cases show the difference in incentives between input- and usage-based contracts, it is difficult to gauge incentives and quality of delivered service in the availability-based contracts. While none of the available based cases (B, C, D) include penalties for the PSSP, the product remains their property, thus they are inclined to perform the appropriate level of service to maximize the product's lifespan and residual value.

2.7 PSS prerequisites

The value proposition of a PSS is thought to be most applicable when the product requires a high level of service or maintenance during its lifespan (Kim et al., 2016), when the product must undergo annual inspections or monitoring (Raposo et al., 2013), or when the product is often replaced before exceeding its technical lifespan(TU Delft, 2020).

Within the four products studied across the five cases, the elevator has the highest degree of applicability to a PSS value proposition. Elevators, with an abundance of moving parts, require a high degree of service, and, as an element of a building's life-safety, and must comply with annual regulatory inspections. Kitchens, on the other hand, do not require high levels of maintenance, nor annual inspections or monitoring, but they are often replaced before exceeding their technical lifespans. Outdated kitchens can drastically reduce the aesthetic quality of a building, and thus the amount residents are willing to pay for rent. As such, the HP in case B noted that, based on their long-term maintenance plan, the kitchens would likely be replaced every 20 years. Lastly, the battery required 24/7 monitoring to ensure there are no fire hazards.

A product may also lend itself to a PSS value proposition when the product is a new piece of innovative technology that requires new specialized expertise for optimized operation, such as the battery. Lastly, the applicability of windows to a PSS value proposition opens grounds for a fourth reason to use a PSS; reduced tax liabilities. If CO2 taxes are in place and reach their maturity, the HP believes it will be logical to procure building elements as-a-service, despite relatively low requirements for maintenance, monitoring and inspection, based on their tax savings ability. If correct, the use of a PSS value propositions in the future may correlate with high-tax building components, such as those that are high-mass, or those that are composed of rare materials, as they can deliver the highest levels of tax reduction.

2.8 Additional observations

Privacy and monitoring

In four of the five cases (A, C, D, E), the PSSP conducts 24/7monitoring of the product. The products (elevator, window, and battery) are being monitored to enable the PSSP to perform dynamic maintenance, or the appropriate maintenance at the appropriate time. Only in case C, the kitchen, is dynamic monitoring not being utilized. In this case, both the HP and PSSP noted that monitoring of a resident' s kitchen infringes on their privacy, as the data collected from a kitchen is far more personal than the data collected from a shared by many residents.

Future owners

In case E (elevator), the HP was required to gain the approval of the building's investor in order to use the PSS. While it did not end up being a problem for this project, it does illuminate the fact that, if a building with a long-term PSS is to be sold, the future owner must take over the contract with the PSSP or pay a penalty to end the contract. When asked, the PSSP in case E noted that several buildings with their Elevator-as-a-Service model have already changed ownership and have not caused any issues to-date.

Value co-creation

In several cases, value co-creation (Ng et al., 2010) is evident between the HP and PSSP. As evidenced in case B (kitchen), the PSSP worked to create a new financial solution for the HP to lease-to-own the PSS, in order for them to gain the tax depreciation benefits. In the same case, the HP and the PSSP are co-developing the contract to include "law of accession" clauses, similar to the legal clauses found within the Circle Economy Façade-as-a-Service (2020) whitepaper. In cases C and E the PSSPs are transparent about their direct costs and profit margins, which allows for the establishment of trust between the parties.

The term “lease”

The PSSPs in cases D and E both made note of the negative connotations of the term “lease” from the perspective of their customers. They believe that HP’s respond negatively to the term lease, thus they use different language when marketing their products.

> *“About a year ago, we started noticing that homeowners associations really hate the word ‘lease’, and we started calling it ‘product-as-a-service’ as well.” — Case D: PSSP*

> *“It’s far more than lease. So, we try to avoid the word “lease”. Lease is only the financial component. If you have a service level contract with penalties if you do not deliver the service, that is much more than just a lease.” — Case E: PSSP*

2.9 Conclusions from cross-analysis of demand + supply cases

The theoretical framework (figure 4.18) has been further developed to incorporate findings from the demand + supply case studies. The results support the notion that PSS value to housing providers increases in the order of input-, availability-, usage-, and performance-based PSSs.

Based on the cases, Housing Providers are primarily using PSSs and contracting for long-term service agreements for financial and risk management purposes. The largest driver to use a PSS was its ability to deliver long-term cost savings when compared to an alternative system. Secondly, the outsourcing of maintenance and operations diminishes the HP’s risk, and the unburdening of responsibilities allows the HP to retain focus on their core business. HPs also choose PSSs due to their minimal, and sometimes zero, upfront investment, which allows them to accomplish project scope without capital or financing. Lastly HPs are choosing PSSs, specifically circular PSSs, to prepare for upcoming government CO2 tax regulations. The use of a circular PSS will afford the HP a reduced tax liability (long-term cost savings) if and when the regulations are established.

HPs noted other advantages of using a PSS. The long-term contracts help HP’s establish predicable costs which helps with capital planning. The use of PSSs also was noted to enhance the material circularity of the HP’s circularity. In some cases, the use of the PSS offered the HP some added market appeal, and even enhanced flexibility.

When considering the use of a long-term PSS contract, HPs most commonly conducted a financial analysis to review and compare Total Cost of Use (TCU) with Total Cost of Ownership (TCO). The risks associated with ownership and in-house maintenance responsibilities were also weighed. When possible, HPs reviewed the historic performance record of the PSSPs. In some cases, HPs reviewed the impact of using a PSS on resident service costs, building operations, and the end-of-use logistics.

HPs faced challenges most commonly regarding the complexity of PSS contracts, a distrust and a lack of confidence in the PSS/PSSP's ability to deliver the promised value proposition, unclear demarcations between the PSS's product and the HP's infrastructure, and the impact of the PSS on the General Contractor's profit. In some cases, HP's faces challenges regarding the inflexibility of the product and contract, dissatisfaction with the provided service, and gaps in the service coverage which led to unforeseen and unpredictable costs.

Among the PSSs studied, there is a wide range of circular principles exhibited, reinforcing the idea that a PSS is not synonymous with circularity (Blüher et al., 2020; Tukker & Tischner, 2006). Based on van Ostaeyen (2013), the usage-based PSS should have scored the highest, however, it is two of the availability-based PSSs, both specifically designed for circularity, that exhibit all four circular principles (Bocken et al., 2016). Pursuant to van Ostaeyen's (2013) framework, the input-based PSS scored lowest, however, one of the availability-based cases also scored equally as low. Such results imply that, while the potential for increased circularity increases from input- to performance-based PSS, the reality of the studied cases is far more variable.

There is a notable difference in PSSP incentives between a usage-based PSS with penalties for poor service vs an input-based PSS with no penalties. In the former, rather than the latter, the HP is far more likely to receive higher quality services, thus the value offered is largely increased.

The applicability of a PSS value proposition was expanded to include products with innovative technologies that require new and specific expertise to operate, as well as products that, when regulations are in place, will have high CO2 tax liabilities.

Additional observations include, first, the PSSP's ability to monitor and operate the PSS remotely illuminates the concern of data privacy on PSSs that are specific to individual residents. Second, the sale and purchase of buildings with long-term PSS contracts has already taken place several times, as mentioned by Case E PSSP. In such cases, the future owner can continue the contract, or pay a penalty to terminate it early. Third, in several cases value co-creation was evident between the HP and PSSP who were transparent and forthcoming with their financial positions which helped the parties establish trust and find a mutually beneficial solution. Lastly, the term "lease" was identified as having negative connotations from the perspective of a HP, and thus the term is replaced with other terms like "Product-as-a-Service", or "usage contract".

PSSs in Rental Housing

Building component prerequisites

Building components that require:
1) intensive maintenance or frequent replacement, and/or
2) inspection or monitoring, and/or
3) replacement before exceeding technical lifespan, and/or
4) advanced expertise to operate at promised efficiencies, and/or
5) large CO2 tax payments (when CO2 taxes are established)

Payment allocation

>50% Product >50% Service

Purchased *Typically Leased*

Type of PSS

Input-based
Purchase building component with service contract add-on

Availability-based
Pay when building component is available

Usage-based
Pay when building component is used

Performance-based
Pay when building component meets performance criteria

Value

Primary Value
Secondary Value
Value Unsubstantiated

Enhance Circularity
Prepare for Changing Regulations (CO2 Taxes)
Accomplish (More) Scope without Capital
Outsource Risk & Responsibilities
Achieve Long-term Cost Savings
Establish Predictable Costs
Stabilize Asset Value
Enhance Resident Satisfaction

Challenges

Ongoing
Initial

Partially Unpredictable Costs
Partial Risk
General Contractor Negotiations
Contract Complexity

Fig. 4.18
Theoretical Framework adjusted based on findings from Demand + Supply Study, own figure.

3. Individual Analysis of Supply-Only Cases

The individual analysis of each case consists of the following parts: 1) case context, 2) propositions offered by the PSS provider, 3) drivers for the housing provider to use the PSS, 4) other advantages of using the PSS, 5) analysis of the PSS, 6) challenges faced, 7) circular principles and 8) summary.

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Case F

Heat Pump

usage-based

Drivers for Housing Provider to use PSS

Strategic
+ Outsource Risk and Responsibilities
Financial
+ Achieve Long-term Cost Savings
+ Accomplish (More) Scope without Capital

Project Context

Installed During
System Replacement

The Netherlands

27
Social (Affordable) Apartments

Housing Provider Strategy

Long-term Ownership

100%
Service to Product Cost Ratio

✓
"as-a-Service" Business Model

Owner of Product

PSS Provider

PSS Business Model

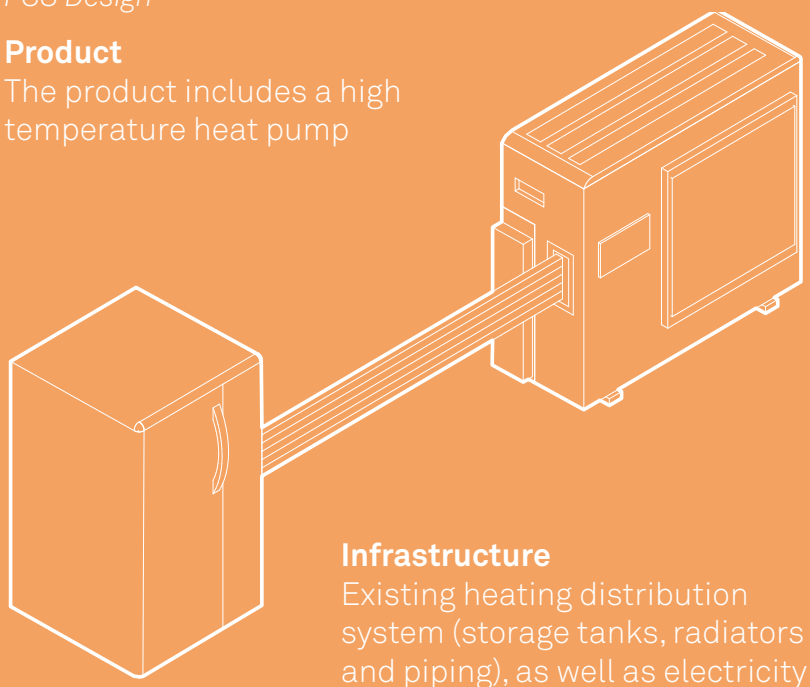
PSS Contract

15
Year Service Contract

✗
Law of Accession "Work-Around"

PSS Design

Product
The product includes a high temperature heat pump



Infrastructure
Existing heating distribution system (storage tanks, radiators and piping), as well as electricity connections.

Service
In addition to financing, service includes a combination of pre-planned and dynamic IoT monitoring: Service includes all maintenance and replacements. Service also includes resident administration. The PSS provider is responsible for all billing and energy bill administration, as well as resident customer service when they have questions about their heating.

Fig. 4.19
PSS Highlights
Case F, own figure.

Case F: Heat Pump

Context

- **Building:** located in The Netherlands, Case F is the modernization of a heating plant within a 27-apartment social (affordable) housing building. The existing combined heat and power (CHP) gas boilers were replaced by new electric heat pumps.
- **Housing Provider:** the Housing Provider (HP), which is a Dutch Housing Corporation (woningcorporatie) was unable to participate in the interview, however they are a long-term owner of social (affordable) rental homes.
- **PSS Provider:** the PSS Provider (PSSP) has been selling and leasing their product for 2+ years and has installed 3 centralized heat pumps to-date.

Propositions offered by PSS Provider

The following propositions were offered by the PSS provider. The housing provider chose those in bold:

Housing Provider is Owner of Product:
- 100% Investment with Service Contract (No Buyback Guarantee)

PSS Provider is Owner of Product:
- Down Payment (Includes Installation Fee), Recurring Service Payments
- **No Down Payment, No Installation Fee, Recurring Service Payments**

Primary drivers for Housing Provider to use PSS

According to the PSSP, the PSS was used by the Housing Provider to 1) outsource the risk and responsibility for the operation of new sophisticated technology, and to 2) achieve long term cost savings due to increased system efficiencies. Additionally, since the HP is required to reduce CO2 emissions of their portfolio (via performance agreements with each municipality), the HP chose to use the PSS to 3) because it requires no up-front investment. By not investing in the heat pumps, the HP can use their capital to invest in other sustainability upgrades, such as solar panels or insulation, which further help them reduce the CO2 emission of their portfolio..

> *1) "The technology is more sophisticated and getting the maximum out of it, the maximum efficiency, mainly in our market with heat pumps, etc. The technology is so sophisticated that they want to outsource the worries and the nightmares for next 15 years, for a certain price." — Case F: PSSP*

> *2) "We have integrated all the energy flows, and we integrated many electricity flows, where it was possible to reduce the purchasing costs for electricity for both organizations. [...] And the taxes are better because we are consuming more electricity on one master meter, instead of two small meters. And then the total price of electricity for both companies is interesting." — Case F: PSSP*

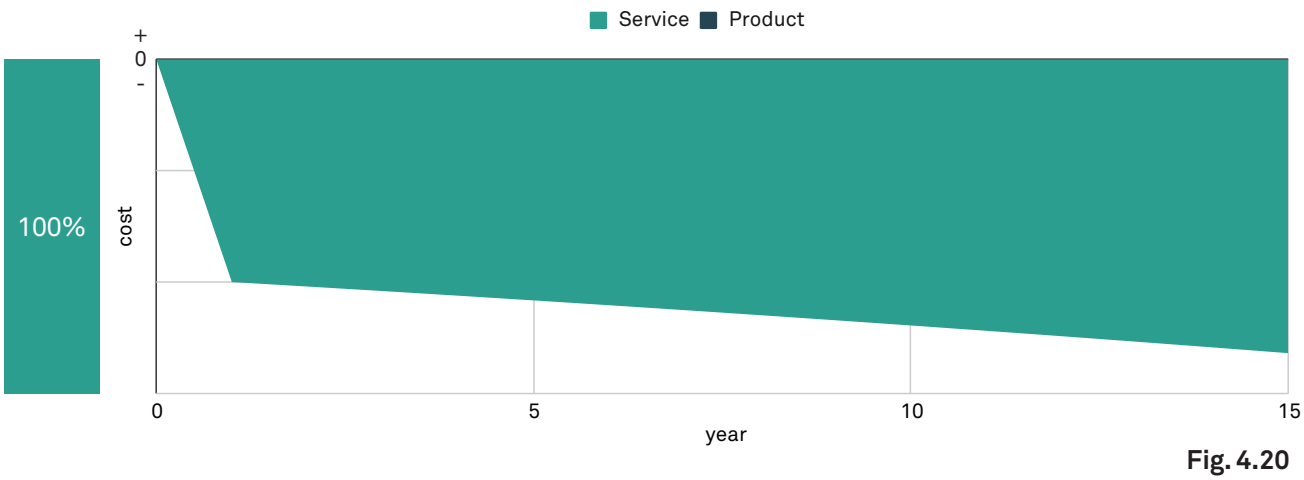


Fig. 4.20
Case F payment proportions over time; own figure.

3) "And now, by combining everything together for one big electricity meter, it was now possible for [HOUSING PROVIDER] to install solar panels on the roof. So, they can combine everything more together, and make bigger steps for the sustainability. [...] We provide our knowledge and information to the housing owner, the housing corporations to do another step like isolation, other activities in the apartments themselves. [...] We see that housing corporations are willing to invest in the isolation, because that's really connected to the structure." — Case F: PSSP who don't have a lot of money. And this battery doesn't really fit in their own strategy, in their own value proposition." — Case D: HP

Analysis Performed by Housing Provider

The PSSP provided the HP with 1) a memo that included two financing alternatives regarding purchasing the heating equipment (TCO) vs procuring the elevator via an as-a-service model (TCU). The HP also assessed 2) the risk associated with owning and operating the heat pump over the next 15 years.

1) "It gives you both financial information, and also the different steps we use to go forward to make the decision work." — Case F: PSSP

2) "The first reaction was, "why can't we buy the system again, so then we own the total system as we normally used to own everything?" And then we showed them the opportunities. And also, if you want to buy the system, again, be aware that you then have a lot of risks which you don't have at the moment. And then they decided already after half an hour discussion, "well, I think it's better to leave it the way it is and let's see how we can make steps in the sustainability"". — Case F: PSSP

Challenges when using PSS

The PSSP stated that the primary challenge was 1) the reluctance of the HP's many decision makers to trust in the PSS and relinquish ownership.

1) "I think the main reason why people are hesitant or reluctant to buy a product-as-a-service is they think they can do it themselves. And they think "why should anybody else make money with something which I have done over the last 10 or 20 years?" Although on the other side, they know that mainly it's a technology-based issue. [...] The decision makers are not only the C-level, because when there is resistance in the other levels below, they're not going to make that decision in favor of you. So, you have to work on all the decision makers. And that's, in the existing housing markets, and existing buildings, the main issue. There are so many stakeholders, and everybody wants to be joined and connected and be convinced." — Case F: PSSP

Circular principles within PSS

The PSS unfortunately does not embody any principles of circular products or business models. While the PSSP will provide preventative maintenance to the heat pump, it is expected to be replaced within 15 years or less by another more efficient product. Thus, the lifespan is not necessarily maximized. Also, the manufacturer of the heat pump does not intentionally design their products for disassembly and technological cycles. The business case of the PSS does not make use of heat pump's residual value, nor of circular inputs.

"The last 10 to 20% of gas reduction is quite expensive at the moment, to reuse that last 20%, so let's see what new technologies will bring us", and this can be 15 years, it can be in 10 years. So, we leave some space open for new innovations. [...] And that depends on the lifetime of the heat pump. In 15 years, then a new investment has to be made for a new heat pump or another system. We believe that 15 years is a

good life span where also a lot of other innovations and products are being developed. And therefore, we think also a housing corporation can decide after 15 years what to do next. [...] We work with several suppliers for heat pumps. And several years ago, I already asked [HEAT PUMP MANUFACTURER], a large company, can you provide us with information about the material, which is using your heat pump, and how it can be reused in 15 years. {...] They have looked at all the different materials, which consist of the pump, and what can be used after 15 years, how circularity comes in and the reuse of material. And we see that the value is very limited. It is very difficult to take out the materials. So, we've asked now, the heating the suppliers, to make a system which can be a modular system where you can take out some blocks in 15 years and put in back another, which they do, of course, but they don't do it with the vision of how to reuse, for example, the structure itself and put in a new software or a new item." — Case F: PSSP

Summary

In summary, the housing provider chose to contract with the PSS Provider for a 15-year contract that will likely be renewed. The PSSP noted that the Housing Provider (HP) is using the PSS to 1) outsource risk and responsibilities, to 2) achieve long-term cost savings, and to 3) preserve their investment capacity for other sustainability initiatives.

When analyzing the PSS, the HP compared 1) the Total Cost of Use (TCU) with the Total Cost of Ownership (TCO), as well as 2) the risks associated with owning and operating the heating equipment themselves.

In terms of challenges, the HP faced challenges 1) establishing support to use the PSS across its many decision makers.

The PSS does not exhibit circular principles.

Fig. 4.21
Case F summary;
own figure .

Case G

PV Panels

usage-based

Drivers for Housing Provider to use PSS

Financial
+ Achieve Long-term Cost Savings
+ Accomplish (More) Scope without Capital

Project Context

Installation of New Technology

The Netherlands

Housing Provider Strategy

Long-term Ownership

PSS Business Model

100% Service to Product Cost Ratio

✓ "as-a-Service" Business Model

Owner of Product

PSS Provider

PSS Contract

20 Year Service Contract

✗ Law of Accession "Work-Around"

PSS Design

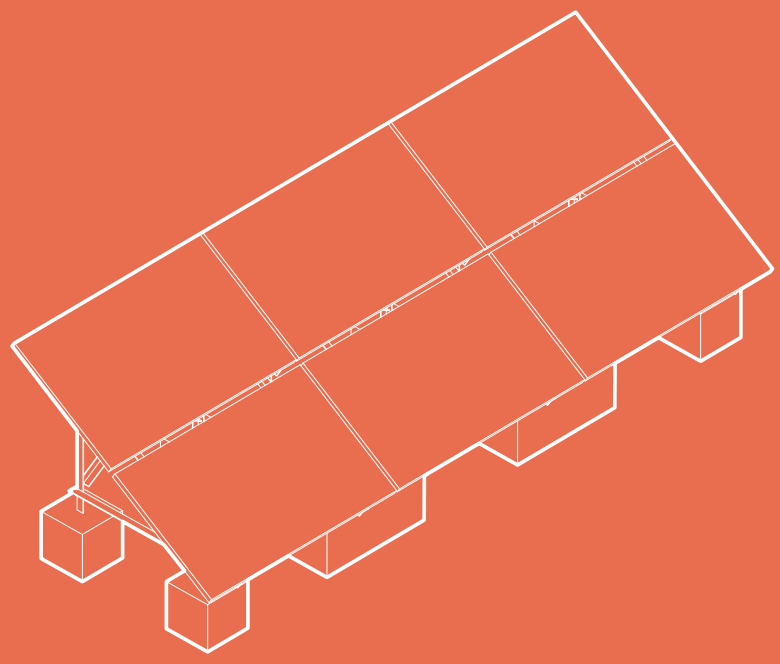


Fig. 4.22
PSS Highlights Case G, own figure.

Product
The product includes the solar panels, mounting structure, and all required wiring.

Service
In addition to financing, service includes a combination of pre-planned and dynamic IoT monitoring: Service includes all maintenance and replacements, and 24/7 monitoring to ensure PV panels are working.

Infrastructure
Building with structurally-sound roof, no asbestos and electrical connections that meet current building code.

Case G: PV Panels

Context

- **Building:** located in The Netherlands, Case G is the installation of solar panels on existing social (affordable) housing buildings.
- **Housing Provider:** the Housing Provider (HP), which is a Dutch Housing Corporation (woningcorporatie) was unable to participate in the interview, however they are a long-term owner of social (affordable) rental homes.
- **PSS Provider:** the PSS Provider (PSSP) has been selling and leasing their product for 9+ years and has provided solar panels for over 22.000 affordable (social) homes.

Propositions offered by PSS Provider

The following propositions were offered by the PSS provider. The housing provider chose those in bold:

Housing Provider is Owner of Product:
- 100% Investment with Service Contract (No Buyback Guarantee)

PSS Provider is Owner of Product:
- **No Down payment, Installation Fee, Recurring Service Payments**

Primary drivers for Housing Provider to use PSS

Similar to Case F, the HP is a social housing corporation (woningcorporatie) that must comply with energy efficiency standards set by the government. Therefore, according to the PSSP, the HP used the PSS because 1) it required zero investment and allowed them to use their limited capital to invest in other sustainability improvements. Thus, the HP was able to accomplish a larger scope than their investment capacity alone could achieve. Additionally, the HP used the PSS because of 2) its ability to achieve cost savings for its low-income residents. Also, the HP benefits from a small additional flow of revenue form the PSSP, which reduces its long-term administrative costs.

> *1) "Why do it via a lease and not buy it yourself? Housing corporations can borrow money, but to a certain limit it is guaranteed. So, they have low interest, and if it is above the limit, you have to pay a higher interest. And their budget, you can only spend it once. So, measures or an installation, but you cannot borrow the same euro twice. But if we finance it, it can speed it up, because there is no budget limit. We can do it at whatever speed is needed. [...] you can say you're increasing the budget for the sustainability and renovation. [...] they do it, because they have a large stock, to reduce the consumption of energy. So, insulation is huge task that they cannot do both for the same budget. [...] they have a lot of old houses. So, there should be a sustainable renovation, quality improvement, etc. Most housing corporations do not have enough money to do all of it." — Case G: PSSP*

> *2) "There is a cost reduction for the tenants.*

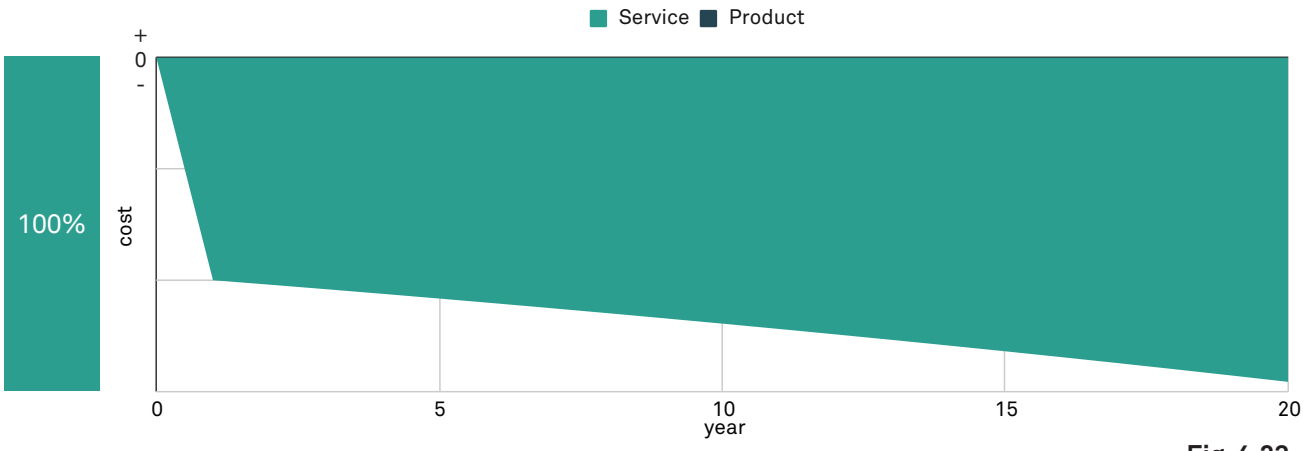


Fig. 4.23
Case G payment proportions over time; own figure.

So, they have less money to spend to their energy bills. So, they are already the poorest people in the Netherlands, so if they can save on their energy bill, it's a benefit [...] How to reduce cost for the tenants, because energy poorness is increasing, and they have to do something. [...] The most fair for the tenant is that hey pays only for a generated or produced kilowatt hour. So, if it is a kilowatt hour, he has to pay 16 and a half cents, instead of 23. So, he has profit, and if it is not generated by the solar power, then he doesn't pay anything. [...] The resident only pays for a produced kilowatt hour, that's the guarantee. [...] We call it an income for their administration, for their risk, because if the tenant is not paying, it is their risk. If there is not tenant, it's also their risk. They have to do some administration. There's roughly 2% for administrative costs. That's an average. Sometimes they have 1%, sometimes you have 3%. It could be minus 0.5%, it will be plus 5%." — Case G: PSSP

Secondary advantages for Housing Provider

An additional advantage for the housing provider is 1) the outsourcing of all monitoring and preventative maintenance to ensure the PV panels are performing as intended.

1) "All the service and monitoring are in the contract. Because they pay 16 cents per kilowatt hour, and that includes everything. And we monitor via gross production meter. Every house has a meter with a SIM card, a GPS connection, and every day we know from all 22,000 houses what is working and what is not working. [...] So, if they don't work, it's our problem. Because it's not a solar thing, it's a technical problem. So, we have to make sure that everything is working. So, we are monitoring every day, every installation [...] We monitor the sun, we monitor what is the production, and if it is less, there could be a little bit of deviation, say 5%, and if it is less than 95% there is something."
— Case G: PSSP

Analysis Performed by Housing Provider

The housing provider reviewed 1) the historic performance of the PSS provider, and 2) the financial comparison of TCO vs TCU.

1) "They are looking around to see who can do this the best. And then they search on quality requirements, who is reliable? Who is big enough? Who has done it before?"
— Case G: PSSP

2) "There's no second [PSS PROVIDER] in the Netherlands, so if they decide for lease, they come to us, but we also offer them, if you have enough money to do everything, that you buy it. [...] And then we focus on 20 years, the total cost of ownership. If they buy via a purchaser, they focus on the short term, and then we are a little bit more expensive, because, for instance, we use micro inverters always, it's a little bit more. But on the total cost of ownership, it's cheaper." — Case G: PSSP

Challenges when using PSS

According to the PSSP, the biggest challenge faced when offering the PSS was 1) the resident's reluctance to trust in the PSS. Without the written approval from residents, the solar panels cannot be installed. Since there is no investment for them, and only a cost savings, many residents think it is too good to be true.

1) "For the tenants, it's too good to be true. It's really, because, we say "you have no risk, and you save approximately, on average 350 euros a year. You don't have to do anything. You just have to sign here. No risk." They don't believe." — Case G: PSSP

Circular principles within PSS

The PSS embodies the following circular principles: 1) the product's slowing of loops by extending the elevator's useful life via preventative maintenance. Unfortunately, the PSS does not embody other circular principles. The product is not intentionally designed for disassembly or technological cycles, and the business case does not capture residual value, nor make use of circular inputs.

1) "Either the solar panels are very good, and everything is normal, so we keep on doing it and make a buffer for reinvestment. Or we reinvest exactly after 20 years, put new panels on, and everything is continuing, or the housing cooperation say's "no its enough". They buy them do the exploitation themselves. Everything is possible."
— Case G: PSSP

"If it is a technical problem, the solar panels do not work anymore, and it's really bad. We have to remove them, then it's going back to the seller. And they have to recycle it. There's a general European regulation, if you have a consumer or whatever, if you have a toaster or a coffee machine, it should be recycled by the producer, and they can organize it, but in principle it is their problem. [...] It will be recycled here in the Netherlands. Because it's not quite useful to send it back to China."
— Case G: PSSP

Summary

In summary, the housing provider chose to contract with the PSS Provider for a 20-year contract. The PSSP noted that the Housing Provider (HP) is using the PSS to 1) avoid investing in the solar panels and preserve their investment capacity for other sustainability initiatives (accomplish more scope without capital), as well as 2) create long-term costs savings for their for their residents.

Another advantage for the HP includes 1) outsourcing all monitoring and maintenance responsibilities to the PSSP.

When analyzing the PSS, the HP reviewed 1) the PSSP's historic performance with other customers, and 2) a comparison of Total Cost of Use (TCU) versus Total Cost of Ownership (TCO).

The largest challenge was 1) the resident's distrust in the PSS, as many residents thought its value proposition was too good to be true.

The PSS does not exhibit principles of circularity.

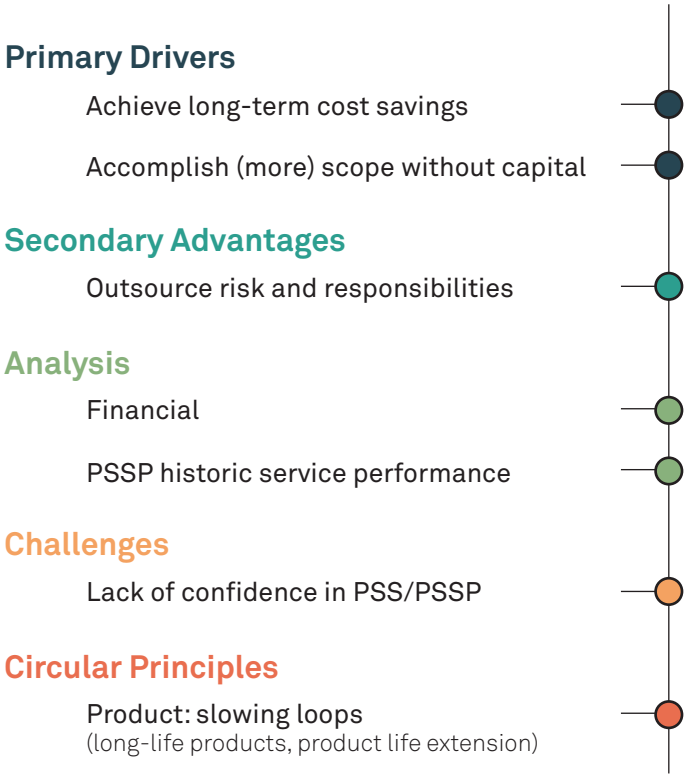


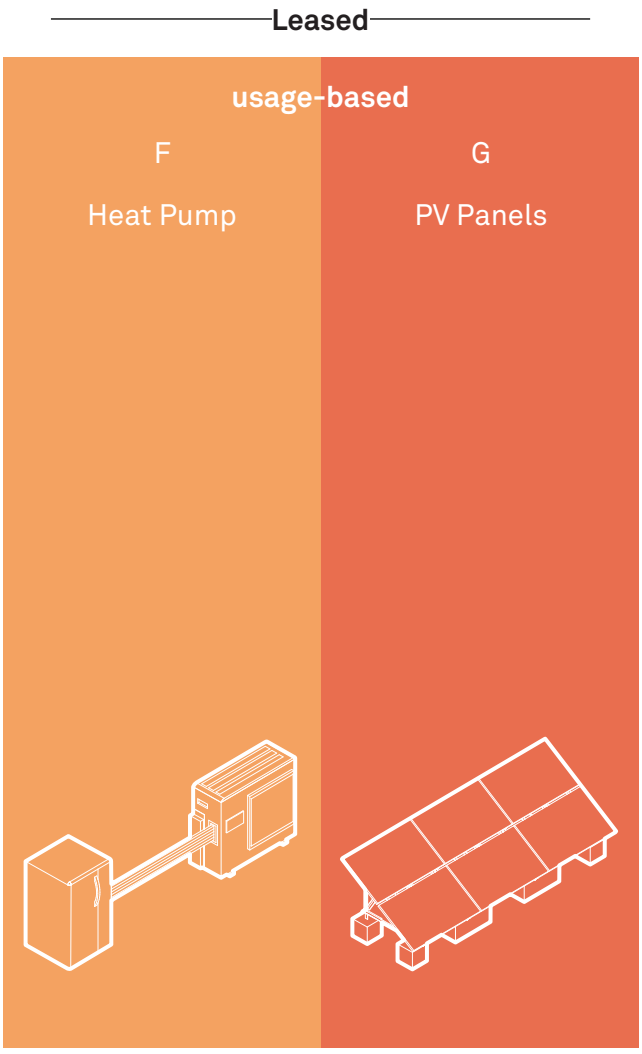
Fig. 4.24
Case G summary; own figure .

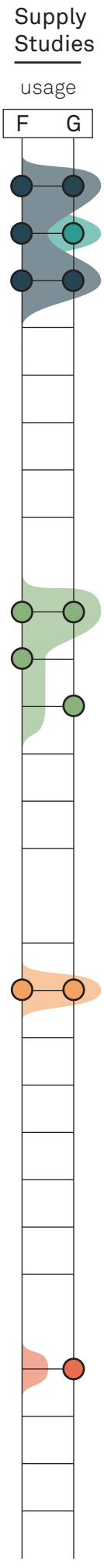
4. Cross Analysis of Supply-Only Cases

The cross-case analysis of the supply-only studies compares the similarities and differences found within the individual cases studies.

Figure 4.25 shows the findings from the case studies and offers supportive reasoning for the cross-case analysis. Each dot represents a finding from an individual case, and the filled areas represent the accumulation of the findings across the cases.

The findings from the cross-case analysis can be grouped into the following categories: 1) Drivers to use a PSS, 2) Analyzing the use of a PSS, 3) Challenges, 4) Circular principles within the PSSs, 5) Additional Observations, 6) Conclusions.





Primary Drivers

Secondary Advantages

- Achieve long-term cost savings
- Outsource risk and responsibilities
- Accomplish (more) scope without capital
- Prepare for changing regulations
- Establish predictable costs
- Enhance portfolio circularity
- Enhance market appeal
- Enhance building flexibility

Analysis

- Financial
- Risks and responsibilities
- PSSP historic service performance
- PSS impacts on resident service costs
- PSS impacts on future building operations
- End-of-use scenarios

Challenges

- Contract complexity
- Lack of confidence in PSS/PSSP
- PSS impact on General Contractor's profit
- Demarcation of PSS
- Product inflexibility
- Contract inflexibility
- Dissatisfactory service
- Incomplete service coverage (unpredictable costs)

Circular Principles

- Product: slowing loops (long-life products, product life extension)
- Product: closing loops (designed for technological/biological cycles)
- Business model: slowing loops (exploit residual value)
- Business model: closing loops (industrial symbiosis, circular inputs)

Fig. 4.25
Overview of cross analysis of supply-only cases, own figure.

4.1 Primary drivers to use a PSS

Achieve long-term cost savings

In both supply studies, long-term cost savings was found to be an important driver for the housing provider (HP). In case F (heating), the HP receives long-term cost savings by replacing the existing gas-fired system with a more efficient electric heat pump. The use of the heat pump, as well at the integration of all electricity flows, provides the HP with long-term cost savings for electricity purchasing costs. Additionally, the residents experience long-term cost savings as their heating costs will increase annually for the next 15-years at the electricity indexation rate, which is lower than the gas rate. In case G (PV panels), cost savings is created for the residents who, when using the PSS PV panels, pay only 16 cents/kWh, as opposed to 23 cents/kWh for grid-provided electricity. This cost savings is again generated by the increased efficiency of the new system (PV panels), when compared to the old system (municipal grid). In case G, the HP also benefits from a small stream of revenue, which reduces their administrative costs. In both cases, both the residents and HPs benefit from long-term cost savings.

Outsource risk and responsibilities

In case F, outsourcing risk and responsibilities to the PSSP was found to be a primary driver for the housing provider (HP), and in case G, it was viewed as an advantage. The knowledge required to achieve the heat pump's promised performance over a 15-year period drove the HP in case F to utilize the PSS, as opposed to own and manage the heat pumps in-house.

Accomplish (more) scope without capital

In both cases, the PSS was selected over ownership because it allowed the social (affordable) housing HPs to accomplish more scope without capital. Since they are under pressure from their local municipalities to meet performance agreements which stipulate CO2 maximums for their portfolios, the HPs must invest in building upgrades such as increased insulation and windows, new heating and cooling plants, and renewable energy sources. Since they don't have the capital to accomplish all the desired scope, the HPs used the zero-investment of the PSSs in order to accomplish more scope than they could otherwise afford.

4.2 Analyzing the use of a PSS

Financial

In both cases, the HPs conducted financial analyses before contracting with the PSSP. Since the HPs did not have the capital to purchase the products themselves, they were persuaded by the realization that the long-term cost savings associated with the PSS was more advantageous than not using the PSS.

Risks and responsibilities

As previously mentioned, the risks associated with owning the heat pumps in house (case F) led the HP to use the PSS. The HP was not confident in their ability to operate the heat pumps and achieve their promised efficiencies over a 15-year period, which led them to outsource the task to the PSSP.

PSSP historic service performance

In case G, the HP reviewed the PSSP's track record at previous projects. They wanted to gain confidence in the PSSP's ability to deliver the promised value proposition

4.3 Challenges

Lack of confidence in PSS/PSSP

In both cases, the either the HP or the residents displayed distrust in the PSS/PSSP. In case F, the HP was reluctant to relinquish ownership of the heating system, and in Case G, the residents did not trust that they could immediately start saving money, and thus are reluctant to sign agreements with the PSSP.

4.4 Circular principles within the PSSs

Despite both PSSs being usage-based, they exhibit relatively low levels of circularity, which is counter to the logic of van Ostaeyen's (2013) refined taxonomy. Only in case G (PV panels) is the life span used to its maximum. In Case F, the product may be disposed of before it reaches its end of use, making it essentially a throw-away technology. In both cases, the product has not been intentionally designed for disassembly or technological cycles. Neither case has embraced circularity in its nosiness model, as the residual value of the products is not retained or used in exploited in secondary uses, and neither project business model makes use of circular inputs.

4.5 PSSP incentives

In both cases, as they are usage-based PSSs, the PSSP is strongly incentivized to deliver exceptional service. Only when the PSS is operational and usable can they receive payment, thus they are incentivized to minimize downtime.

4.6 PSS prerequisites

In both heat pumps and PV panels, a high-level of monitoring is required to ensure the performance is delivered, which makes them fitting products for a PSS value proposition(Raposo et al., 2013). Additionally, heating systems are required to undergo annual inspections, which makes them even more applicable (Raposo et al., 2013).

Both of the products, similar to the battery studied in Case D, are new technologies that require new forms of expertise to operate and maintain properly, which help support this reasoning.

4.7 Additional Observations

Privacy and monitoring
In both cases, the PSSP uses 24/7 monitoring to operate their PSS. The monitoring of someone's thermostat or electricity usage could easily pose privacy issues, however no such issues were discussed by the PSSPs.

4.8 Conclusions from cross-analysis of supply-only cases

The theoretical framework (figure 4.26) has been further developed to incorporate findings from the supply-only case studies. The results support the notion that PSS value to housing providers increases in the order of input-, availability-, usage-, and performance-based PSSs. Similar to the demand + supply cases, HPs were driven to use a PSS to achieve long-term cost savings, outsource risk and responsibilities, and accomplish scope without capital. Before signing long-term contracts, the HPs conducted financial and risk assessments, as well as reviewed the PSSP's historic performance record. PSSPs in usage-based PSSs are strongly incentivized to deliver exceptional service and minimize downtime. A new finding in one case is the direct interaction between the PSSP and the resident. Case G highlights, for the first time, the resident as a decision-maker, and subsequently, the challenge of resident's distrust in the value proposition, and hence reluctance to sign agreements with the PSSP. Despite both PSS being use-age based, they both exhibit few, and sometime no, principles of circularity (Bocken et al., 2016), again reinforcing the idea that a PSS is not synonymous with circularity (Blüher et al., 2020; Tukker & Tischner, 2006). Additional observations include potential privacy issues regarding the tracking of individual resident behavior, and the strengthening of the idea that products which require specific and new expertise to operate may be good candidates for a PSS value proposition.

PSSs in Rental Housing

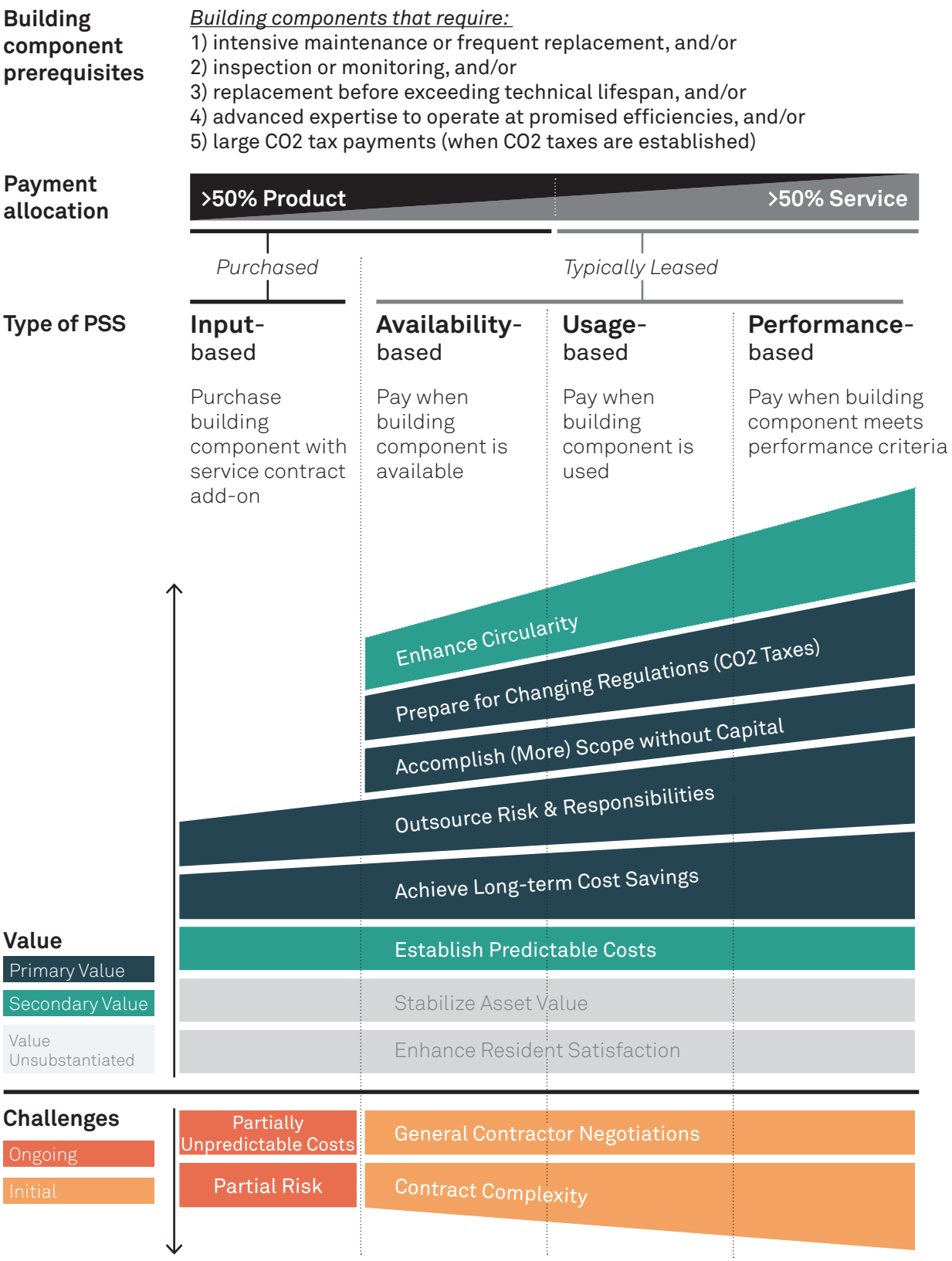


Fig. 4.26
Theoretical Framework adjusted based on findings from Supply-Only Study, own figure.

5. Cross Case Analysis: All Cases (Demand + Supply, and Supply-Only)

When analyzing all cases by contract duration and payment allocation over the contract period, short contracts and low percentages of service payments offer the least value to housing providers, as both reduce the risk of the PSSP. When contracts are short in duration, PSSPs can redefine services costs at each contract renewal, and when PSSs are majority product-related costs, they capture majority of their payment value before delivering satisfactory service. When contracts are long in duration and majority service-rated payments, the PSSP is incentivized to deliver continuous satisfactory service in order to collect payments over the contract duration. This phenomenon is strengthened when the PSSP exploits residual value, faces penalties for dissatisfactory service, and offers their solution via a usage- or performance-based PSS. The contract duration and percent service of all cases can be seen in figure 4.27. The averages of each type of PSS can be seen in figure 4.28. which demonstrates that availability- and usage-based contracts tend to be much longer in duration, and a higher percentage of service-related costs, than input-based PSSs.

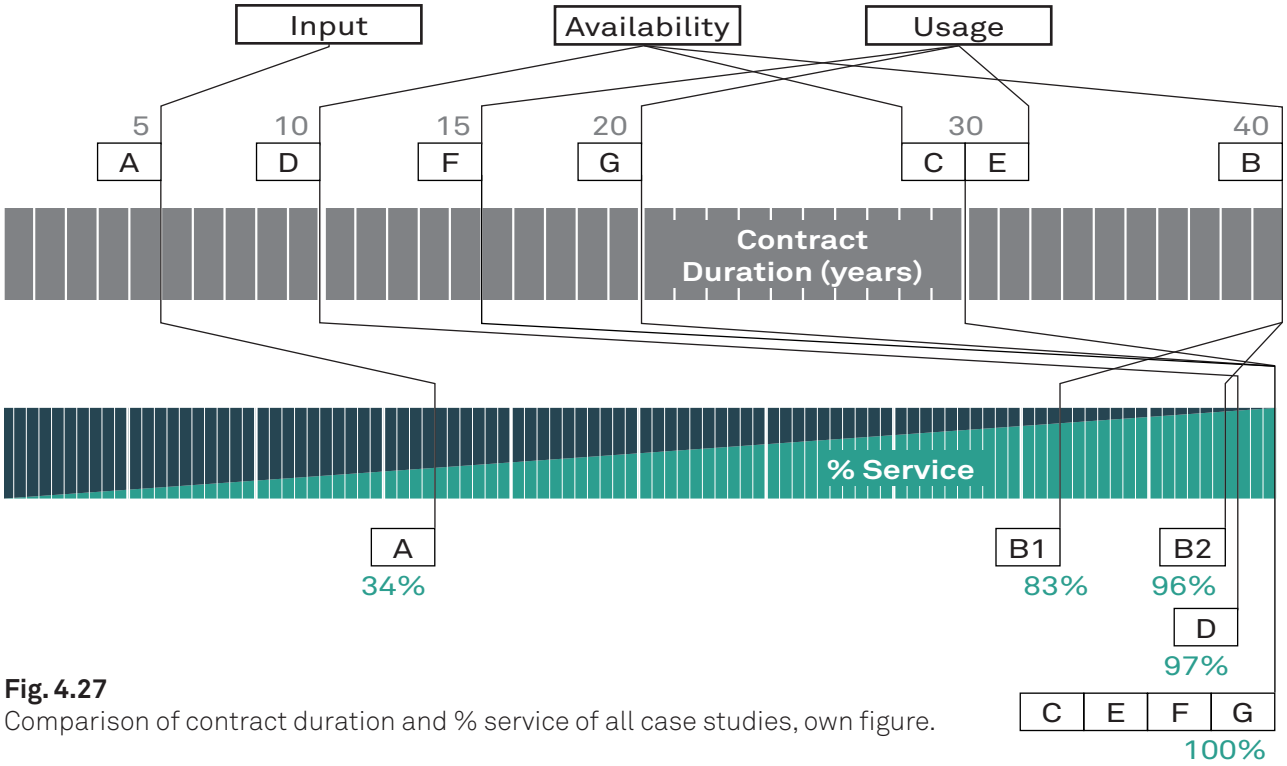


Fig. 4.27
Comparison of contract duration and % service of all case studies, own figure.

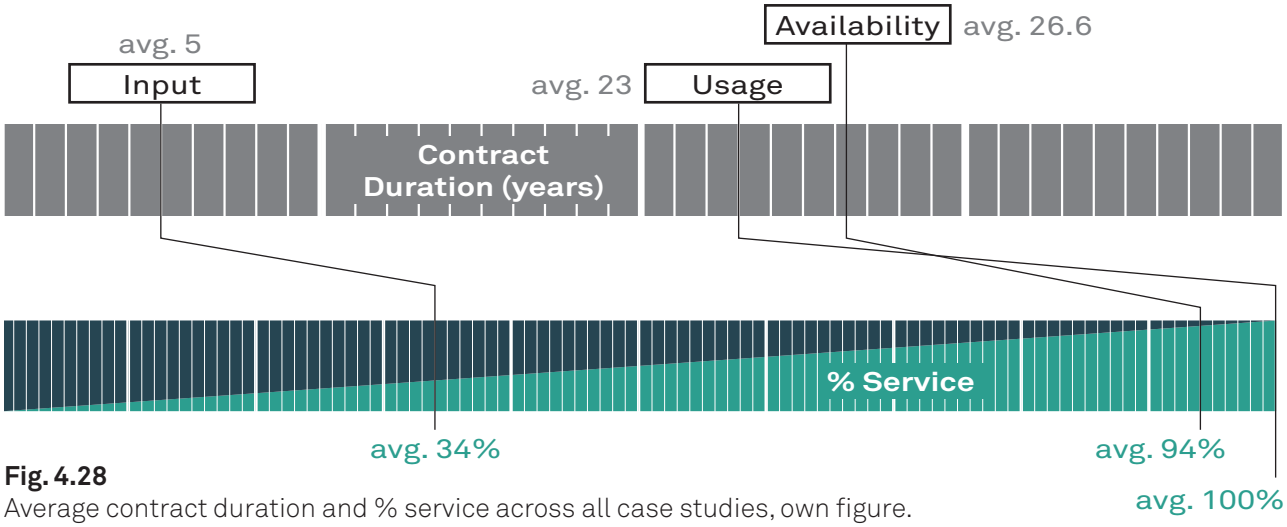


Fig. 4.28
Average contract duration and % service across all case studies, own figure.

Figure 4.29 abstracts the findings displayed in figure 4.30 and displays them based on the potential for each type of PSS to deliver value to an HP. Congruent with theory, the value of PSSs for HPs increases in the order of input-, availability-, usage- and performance-based PSSs.

Figure 4.30 highlights the details of each case which contribute to value offered, as well as the challenges faced, by housing providers using them. As is evidenced by the last row of the figure, cases of a similar type of PSS can offer varied levels of value to a HP. The cumulative value is the sum of all primary values, secondary values, challenges avoided, and strong incentives for PSSPs to deliver satisfactory service.

	Purchased	Typically Leased		
	Input-based	**Availability-based**	**Usage-based**	**Performance-based**
Primary value delivered to HP by PSS				
Potential for long-term cost savings	yes	yes	yes	yes
Potential for outsourcing of risk + responsibilities	partial	yes	yes	yes
Potential for accomplishing (more) scope without capital	no	yes	yes	yes
Potential to reduce CO2 tax liability in future (4 principles exhibited)	unlikely	yes	yes	yes
Secondary value delivered to HP by PSS				
Potential to establish predictable costs	partial	yes	yes	yes
Potential to enhance portfolio circularity (4 principles exhibited)	unlikely	yes	yes	yes
Challenges when using PSS				
Tax disadvantages of leasing	no	yes	yes	yes
Negotiations with General Contractor	no	yes	yes	yes
Complex Contracts	no	likely	likely	likely
Incentives for PSSP to deliver excellent service				
Percent of payment remaining to be captured after installation	far less than 100%	up to 100%	up to 100%	up to 100%
Payment dependent on PSS being operational	no	no	yes	yes
Payment dependent on PSS delivering functional demand (van Ostaeyen, 2013	no	no	no	yes
Potential to exploit residual value	no	yes	yes	yes
Financial penalties if PSS is not functional	unlikely	unlikely	potentially	potentially
Cumulative Value	**4**	**8**	**10**	**11**

Fig. 4.29
Potential of each PSS type to deliver value to housing providers, own figure.

	Purchased	Leased						
	Input-based	**Availability- based**			**Usage-based**			**Performance-based**
Case	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**...**
PSS	Elevator	Kitchen	Window	Battery	Elevator	Heat Pump	PV Panels	...
Functional demand delivered by PSS	Vertical Access	Food Storage, Prep + Cooking	Light + Thermal Comfort	Electricity Storage	Vertical Access	Thermal Comfort	Electricity	...
Primary value delivered to HP by PSS								
Long-term cost savings	yes	yes	yes	yes	yes	yes	yes	potentially
Outsourcing of risk + responsibilities	partial	yes	yes	yes	yes	yes	yes	potentially
Accomplishing (more) scope without capital	no	yes	yes	yes	yes	yes	yes	potentially
Potential to reduce CO2 tax liability in future (4 principles exhibited)	no	yes	yes	no	yes	no	no	yes
Secondary value delivered to HP by PSS								
Establish predictable costs	partial	yes	yes	yes	yes	yes	yes	potentially
Enhance portfolio circularity (4 principles exhibited)	no	yes	yes	no	yes	no	no	potentially
Challenges when using PSS								
Tax disadvantages of leasing	no	yes	yes	yes	yes	yes	yes	yes
Negotiations with General Contractor	no	no	yes	no	yes	no	no	potentially
Complex Contracts	no	yes	yes	no	yes	no	no	potentially
Incentives for PSSP to deliver excellent service								
Percent of payment remaining to be captured after installation	34%	83-96%	100%	97%	100%	100%	100%	up to 100%
Payment dependent on PSS being operational	no	no	no	no	yes	yes	yes	yes
Payment dependent on PSS delivering functional demand (van Ostaeyen, 2013	no	no	no	no	no	no	no	yes
Potential to exploit residual value	no	yes	yes	yes	yes	yes	yes	yes
Financial penalties if PSS is not functional	no	no	no	no	yes	no	no	potentially
Cumulative Value	**4**	**9**	**8**	**8**	**10**	**9**	**9**	**11**

Fig. 4.30
Value delivered to housing provider in each case, own figure.

Based on the case studies, it is also evident that the volume of building components procurable by PSS type decreases from input-, availability-, usage-, to performance-based PSSs (figure 4.31). While only one input-based PSS was studied, in theory, all building components meeting the PSS prerequisites can be sold with an additional service contract add on. Building components meeting the prerequisites that are continuously available with unknown usage can be offered through an availability-based PSS contract. Even less building components can be offered through a usage-based PSS, as these components must have predictable, intermittent usage for a PSSP to offer the PSS on the market. Lastly, performance-based PSSs are likely to exist in the least volume of building components on the market. When searching for case studies, none could be found, however the availability-based window PSS, serves as a rudimentary version of what the PSSP aims to eventually offer as a performance-based integrated-façade PSS, complete with heating, cooling, and ventilation.

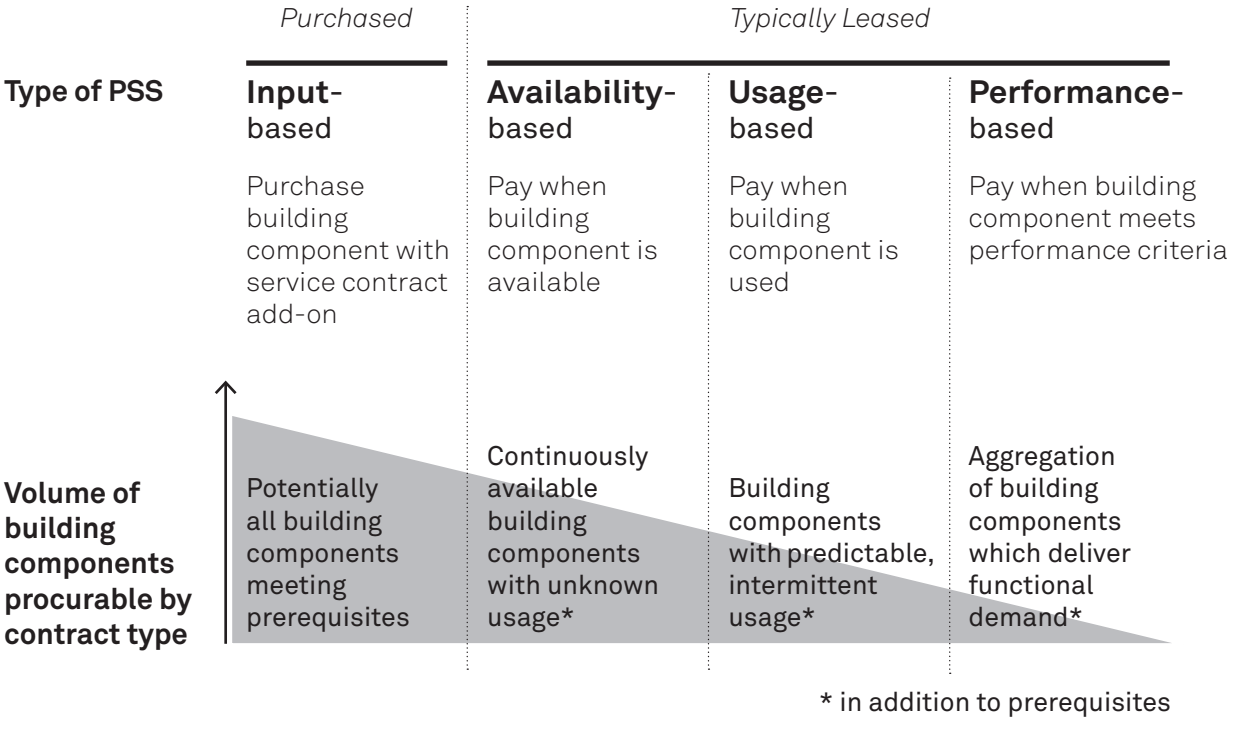


Fig. 4.31
Volume of market implements building components procurable by contract type, own figure.

6. Expert Study Results

The findings from the expert study are be grouped into the following categories: 1) Trends fueling PSSs, 2) Barriers to PSSs, 3) Reasons to use a PSS as a real estate owner, 4) Circular principles within PSSs, 5) PSS prerequisites, 6) PSS impact on building value, 7) Additional Observations, 8) Current status of PSSs within the market, 9) Future of PSSs, 10) Conclusions.

6.1 Trends fueling PSSs

Delivering function via access instead of ownership

The evolving trend of access over ownership has proven viable in market sectors such as Mobility-as-a-Service, Security-as-Service, or Software-as-a-Service (SaaS), among other ubiquitous as-a-service propositions like Netflix and Spotify. Experts 2 and 4 stated that, in these propositions, the user receives their desired utility or function without necessarily becoming the owner of the product. This trend has helped normalize ongoing use-contracts instead of purchase agreements.

> *"They say 'why do I want ownership? I want to have availability, I want to pay for availability, I want to pay per use, maybe, because ownership is not is not high on the list anymore. [...] And these generations are far freer in their mind than my generation." — Expert 2 Mark van Ommen (TNO)*

> *"If I do that with a red camera, or a purple camera, that's not your concern, the only thing you want is 24/7, you want to know who goes in who goes out, or whatever. [...] We felt that people didn't want to own security tools anymore, they just want to use them. [...] We're stepping away from ownership. And that might take a couple of generations before you really step away from that." — Expert 4 Rick Ruisch (Een Veilig Gevoel)*

Circularity: material scarcity, CO2 emissions, and value capture

Growing awareness of humanity's detrimental impact on the natural world has led to the development of the concept of circularity. Expert 2 stated that circularity is concept that can address the issues of raw material scarcity and CO2 emission reduction, without sacrificing financial value.

> *"When I talk about circularity and circular economy for build environment and infrastructure, and the transition into a circular economy is, when I really make it in short, it comes down in these two domains to two topics in my mind. [...] The first one, the scarcity of materials, raw materials in the built environment and in infrastructure is not a really big problem. Because there are not a lot of things used in these two domains that really face scarcity, that really face ending before the end of the century. It doesn't mean that we don't need to look at it. It also doesn't mean that we can forget it or take it lightly. But if you have to prioritize, and then the second one, the latter one, the environmental impact of all the things that we do in these two domains, and also outside, is more important. So, when I think about circularity, I think about value preservation. And so, the value of products, the value of solutions, the value of elements, the value of buildings, we need to preserve as good as we can. And we need to make sure that we do it in an environmentally friendly CO2 neutral way, we need to step towards the CO2 neutrality. So, those are the two biggest issues I always keep in mind when I talk to people or customers." — Expert 2 Mark van Ommen (TNO)*

Evolving business models that link ecological and business paradigms

New circular business models have made it possible to reduce material consumption while simultaneously capturing and retaining additional value. Several experts (3,1,5) noted that the business models have evolved over the last decade and have even come from other sectors such as Software-as-a-Service, despite its lack of a physical product.

> *"But getting sort of the business paradigm and the ecological paradigm together was really hard, and people started, 'okay, maybe this Cradle-to-Cradle thing can bring us something'. But by the time we started Turntoo, we saw that, after about three years of working with Cradle-to-Cradle, people were sort of getting disappointed by it because they didn't see a real business advantage. So very often, in the beginning, when I was telling what we were doing, they said, 'Oh, you are developing the business-to-business model for cradle to cradle'. And well, you could argue that in fact, I think the Cradle-to-Cradle thinking is a really good design*

paradigm for the circular economy. But it does lack the business side." — Expert 3 Sabine Oberhuber (Turntoo)

"So, actually, one of the business models in the IT sector is SaaS, Software-as-a-Service. And, of course, that's a lot of the same points in SaaS we mentioned we are facing in PaaS. So, the big difference is, of course, the product itself is not a physical product. [...] Software as a service has not much to do with sustainability, of course, or with circularity, but with PaaS it does." — Expert 1 Rob van Willigen (ABN AMRO)

"There are just like three reasons or three parameters entrepreneurs are willing to innovate or to change for. One, you can earn money with something new. Two, you have to change due to law and regulations. And three, there are entrepreneurs with a huge ambition. [...] So, you have entrepreneurs who see, "OK, a circular business model or a product-as-a-service, it can earn me a lot of money. So, I'm willing to invest into that". — Expert 5 Jeroen Reumkens (Volantis)

Internet of things and big data

Expert 1 stated that sensor technology has enabled PSSPs to collect 24/7 data which enables them to perform dynamic preventative maintenance. The use of such data reduces their maintenance risks when offering long-term contracts to their customers.

" With Internet of Things, and with sensors, etc., you can get a lot of information, a lot of data, you can use, of course, for your product and for your proposition. But also, for maintenance, etc. So, you can see when something's going to be broke tomorrow, for instance, we have a client with speed gates, for parking places, the speed gates, you know, them, they have a lot of sensors in it, so they can see when it's almost not working anymore. Then they send a crew to fix it before it even breaks. [...] All that kind of information, you can get this information because you are still the owner of the product. I don't know if you are always the owner of the data, but you can get the data and it's very hard when you sell your machine because there is no connection anymore." — Expert 1 Rob van Willigen (ABN AMRO)

6.2 Barriers to PSSs

Financing

Almost all of the experts noted financing as a large barrier facing the growth of PSSs. When financing PSSs, the residual value of the product at its end of use is often not calculable, at least based on current accounting practices. Often the value of the raw materials is calculated, but this is far below the actual value of the product, as the calculations do not take into account the engineering and manufacturing value embedded within the product. As such, PSSs are not able to take advantage of their residual value when they request financing. Even if a manufacturer is confident there is say, 30% residual value, they still need to finance the product for 100%, as opposed to 70%. Additionally, banks and investors are not yet looking at raw materials as an asset on a company's long-term balance sheet.

"One of the biggest barriers, of course, it's the financing part. So almost every company who start with product as a service mentioned financing as a big problem. [...] When we want to finance this business model, or clients with his business model, we have to change a lot of things of analyzing also. Yeah, for instance, we don't only look to the assets, but also to the contracts for instance, and the residual value, for instance, on the balance sheet, all those kinds of things are difficult or different compared to the normal linear risk of a business model". — Expert 1 Rob van Willigen (ABN AMRO)

"I think also about how we value company companies, how analysts look at companies. And I believe that maybe at a certain point in time, analysts should look at the risk profile of company if they already have secured a certain asset base in form of raw materials out there with their clients ready to be reused. But that requires a completely complete mind shift." — Expert 3 Sabine Oberhuber (Turntoo)

Lack of government regulation

Expert 1 stated, based on the current lack of legislation, that there is no penalty for companies that use material and labor from other parts of the world, despite the CO2 emissions they create during transportation. Put another way, the linear economy is simply too profitable to warrant change within companies. Thus, a company that aims to develop a locally based circular PSS is disadvantaged when completing with global supply chains since they must pay much higher local wages and material prices. Expert 2 reinforced this concept, noting that if companies were required to pay for the CO2 emitted during global transportation, they likely would reconsider local production of products.

> *1)" It is hard to compete with a company who can import products from Asia with cheap materials and with cheap labor costs. And when you want to make a very circular product, for instance, you produce this in Holland, with high labor costs and with quality materials, because you want to make it circular, then the competition is not the same, of course. And the reason why it is possible to make cheap products in Asia is because there is no legislation about what kind of materials you use, or we have no legislation in Holland for how to pay people who are working in China, for instance, human rights, all that kind of stuff. So that's one of the biggest problems to get an honest competition." — Expert 1 Rob van Willigen (ABN AMRO)*

> *2)" The solution for that, in my mind, is to balance or maybe add up the financial costs for the transport of the containers and add the environmental costs. Because you pay X amount for the transportation of the units, but you pay far more for the environmental costs. They don't charge you, but if they would charge it to you, you would never to do it. — Expert 2 Mark van Ommen (TNO)*

6.3 Reasons to use a PSS as a real estate owner (Drivers/Advantages)

Achieve long-term cost savings

When discussing the potential of long-term cost savings, Expert 2 noted that it is imperative to consider who is capturing the financial value, and when. The value can be captured by either the Housing Provider, PSS Provider, or resident, or perhaps all three collectively. Additionally, long-term cost savings can be created by the residual value of the PSS at the end of its contract period. When preventative maintenance is performed to preserve the product's residual value, the PSS can be offered to the HP for a reduced amount, therefore creating cost savings for the HP.

> *"1) And it's really good to keep in mind, but from what perspective are you looking at the topic? Are you from the building owner, from the supplier, from the tenant? So, who, can grasp what value, when? [...] And it has residual value, financial value, that could be 50%. So, you don't write it down. Maybe accounting wise you write it down to zero. Because accountancy, we need to talk about that as well. But he doesn't write it off in his mind. And in his books, he writes it down to 50%. Because after 20 years, it's still 50% of the value. And that's a financial trigger for him to offer you a really good deal on the elevator." — Expert 2 Mark van Ommen (TNO)*

Outsource risk and responsibilities

Similar to the case studies, PSSs are used in order to outsource risk and responsibilities, and in order to guarantee that desired performance or utility will be delivers at all times. Counter to the benefit of long-term cost savings, Expert 4 stated that consumers are willing to pay a premium to diminish risk. Expert 5 noted that and advantage of using a PSS is that it allows a company to focus on their core business.

> *"So, in other words, if I tell people, "hey, by paying 50 euros a month, I take away your problem. From that moment on, you don't have to worry about the camera anymore,*

there will always be a camera, and it's always working". Because, apart from this money thing, we added the fact that we monitor the cameras. So basically, every day, 24/7, we make sure that the cameras working and that you get the image you want. [...] So, people, if I tell them what we work with, they say I can buy that easily at one of the convenience stores or the building supply markets, whatever. It's much cheaper money. I say it's true. But be aware, if you spend 1000 euros now. And next year, you have to spend another 1000, and you don't know if it's working, etc., etc. You're better off paying me on a monthly fee, which is of course at the end of the 60 months, you paid more than the cheap set you bought at the store." — Expert 4 Rick Ruisch (Een Veilig Gevoel)

"They just want to do their core business. And whenever they can switch from capital expenditures to operational expenditures, and they just pay us a lease fee. Then they, yeah, of course, they have more time to focus on their core business and to do what they're good at and what they're supposed to do of course. So, in that way, it's a big win for customers as well, in my opinion. And yeah, as I said before, it's just a part of carefree services, actually. You just want to use it. And you don't have to own it necessarily." — Expert 5 Jeroen Reumkens (Volantis)

Accomplish (more) scope without capital

Experts 2 and 4 stated that, since many PSSs do not require any down payment, it allows businesses to accomplish more scope without necessary capital. If enough CAPEX value was to be removed from a development, it could even allow a real estate owner to purchase additional properties and thus expand their portfolios.

1)" If you don't have to buy the facade, but pay a monthly fee, depending on your own financial situation, as a real estate owner, or investor. What do you have your own cash position? Do you finance it by your own account? Or is it an investor or a bank, etc.? Together with the current interest rate? That's really important factor as well. So, if you would lease the facade and use that money to buy another building, then you make good use of it. [...] Take that money, use that money to buy the building next door." — Expert 2 Mark van Ommen (TNO)

"With less money, you can do more. So basically, if you're a builder, you can build more buildings if you don't spend money on all the things you can outsource. So, the possibilities for the builders, is of course, to own more buildings with less money." — Expert 4 Rick Ruisch (Een Veilig Gevoel)

Prepare for changing regulations (CO2 taxes on the horizon)

Two experts (1,2) stated that the use of PSSs will allow existing businesses to prepare for upcoming Dutch tax regulations that will penalize CO2 emissions. The use of a circular PSS, based on its reduced tax liability, will benefit both producers of products, such as facades and elevators, as well as the real estate organizations who use such products.

1) "The Dutch government signed to be circular in 2050. We signed this contract, like most of the countries in Europe, because a lot of primary raw materials are ending worldwide. So, this is, of course, the main reason, and so when you are prepared before legislation will come, because I think it will come, when you are prepared as a company, you're are a step forward." — Expert 1 Rob van Willigen (ABN AMRO)

2)" So that's another trigger, another motivation to use this model, to avoid taxes on CO2. [...] he wants you, as a customer, as a real estate owner, I want you as my customers. So, I want to make it as attractive as possible for me to install the facade on your building. [...] You will avoid these taxes as well, for the major part. So that's an important trigger, what will happen in the near future for these Product- as-a-Service providers [...] And then comes the CO2 taxes within the next couple of years. And that's going to be a very good driver, and it will speed up things." — Expert 2 Mark van Ommen (TNO)

Enhance portfolio circularity

For real estate organizations who aim to reduce the CO2 footprint of their organization, Expert 2 stated that the use of a PSS can help achieve significant savings. The idea being that, when the PSSP retains ownership of their products, they will be incentivized to maximize material reuse to minimize the need to purchase more raw materials.

> *1) "We do a lot of work for Rijkswaterstaat. And they are now into tendering roads for companies for them to install, but also keep ownership, do their maintenance, and remove it in 15 years, because that's a bit of the normal and average lifespan of an asphalt road. And why do they do that? Because they want to create a better surface, a better product, both in functionality, safety for everyone, for you and me to drive on, and they want to have lower impact for the environment, because in 2030, they want to be without any waste and reduce 50% of CO2. So, because of these targets, they think about why do we need to buy roads? Why do we need a contractor? And why do we want to stay ownership? Because if the contractor does the roads, based on environmental costs indicators, he is then going to make sure that he is providing a very good road, being a very good house father to the road, and knows that after 15 years, he makes it in a way that he can take it back and reuse it 100%. So, there's a benefit for both." — Expert 2 Mark van Ommen (TNO)*

Enhance market appeal

Expert 2 also stated that the use of a PSS, and the incentives embedded within it, could lease to increased market appeal. Since the PSSP aims to retain as must residual value as possible, they are incentivized to provide a high-level of preventative maintenance which keeps the product looking new.

> *1)" Because the owner of the facade has an incentive to be really a good house father for his own facade. [...] And if you do that, you have a really good facade and building. The curb appeal, as the English say. The curb appeal is really high, is really good." — Expert 2 Mark van Ommen (TNO)*

Enhance flexibility

Expert 1 stated that, when PSS contracts reach their end, the real estate owner is afforded the flexibility to change service providers or upgrade to a better product without necessary investment costs.

> *1) "Because you have a contract - you don't own it. So, you can at the end of the contract, you can say: "I'm not quite happy with it, or it costs me a lot of energy still, so I want to switch to another brand." This is much easier than when you are the owner, of course. Because then you have a lot of costs. So sometimes flexibility may be also an advantage." — Expert 1 Rob van Willigen (ABN AMRO)*

6.4 Circular principles within PSSs

Product: slowing loops

The high-quality design of a product can maximize its lifespan, thus keeping the inherent raw materials in use for as long as possible.

> *"So, when you have a good product and you have a good design, etc. And you can rent it out for much longer periods, so you can earn more money. So that's also be an advantage." — Expert 1 Rob van Willigen (ABN AMRO)*

Product: closing loops

If a product is designed for disassembly from concept phase, Expert 5 noted that the raw materials can easily be retained when the product reaches its end of life.

> *"If we can design that installation from scratch, we can as well think about disassembly of the materials as well. — Expert 5 Jeroen Reumkens (Volantis)*

Business model: slowing loops

The exploitation of a product's residual value allows for prolonged value capture, as noted by Experts 2 and 3. When the products are maintained properly, they can be exploited multiple times with less costs than producing an entirely new product.

"We did the residual value calculation. [...] So, they come every year, every five years, every 10 years, a bunch come back, they refurbish, and they go out again. They really think about the design, about materials choices, about maintenance, in order to keep this residual value as high as possible, because that's their business model. And we did the calculation, and it was really good and surprising in a positive way, their residual value, how they go about it, so we can learn from them." — Expert 2 Mark van Ommen (TNO)

"Frans van Houten said 'I'm really intrigued by this business model, because it allows me to sell my product twice'. So, I think that's really capitalizing on the quality of your products and making sure that you are able to capitalize on the secondary or maybe even third market opportunities which are out there. — Expert 3 Sabine Oberhuber (Turntoo)

Business model: closing loops

A PSS also have the ability to make use of residual outputs from either its own processes, or those of other companies. This can result in the use of secondary materials which again reduce production costs and the need for continued resource extraction.

"And it is also sometimes also cheaper because you are using secondary raw materials. Actually, your own products who are getting back to you. And sometimes, not always, but sometimes it's cheaper than buying new primary raw materials. And, when the raw materials are scarce, it will be more expensive, the primary raw materials and so when you get your own materials back, you can use them instead of buying scarce materials. So, this is also an advantage." — Expert 1 Rob van Willigen (ABN AMRO)

6.5 PSS prerequisites

Expert 3 doubts that PSS value propositions will be applied to all products within a building, noting that the level of service required, or perhaps the rate of replacement, makes some product more applicable than others. For products that require no service and last a long time, perhaps ownership remains a better procurement model.

"I'm doubting whether they are being applied to everything which is really part of the building. So, facades, well every elevator maybe because there's still a huge service element because I think, also a question, where does it make sense and in which part of the building do you have really a service element? So, when it comes to leasing walls as a service, or bricks as a service. I don't think it really makes sense. [...] And I think that also a time element to it. So, there is something like either innovation or tear or whatsoever. [...] Everything which I'm using and which I know is influenced by technology, by innovation, by tear and wear, which is a sort of technical device, that I don't have any emotional attachment for, that's perfect for as-a-service." — Expert 3 Sabine Oberhuber (Turntoo)

6.6 PSS impact on building value

Several experts (1,2,3) noted that it remains unknown how a building's value will be impacted by the use of PSSs. Expert 1 noted that there is likely a difference in building valuation, as the tax liabilities associated with interest and deprecation will be different on a building that does not own all of its installations. Experts 2 and 3 noted that, while it still remains unknown, they believe that the use a PSSs within a building, due to their high degree of preventative maintenance and high-quality design and materials, may positively impact a building's overall valuation.

"What is the value of the building without all these installations? And that's a question I have no answer on because I didn't speak with an appraiser who can tell me what the value of a building is without all the installations, because they are renting them. And I don't know for sure if it is a disadvantage, because it could also be an advantage, of course. So, when you want to sell your building, you can also sell all the contracts, all the subscriptions together with it. [...] Instead of interest and depreciation, you have to pay the contracts and the subscription. [...] So, at the end,

maybe it's as cheap or as expensive? I don't know. But really, I think there is a tax difference between interest on a mortgage and a subscription model, of course." — Expert 1 Rob van Willigen (ABN AMRO)

"What I think, is that it will certainly not influence the value of your building negatively. So, it will probably be positive, because this facade you're talking about, this will be taken care of really, really good. Better than if you would own it yourself. Because the owner of the facade has an incentive to be really a good house father for his own facade. [...] And if you do that, you have a really good facade and building. The curb appeal, as the English say. The curb appeal is really high, is really good. It doesn't negatively affect your building. I would say the other way around, actually. [...] But on that topic, I think banks and accountancy firms need to make a couple of steps, because you're not we're not there yet." — Expert 2 Mark van Ommen (TNO)

"I would argue, yes, probably what you would have, instead of depreciations, you would have monthly or yearly bills for the use of the facade. So, probably, from a total cost of ownership perspective, this building is even cheaper to run, because it's made of better materials, higher quality. So probably, I would assume that the quality of the building would be higher, enhance the value." — Expert 3 Sabine Oberhuber (Turntoo)

6.7 Additional Observations

Future owners

Expert 1 stated that the sale/purchase of building with long-term PSS contracts in place should not serve as an issue, as the concept of chain liability is commonly used in business-to-business transactions.

"In the business to business there is a chain liability, do you know what I mean? So when you for instance, when you have a BV, with a building in it, on the balance sheet, and you sell your BV, so you sell your limited with your building on the balance sheet, then all the contracts are going on, are doesn't stop when you sell your entity. In Dutch it's called "ketenaansprakelijkheid". So, chain liability, it's called. So, all the contracts, also rent the contracts are going on. They don't they don't stop when you sell your property. [...] So, all the contracts, all the subscription models you have for your installations, they automatically go to the new owner." — Expert 1 Rob van Willigen (ABN AMRO)

6.8 Current status of PSSs within the market

Market share

Expert 1 stated that currently PSSs only comprise a small share of the overall market of products being offered to consumers, as most products are still purchased instead of leased.

"It's very small, the market is very small for this kind of products, and I think the coming years, it will grow very fast. But it would be still a very small part of the total market within the coming years. Maybe when the government starts with regulation from Europe or from the Dutch government, then it will increase. But until that time, I think it will only be the companies that want to be circular or the companies who can start a very good earning model." — Expert 1 Rob van Willigen (ABN AMRO)

6.9 Future of PSSs

Growth potential

Once legislation is in place to tax transportation CO2 emissions and raw material extraction, the PSS business model will become more and more widespread. This will be further fueled by businesses that realize they can capture prolonged value by converting to a leasing model. PSSs have been seen to grow in size, as now facades and roads are being offered as-a-service, showing that the scale of the product is not necessarily an issue. Additionally, PSSs will likely continue to grow in unison with expensive equipment, since the as-a-service proposition eliminates the need for investment capital.

"It's depending on the legislation will come and financing solutions. Because when those two problems are tackled, then it can be the huge, the market in the future." — Expert 1 Rob van Willigen (ABN AMRO)

"It's a hard topic, the future, right? When you look in perspective, it started with small things, physically, and then it became bigger and bigger, and now facades and what have you, and roads, you know, a lot of square meters, a lot of cubic meters, etc. So, it points towards bigger and heavier, not only physically, but also maybe geographically? I don't know. I really don't know. But looking back, you can learn. So, this gaining momentum will lead to more and wider and broader but also in different domains." — Expert 2 Mark van Ommen (TNO)

"What I absolutely believe in is that product-service-systems will be around for capital goods and for more expensive equipment. I do see that it makes absolutely sense to have that." — Expert 3 Sabine Oberhuber (Turntoo)

5.8 Conclusions from expert study

The expert study corroborated the findings from the case studies and helped establish a deeper understanding of PSSs within a larger context, with a higher degree of abstraction. The growing trends of access over ownership, enhancing circularity while capturing value, evolving business models, and the internet of things are all enabling and driving the growth of PSSs within multiple sectors such as mobility, consumer goods, and even infrastructure. The largest barriers facing the growth of PSSs were found to be financing (residual value calculations and balance sheet extension) and a lack of government regulations which penalize CO2 emissions and linear economy business models.

The theoretical framework (figure 4.32) has been further developed to incorporate findings from the expert study. Similar to the demand + supply cases and the supply-only cases, the experts noted that PSSs could be advantageous to housing providers and real estate owners in general because PSSs can achieve long-term cost savings, reduce risk and responsibilities, allow scope to be accomplished without capital, and prepare for changing regulations, Additionally, the use of PSSs will allow HPs and real estate owners to enhance portfolio circularity, market appeal, and flexibility. The experts also stated that when a PSS is constructed properly, it can achieve all four principles of circularity Bocken et al., 2016).

One expert noted that all building elements are likely not suitable for a PSS value proposition, especially those that have minimal service requirements and long lifespans.

When considering the impact of a PSS on a building's overall asset value, three experts believe that the use of PSSs will enhance and preserve asset value, due to the PSSPs delivery of exceptional preventative maintenance. One expert, however, did make note of the tax benefits of ownership vs leasing.

Additional findings form the expert study include the use of "chain-liability" (ketenaansprakelijkheid) should allow for the easy transfer of PSS contracts from one building owner to the next during sale/ purchase.

The experts noted that PSSs currently only comprise a small market share when compared with the traditional means of purchasing a product outright. When considering the future of PSSs, several experts noted that once CO2 taxes are established by national governments, PSSs will grow in popularity and prevalence.

PSSs in Rental Housing

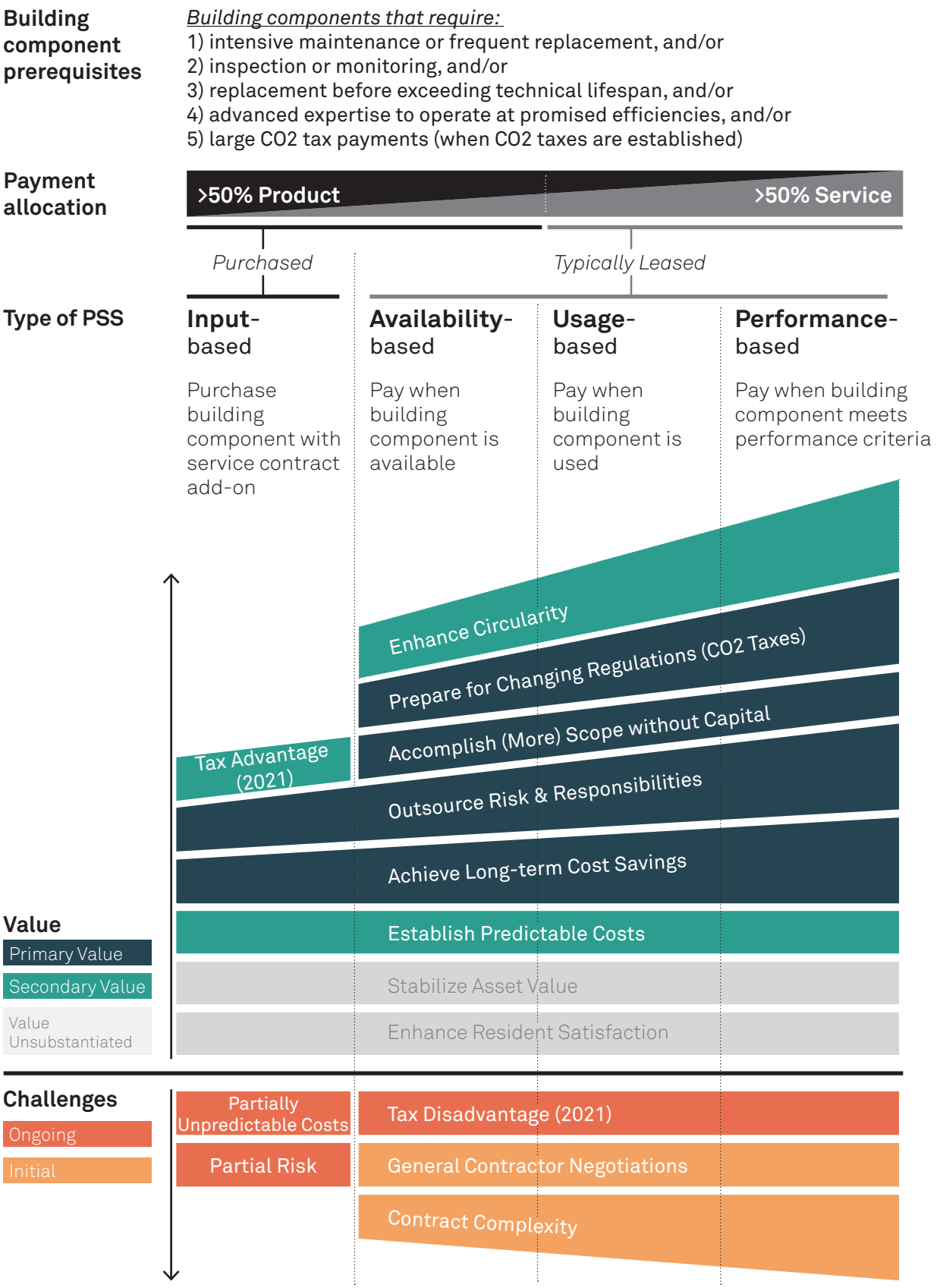
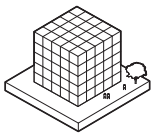
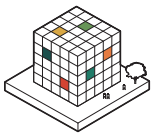


Fig. 4.32
Theoretical Framework adjusted based on findings from Expert Study, own figure.

7. Financial Simulation

The financial implications of leasing are explored through a simulated discounted cash flow (DCF) model.

All Scenarios: €10 million building is constructed

		 0% PSS	 10% PSS	 20% PSS	 30% PSS	 40% PSS	 50% PSS
CAPEX Investment		€10m	€9m	€8m	€7m	€6m	€5m
OPEX Increase (Net Present Value)	**TCU/TCO**						
	1.0 0% savings	-	€1.00m	€2m	€3m	€4m	€5m
	.75 25% savings	-	€.75m	€1.5m	€2.25m	€3m	€3.75m
	.50 50% savings	-	€.50m	€1m	€1.5m	€2m	€2.5m

15 iterations

Fig. 4.33
Traditional building with no PSSs compared with 15 iterations of an identical physical building.

7.1 PSS Impacts on Asset Value

Findings from the empirical research, especially the expert study, highlight that it is still too early in the development and implementation of PSSs to understand how a building's asset value will be impacted. An understanding may only be possible retrospectively, as there are many factors at play, such as which specific building components are being procured as PSSs, the quality of the preventative maintenance provided by the service provider, and whether or not the PSS has a direct impact on the building's market appeal from the perspective of its users (ex: futurist facade vs heat pump). Despite the unknown impacts, many experts believe that the use of PSSs will positively impact a building's asset value since they theoretically facilitate the continuous replacement of faulty components with those that are new.

Expert 1, Rob van Willigen of ABN AMRO, made note that since PSSs imply leasing instead of purchasing building components, there will be an impact on the tax liability of the building owner. This is because the building components procured as a PSS will not be depreciable, nor will the financing interest for the components be tax deductible. As such, the operational research aims to gain clarity into the tax implications of using PSSs within a building.

7.2 Financial Model

The operational research uses a simplified model in which a traditional building (no PSSs) is compared with 15 iterations of itself that use a variable amount of PSSs. All PSSs in the model are considered to have zero-upfront investment, meaning that investment CAPEX costs are moved to operational OPEX costs and spread over the 15-year model. The model compares a traditional building (0% PSS) with identical versions that are 10, 20, 30, 40, and 50% comprised of PSSs. The percentages are not tied to specific building components, however for example, 10% could represent the building's envelope and 20% could represent the building's envelop and mechanical systems. Such percentages are seen in the x-axis of figures 4.33 – 4.36.

The traditional building, or baseline for the model, sits upon a €3 million piece of land, and costs €10 million to construct, resulting in €13 million total. Market-rate (non-social) housing is using in the simulation with an income tax and capital gain tax rates of 25%, as set by 2021 Netherlands corporate tax law (GreenbergTraurig, 2020). The building is depreciated over a period of 30 years, at which point is has a 50% residual value.

The benchmark building has 0% of its €10 million construction costs procured as a PSS and includes hypothetical OPEX costs. For all the other scenarios, a % of the €10 million has been reduced from the upfront investment costs and moved to annual OPEX costs with an equivalent Net Present Value (NPV). For example, if the building is 10% PSS, it means it cost €9 million to construct [€10 million * (1-10%)], as 90% of the construction was purchased in a traditional manner. The construction cost scenarios can be seen in figure 4.36, and the equity investments vs building net present values can be seen in figure 4.35.

Additionally, when a percentage of a building is procured via a PSS, for example 10%, the equivalent percentage of OPEX costs (10%) are deducted from the owner's traditional OPEX costs and applied to

the PSS operating costs. By doing so, the scenario of Total Cost of Ownership (TCO) is equal to Total Cost of Use (TCU). This scenario is considered TCU/TCO = 1.0.

As PSSs are used to achieve long-term cost savings based on their optimized operation and exploitation of residual value, a variable ratio of TCU/TCO is utilized. These scenarios can be seen in the additional lines of figure 4.34 which show scenarios of TCU=0.75 and TCU=0.50 of TCO.

As evidenced by figure 4.34, based on after-tax net equity cashflows, the use of PSSs with TCU=1.0 of TCO results in a reduced Internal Rate of Return (IRR). The more a building is procured via PSSs, or the higher percentage of PSSs used, the larger the impact on the buildings IRR. It is also evident that if a PSS can achieve a cost reduction of 50% (TCU/TCO = 0.5), it will positively impact a building's IRR. Based on the study, a TCU/TCO ratio of approximately 0.61 (39% cost savings) retains the building's IRR equal with that of the benchmark building with 0% PSS.

7.3 Conclusions from financial simulation

While the model only simulates a single market-rate (non-social) rental housing building development and is by no means representative of all rental housing developments, it does illustrate the substantial tax benefits of ownership in the context of the Netherlands. The findings imply that a building's IRR will be positively impacted when TCU savings are approximately 39% or more (TCU/TCO is less than 0.61). While the IRR may be reduced if TCU savings are less than 39%, the additional benefits of reducing risk and responsibilities, accomplishing construction scope without capital, and establishing predictable long-term costs have not been accounted for.

Such findings support the reasoning of the HP in Case B who used a 5-year lease-to-own financing structure to initially accomplish construction scope without capital, yet after 5 years of payments, have the kitchens on their balance sheet to capitalize on tax depreciation.

The tax implications should be reevaluated when CO2 taxes are established by the national government and a circular low carbon PSS is used. In such a scenario, it is likely that a circular PSS will positively impact a building's value.

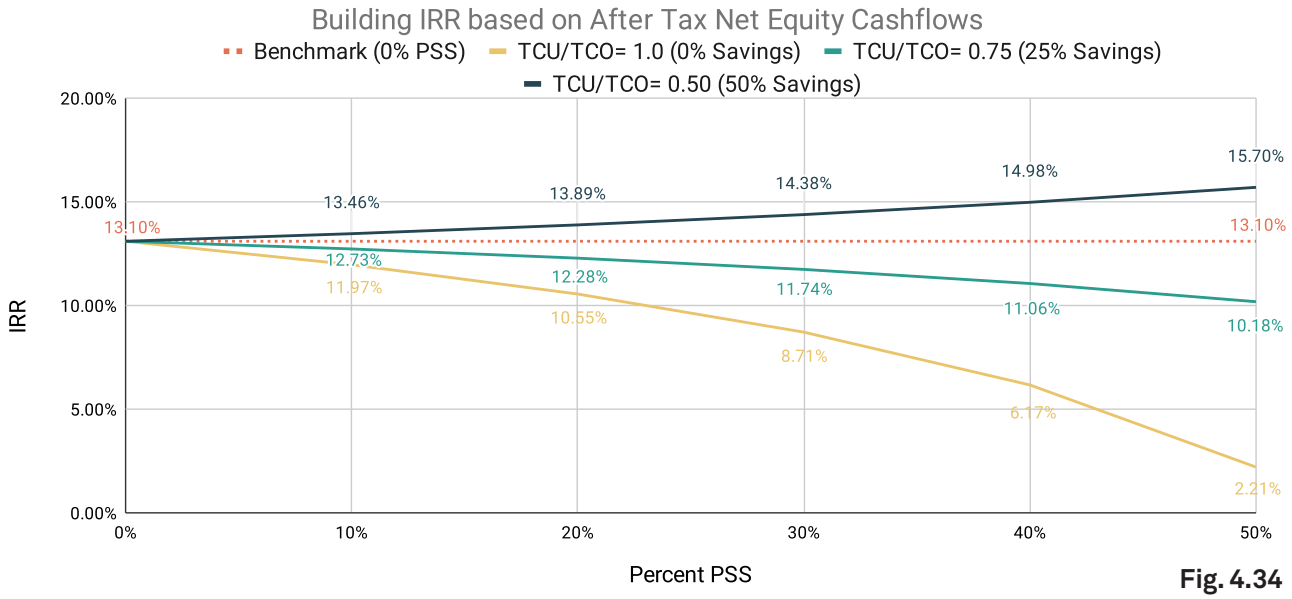


Fig. 4.34
Building IRRs, own figure.

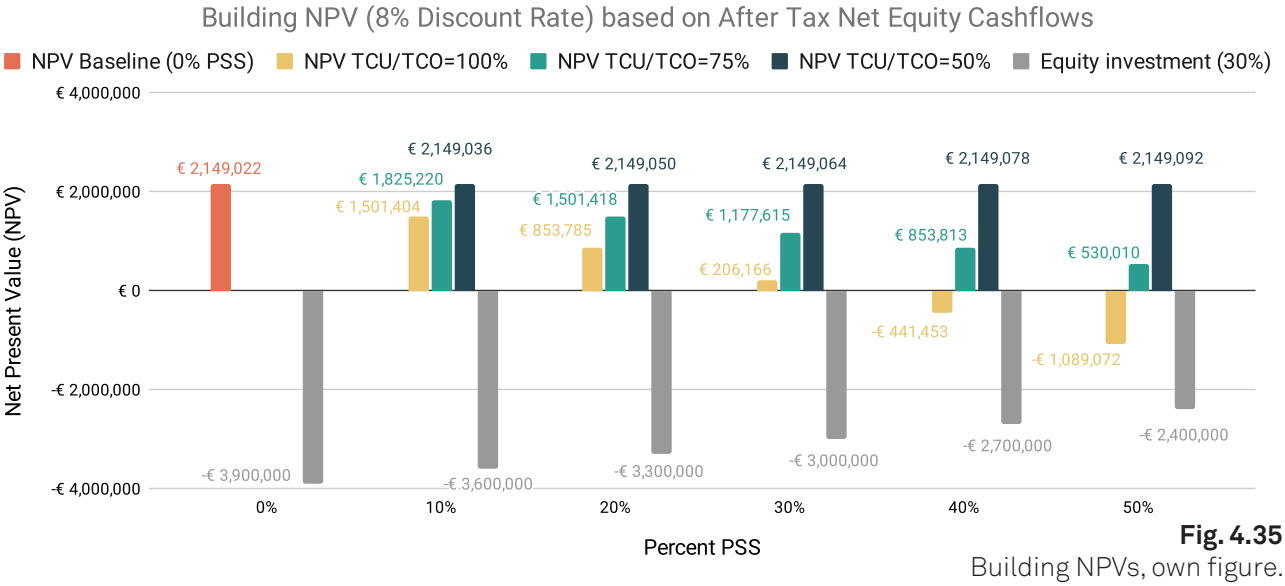


Fig. 4.35
Building NPVs, own figure.

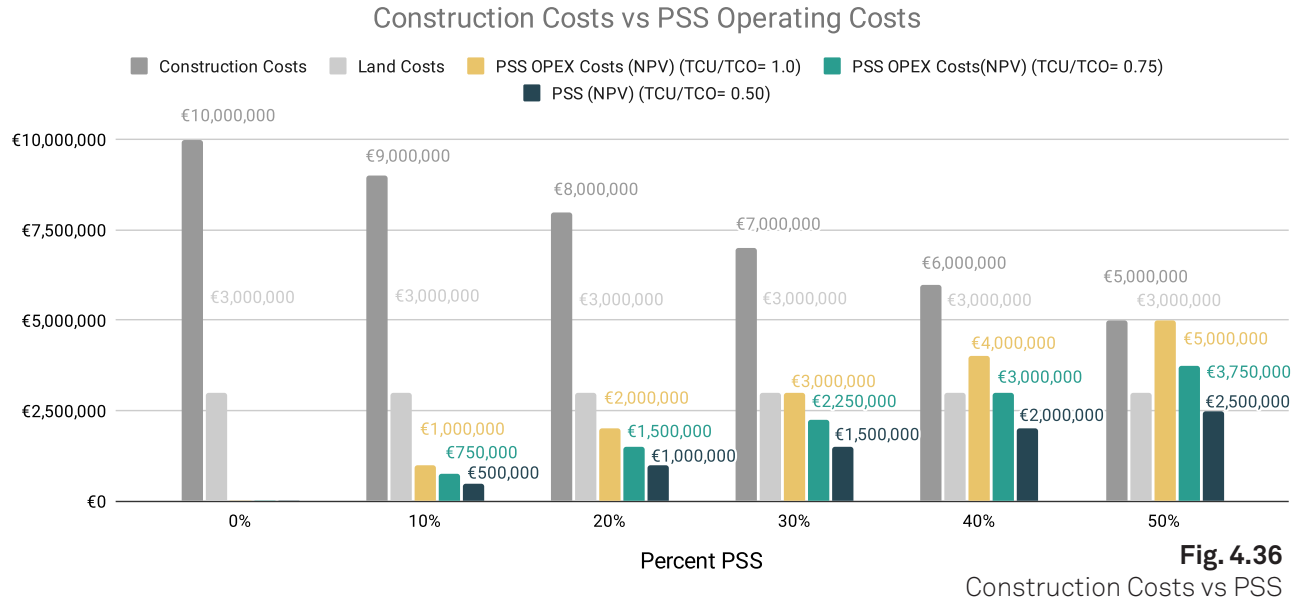


Fig. 4.36
Construction Costs vs PSS Operating Costs, own figure.

05
Discussion & Recommendations

1. Discussion

The findings from the research are offered in comparison with the theory established in Chapter 2, as seen in figure 5.01.

Primary drivers for a Housing Provider to use a PSS

The findings from the case studies establish which advantages of PSSs drive HPs to use them. Based on theory, many advantages could be identified, but no theory specifically highlighted which advantages of PSSs would be most valued by HPs. Congruent with theory, HPs use PSSs to achieve long-term cost savings (Blüher et al., 2020), outsource risk and responsibilities to PSSPs (Reim et al., 2016), and to accomplish project scope without capital (Azcarate-Aguerre et al., 2017). Lastly, a single HP chose to use a PSS to prepare themselves for upcoming CO2 tax regulations, which was an emergent finding. Findings imply that HPs primarily derive value from PSSs primary though enhanced financial performance and an unburdening of risk and responsibilities.

Secondary advantages for HP when using a PSS

HPs identified other secondary advantages of using PSSs. Similar to above, no theory specifically identified what advantages of PSSs would be secondarily valued by HPs. Congruent with theory, HPs found secondary value in PSSs which enhance circularity in their buildings by demonstrating circular principles (Bocken et al., 2016), those which enhance market appeal (Gielingh et al., 2008), and those which establish long-term predictable costs (Pereira et al., 2019). Emergent finding were that HPs find value in PSSs which can enhance a building's future physical and financial flexibility. These findings imply that HPs view the physical and sustainable nature of PSSs as secondary advantages.

Incorrect assumptions

When constructing the theoretical framework, two potential drivers/advantages of a PSS were identified, yet they were not reinforced during the empirical research. Firstly, HPs do not choose PSSs based on their ability to enhance resident satisfaction. While the use of a PSS may benefit the resident, such as an elevator having a higher guaranteed up-time, such benefits were not considered drivers to use a PSS, nor mentioned as secondary advantages. Additionally, the use of a PSS, theoretically, is able to stabilize a building's asset value, since the continual maintenance and replacement of faulty components keeps a building functioning and looking "new" (Gielingh et al., 2008). However, experts noted that it is still too early to know how the use of PSSs will impact a building's asset value.

How HPs analyze the use of a PSS

When making the decision to use a PSS, congruent with theory (Coalition Circular Accounting, 2020), HPs primarily focus on financial comparisons of Total cost of Ownership (TCO) vs Total Cost of Use (TCU), and conducted financial comparisons by reviewing historic or forecasted portfolio costs (A. F. Thomsen & Straub, 2018). While speculated, an emergent finding was that HPs support their decisions making through risk assessments. Other emergent findings include 1) when possible, HPs review historic service records to gain confidence in the PSSP and their value proposition, 2) when applicable, HPs review the impact of a long-term PSS contract on resident service costs and future building demands and operations, and 3) HPs review the end-of-use scenarios, either when the contract reaches its end, or should the HP desire to end the contract early.

Challenges faced when using a PSS

Based on theory, challenges regarding contract complexity (Reim et al., 2015) and general contractor negotiations (Lingegård, 2010). Emergent findings were that HPs faced challenges with 1) a lack of trust in the PSSP's ability to deliver the promised value proposition, 2) unclear demarcation between the product and required infrastructure, 3) product and 4) contract inflexibility, 5) dissatisfactory service, and 6) gaps in service coverage which result in unpredictable costs.

Circular principles within PSS

Congruent with theory, not all PSSs are inherently circular (Blüher et al., 2020; Tukker & Tischner, 2006), as exemplified by the cases. PSSs specifically designed to be circular displayed the most circular principles (Bocken et al., 2016), while those using "off-the-shelf" products displayed the lease.

PSSP incentives

Based on the case studies, clear incentives for PSSPs to deliver continuous satisfactory service for the duration of the contract were identified. These are emergent findings and compliment the framework of van Ostaeyen (2013). add to the value offered to HPs.

PSS Prerequisites

Congruent with theory, building components which require high levels of service or maintenance (Kim et al., 2016), frequent inspections or monitoring (Raposo et al., 2013), or replacement before exceeding their technical lifespan (A. F. Thomsen & Straub, 2018; TU Delft, 2020) are fitting for a PSS value proposition. Emergent findings were that building components may be fitting for PSS value propositions when they are 1) highly innovative (PV panels, batteries) and require technical expertise to operate at promised efficiencies, or 2) when CO2 taxes reach their maturity, bear exceptionally high CO2 tax liabilities.

PSS impacts on asset value

Despite theory claiming that PSSs will benefit a building's asset value (Gielingh et al., 2008), it is still too early to know how if this is true or not. Several experts noted that it will likely be improved due to a PSS's preventative maintenance and frequent replacement of faulty parts, and thus improved functionality and "curb appeal". One expert (Expert 1 Rob van Willigen (ABN AMRO)) made note that there is likely a tax disadvantage associated with PSSs, as interest and depreciation can no longer be used to reduce a HP's tax liability, which was an emergent finding. The financial simulation revealed the significant tax advantage of leasing building components in market-rate (non-social) housing developments.

Additional Findings

Congruent with theory, value co-creation (Ng et al., 2010) was evident between HP and PSSP, especially when it came to financial transparency and finding beneficial solutions for both parties. Emergent findings include 1) while the use of 24/7 monitoring and data collection assists the PSSP with dynamic preventative maintenance and remote operation, it could potentially lead to privacy issues, especially when the PSS is resident specific. 2) the use of "chain liability" (ketenaansprakelijkheid) enables businesses, such as property specific entities, to take over pre-existing long-term contracts, even then the building changes ownership. Lastly, 3) the term "lease" was found to bear negative connotations form the perspective of HPs, thus PSSPs use the terminology of "Product-as-a-Service (PaaS) and "usage-contracts".

Theme	Code	Origin
Context	Building	-
	Housing Provider	-
	PSS Provider	-
Drivers/ Advantages of using a PSS	Advantage - Strategic - Enhance Market Appeal	Theory
	Advantage - Strategic - Outsource Risk and Responsibilities	Theory
	Advantage - Strategic - Prepare for Changing Regulations	Emergent
	Advantage - Functional - Enhance Resident Satisfaction	Theory
	Advantage - Financial - Achieve Long-term Cost Savings	Theory
	Advantage - Financial -Accomplish (More) Scope without Capital	Theory
	Advantage - Financial -Establish Predictable Costs	Theory
	Advantage - Financial -Stabilize Asset Value	Theory
	Advantage - Physical - Enhance Circularity	Theory
	Advantage - Physical - Enhance Flexibility	Emergent
Analysis Type	Analysis - Financial	Theory
	Analysis - Risk and Responsibilities	Emergent
	Analysis - PSSP Historic Service Performance	Emergent
	Analysis - Impacts on Resident Service Costs	Emergent
	Analysis - Impacts on Future Building Operations	Emergent
	Analysis - End-of-use Scenarios	Emergent
Challenges	Challenge - Contract Complexity	Theory
	Challenge - Lack of Confidence in PSS/PSSP	Emergent
	Challenge - Demarcation of PSS	Theory
	Challenge - PSS Impact on General Contractor Profit	Theory
	Challenge - Product Inflexibility	Emergent
	Challenge - Contract Inflexibility	Emergent
	Challenge - Dissatisfactory Service	Emergent
	Challenge - Incomplete Service Coverage	Emergent
	Challenge - Tax disadvantage of leasing	Emergent
Circular Principles	Circular - Product: Slowing Loops	Theory
	Circular - Product: Closing Loops	Theory
	Circular - Business Model: Slowing Loops	Theory
	Circular - Business Model: Closing Loops	Theory

Fig. 5.01
List of Codes used in ATLAS.ti

2. Recommendations

Recommendations for housing providers and real estate owners have been formulated regarding the use of PSSs within a building or portfolio.

Define core business versus auxiliary tasks

Housing providers should re-consider which service-related tasks are associated with their core business, and which are considered auxiliary in order to identify what can potentially be outsourced. Housing providers may consider outsourcing maintenance on building components that require frequent service or replacement, those that require annual inspections and monitoring, those that require replacement before exceeding their technical lifespan due to outdated aesthetics, and those that require advanced technical expertise to achieve the product's optimized performance.

Establish TCO costs

For the building components meeting the above criteria, housing providers should review and establish historic portfolio management costs from a total cost of ownership perspective, which includes all investment, ongoing maintenance, replacement, disposal, insurance, and personnel costs per building element/system. Without a strong understanding of building component TCO costs, it is difficult to gauge if a PSS is financially advantageous. With quantitative data at hand, the Net Present Value (NPV) of a multi-year PSS agreement (TCU) can easily be compared with the organization's Total Cost of Ownership (TCO) for the building component.

Scan the market for as-a-Service offerings

With a good sense of TCO costs and a clear delineation of core business- vs auxiliary-tasks, housing providers can begin scanning the market for potentially suitable as-a-service offerings.

Consider what additional scope can be accomplished through leasing

Based on the quantity and investment value of the building components, HP's can potentially use leased PSSs to free up substantial capital at a building and portfolio level. Such capital could be allocated towards additional scope, such as extra homes, or used to accomplish sustainability scope (ex: insulation) in light of evolving regulatory building performance requirements.

Don't over burden the residents

When using a leased PSS, HPs must establish if recurring service costs will be carried by the HP, the resident, or a combination of both. Thus, while a zero-upfront investment PSS may be appealing in the present, it may create vacancy issues in the future if resident service costs are inflated beyond market-acceptable standards.

Assess the PSSP's incentives to deliver high-quality service

HPs should consider what incentives the PSSP has to deliver high-quality and timely services, and make note of the payment structure of the PSS, any guarantees provided, and any penalties for the PSSP when dissatisfactory service is delivered. HPs will likely receive better quality service in the order of input-, availability-, usage-, or performance-based contracts. Also, the quality of the service will likely be higher when initial investments are reduced.

Talk to the Legal Team

Based on the nature of a PSS and its potential reversal of ownership, PSS contracts may be complex and time consuming, at least during their initial use. As such, HPs should involve their legal team early on to make sure the contract is well-balanced regarding risk and reward. Once the contract is established, it should be easy to duplicate in future projects.

Talk to the General Contractor

When using a leased PSS, HPs become the contracting party for a scope item that typically would fall under the responsibility of the general contractor (GC). As such, the use of a leased PSS should proportionally reduce their profit margins on the project. However, the GC will likely still carry some coordination and site-logistics costs regarding the PSS. Therefore, HPs should communicate with GCs to make sure they are not paying for things twice, as their in-house personal is now managing some of what used to be the contractor's work.

Be aware of coming CO2 taxes

While no definitive date has been established, experts in the Netherlands believe CO2 taxes will be implemented within the next decade. When in place, it will be advantageous to use PSSs which embody circular principles, as they will offer reduced tax liabilities to both the housing provider and PSS provider. If a PSS is not designed for disassembly and does not make use of circular inputs, if may have very little tax benefits.

Consider end-of-life scenarios, but remain flexible

When discussing long-term contracts for 10+ years, HPs and PSSPs should consider what will happen at the end of the contract, as well as what will happen if the contract is ended prematurely. For scenarios in the future, it may be best to remain flexible by identifying how the situation will be resolved (analysis or advice from third parties), rather than what the exact resolutions will be.

06
Conclusion

1. Conclusion of the Research

The sub questions will be answered before answering the main research question.

Q1) What is a PSS?

A PSS, based on theory, is any combination of products and services that together deliver the user a desired solution (Mont, 2004). The ambition of delivering solutions over mere products and services is best illustrated by the quote "people do not need cars and washing machines, but mobility and clean clothes" (Meijkamp, 1998). PSSs in practice can take shape in various forms; the product can be sold in combination with supplemental services, or the product can be rented or leased to a user who utilizes it without becoming the owner (Tukker, 2004; van Ostaeyen et al., 2013).

Leased PSSs, or those in which products are not sold to customers but instead remain under the ownership of manufacturers or service providers, are considered to have the highest potential for circularity. When PSS providers (PSSPs) consider their products assets instead of goods, they are incentivized to minimize operational costs associated with parts and labor while simultaneously maximizing the lifespan of their products (van Ostaeyen et al., 2013). Additionally, PSSPs are incentivized to exploit the residual value of their assets, which often leads to the remanufacturing of used products so they may be used again. When configured properly, PSSs can thus decouple economic growth from continued resource consumption and assist the transition from a linear economy to one that is circular in nature (Ellen MacArthur Foundation, 2013; Lacy et al., 2014).

To think that all PSSs are inherently circular and environmentally beneficial is unfortunately not true (Blüher et al., 2020; Tukker & Tischner, 2006). If a PSS is not designed for disassembly, nor does it make use of circular inputs, it inherently relies on the continued extraction of raw material that must be extracted, transported, and manufactured - all of which has environmental consequences. A truly circular PSS relies on the cooperation of various supply-chain actors during production, use, and reverse logistics (Böhm et al., 2017; Windahl & Lakemond, 2006; Xing et al., 2013).

Q2) How can PSSs be applied in rental housing?

A housing provider (HP) can procure a PSS in one of four ways (input-, availability-, usage-, or performance-based), as either a purchased or leased PSS (van Ostaeyen et al., 2013). The PSS type is based on how the majority of payment value is delivered to the PSSP during the contract duration, meaning ownership does not necessarily determine the type of PSS (van Ostaeyen et al., 2013). First, HPs may use an input-based PSS contract to purchase a product with a supplemental service contract (ex: purchasing a heat pump with an annual inspection and maintenance contract). In input-based PSSs, the majority of payment is associated with the purchasing of the product. Second, they may use an availability-based PSS, typically in the form of a lease, to pay for the PSS to be available in their building (ex: leasing a kitchen and paying for it to be available, independent of how much it is used). Third, they may use a usage-based PSS, typically in the form of a lease, to pay per use of the PSS (ex: leasing an elevator and paying based on the total annual vertical distance traveled). And fourth, they may use a performance-based PSS, typically in the form of a lease, to pay for the PSS only when performance criteria are met (ex: lease an integrated solution of heating, cooling, ventilation, and building envelope, and paying based on the amount of time a comfortable indoor environment is provided). Availability-, usage-, and performance-based PSSs can also be owned by the HP, although the majority of payment value must derive from service-rated costs. Each type of contract offers different payment structures and incentives for the PSS providers (PSSPs) to deliver quality service to the housing provider. In the order of input-, availability-, usage-, and performance-based, PSSs will increase in circularity (van Ostaeyen et al., 2013), increase in risk for the PSS provider (van Ostaeyen et al., 2013), increase in contract complexity (Reim et al., 2015), and decrease in contract standardization (Reim et al., 2015).

In theory, any product and complementary service can constitute a PSS, however there is an underlying logic regarding which products are most fitting for a PSS value proposition. Building components which require intensive maintenance or frequent replacement (Kim et al., 2016), and those that require recurring inspections or continuous monitoring (perhaps due to life-safety risks) (Raposo et al., 2013) are fitting for a PSS business model. Also, building components that are often replaced before they exceed their technical lifespan are fitting as a PSS (TU Delft, 2020). This is well illustrated by the fact that kitchens are often replaced far before the end of their useful life, simply because their outdated aesthetics reduce a building's ability to generate revenue. Findings from the empirical research also identified more criteria that may make some products more fitting than others as a PSS. Building components which are technologically innovative and require advanced expertise to achieve their promised operational efficiencies may lend themselves to a PSS value proposition. This is because housing providers (HPs) often outsource the expertise when it is not considered part of their core business (ex: operating a battery). Lastly, when CO2 taxes are established by governments, building components with exceptionally high CO2 footprints, and thus tax liabilities, may be good candidates for circular PSSs.

HPs should be aware of the legal concept of "accession", which states that components installed in a building become the property of the building owner when they cannot be removed without significantly damaging the rest of the building, or when the building would be considered incomplete without them. Due to accession, a building's structure cannot be procured as a leased PSS, as it cannot be removed without damaging the building. Other large building components, such as façades, HVAC and kitchens, can be offered as leased PSSs when designed in a modular, demountable manner. In such cases, PSS providers (PSSPs) may opt for a pair of contracts to be used to circumnavigate the legal concept of accession so they may retain legal ownership of the PSS. First, the building owner (HP) will rent suspension points to the PSSP, and secondly, the PSSP will deliver a contract for the HP to use their PSS (Coalition Circular Accounting, 2020).

HPs considering the sale or purchase of buildings with preexisting long-term PSS contracts should also be aware of the legal concept of "chain liability" (ketenaansprakelijkheid) which enables businesses, such as property specific entities, to transfer or take over PSS contracts. Based on interviews with experts and PSSPs, buildings can easily be purchased and sold without disturbing such contracts.

Experts noted that PSSs currently comprise only a small portion of the overall products and services sold on the market. While their market share is limited, the number of PSSs has grown over the last few years due to companies which aim to be circular by nature, or more commonly, due to companies which strengthen their profit margins by integrating products with services. Once CO2 emission tax regulations are established, experts believe the pervasiveness of PSSs, especially those which embrace circular principles, will substantially increase.

Q3) What are the drivers for housing providers to use PSSs?

Based on empirical research, HPs use PSS for several reasons, as seen in figure III. Firstly, HPs use purchased and leased PSSs to achieve long-term cost savings, which is congruent with theory. Cost savings can be achieved by PSSs with higher than usual operational efficiencies (Case studies D, F, G; battery, heat pump, PV panels), or by those with longer than usual lifespans (Cases B, E; kitchen, elevator) (Blüher et al., 2020). Also consistent with theory, HPs use PSSs to outsource risk and unburden themselves of the maintenance and operational responsibilities associated with specific building component (van Ostaeyen et al., 2013). By doing so, HPs can maintain focus on their core business and avoid hiring additional expertise in-house. HPs also use leased PSSs to accomplish project scope without capital. Since many leased PSSs require minimal- or zero-upfront investments, HPs can accomplish more scope than they can afford to purchase, which is especially helpful considering evolving

building energy performance requirements. Additionally, one HP (Case C) is using a circular PSS to prepare their organization for the inevitability of CO2 taxes. When CO2 taxes penalize transportation and raw material extraction, the HP can theoretically reduce their CO2 tax liability by using a locally based circular PSS. Other secondary advantages of using a PSS include establishing predictable costs and enhancing portfolio circularity.

Q4) What analysis do housing providers conduct before using a PSS?

HPs primarily conduct financial and risk analyses when considering the use of a PSS. Among leased PSSs, housing providers compare the Total Cost of Ownership (TCO) with the Total Cost of Use (TCU) for the specific building component during its lifespan, congruent with theory (Coalition Circular Accounting, 2020). Additionally, HPs consider the risk and responsibilities of ownership, and sometimes decide to use a leased PSS to diminish their risk profile, even when it is more financially beneficial to own the building component. When possible, HPs review the historic service performance of PSSPs. Lastly, and to a lesser extent, HPs consider the PSS's impact on resident service costs, impact on future building flexibility, and end-of-use- scenarios.

Q5) What challenges do housing providers face when using a PSS?

HP's often do not trust the PSSP's ability to deliver the promised value proposition pertaining to a leased PSS, as they find the combination of no initial investment and instant cost savings "too good to be true". HP's also faced challenges regarding the complexity of contracts when leasing building components for upwards of 40 years, which is consistent with theory (Reim et al., 2015). In several cases, HPs faced challenges regarding the unclear demarcation of what products and services are included in the PSS. HPs also faced challenges when serving as the contracting party for leased PSSs, as it results in negotiations to reduce the general contractor's scope and profit. One HP faced challenges regarding the inflexibility of a PSS to accommodate unique site conditions due to its very high degree of circularity. Lastly, the misalignment of incentives and lack of penalties for the PSSP in the Input-based PSS, due to the HP owning the product but the PSSP maintaining it, led to incomplete service coverage, unpredictable costs, and dissatisfactory service from the HPs perspective. Consistent with theory, input-based PSSs are those where the PSSP takes the least amount of risk, meaning the HP still has partial risk (van Ostaeyen et al., 2013).

Q6) What circular principles do market implemented PSSs exhibit?

Based on theory, the circular principles exhibited in each case should have increased in the order of input-, availability-, usage-, and performance-based PSSs (van Ostaeyen et al., 2013). However, this was not found to be true in practice, as the most circular cases were found to be availability- and usage-based PSSs, and the least circular cases were found to be input- and usage-based PSS. The cases studied displayed a wide range of circular principles, making clear that the circularity of each PSS must be studied individually. For a PSS to be circular, 1) the product must slow material loops by being designed to maximize its lifespan and 2) the product must close material loops by being designed for disassembly. Additionally, 3) the business model must slow material loops by exploiting the product's residual value after its initial use, and 4) the business model must close material loops by making use of circular material inputs in its products (Bocken et al., 2016). All four circular principles were exhibited in the cases. Based on the seven cases, circular principles increase in the following order from least exhibited to most exhibited: 1) business model closing loops, 2) product closing loops, 3) business model slowing loops, and 4) product slowing loops. The findings are consistent with theory which states that PSSs are not automatically synonymous with sustainability and circularity (Blüher et al., 2020; Tukker & Tischner, 2006).

Q7) How does the use of PSSs impact a building's asset value?

The impact of using PSSs on a building's value remains largely unknown. Theoretical research implies that PSSs will positively

impact a building's value, as they foster effective preventative maintenance and gradual replacement of faulty parts during their lifespan (Gielingh et al., 2008). The expert study supported this theory, however the experts noted that it is still too early in the development of PSSs in buildings to understand their actual impact. Variables such as the specific product and the quality of the service make it very difficult to anticipate the financial impacts of PSSs. One expert noted that there will be tax implications when leasing building components, thus leased PSSs were studied through a simulated financial model. The model simulates a specific market-rate (non-social) rental housing building development in the Netherlands and is by no means representative of all housing developments. The simulation found that, due to the tax disadvantages of leasing, leased PSSs must achieve a TCU savings of 39% or more, when compared with TCO, to be financially advantageous for a HP. Put another way, based on the financial simulation, the first 39% of cost savings associated with a leased PSS are negated by the tax disadvantage of leasing. Additionally, the more a building is comprised of leased PSSs, the larger the impact on the building's asset value either positively or negatively. The simplified simulation does not consider other advantages of using a leased PSS, such as reducing risk or accomplishing other construction scope without capital, which are difficult to quantify. Nonetheless, the simulation implies that real estate owners will opt to remain the owner of majority of their buildings to achieve advantageous investment returns and may only lease building components with the highest associated risk, or when leasing is the only way to make projects viable. Such findings support the reasoning of the HP in Case B who used a 5-year lease-to-own financing structure to initially accomplish construction scope without capital, yet after 5 years of payments, have the kitchens on their balance sheet to capitalize on tax depreciation. The tax implications should be reevaluated when CO2 taxes are established by the national government and a circular low carbon PSS is used. In such a scenario, it is likely that a circular PSS will positively impact a building's value.

Main Question:
"How can Product-Service-Systems (PSSs) offer value to housing providers?"

As the Netherlands national government aims for a circular economy by 2050, housing providers (HPs) simultaneously seek alternative procurement and maintenance methods to enhance the performance of their organizations, buildings, and portfolios. PSSs serve as a solution with the potential of increasing circularity in the built environment while offering value to HPs who procure them.

PSSs primarily offer HPs financial, risk management, and sustainability/circularity value. HPs can capture value by reducing their long-term costs and by outsourcing the risk, maintenance and operational responsibilities associated with specific building components. When leasing PSSs, housing providers can also outsource the financing of building components, enabling them to accomplish construction scope when capital is unavailable. The use of PSSs also can establish predictable costs and enhance portfolio circularity.

However, the value offered by a PSS is largely depended on the type of PSS used, as seen in figure 6.01. Based on the research, the value a PSS offers a HP increases in order of input-, availability-, usage-, and performance-based PSSs. This is particularly outstanding since the potential for circularity increases in the same order (van Ostaeyen et al., 2013), meaning the demand-oriented perspective for PSSs in rental housing supplements the realization of a circular economy. However, the volume of building components procurable by each contract type likely decreases in the same order, and not all building components are applicable to each contract type. Additionally, the value offered to HPs was found to increase as the proportion of service-related costs increase, assuming there are also penalties for the PSSP when dissatisfactory service is provided.

Although leased PSSs have higher circular potential than owned PSSs, Dutch commercial real estate tax incentivizes HPs to retain ownership of their building components while outsourcing the

PSSs in Rental Housing

Building component prerequisites

Building components that require:
1) intensive maintenance or frequent replacement, and/or
2) inspection or monitoring, and/or
3) replacement before exceeding technical lifespan, and/or
4) advanced expertise to operate at promised efficiencies, and/or
5) large CO2 tax payments (when CO2 taxes are established)

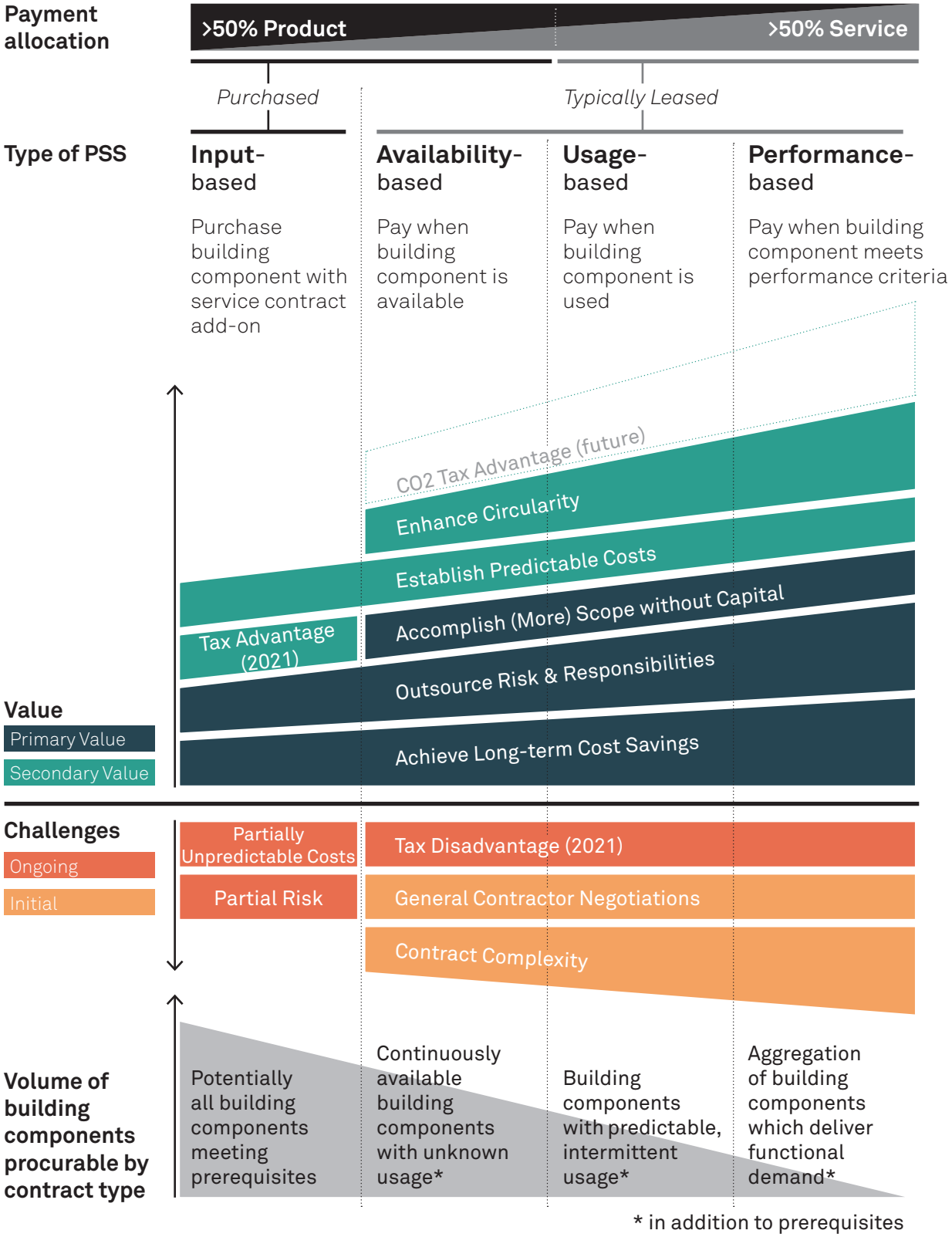


Fig. 6.01
Theoretical Framework based on theoretical and empirical research, own figure.

maintenance, operation, and risk. Thus, real estate owners will not procure entire buildings as leased PSSs since it is not financially feasible. Leased PSSs will likely remain a minority of how building components are procured, however they will become more commonplace as construction budgets are stressed by the energy transition, as technology advances, and as CO2 taxes are implemented. Leased PSSs contribute to achieving circularity in the built environment, with clear value from both supply + demand perspectives. To achieve circularity in the built environment, leased PSSs are part of the solution, however, building owners, in addition to PSS providers, must be incentivized to return materials to either technological or biological cycles. When CO2 taxes are established and reach their maturity, the leasing of circular PSSs with reduced tax liabilities may enhance the value of leasing PSSs. The value offered by each contract type is elaborated below.

While input-based PSSs have the tax advantages of ownership, they offer the least value to HPs. HPs using input-based PSSs still bear partial risk since they are the owner of the PSS and are liable for costs and risks not captured within the service agreement. Additionally, in input-based PSSs, PSSPs capture majority of their financial payments (50+%) at the moment of contracting and installation, meaning their financial incentive to deliver prolonged high-quality service is greatly diminished. If service penalties are not established, HPs may find it challenging to receive timely service when their products are not operational. Based on the research, input-based PSSs come with the shortest service contract durations of the four types, which reduce the risk undertaken by the PSSP and transfer it to the HP. When PSSPs can renegotiate terms every few years, HPs are not able to establish long-term cost predictability. Input-based PSSs have the lowest potential for cost-savings, as the PSSP does not exploit the product's residual value, meaning savings cannot be captured nor shared with the HP. Input-based contracts have the highest likelihood of existing on the market, as they bear the least risk for PSS providers. Input-based PSSs can be established by adding service contracts or simple warranties to products traditionally purchased by HPs.

Availability-based PSSs offer the second highest value to HPs. When leased, availability-based PSSs face tax disadvantages, however, they allow HPs to accomplish construction scope without investment capital. HPs can utilize leased availability-based PSSs to bring over-budget construction projects back into budget, or to expand the scope of on-budget projects, both of which are especially helpful as HPs grapple with the energy transition. When leased, availability-based PSSs establish predicable costs over their contract duration, which, based on the cases, can be upwards of 40 years. Since HPs pay for the product to simply be available, there may not be strong incentives for the PSSP to deliver exceptional service, unless service penalties for down-time are established in the contract. When PSSPs remain the owner of their products, they are incentivized to exploit residual value, thus they can offer larger long-term cost savings to HPs. When using leased PSS, HPs should be aware of initial challenges such as scope and profit negotiations with General Contractors, and contracts with increased complexity. HPs can alternatively choose to purchase or leasing-to-own an availability-based PSS to take advantage of tax deductions, however the PSSP will likely establish a right to reclaim or "take-back" the PSS at the end of the contract, and perhaps the PSSP's incentives to deliver exceptional service may be reduced since the PSS is no longer their asset. Availability-based PSSs have the second highest likelihood of existing on the market, as all building components, except structure and foundation, can in theory be offered as a leased product with majority of costs associated with service payments.

Usage-based PSSs offer the third highest value to HPs. Although they also face tax disadvantages when leased, usage-based PSSs establish strong incentives for the PSSP to deliver exceptional service. If the product is not able to be used, the PSSP cannot capture payment from the HP. Thus, the PSSP is incentivized to minimize downtime and always keep the product operational through the duration of the contract, which, based on the cases, can be upwards of 30

years. Of the cases studied, the difference in PSSP incentives is most evident between the input-based elevator PSS with no performance penalties (Case A), and the usage-based elevator PSS with performance penalties (Case E). In Case A, where the HP owns the elevator, the HP faced challenges regarding incomplete service coverage, unpredictable costs, and dissatisfactory service. However, in Case E, where the HP leases the functionality of the elevator, the HP can be confident about receiving satisfactory high-quality service since the PSSP will only be paid when the elevator is operational and will be financially penalized when the elevator is, on an annual basis, out of service more instances or more total time than the contract's agreed maximums. Usage-based PSSs, like availability-based PSSs, incentivize PSSPs to minimize operational costs and exploit residual value, thus increasing the likelihood of cost savings for the HP. Leased usage-based PSSs also enable HPs to accomplish construction scope when capital is unavailable and to establish predictable long-term costs. When leased, usage-based PSSs also face the potential initial challenges of profit negotiations with GCs and complex contracts. Usage-based PSSs can also be owned by an HP, offering them tax advantages. In such an arrangement, the HP pays the PSSP fees based on measured usage which are thus used as a reserve for service. When the HP is the owner of the product, they create a trade-off between increasing their risk profile and decreasing their tax liability. HPs of owned usage-based PSSs should be informed of which party (HP or PSSP) pays for service costs when they exceed the allotted reserve. Usage-based PSSs have the third highest likelihood of existing on the market, as they are only applied to building components with predictable and measurable intermittent usage.

Performance-based PSSs offer the highest value to HPs as they only pay when the expected result or function is delivered. However, performance-based PSSs may not be readily found in the market as they are the riskiest for PSSPs. To be offered, performance-based PSSPs need to integrate all aspects of performance into a single solution, which may only be possible through multiple iterations and the incorporation of new technologies. Performance-based PSSs also have the highest potential for circularity, as they put the PSSP in full control of delivering the desired outcome (van Ostaeyen et al., 2013), thus they have the highest potential for exploiting residual value and creating cost-savings for the HP. Case D, the availability-based window PSS, serves as a rudimentary version of what the PSSP aims to eventually offer as a performance-based integrated-façade PSS, complete with heating, cooling, and ventilation. The currently offered window PSS serves as an exploration in the contract, maintenance, and eventual takeback of a long-term leased product. Until performance-based PSSs are offered on the market, usage-based PSSs likely offer HPs the highest value.

2. Contributions of the Research

This research contributes to the arenas of real estate management, rental housing management, and Product-Service-Systems (PSSs) by establishing a link between the discrete concepts of PSSs and rental housing. The main contribution of the research is a consolidated demand-perspective on PSSs in the built environment. The research identifies the value PSSs offer HPs that use them, how HPs consider the use of a PSS, as well as what challenges they face when using PSSs.

The research builds upon the van Ostaeyen's (2013) "Refined Typology" of PSSs framework, which is a refinement of Tukker's (2004) "Eight Types" of PSS, to establish the value of PSSs from a real estate owner perspective. The research establishes a framework of its own which shows increasing value for real estate owners in the order of input-, availability-, usage-, and performance-based PSSs. The research also establishes the correlation between PSSs increasing in potential for circularity and PSSs increasing in value for real estate owners that use them.
In a practical sense, 6 building components have been identified as market-implemented PSSs that HPs can immediately consider procuring. With such insights, HPs, and real estate owners at large may consider the use of PSSs within their organizations.

3. Evaluation of the research

The research can be evaluated via construct validity, external validity, and reliability (Yin, 2003). The research uses a variety of sources (case studies, expert interviews, and financial simulation) and a chain of evidence to validate the constructs being studied. The case studies have been replicated across seven cases, and the findings have been corroborated by expert opinion, enabling findings to be generalized beyond the specific context of this research. Lastly, the procedures for conducting the research have been well documented, enabling future researchers to conduct similar studies.

4. Research Limitations

Limitations to the research include a relatively small number of cases, and their proportion of each PSS type. Ideally, several market-implemented PSSs of each PSS type (input, availability-, etc.) would have been studied. However, studied cases were based on those that could be found within a short time frame, as well as those that had representatives available for interview. Cases were only studied in the context of American and Dutch rental housing, meaning the value offered by PSSs could be different in other markets.

5. Recommendations for Future Research

Several topics were identified during the study that warrant future research, namely 1) the impact of PSSs on resident service costs, 2) the impact of leased PSSs on a general contractor's scope and profit, 3) insight into what specific details make a PSS contract especially complex, 4) quantitative life-cycle analyses of the studied PSSs cases to more definitively gauge their level of circularity, and 5) a more robust financial study of leasing vs owning building components that takes into account a variety of development financing scenarios. Lastly, a repeat of this study in the future (5 years+) with real estate owners who have a prolonged experience using PSSs would be valuable, as many of the studied cases were only installed within the last 2 years, meaning their performance history is rather limited.

07
Reflection

1. Position within the Master Track and Master Program

This research was conducted within the Management in the Built Environment (MBE) track of the MSc Architecture, Urbanism and Building Sciences (AUBS) program at TU Delft. More specifically, the research was conducted within the Real Estate Management (REM) department. The research was supported by two mentors within the department: Tuuli Jylhä, who specializes in Real Estate Management, and Gerard van Bortel who specializes in Housing Management. Additionally, a third mentor, Daan Schraven of Civil Engineering, supported the research and offered his expertise in the economics of Product-Service-Systems in the Built Environment. Lastly, this research participates in the Circular Business Models (CBMs) & Product-Service-Systems (PSSs) MSc studio, which is a cross-disciplinary group of students from the Architecture and Civil Engineering faculties. In combination, the research focuses on the value of Product-Service-Systems for organizations that either develop and sell, or develop and manage, rental housing. By highlighting such value, the research contributes to the growing body of knowledge on the circular economy.

2. Relevance

Scientific relevance

The findings contribute to understanding the demand-side perspective of using PSSs in the built environment, which is currently a rather limited body of knowledge. The research builds upon van Ostaeyen's (2013) framework and illuminates the value of each PSS type for organizations that develop, own, or manage rental housing. The research concludes that PSS types increase in the potential for circularity in the same order that they increase in the value offered to housing providers (consumers), yet also decrease in market availability in the same order. The research specifies which benefits and advantages of PSSs are the primary drivers for housing providers to use them, and which are secondary and do not necessarily sway decision making. The research confirms, due to the substantial value they offer, there is substantial demand for PSSs, meaning their adoption by housing providers serves as a demand-driven catalyst for enhanced circularity in the built environment.

Practical Relevance

The research provides practical insights for housing providers (HPs) who may be considering the use of PSSs within their portfolios. First, the research provides the primary and secondary value fellow HP organizations find in the use of PSSs. Second, the research provides information regarding how PSSs are analyzed before being used, and what challenges are faced by HPs that use them. Third, seven market-implemented building component PSSs have been identified and studied, providing HPs tangible examples that they may also consider implementing within individual buildings or across entire portfolios. Fourth, the research highlights the prerequisites for building components that may be good candidates for PSSs, allowing HPs to review their own data and identify PSS opportunities, before reviewing market offerings.

Societal Relevance

PSSs have already proven their value in other sectors such as mobility (Uber & Lift) and media (Spotify, Netflix & Amazon). This research offers valuable insights into how the concept of "access over ownership" may transcend yet another product: buildings. The use of PSSs has the potential to change the way real estate portfolios are procured, managed, and maintained. When PSSs are leased, the traditional ownership model of a building becomes even more fragmented. The ownership of a building asset is no longer comprised of just owners, investors, and banks, but now includes manufacturers and service providers of specific building components. Since buildings are considered an appreciating asset, far more so than cars, music, or movies, the large-scale transition to "access over ownership" for building components will likely be met with greater reluctance until owners gain greater clarity regarding the financial implications of leasing.

3. Research Method and Approach

Literature Review

The literature review conducted at the beginning of the research was essential to gain an understanding of the evolution of PSSs over the last 20+ years, and how they can be applied within rental housing. The literature review was used as the basis for the theoretical framework which highlighted potential advantages and challenges for housing providers when using PSSs. The literature including reviewing academic journals and publications, other researcher's literature reviews on the topic, as well as recent publications from "communities of practice", which integrate practitioners with academics. The theoretical framework was continuously refined during the empirical research phase.

Empirical Research

The empirical research includes multiple case studies, expert interviews, and a financial simulation. The combination of research strategies provided a more cohesive understanding of the value PSSs offer to housing providers that use them. The qualitative case studies and expert interviews, via semi-structured interviews, allowed new information and concepts to emerge. The case studies allowed for a deep understanding of specific PSS building components, while the expert interviews allowed for a broad understanding of the phenomenon of PSSs-in-the-built-environment at large. While the transcription and coding of qualitative data was quite time consuming, it offered far more meaningful insights to be captured. With insights in-hand, the financial simulation was easier to construct, as logical constraints and variables could be identified to answer the somewhat simple question being asked.

4. Research Process and Planning

The research was conducted per the standard TU Delft MSc schedule, following the standard checkpoints (P1-P5) of the Architecture faculty. The literature review and theoretical framework were more arduous tasks than expected, which required reviewing a vast amount of information in a short period of time. The empirical research served as a much-welcomed change of pace, comprising many enjoyable conversations with other passionate people working within the built environment. From the beginning of the research, a weekly schedule was used and frequently updated to monitor the pace and ensure the deadlines could be met with a high-quality output.

The COVID-19 pandemic has certainly impacted the research, as opportunities to interact and share ideas with other students and researchers at the facility has been reduced to a minimum. Also, conducting interviews via video chat meant at times the conversation was delayed (lag in the connection), and likely some data collection was missed as the dialogue became hard to understand. Additionally, just like the students, advisors have been impacted as well with more and more meetings each day, meaning opportunities to meet with advisors was seldom. Lastly, the COVID-19 pandemic meant that opportunities to recharge energy levels and “blow off steam” were very rare, which at times slowed progress and diminished motivation.

In conclusion, the research process required both flexibility and discipline to produce a high-quality outcome. The final research produced was above my expectations and served as a great tool-building and learning experience that I will carry with me moving forward.

08
References

ABF Research. (2020). Socrates - Housing market forecast. https://www.abfresearch.nl/producten/prognoses/socrates-woningmarktprognose/

Achterberg, E., Hinfelaar, J., & Bocken, N. (2016). Master circular business with the value hill. Circle Economy, 18.

American Association For The Advancement Of Science (AAAS). (2009). AAAS Reaffirms Statements on Climate Change and Integrit. https://www.aaas.org/news/aaas-reaffirms-statements-climate-change-and-integrity

Andrews, D. (2015). The circular economy, design thinking and education for sustainability. Local Economy, 30(3), 305–315. https://doi.org/10.1177/0269094215578226

Attenborough, D. (2020). A Life on Our Planet.

Azcarate-Aguerre, J. F., Den Heijer, A. C., & Klein, T. (2017). Integrated Facades as a Product-Service System: Business process innovation to accelerate integral product implementation. Journal of Facade Design and Engineering, 6(1), 41–56.

Baines, T. S., Lightfoot, H. W., Evans, S., Neely, A., Greenough, R., Peppard, J., Roy, R., Shehab, E., Braganza, A., Tiwari, A., Alcock, J. R., Angus, J. P., Bastl, M., Cousens, A., Irving, P., Johnson, M., Kingston, J., Lockett, H., Martinez, V., … Wilson, H. (2007). State-of-the-art in product-service systems. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 221(10), 1543–1552. https://doi.org/10.1243/09544054JEM858

Batista, L., Davis-Poynter, S., Ng, I., & Maull, R. (2017). Servitization through outcome-based contract – A systems perspective from the defence industry. International Journal of Production Economics, 192, 133–143. https://doi.org/https://doi.org/10.1016/j.ijpe.2016.12.005

Bertoni, M., Rondini, A., & Pezzotta, G. (2017). A systematic review of value metrics for PSS design.

Blüher, T., Riedelsheimer, T., Gogineni, S., Klemichen, A., & Stark, R. (2020). Systematic literature review-Effects of PSS on sustainability based on use case assessments. Sustainability (Switzerland), 12(17), 1–25. https://doi.org/10.3390/su12176989

Bocken, N. M. P., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering, 33(5), 308–320. https://doi.org/10.1080/21681015.2016.1172124

Böhm, E., Eggert, A., & Thiesbrummel, C. (2017). Service transition: A viable option for manufacturing companies with deteriorating financial performance? Industrial Marketing Management, 60, 101–111.

Brand, S. (1994). How buildings learn : what happens after they’re built LK - https://tudelft.on.worldcat.org/oclc/29566065. In TA - TT -. Viking. http://bvbr.bib-bvb.de:8991/F?func=service&doc_library=BVB01&doc_number=015618749&line_number=0001&func_code=DB_RECORDS&service_type=MEDIA

Brennan, G., Tennant, M., & Blomsma, F. (2015). Business and production solutions: Closing loops and the circular economy. Sustainability: Key Issues, 219–239. https://doi.org/10.4324/9780203109496-11

Bryman, A. (2016). Social research methods. Oxford university press.

Catulli, M., Sopjani, L., Reed, N., Tzilivakis, J., & Green, A. (2021). A socio-technical experiment with a resource efficient product service system. Resources, Conservation and Recycling, 166, 105364. https://doi.org/https://doi.org/10.1016/j.resconrec.2020.105364

CBS. (2011). Dutch population set to grow substantially in Randstad region to 2025. https://www.cbs.nl/en-gb/news/2011/41/dutch-population-set-to-grow-substantially-in-randstad-region-to-2025

Chao-Duivis, M., Koning, A., & Ubink, A. (2013). A practical guide to Dutch building contracts.’s-Gravenhage. Nederland: Ibr.

Circle Economy. (2021). The Circularity Gap Report 2021. 71. https://www.circularity-gap.world/2021

Clegg, B., MacBryde, J., Dey, P., Dimache, A., & Roche, T. (2013). A decision methodology to support servitisation of manufacturing. International Journal of Operations & Production Management.

Coalition Circular Accounting. (2020). The circular facade.

Coreynen, W., Matthyssens, P., & Van Bockhaven, W. (2017). Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers. Industrial Marketing Management, 60, 42–53.

den Heijer, A. (2011). Managing the University Campus: Information to support real estate decisions. Eburon Uitgeverij BV.

ECLI: NL: HR: 2018: 424, (2018). http://deeplink.rechtspraak.nl/uitspraak?id=ECLI:NL:HR:2018:424

Ekins, P., Hughes, N., Bringezu, S., Arden Clarke, C., Fischer-Kowalski, M., Graedel, T., Hajer, M., Hashimoto, S., Hatfield-Dodds, S., Havlik, P., Hertwich, E., Ingram, J., Kruit, K., Milligan, B., Moriguchi, Y., Nasr, N., Newth, D., Obersteiner, M., Ramaswami, A., … Pedroza, A. (2017). Resource Efficiency: Potential and Economic Implications. In A report of the International Resource Panel (UNEP). http://www.resourcepanel.org/sites/default/files/documents/document/media/resource_efficiency_report_march_2017_web_res.pdf

Elinder, M., Escobar, S., & Petré, I. (2017). Consequences of a price incentive on free riding and electric energy consumption. Proceedings of the National Academy of Sciences of the United States of America, 114(12), 3091–3096. https://doi.org/10.1073/pnas.1615290114

Ellen MacArthur Foundation. (2013). Towards the circular economy - Economic and Business Rationale for an Accelerated transition. Ellen Macarthur Foundation Rethink the Future, 100.

Gebauer, H., Fleisch, E., & Friedli, T. (2005). Overcoming the Service Paradox in Manufacturing Companies. European Management Journal, 23(1), 14–26. https://doi.org/https://doi.org/10.1016/j.emj.2004.12.006

Giarini, O., & Stahel, W. R. (1990). The limits to certainty: Facing risks in the new service economy. Long Range Planning, 23(5), 126–127. https://doi.org/10.1016/0024-6301(90)90274-8

Gielingh, W., de Ridder, H., Jonkers, L., & Vedder, H. (2008). Business innovation in construction through value oriented product/service offerings for living buildings. 1st International Conference on Industrialised, Integrated, Intelligent Construction (I3CON), 159.

Goedkoop, M. J. (1999). Product Service systems, Ecological and Economic Basics Product Service systems, Ecological and Economic Basics (Issue March 1999).

Government of the Netherlands. (2016). A circular economy in the Netherlands by 2050. 72. https://www.government.nl/binaries/government/documents/policy-notes/2016/09/14/a-circular-economy-in-the-netherlands-by-2050/17037+Circulaire+Economie_EN.PDF

GreenbergTraurig. (2020). Dutch 2021 Tax Bill and Real Estate in the Netherlands. https://www.gtlaw.com/en/insights/2020/9/dutch-2021-tax-bill-and-real-estate-in-the-netherlands

Gruneberg, S., Hughes, W., & Ancell, D. (2007). Risk under performance-based contracting in the UK construction sector. Construction Management and Economics, 25(7), 691–699.

Halme, M., Jasch, C., & Scharp, M. (2004). Sustainable homeservices? Toward household services that enhance ecological, social and economic sustainability. Ecological Economics, 51(1–2), 125–138. https://doi.org/10.1016/j.ecolecon.2004.04.007

Herman, R., Ardekani, S. A., & Ausubel, J. H. (1990). Dematerialization. Technological Forecasting and Social Change, 38(4), 333–347.

Hoornweg, D., Sugar, L., & Gómez, C. L. T. (2011). Cities and greenhouse gas emissions: moving forward. Environment and Urbanization, 23(1), 207–227. https://doi.org/10.1177/0956247810392270

Huikkola, T., Kohtamäki, M., & Rabetino, R. (2016). Resource Realignment in Servitization: A study of successful service providers explores how manufacturers modify their resource bases in transitioning to service-oriented offerings. Research-Technology Management, 59(4), 30–39.

IEA and UNEP. (2019). 2019 Global Status Report for Buildings and Construction: Towards a zero-emissions, efficient and resilient buildings and constructi on sector. In UN Enviroment programme (Vol. 224).

Ijomah, W. L., McMahon, C. A., Hammond, G. P., & Newman, S. T. (2007). Development of design for remanufacturing guidelines to support sustainable manufacturing. Robotics and Computer-Integrated Manufacturing, 23(6), 712–719. https://doi.org/https://doi.org/10.1016/j.rcim.2004.34.017

Katz, S. (1983). Assessing self-maintenance: activities of daily living, mobility, and instrumental activities of daily living. Journal of the American Geriatrics Society, 31(12), 721–727.

Kim, K.-J., Lim, C.-H., Heo, J.-Y., Lee, D.-H., Hong, Y.-S., & Park, K. (2016). An evaluation scheme for product--service system models: development of evaluation criteria and case studies. Service Business, 10(3), 507–530.

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling, 127(April), 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

Kowalkowski, C., Gebauer, H., & Oliva, R. (2017). Service growth in product firms: Past, present, and future. Industrial Marketing Management, 60, 82–88.

Kriston, A., Szabó, T., & Inzelt, G. (2010). The marriage of car sharing and hydrogen economy: A possible solution to the main problems of urban living. International Journal of Hydrogen Energy, 35(23), 12697–12708.

Kühl, C., Tjahjono, B., Bourlakis, M., & Aktas, E. (2018). Implementation of Circular Economy principles in PSS operations. Procedia CIRP, 73, 124–129.

Lacy, P., Keeble, J., McNamara, R., Rutqvist, J., Haglund, T., Cui, M., Cooper, A., Pettersson, C., Eckerle, K., Buddemeier, P., Sharma, A., & Senior, T. (2014). Circular Advantage: Innovative Business Models and Technologies to Create Value in a World without Limits to Growth. Accenture Strategy, 24.

Leoni, L. (2015). Servitization and Productization: two faces of the same coin. RESER 2015.

Li, A. Q., Kumar, M., Claes, B., & Found, P. (2020). The state-of-the-art of the theory on Product-Service Systems. International Journal of Production Economics, 222, 107491. https://doi.org/https://doi.org/10.1016/j.ijpe.2019.09.012

Lingegård, S. (2010). PSS for rail and road infrastructure: a literature study.

Maxwell, D., Sheate, W., & Van Der Vorst, R. (2006). Functional and systems aspects of the sustainable product and service development approach for industry. Journal of Cleaner Production, 14(17), 1466–1479.

Meier, H., Roy, R., & Seliger, G. (2010). Industrial product-service systems—IPS2. CIRP Annals, 59(2), 607–627.

Meijkamp, R. (1998). Changing consumer behaviour through eco-efficient services: an empirical study of car sharing in the Netherlands. Business Strategy and the Environment, 7(4), 234–244.

Merriam-Webster. (2021). Definition of Value. https://www.merriam-webster.com/dictionary/value

Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2019). Cijfers over Wonen en Bouwen 2019. https://www.woononderzoek.nl/nieuws/Cijfers-over-Wonen-en-Bouwen-2019/85

Mont, O. (2000). Product-service systems (Vol. 3). Naturvårdsverket.

Mont, O. (2002). Clarifying the concept of product–service system. Journal of Cleaner Production, 10(3), 237–245. https://doi.org/https://doi.org/10.1016/S0959-6526(01)00039-7

Mont, O. (2004). Product-service systems: panacea or myth? Lund University.

Ng, I. C. L., Nudurupati, S. S., & Tasker, P. (2010). Value co-creation in the delivery of outcome-based contracts for business-to-business service.

Pereira, V. R., Kreye, M. E., & Carvalho, M. M. de. (2019). Customer-pulled and provider-pushed pathways for product-service system: The contingent effect of the business ecosystems. Journal of Manufacturing Technology Management, 30(4), 729–747. https://doi.org/10.1108/JMTM-07-2018-0209

Preventive Maintenance for Multi-Family Housing. (2009). The Special Maintenance Requirements of Multi-Family Housing. https://www.cmdgroup.com/images/rsmeans-2010/sample-pages/PM-Multi-Family-Housing-67346-Sample.pdf

Rabetino, R., Harmsen, W., Kohtamäki, M., & Sihvonen, J. (2018). Structuring servitization-related research.

Raposo, S., de Brito, J., & Fonseca, M. (2013). Planned preventive maintenance activities: Analysis of guidance documents. In Durability of Building Materials and Components (pp. 35–60). Springer.

Reim, W., Parida, V., & Örtqvist, D. (2015). Product–Service Systems (PSS) business models and tactics – a systematic literature review. Journal of Cleaner Production, 97, 61–75. https://doi.org/https://doi.org/10.1016/j.jclepro.2014.07.003

Reim, W., Parida, V., & Sjödin, D. R. (2016). Risk management for product-service system operation. International Journal of Operations \& Production Management.

Roy, R., Shehab, E., Tiwari, A., Azarenko, A., Roy, R., Shehab, E., & Tiwari, A. (2009). Technical product-service systems: some implications for the machine tool industry. Journal of Manufacturing Technology Management.

Satterthwaite, D. (2009). The implications of population growth and urbanization for climate change. Environment and Urbanization, 21(2), 545–567. https://doi.org/10.1177/0956247809344361

Schuh, G., Lenders, M., & Hieber, S. (2011). Lean Innovation--Introducing value systems to product development. International Journal of Innovation and Technology Management, 8(01), 41–54.

Sundin, E., & Bras, B. (2005). Making functional sales environmentally and economically beneficial through product remanufacturing. Journal of Cleaner Production, 13(9), 913–925.

Thomsen, A., & der Flier, K. (2007). Demolition of private housing stock in the Netherlands, volume and motives. Proceedings of the International Research Conference on Sustainable Urban Areas, Housing Regeneration and Maintenance.

Thomsen, A. F., & Straub, A. (2018). Lifespan assessment of dwellings. ENHR Conference 2018.

TU Delft. (2020). CIK: The Circular Kitchen. https://www.tudelft.nl/en/thecircularkitchen/

Tukker, A. (2004). Eight types of product–service system: eight ways to sustainability? Experiences from SusProNet. Business Strategy and the Environment, 13(4), 246–260. https://doi.org/https://doi.org/10.1002/bse.414

Tukker, A., & Tischner, U. (2006). Product-services as a research field: past, present and future. Reflections from a decade of research. Journal of Cleaner Production, 14(17), 1552–1556. https://doi.org/10.1016/j.jclepro.2006.01.022

United Nations. (2007). The Greatest Threat To Global Security: Climate Change Is Not Merely

An Environmental Problem. https://www.un.org/en/chronicle/article/greatest-threat-global-security-climate-change-not-merely-environmental-problem

United Nations. (2018). World Urbanization Prospects: The 2018 Revision.

United Nations. (2019). World Population Prospects 2019. In Department of Economic and Social Affairs. World Population Prospects 2019. (Issue 141). http://www.ncbi.nlm.nih.gov/pubmed/12283219

United Nations. (2020). Global housing crisis results in mass human rights violations – UN expert. https://www.ohchr.org/EN/NewsEvents/Pages/DisplayNews.aspx?NewsID=25662&LangID=E

van Ostaeyen, J., Horenbeek, A., Pintelon, L., & Duflou, J. (2013). A refined typology of Product-Service Systems based on Functional Hierarchy Modeling. Journal of Cleaner Production, 51. https://doi.org/10.1016/j.jclepro.2013.01.036

Vandermerwe, S., & Rada, J. (1988). Servitization of business: Adding value by adding services. European Management Journal, 6(4), 314–324. https://doi.org/https://doi.org/10.1016/0263-2373(88)90033-3

Wackernagel, M., Beyers, B., & Rout, K. (2019). Ecological Footprint: Managing Our Biocapacity Budget. New Society Publishers. https://books.google.nl/books?id=qCQ8wQEACAAJ

Wimberley, R., & Fulkerson, G. (2007). Mayday 23: World population becomes more urban than rural. Rural Sociologist, 27(1), 42–43.

Windahl, C., & Lakemond, N. (2006). Developing integrated solutions: The importance of relationships within the network. Industrial Marketing Management, 35(7), 806–818.

Xing, K., Ness, D., & Lin, F. (2013). A service innovation model for synergistic community transformation: Integrated application of systems theory and product-service systems. Journal of Cleaner Production, 43, 93–102.

Yin, R. K. (2003). Designing case studies. Qualitative Research Methods, 359–386.

09
Appendices

List of Appendices

Appendix A - Interview Protocol Case Study (Housing Provider)

Graduation Project
12/02/2021

Interview Protocol

Research: Why Rental Housing Providers Use Product-Service-Systems (PSSs)
Institution: Delft University of Technology
Interviewer: David Parker

Introduction

Firstly, thank you for taking the time to participate in this research during this unprecedented period in history. This interview contributes to my Management in the Built Environment (MBE) master's degree graduation project at TU Delft, which would not be possible without your contribution. The research focuses on understanding why rental housing organizations choose to procure parts of their buildings using a Product-Service-System (PSS) business model, instead of simply purchasing it outright. The research aims to understand what advantages the PSS offers the rental housing organization, and what information and evaluation was used to compare the PSS vs purchasing the product outright.

What is a Product-Service-System (PSS)?

Product-Service-Systems (PSSs) can take shapes in multiple forms, but for simplicity sake they are one of two options:

1. a physical product that is purchased *in combination* with a service/maintenance contract
    - Note: the product and service contract must be from the same company.
2. or a physical product that is leased
    - Note: the lease payments must include the servicing/maintenance of the product.

Data Collection

The information gathered in the interview will be used to adjust the propositions that have resulted from my theoretical research and give new understandings of why rental housing organizations use PSSs. Please remember there are no "correct" or "incorrect" answers, and the responses will only be used for academic purposes only. Before we proceed, I will need to you to complete and sign *Appendix D: Form of Consent* (attached separately). Additionally, I will ask for your consent to record the interview so I may transcribe it into text, and afterwards delete the recording. Your answers in the interview will remain confidential, and findings will be presented in the following format to preserve anonymity. At any point you can decline to answer a question or withdraw from the interview.

Case	*PSS*	*Organization*	*Interviewee*	*Role*
Case A	Kitchen	Market-rate rental housing organization	A1	CEO & Founder
		Kitchen Company	A2	Director of Sales
Case B	Elevator	Social rental housing organization	B1	Director of Development
		Elevator Company	B2	Director of Sales
…	…	…	…	…

Part 1: Introductions and defining the case *(10 mins)*
- Can you briefly explain your role at your organization, what you are responsible for, and how many years you have been working in the field?
- Introduce the case (the building, the PSS, and the stakeholders)
- How long has your organization been using the PSS, and at how many homes is it used?

Part 2: Why did the housing provider use the PSS? *(15 mins)*
- What advantages/benefits does the PSS offer your organization?
- What problem(s) does the PSS solve?

Part 3: How did the housing provider evaluate the PSS and determine the benefits? *(10 mins)*
- What analysis did you use when considering the PSS? (Ex: Total Cost of Ownership (TCO) vs Total Cost of Use (TCU), Life-Cycle-Assessment (LFA), etc.)
- How did you source information?
- How long did it take to come to a decision to use the PSS?

Part 4: How does the arrangement between the stakeholders work? *(15 mins)*
- What are the responsibilities and risks of each party? (Housing Provider and PSS Provider)
- What is the contract duration?
- How are payments structured?
- What is the physical “product" included in the contract? (Also, what’s not included?)
- What is the intangible “service" included in the contract? (Also, what’s not included?)
- What “infrastructure” was required to enable the PSS? (Ex: structure, connections to electricity/water/sewage/internet, etc.)

Part 5: Challenges *(5 mins)*
- What challenges did you face when procuring or using the PSS?
- If challenges exist, how would you revise/improve the PSS?
- Will your organization renew the contract for the PSS, or expand its use elsewhere in your portfolio?
    - Why, or why not?

Part 6: Wrap-up and conclude *(5 mins)*
- Is there any other material/documents that you can share that would help me better understand the case?
- Do you have any suggestions to other housing organizations who are considering the use of PSSs?
- Is there anything else that you would like to mention that you think is relevant to my study?

Part 7 (Only if time permits)
- Does your organization use another other PSSs?
    - If yes, what are some examples?

Thank you!
Again, thank you for taking the time to participate in my research, especially during these hard times. If you would like, I can share my case study report with you before I publish it so you may confirm the details of the report, and either decide to remain anonymous, or opt-in to include your identity. Additionally, if you would like, I can share my finished project with you later this summer once I graduate.

Study contact details for further information: [*David Parker, D.F.Parker@student.tudelft.nl*]

Appendix B - Interview Protocol Case Study (PSS Provider)

Graduation Project
12/02/2021

Interview Protocol

Research: Why Rental Housing Providers Use Product-Service-Systems (PSSs)
Institution: Delft University of Technology
Interviewer: David Parker

Introduction

Firstly, thank you for taking the time to participate in this research during this unprecedented period in history. This interview contributes to my Management in the Built Environment (MBE) master's degree graduation project at TU Delft, which would not be possible without your contribution. The research focuses on understanding why rental housing organizations choose to procure parts of their buildings using a Product-Service-System (PSS) business model, instead of simply purchasing it outright. The research aims to understand what advantages the PSS offers the rental housing organization, and what information and evaluation was used to compare the PSS vs purchasing the product outright.

What is a Product-Service-System (PSS)?

Product-Service-Systems (PSSs) can take shapes in multiple forms, but for simplicity sake they are one of two options:

1. a physical product that is purchased *in combination* with a service/maintenance contract
    - Note: the product and service contract must be from the same company.
2. or a physical product that is leased
    - Note: the lease payments must include the servicing/maintenance of the product.

Data Collection

The information gathered in the interview will be used to adjust the propositions that have resulted from my theoretical research and give new understandings of why rental housing organizations use PSSs. Please remember there are no "correct" or "incorrect" answers, and the responses will only be used for academic purposes only. Before we proceed, I will need to you to complete and sign *Appendix D: Form of Consent* (attached separately). Additionally, I will ask for your consent to record the interview so I may transcribe it into text, and afterwards delete the recording. Your answers in the interview will remain confidential, and findings will be presented in the following format to preserve anonymity. At any point you can decline to answer a question or withdraw from the interview.

Case	*PSS*	*Organization*	*Interviewee*	*Role*
Case A	Kitchen	Market-rate rental housing organization	A1	CEO & Founder
		Kitchen Company	A2	Director of Sales
Case B	Elevator	Social rental housing organization	B1	Director of Development
		Elevator Company	B2	Director of Sales
…	…	…	…	…

Part 1: Introductions and defining the case *(10 mins)*

- Can you briefly explain your role at your organization, what you are responsible for, and how many years you have been working in the field?
- Introduce the case (the building, the PSS, and the stakeholders)
- How long has your organization been offering the PSS?
- How many installations of the PSS have you completed?
- How many installations are in negotiations with customers?

Part 2: Why did the housing provider use the PSS? *(10 mins)*

Regarding your customer:

- What advantages/benefits do you think your PSS offers your customer?
- What problem(s) do you think your PSS solves for them?

Part 3: How did the housing provider evaluate the PSS and determine the benefits? *(10 mins)*

Regarding your customer:

- What analysis did they use when considering the PSS? (Ex: Total Cost of Ownership (TCO) vs Total Cost of Use (TCU), Life-Cycle-Assessment (LFA), etc.)
- What information did you provide them initially?
- Did they require additional information from you before they decided to use the PSS?
- How long did it take them to decide to use the PSS?

Part 4: How does the arrangement between the stakeholders work? *(15 mins)*

- What are the responsibilities and risks of each party? (Housing Provider and PSS Provider)
- What is the contract duration?
- How are payments structured?
- What is the physical “product" included in the contract? (Also, what’s not included?)
- What is the intangible “service" included in the contract? (Also, what’s not included?)
- What “infrastructure” was required to enable the PSS? (Ex: structure, connections to electricity/water/sewage/internet, etc.)

Part 5: Challenges *(5 mins)*

- What challenges did you face when offering the PSS to your customer?
- If challenges exist, how would you revise/improve the PSS? (Ex: contracts, product, service, etc.)

Part 6: Reduced Environmental Impact *(5 mins)*

- Does your organization remanufacture/recycle materials during the PSS’s use, or at end-of-life?

Part 7: Wrap-up and conclude *(5 mins)*

- Is there any other material/documents that you can share that would help me better understand the case?
- Is there anything else that you would like to mention that you think is relevant to my study?

Thank you!

Again, thank you for taking the time to participate in my research, especially during these hard times. If you would like, I can share my case study report with you before I publish it so you may confirm the details of the report, and either decide to remain anonymous, or opt-in to include your identity. Additionally, if you would like, I can share my finished project with you later this summer once I graduate.

Study contact details for further information: [*David Parker, D.F.Parker@student.tudelft.nl*]

Appendix C - Interview Protocol Expert Study

Graduation Project
12/02/2021

Interview Protocol
Research: Why Rental Housing Providers Use Product-Service-Systems (PSSs)
Institution: Delft University of Technology
Interviewer: David Parker

Introduction

Firstly, thank you for taking the time to participate in this research during this unprecedented period in history. This interview contributes to my Management in the Built Environment (MBE) master's degree graduation project at TU Delft, which would not be possible without your contribution. The research focuses on understanding why rental housing organizations choose to procure parts of their buildings using a Product-Service-System (PSS) business model, instead of simply purchasing it outright. The research aims to understand what advantages the PSS offers the rental housing organization, and what information and evaluation was used to compare the PSS vs purchasing the product outright.

However, since information pertaining to the use of PSSs in rental housing is relatively scarce, these preliminary expert interviews are intended to focus on the use of PSSs and circular busines models (CBMs) within the larger context of the built environment, and real estate in general. Specifically, these interviews aim to provide insight into the historic trends, state-of-the-art, and future possibilities of PSSs in the built environment. Additionally, these interviews are intended to gather insights about the advantages of PSSs for organizations that own real estate.

What is a Product-Service-System (PSS)?

Product-Service-Systems (PSSs) can take shapes in multiple forms, but for simplicity sake they are one of two options:

1. a physical product that is purchased *in combination* with a service/maintenance contract
    - Note: the product and service contract must be from the same company.
2. or a physical product that is leased
    - Note: the lease payments must include the servicing/maintenance of the product.

Data Collection

The information gathered in the interview will be used to adjust the propositions that have resulted from my theoretical research and give new understandings of why real estate owners, and more specifically rental housing organizations, use PSSs. Please remember there are no "correct" or "incorrect" answers, and the responses will only be used for academic purposes only. Before we proceed, I will need to you to complete and sign *Appendix E: Form of Consent* (attached separately). Additionally, I will ask for your consent to record the interview so I may transcribe it into text, and afterwards delete the recording. Your responses will be used in the research with your name and affiliation to establish credibility on the topic.

Part 1: Introductions *(10 mins)*

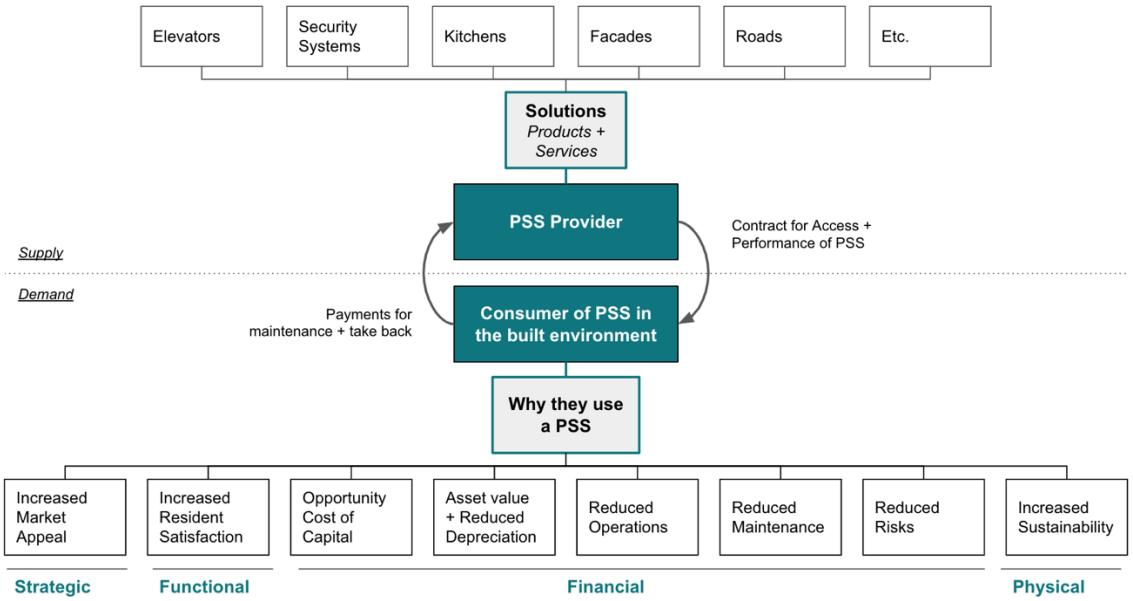
- Can you briefly explain your role at your organization, what you are responsible for, and how many years you have been working in the field?

Part 2: Historic and current market trends regarding PSSs in the built environment *(15 mins)*

- What trends have you seen over the last ± decade pertaining to the adoption of circular business models (CBMs) and Product-Service-Systems (PSSs) in the built environment?
- What are the drivers / enablers of PSSs? (Ex: Internet of Things, data, partnerships, etc.)
- What are the barriers? (Ex: financing, balance sheet extension, residual value calculation, etc.)
- What are the advantages of PSSs?
- What are the disadvantages?
- What PSSs are at the cutting edge of innovation? (ex: roads, facades, elevators, etc.)

Part 3: Review of main concepts of theoretical framework *(15 mins)*

Based on my research so far, PSSs are likely advantageous for organizations that own real estate based on the strategic, functional, financial, or physical benefits listed at the bottom of this graphic:



- What are your thoughts on the 8 advantages at the bottom of this graphic?
- Am I missing or overlooking critical reasons why PSSs might be advantageous to real estate owners?
- What must a real estate owner be aware of, and take into consideration when considering using a PSS within their portfolio?

Part 3: Future possibilities of PSSs *(15 mins)*

- How do you envision PSSs in the future of the built environment?
- How do they impact the stakeholders of the built environment?
    - Real estate owners, users, financiers, manufacturers, service providers?

Part 4: Wrap-up and conclude *(5 mins)*

- Is there any other material/documents that you can share that would help me with my research?
- Is there anything else that you would like to mention that you think is relevant to my study?

Thank you!

Again, thank you for taking the time to participate in my research, especially during these hard times. If you would like, I can share my case study report with you before I publish it so you may confirm the details of the report, and either decide to remain anonymous, or opt-in to include your identity. Additionally, if you would like, I can share my finished project with you later this summer once I graduate.

Study contact details for further information: [*David Parker, D.F.Parker@student.tudelft.nl*]

Appendix D - Form of Consent Case Study

Informed Consent Form
Research: Why Rental Housing Providers Use Product-Service-Systems (PSSs)
Institution: Delft University of Technology
Interviewer: David Parker

Please tick the appropriate boxes

Taking part in the study	Yes	No
1. I have read and understood the study information dated 12/02/2021, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves answering questions that will be audio-recorded, with the sole purpose of transcribing the interview, after which, the recordings will be deleted.	☐	☐
Use of the information in the study		
4. I understand that information I provide will be used only for academic purposes for the graduation project and corresponding presentation at TU Delft, unless indicated that certain information is confidential.	☐	☐
5. I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	☐	☐
6. I agree that my information can be quoted in research outputs.	☐	☐
Future use of information by others		
7. I give permission for the publication of graduation thesis results at the TU Delft educational repository, which are partially based on the anonymized transcripts of this interview, to be used for future research and learning.	☐	☐

Name of participant [printed]	Signature	Date [DD/MM/YYY]

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

David Parker		12/02/2021
Researcher name [printed]	Signature	Date [DD/MM/YYY]

Study contact details for further information: [*David Parker, D.F.Parker@student.tudelft.nl*]

Appendix E - Form of Consent Expert Study

Informed Consent Form
Research: Why Rental Housing Providers Use Product-Service-Systems (PSSs)
Institution: Delft University of Technology
Interviewer: David Parker

Please tick the appropriate boxes

Taking part in the study	Yes	No
1. I have read and understood the study information dated 12/02/2021, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves answering questions that will be audio-recorded, with the sole purpose of transcribing the interview, after which, the recordings will be deleted.	☐	☐
Use of the information in the study		
4. I understand that information I provide will be used only for academic purposes for the graduation project and corresponding presentation at TU Delft, unless indicated that certain information is confidential.	☐	☐
5. I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	☐	☐
6. I agree that my information can be quoted in research outputs.	☐	☐
7. I agree that my real name can be used for quotes.	☐	☐
Future use of information by others		
8. I give permission for the publication of graduation thesis results at the TU Delft educational repository, which are partially based on the transcripts of this interview, to be used for future research and learning.	☐	☐

Name of participant [printed]	Signature	Date [DD/MM/YYY]

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

David Parker		12/02/2021
Researcher name [printed]	Signature	Date [DD/MM/YYY]

Study contact details for further information: [*David Parker, D.F.Parker@student.tudelft.nl*]

Appendix F - List of Interviews

	Code	#	Organization	Role	Interviewee Name	Type
Demand + Supply	Case A - HP1	01	Social/ Affordable Housing Provider	Regional Director of Maintenance	-	Video call
	Case A - HP2			Regional Director of Maintenance	-	
	Case A - PSSP	02	Elevator Provider	National Account Manager	-	Video call
	Case B - HP	03	Market Rate Housing Provider	Owner & CEO	-	Video call
	Case B - PSSP	04	Kitchen Provider	Co-founder & CEO	-	Video call
	Case C - HP	05	Market Rate Housing Provider	Technical Developer	-	Video call
	Case C - PSSP	06	Window Provider	Specialist Circular Facades	-	Video call
	Case D - HP	07	Social/ Affordable Housing Provider	Project Leader and Consultant Sustainable Energy	-	Video call
	Case D - PSSP	08	Battery Provider	Client Developer	-	Video call
	Case E - HP	09	Market Rate Housing Provider	Senior Project Developer	-	Video call
	Case E - PSSP	10	Elevator Provider	Head of Sales New Installations	-	Video call
Supply-Only	Case F - PSSP	11	Heat Pump Provider	Managing Partner	-	Video call
	Case G - PSSP	12	PV Panel Provider	Director	-	Video call
Experts	Expert 1	13	ABN AMRO	Commercial Advisor Product-as-a-Service (PaaS)	Rob van Willigen	Video call
	Expert 2	14	TNO	Business Developer, Circular Economy Buildings & Infrastructure	Mark van Ommen	Video call
	Expert 3	15	Turntoo	Co Founder, circular economy expert and innovator, experienced speaker, author of Material Matters	Sabine Oberhuber	Video call
	Expert 4	16	Een Veilig Gevoel	Founder and Shareholder	Rick Ruisch	Video call
	Expert 5	17	Volantis	Circular Innovation Consultant	Jeroen Reumkens	Video call

Appendix G - Financial Model

DEVELOPMENT FINANCING	
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%
DEBT SERVICE	
Loan-to-value	70%
Interest Rate	3.5%
Ammortization	1.0%
DEVELOPMENT COSTS	
Development Costs	€10,000,000
Land Cost	€3,000,000
All-Inclusive Development Costs	**€ 13,000,000**
ASSET MANAGMENT	
INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
INCOME GENERATION	
Aparment Monthly Rent	€ 1,600
Number of Apartments	50
Building Annual Rent	€ 960,000
EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-1500
Annual Mgmt./Maint. costs	-€ 75,000
TAXES	
Income tax	25%
Capital gain tax	25%
Risidual Value % (of Purchase Price)	50%
Depreciable Life	30
PSS	
Annual Payments	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

PSS	**0.00%**
TCU/TCO	**100.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€91,000

ANNUAL DEPRECIATION	
Initial purchase price property	€10,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€5,000,000
Depreciable basis	€2,000,000
Depreciable Life	30
Annual depreciation	€66,667

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 1,143,17
Terminal value at t=16	€ 19,052,8
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	**Basis**		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
PSS		€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0	€ 0
Operating Expenses			**€ 0**	**-€ 75,000**	**-€ 76,575**	**-€ 78,183**	**-€ 79,825**	**-€ 81,501**	**-€ 83,213**	**-€ 84,960**	**-€ 86,744**	**-€ 88,566**	**-€ 90,426**	**-€ 92,325**	**-€ 94,264**	**-€ 96,243**	**-€ 98,264**	**-€ 100,328**	**-€ 102,435**
Net Operating Income			**€ 0**	**€ 837,000**	**€ 854,577**	**€ 872,523**	**€ 890,846**	**€ 909,554**	**€ 928,655**	**€ 948,156**	**€ 968,068**	**€ 988,397**	**€ 1,009,15**	**€ 1,030,34**	**€ 1,051,983**	**€ 1,074,07**	**€ 1,096,63**	**€ 1,119,659**	**€ 1,143,172**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 10,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 13,000,000**															**€ 19,052,86**	
Debt			€ 9,100,000															-€ 7,826,00	
Equity Investment			**-€ 3,900,000**																
Debt Services																			
Interest Payments			€ 0	-€ 318,500	-€ 318,500	-€ 315,315	-€ 312,130	-€ 308,945	-€ 305,760	-€ 302,575	-€ 299,390	-€ 296,205	-€ 293,020	-€ 289,835	-€ 286,650	-€ 283,465	-€ 280,280	-€ 277,095	
Ammortization			€ 0	-€ 91,000.00	-€ 91,000.	-€ 91,000.00	-€ 91,000.	-€ 91,000.00	-€ 91,000.(	-€ 91,000.(	-€ 91,000.(	-€ 91,000.00	-€ 91,000.	-€ 91,000.(	-€ 91,000.00	-€ 91,000.(	-€ 91,000.0	-€ 91,000.0	
Total Debt Service			**€ 0**	**-€ 409,500**	**-€ 409,500**	**-€ 406,315**	**-€ 403,130**	**-€ 399,945**	**-€ 396,760**	**-€ 393,575**	**-€ 390,390**	**-€ 387,205**	**-€ 384,020**	**-€ 380,835**	**-€ 377,650**	**-€ 374,465**	**-€ 371,280**	**-€ 368,095**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 451,833	€ 469,410	€ 490,541	€ 512,049	€ 533,942	€ 556,228	€ 578,915	€ 602,011	€ 625,525	€ 649,467	€ 673,844	€ 698,666	€ 723,943	€ 749,683	€ 775,898	
Income Tax			€ 0	-€ 112,958	-€ 117,353	-€ 122,635	-€ 128,012	-€ 133,486	-€ 139,057	-€ 144,729	-€ 150,503	-€ 156,381	-€ 162,367	-€ 168,461	-€ 174,667	-€ 180,986	-€ 187,421	-€ 193,974	
Capital gain Tax																		-€ 2,513,21	
Total Tax Liability			**€ 0**	**-€ 112,958**	**-€ 117,353**	**-€ 122,635**	**-€ 128,012**	**-€ 133,486**	**-€ 139,057**	**-€ 144,729**	**-€ 150,503**	**-€ 156,381**	**-€ 162,367**	**-€ 168,461**	**-€ 174,667**	**-€ 180,986**	**-€ 187,421**	**-€ 2,707,19**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 9,100,000	€ 9,100,000	€ 9,009,00	€ 8,918,000	€ 8,827,00	€ 8,736,000	€ 8,645,00	€ 8,554,00	€ 8,463,00	€ 8,372,000	€ 8,281,00	€ 8,190,00	€ 8,099,000	€ 8,008,00	€ 7,917,00	€ 7,826,000	
Amortization			€ 0	€ 91,000	€ 91,000	€ 91,000	€ 91,000	€ 91,000	€ 91,000	€ 91,000	€ 91,000	€ 91,000	€ 91,000	€ 91,000	€ 91,000	€ 91,000	€ 91,000	€ 91,000	
Interest Payments			€ 0	€ 318,500	€ 318,500	€ 315,315	€ 312,130	€ 308,945	€ 305,760	€ 302,575	€ 299,390	€ 296,205	€ 293,020	€ 289,835	€ 286,650	€ 283,465	€ 280,280	€ 277,095	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 10,000,000**	€ 9,933,333	€ 9,866,66	€ 9,800,000	€ 9,733,33	€ 9,666,667	€ 9,600,00	€ 9,533,33	€ 9,466,66	€ 9,400,000	€ 9,333,33	€ 9,266,66	€ 9,200,000	€ 9,133,33	€ 9,066,66	€ 9,000,000	
Total Depreciation				**€ 66,667**	**€ 66,667**	**€ 66,667**	**€ 66,667**	**€ 66,667**	**€ 66,667**	**€ 66,667**	**€ 66,667**	**€ 66,667**	**€ 66,667**	**€ 66,667**	**€ 66,667**	**€ 66,667**	**€ 66,667**	**€ 66,667**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**8.84%**	€ 1,004,296	-€ 13,000,000	€ 837,000	€ 854,577	€ 872,523	€ 890,846	€ 909,554	€ 928,655	€ 948,156	€ 968,068	€ 988,397	€ 1,009,15	€ 1,030,34	€ 1,051,983	€ 1,074,07	€ 1,096,63	€ 20,172,52	
Net Equity Cashflow (Before Tax)	**16.76%**	€ 4,019,125	-€ 3,900,000	€ 427,500	€ 445,077	€ 466,208	€ 487,716	€ 509,609	€ 531,895	€ 554,581	€ 577,678	€ 601,192	€ 625,133	€ 649,511	€ 674,333	€ 699,609	€ 725,350	€ 11,978,43	
Net Equity Cashflow (After Tax)	**13.10%**	€ 2,149,022	-€ 3,900,000	€ 314,542	€ 327,724	€ 343,573	€ 359,704	€ 376,123	€ 392,838	€ 409,853	€ 427,175	€ 444,811	€ 462,767	€ 481,050	€ 499,666	€ 518,624	€ 537,929	€ 9,271,240	

PSS	**10.00%**
TCU/TCO	**100.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€84,000

ANNUAL DEPRECIATION	
Initial purchase price property	€9,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€4,500,000
Depreciable basis	€1,500,000
Depreciable Life	30
Annual depreciation	€50,000

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 1,002,029
Terminal value at t=16	€ 16,700,48
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	Basis		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 69,793	€ 0	€ 7,500	€ 7,658	€ 7,818	€ 7,982	€ 8,150	€ 8,321	€ 8,496	€ 8,674	€ 8,857	€ 9,043	€ 9,232	€ 9,426	€ 9,624	€ 9,826	€ 10,033	€ 10,243
PSS		-€ 1,069,793	€ 0	-€ 110,841	-€ 113,169	-€ 115,545	-€ 117,972	-€ 120,449	-€ 122,979	-€ 125,561	-€ 128,198	-€ 130,890	-€ 133,639	-€ 136,445	-€ 139,311	-€ 142,236	-€ 145,223	-€ 148,273	-€ 151,387
Operating Expenses			**€ 0**	**-€ 178,341**	**-€ 182,086**	**-€ 185,910**	**-€ 189,814**	**-€ 193,800**	**-€ 197,870**	**-€ 202,025**	**-€ 206,268**	**-€ 210,600**	**-€ 215,022**	**-€ 219,538**	**-€ 224,148**	**-€ 228,855**	**-€ 233,661**	**-€ 238,568**	**-€ 243,578**
Net Operating Income			**€ 0**	**€ 733,659**	**€ 749,066**	**€ 764,796**	**€ 780,857**	**€ 797,255**	**€ 813,997**	**€ 831,091**	**€ 848,544**	**€ 866,363**	**€ 884,557**	**€ 903,133**	**€ 922,099**	**€ 941,463**	**€ 961,233**	**€ 981,419**	**€ 1,002,029**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 9,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 12,000,000**															**€ 16,700,48**	
Debt			€ 8,400,000															-€ 7,224,00	
Equity Investment			**-€ 3,600,000**																
Debt Services																			
Interest Payments			€ 0	-€ 294,000	-€ 294,000	-€ 291,060	-€ 288,120	-€ 285,180	-€ 282,240	-€ 279,300	-€ 276,360	-€ 273,420	-€ 270,480	-€ 267,540	-€ 264,600	-€ 261,660	-€ 258,720	-€ 255,780	
Ammortization			€ 0	-€ 84,000.00	-€ 84,000.	-€ 84,000.00	-€ 84,000.	-€ 84,000.00	-€ 84,000.(	-€ 84,000.(	-€ 84,000.(	-€ 84,000.00	-€ 84,000.	-€ 84,000.(	-€ 84,000.0(	-€ 84,000.(	-€ 84,000.0	-€ 84,000.0	
Total Debt Service			**€ 0**	**-€ 378,000**	**-€ 378,000**	**-€ 375,060**	**-€ 372,120**	**-€ 369,180**	**-€ 366,240**	**-€ 363,300**	**-€ 360,360**	**-€ 357,420**	**-€ 354,480**	**-€ 351,540**	**-€ 348,600**	**-€ 345,660**	**-€ 342,720**	**-€ 339,780**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 389,659	€ 405,066	€ 423,736	€ 442,737	€ 462,075	€ 481,757	€ 501,791	€ 522,184	€ 542,943	€ 564,077	€ 585,593	€ 607,499	€ 629,803	€ 652,513	€ 675,639	
Income Tax			€ 0	-€ 97,415	-€ 101,266	-€ 105,934	-€ 110,684	-€ 115,519	-€ 120,439	-€ 125,448	-€ 130,546	-€ 135,736	-€ 141,019	-€ 146,398	-€ 151,875	-€ 157,451	-€ 163,128	-€ 168,910	
Capital gain Tax																		-€ 2,112,62	
Total Tax Liability			**€ 0**	**-€ 97,415**	**-€ 101,266**	**-€ 105,934**	**-€ 110,684**	**-€ 115,519**	**-€ 120,439**	**-€ 125,448**	**-€ 130,546**	**-€ 135,736**	**-€ 141,019**	**-€ 146,398**	**-€ 151,875**	**-€ 157,451**	**-€ 163,128**	**-€ 2,281,53**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 8,400,000	€ 8,400,000	€ 8,316,00	€ 8,232,000	€ 8,148,00	€ 8,064,000	€ 7,980,00	€ 7,896,00	€ 7,812,00	€ 7,728,000	€ 7,644,00	€ 7,560,00	€ 7,476,000	€ 7,392,00	€ 7,308,00	€ 7,224,000	
Amortization			€ 0	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	
Interest Payments			€ 0	€ 294,000	€ 294,000	€ 291,060	€ 288,120	€ 285,180	€ 282,240	€ 279,300	€ 276,360	€ 273,420	€ 270,480	€ 267,540	€ 264,600	€ 261,660	€ 258,720	€ 255,780	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 9,000,000**	€ 8,950,000	€ 8,900,00	€ 8,850,000	€ 8,800,00	€ 8,750,000	€ 8,700,00	€ 8,650,00	€ 8,600,00	€ 8,550,000	€ 8,500,00	€ 8,450,00	€ 8,400,000	€ 8,350,00	€ 8,300,00	€ 8,250,000	
Total Depreciation				**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**8.30%**	€ 320,059	-€ 12,000,000	€ 733,659	€ 749,066	€ 764,796	€ 780,857	€ 797,255	€ 813,997	€ 831,091	€ 848,544	€ 866,363	€ 884,557	€ 903,133	€ 922,099	€ 941,463	€ 961,233	€ 17,681,90	
Net Equity Cashflow (Before Tax)	**15.53%**	€ 3,102,978	-€ 3,600,000	€ 355,659	€ 371,066	€ 389,736	€ 408,737	€ 428,075	€ 447,757	€ 467,791	€ 488,184	€ 508,943	€ 530,077	€ 551,593	€ 573,499	€ 595,803	€ 618,513	€ 10,118,12	
Net Equity Cashflow (After Tax)	**11.97%**	€ 1,501,404	-€ 3,600,000	€ 258,244	€ 269,799	€ 283,802	€ 298,053	€ 312,556	€ 327,318	€ 342,343	€ 357,638	€ 373,208	€ 389,058	€ 405,195	€ 421,624	€ 438,352	€ 455,385	€ 7,836,592	

PSS	**10.00%**
TCU/TCO	**75.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€84,000

ANNUAL DEPRECIATION	
Initial purchase price property	€9,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€4,500,000
Depreciable basis	€1,500,000
Depreciable Life	30
Annual depreciation	€50,000

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 1,039,87
Terminal value at t=16	€ 17,331,2

PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	Basis		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 69,793	€ 0	€ 7,500	€ 7,658	€ 7,818	€ 7,982	€ 8,150	€ 8,321	€ 8,496	€ 8,674	€ 8,857	€ 9,043	€ 9,232	€ 9,426	€ 9,624	€ 9,826	€ 10,033	€ 10,243
PSS		-€ 802,345	€ 0	-€ 83,131	-€ 84,877	-€ 86,659	-€ 88,479	-€ 90,337	-€ 92,234	-€ 94,171	-€ 96,148	-€ 98,168	-€ 100,22	-€ 102,33	-€ 104,483	-€ 106,67	-€ 108,917	-€ 111,205	-€ 113,540
Operating Expenses			**€ 0**	**-€ 150,631**	**-€ 153,794**	**-€ 157,024**	**-€ 160,321**	**-€ 163,688**	**-€ 167,12**	**-€ 170,635**	**-€ 174,218**	**-€ 177,877**	**-€ 181,61**	**-€ 185,42**	**-€ 189,320**	**-€ 193,296**	**-€ 197,355**	**-€ 201,500**	**-€ 205,731**
Net Operating Income			**€ 0**	**€ 761,369**	**€ 777,358**	**€ 793,682**	**€ 810,350**	**€ 827,367**	**€ 844,742**	**€ 862,481**	**€ 880,593**	**€ 899,086**	**€ 917,967**	**€ 937,244**	**€ 956,926**	**€ 977,022**	**€ 997,539**	**€ 1,018,48**	**€ 1,039,876**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 9,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 12,000,000**															**€ 17,331,26**	
Debt			€ 8,400,000															-€ 7,224,00	
Equity Investment			**-€ 3,600,000**																
Debt Services																			
Interest Payments			€ 0	-€ 294,000	-€ 294,000	-€ 291,060	-€ 288,120	-€ 285,180	-€ 282,240	-€ 279,300	-€ 276,360	-€ 273,420	-€ 270,480	-€ 267,540	-€ 264,600	-€ 261,660	-€ 258,720	-€ 255,780	
Ammortization			€ 0	-€ 84,000.00	-€ 84,000.	-€ 84,000.00	-€ 84,000.	-€ 84,000.00	-€ 84,000.(	-€ 84,000.(	-€ 84,000.(	-€ 84,000.00	-€ 84,000.	-€ 84,000.(	-€ 84,000.00	-€ 84,000.(	-€ 84,000.0	-€ 84,000.0	
Total Debt Service			**€ 0**	**-€ 378,000**	**-€ 378,000**	**-€ 375,060**	**-€ 372,120**	**-€ 369,180**	**-€ 366,240**	**-€ 363,300**	**-€ 360,360**	**-€ 357,420**	**-€ 354,48**	**-€ 351,540**	**-€ 348,600**	**-€ 345,660**	**-€ 342,720**	**-€ 339,780**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 417,369	€ 433,358	€ 452,622	€ 472,230	€ 492,187	€ 512,502	€ 533,181	€ 554,233	€ 575,666	€ 597,487	€ 619,704	€ 642,326	€ 665,362	€ 688,819	€ 712,707	
Income Tax			€ 0	-€ 104,342	-€ 108,339	-€ 113,156	-€ 118,057	-€ 123,047	-€ 128,125	-€ 133,295	-€ 138,558	-€ 143,916	-€ 149,37	-€ 154,926	-€ 160,582	-€ 166,340	-€ 172,205	-€ 178,177	
Capital gain Tax																		-€ 2,270,31	
Total Tax Liability			**€ 0**	**-€ 104,342**	**-€ 108,339**	**-€ 113,156**	**-€ 118,057**	**-€ 123,047**	**-€ 128,125**	**-€ 133,295**	**-€ 138,558**	**-€ 143,916**	**-€ 149,37**	**-€ 154,926**	**-€ 160,582**	**-€ 166,340**	**-€ 172,205**	**-€ 2,448,49**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 8,400,000	€ 8,400,000	€ 8,316,00	€ 8,232,000	€ 8,148,00	€ 8,064,000	€ 7,980,00	€ 7,896,00	€ 7,812,00	€ 7,728,000	€ 7,644,00	€ 7,560,00	€ 7,476,000	€ 7,392,00	€ 7,308,00	€ 7,224,000	
Amortization			€ 0	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	
Interest Payments			€ 0	€ 294,000	€ 294,000	€ 291,060	€ 288,120	€ 285,180	€ 282,240	€ 279,300	€ 276,360	€ 273,420	€ 270,480	€ 267,540	€ 264,600	€ 261,660	€ 258,720	€ 255,780	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 9,000,000**	€ 8,950,000	€ 8,900,00	€ 8,850,000	€ 8,800,00	€ 8,750,000	€ 8,700,00	€ 8,650,00	€ 8,600,00	€ 8,550,000	€ 8,500,00	€ 8,450,00	€ 8,400,000	€ 8,350,00	€ 8,300,00	€ 8,250,000	
Total Depreciation				**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**8.69%**	€ 751,814	-€ 12,000,000	€ 761,369	€ 777,358	€ 793,682	€ 810,350	€ 827,367	€ 844,742	€ 862,481	€ 880,593	€ 899,086	€ 917,967	€ 937,244	€ 956,926	€ 977,022	€ 997,539	€ 18,349,74	
Net Equity Cashflow (Before Tax)	**16.41%**	€ 3,534,733	-€ 3,600,000	€ 383,369	€ 399,358	€ 418,622	€ 438,230	€ 458,187	€ 478,502	€ 499,181	€ 520,233	€ 541,666	€ 563,487	€ 585,704	€ 608,326	€ 631,362	€ 654,819	€ 10,785,96	
Net Equity Cashflow (After Tax)	**12.73%**	€ 1,825,220	-€ 3,600,000	€ 279,027	€ 291,018	€ 305,467	€ 320,172	€ 335,140	€ 350,376	€ 365,886	€ 381,675	€ 397,749	€ 414,115	€ 430,778	€ 447,745	€ 465,021	€ 482,614	€ 8,337,476	

PSS	**10.00%**
TCU/TCO	**50.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€84,000

ANNUAL DEPRECIATION	
Initial purchase price property	€9,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€4,500,000
Depreciable basis	€1,500,000
Depreciable Life	30
Annual depreciation	€50,000

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 1,077,72
Terminal value at t=16	€ 17,962,0
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	**Basis**		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 69,793	€ 0	€ 7,500	€ 7,658	€ 7,818	€ 7,982	€ 8,150	€ 8,321	€ 8,496	€ 8,674	€ 8,857	€ 9,043	€ 9,232	€ 9,426	€ 9,624	€ 9,826	€ 10,033	€ 10,243
PSS		-€ 534,897	€ 0	-€ 55,421	-€ 56,584	-€ 57,773	-€ 58,986	-€ 60,225	-€ 61,489	-€ 62,781	-€ 64,099	-€ 65,445	-€ 66,819	-€ 68,223	-€ 69,655	-€ 71,118	-€ 72,612	-€ 74,136	-€ 75,693
Operating Expenses			**€ 0**	**-€ 122,921**	**-€ 125,502**	**-€ 128,137**	**-€ 130,828**	**-€ 133,576**	**-€ 136,381**	**-€ 139,245**	**-€ 142,169**	**-€ 145,155**	**-€ 148,203**	**-€ 151,315**	**-€ 154,493**	**-€ 157,737**	**-€ 161,049**	**-€ 164,431**	**-€ 167,885**
Net Operating Income			**€ 0**	**€ 789,079**	**€ 805,650**	**€ 822,569**	**€ 839,843**	**€ 857,479**	**€ 875,486**	**€ 893,872**	**€ 912,643**	**€ 931,808**	**€ 951,376**	**€ 971,355**	**€ 991,754**	**€ 1,012,58**	**€ 1,033,84**	**€ 1,055,556**	**€ 1,077,722**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 9,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 12,000,000**															**€ 17,962,03**	
Debt			€ 8,400,000															-€ 7,224,00	
Equity Investment			**-€ 3,600,000**																
Debt Services																			
Interest Payments			€ 0	-€ 294,000	-€ 294,000	-€ 291,060	-€ 288,120	-€ 285,180	-€ 282,240	-€ 279,300	-€ 276,360	-€ 273,420	-€ 270,480	-€ 267,540	-€ 264,600	-€ 261,660	-€ 258,720	-€ 255,780	
Ammortization			€ 0	-€ 84,000.00	-€ 84,000.	-€ 84,000.00	-€ 84,000.	-€ 84,000.00	-€ 84,000.(	-€ 84,000.(	-€ 84,000.(	-€ 84,000.00	-€ 84,000.	-€ 84,000.(	-€ 84,000.00	-€ 84,000.(	-€ 84,000.0	-€ 84,000.0	
Total Debt Service			**€ 0**	**-€ 378,000**	**-€ 378,000**	**-€ 375,060**	**-€ 372,120**	**-€ 369,180**	**-€ 366,240**	**-€ 363,300**	**-€ 360,360**	**-€ 357,420**	**-€ 354,480**	**-€ 351,540**	**-€ 348,600**	**-€ 345,660**	**-€ 342,720**	**-€ 339,780**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 445,079	€ 461,650	€ 481,509	€ 501,723	€ 522,299	€ 543,246	€ 564,572	€ 586,283	€ 608,388	€ 630,896	€ 653,815	€ 677,154	€ 700,921	€ 725,125	€ 749,776	
Income Tax			€ 0	-€ 111,270	-€ 115,413	-€ 120,377	-€ 125,431	-€ 130,575	-€ 135,812	-€ 141,143	-€ 146,571	-€ 152,097	-€ 157,724	-€ 163,454	-€ 169,288	-€ 175,230	-€ 181,281	-€ 187,444	
Capital gain Tax																		-€ 2,428,00	
Total Tax Liability			**€ 0**	**-€ 111,270**	**-€ 115,413**	**-€ 120,377**	**-€ 125,431**	**-€ 130,575**	**-€ 135,812**	**-€ 141,143**	**-€ 146,571**	**-€ 152,097**	**-€ 157,724**	**-€ 163,454**	**-€ 169,288**	**-€ 175,230**	**-€ 181,281**	**-€ 2,615,45**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 8,400,000	€ 8,400,000	€ 8,316,00	€ 8,232,000	€ 8,148,00	€ 8,064,000	€ 7,980,00	€ 7,896,00	€ 7,812,00	€ 7,728,000	€ 7,644,00	€ 7,560,00	€ 7,476,000	€ 7,392,00	€ 7,308,00	€ 7,224,000	
Amortization			€ 0	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	€ 84,000	
Interest Payments			€ 0	€ 294,000	€ 294,000	€ 291,060	€ 288,120	€ 285,180	€ 282,240	€ 279,300	€ 276,360	€ 273,420	€ 270,480	€ 267,540	€ 264,600	€ 261,660	€ 258,720	€ 255,780	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 9,000,000**	€ 8,950,000	€ 8,900,00	€ 8,850,000	€ 8,800,00	€ 8,750,000	€ 8,700,00	€ 8,650,00	€ 8,600,00	€ 8,550,000	€ 8,500,00	€ 8,450,00	€ 8,400,000	€ 8,350,00	€ 8,300,00	€ 8,250,000	
Total Depreciation				**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	**€ 50,000**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**9.07%**	€ 1,183,569	-€ 12,000,000	€ 789,079	€ 805,650	€ 822,569	€ 839,843	€ 857,479	€ 875,486	€ 893,872	€ 912,643	€ 931,808	€ 951,376	€ 971,355	€ 991,754	€ 1,012,58	€ 1,033,84	€ 19,017,59	
Net Equity Cashflow (Before Tax)	**17.27%**	€ 3,966,488	-€ 3,600,000	€ 411,079	€ 427,650	€ 447,509	€ 467,723	€ 488,299	€ 509,246	€ 530,572	€ 552,283	€ 574,388	€ 596,896	€ 619,815	€ 643,154	€ 666,921	€ 691,125	€ 11,453,81	
Net Equity Cashflow (After Tax)	**13.46%**	€ 2,149,036	-€ 3,600,000	€ 299,810	€ 312,238	€ 327,132	€ 342,292	€ 357,725	€ 373,435	€ 389,429	€ 405,712	€ 422,291	€ 439,172	€ 456,362	€ 473,865	€ 491,690	€ 509,844	€ 8,838,360	

PSS	**20.00%**
TCU/TCO	**100.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€77,000

ANNUAL DEPRECIATION	
Initial purchase price property	€8,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€4,000,000
Depreciable basis	€1,000,000
Depreciable Life	30
Annual depreciation	€33,333

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 860,886
Terminal value at t=16	€ 14,348,1
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	**Basis**		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 139,587	€ 0	€ 15,000	€ 15,315	€ 15,637	€ 15,965	€ 16,300	€ 16,643	€ 16,992	€ 17,349	€ 17,713	€ 18,085	€ 18,465	€ 18,853	€ 19,249	€ 19,653	€ 20,066	€ 20,487
PSS		-€ 2,139,587	€ 0	-€ 221,682	-€ 226,338	-€ 231,091	-€ 235,944	-€ 240,898	-€ 245,957	-€ 251,122	-€ 256,396	-€ 261,780	-€ 267,278	-€ 272,891	-€ 278,621	-€ 284,472	-€ 290,446	-€ 296,546	-€ 302,773
Operating Expenses			**€ 0**	**-€ 281,682**	**-€ 287,598**	**-€ 293,637**	**-€ 299,804**	**-€ 306,099**	**-€ 312,528**	**-€ 319,091**	**-€ 325,792**	**-€ 332,633**	**-€ 339,618**	**-€ 346,750**	**-€ 354,032**	**-€ 361,467**	**-€ 369,058**	**-€ 376,808**	**-€ 384,721**
Net Operating Income			**€ 0**	**€ 630,318**	**€ 643,554**	**€ 657,069**	**€ 670,867**	**€ 684,956**	**€ 699,340**	**€ 714,026**	**€ 729,020**	**€ 744,330**	**€ 759,961**	**€ 775,920**	**€ 792,214**	**€ 808,851**	**€ 825,837**	**€ 843,179**	**€ 860,886**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 8,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 11,000,000**															**€ 14,348,10**	
Debt			€ 7,700,000															-€ 6,622,00	
Equity Investment			**-€ 3,300,000**																
Debt Services																			
Interest Payments			€ 0	-€ 269,500	-€ 269,500	-€ 266,805	-€ 264,110	-€ 261,415	-€ 258,720	-€ 256,025	-€ 253,330	-€ 250,635	-€ 247,940	-€ 245,245	-€ 242,550	-€ 239,855	-€ 237,160	-€ 234,465	
Ammortization			€ 0	-€ 77,000.00	-€ 77,000.	-€ 77,000.00	-€ 77,000.	-€ 77,000.00	-€ 77,000.	-€ 77,000.	-€ 77,000.	-€ 77,000.00	-€ 77,000.	-€ 77,000.	-€ 77,000.00	-€ 77,000.	-€ 77,000.0	-€ 77,000.0	
Total Debt Service			**€ 0**	**-€ 346,500**	**-€ 346,500**	**-€ 343,805**	**-€ 341,110**	**-€ 338,415**	**-€ 335,720**	**-€ 333,025**	**-€ 330,330**	**-€ 327,635**	**-€ 324,940**	**-€ 322,245**	**-€ 319,550**	**-€ 316,855**	**-€ 314,160**	**-€ 311,465**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 327,484	€ 340,721	€ 356,931	€ 373,424	€ 390,207	€ 407,286	€ 424,668	€ 442,357	€ 460,362	€ 478,687	€ 497,342	€ 516,331	€ 535,662	€ 555,343	€ 575,381	
Income Tax			€ 0	-€ 81,871	-€ 85,180	-€ 89,233	-€ 93,356	-€ 97,552	-€ 101,822	-€ 106,167	-€ 110,589	-€ 115,090	-€ 119,672	-€ 124,335	-€ 129,083	-€ 133,916	-€ 138,836	-€ 143,845	
Capital gain Tax																		-€ 1,712,02	
Total Tax Liability			**€ 0**	**-€ 81,871**	**-€ 85,180**	**-€ 89,233**	**-€ 93,356**	**-€ 97,552**	**-€ 101,822**	**-€ 106,167**	**-€ 110,589**	**-€ 115,090**	**-€ 119,672**	**-€ 124,335**	**-€ 129,083**	**-€ 133,916**	**-€ 138,836**	**-€ 1,855,87**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 7,700,000	€ 7,700,000	€ 7,623,00	€ 7,546,000	€ 7,469,00	€ 7,392,000	€ 7,315,00	€ 7,238,00	€ 7,161,00	€ 7,084,000	€ 7,007,00	€ 6,930,00	€ 6,853,000	€ 6,776,00	€ 6,699,00	€ 6,622,000	
Amortization			€ 0	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	
Interest Payments			€ 0	€ 269,500	€ 269,500	€ 266,805	€ 264,110	€ 261,415	€ 258,720	€ 256,025	€ 253,330	€ 250,635	€ 247,940	€ 245,245	€ 242,550	€ 239,855	€ 237,160	€ 234,465	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 8,000,000**	€ 7,966,667	€ 7,933,33	€ 7,900,000	€ 7,866,66	€ 7,833,333	€ 7,800,00	€ 7,766,66	€ 7,733,33	€ 7,700,000	€ 7,666,66	€ 7,633,33	€ 7,600,000	€ 7,566,66	€ 7,533,33	€ 7,500,000	
Total Depreciation				**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**7.62%**	-€ 364,178	-€ 11,000,000	€ 630,318	€ 643,554	€ 657,069	€ 670,867	€ 684,956	€ 699,340	€ 714,026	€ 729,020	€ 744,330	€ 759,961	€ 775,920	€ 792,214	€ 808,851	€ 825,837	€ 15,191,27	
Net Equity Cashflow (Before Tax)	**14.00%**	€ 2,186,831	-€ 3,300,000	€ 283,818	€ 297,054	€ 313,264	€ 329,757	€ 346,541	€ 363,620	€ 381,001	€ 398,690	€ 416,695	€ 435,021	€ 453,675	€ 472,664	€ 491,996	€ 511,677	€ 8,257,814	
Net Equity Cashflow (After Tax)	**10.55%**	€ 853,785	-€ 3,300,000	€ 201,947	€ 211,874	€ 224,031	€ 236,401	€ 248,989	€ 261,798	€ 274,834	€ 288,101	€ 301,604	€ 315,349	€ 329,340	€ 343,582	€ 358,080	€ 372,841	€ 6,401,944	

PSS	**20.00%**
TCU/TCO	**75.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€77,000

ANNUAL DEPRECIATION	
Initial purchase price property	€8,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€4,000,000
Depreciable basis	€1,000,000
Depreciable Life	30
Annual depreciation	€33,333

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 936,579
Terminal value at t=16	€ 15,609,65
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	Basis		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 139,587	€ 0	€ 15,000	€ 15,315	€ 15,637	€ 15,965	€ 16,300	€ 16,643	€ 16,992	€ 17,349	€ 17,713	€ 18,085	€ 18,465	€ 18,853	€ 19,249	€ 19,653	€ 20,066	€ 20,487
PSS		-€ 1,604,690	€ 0	-€ 166,262	-€ 169,753	-€ 173,318	-€ 176,958	-€ 180,674	-€ 184,468	-€ 188,342	-€ 192,297	-€ 196,335	-€ 200,458	-€ 204,668	-€ 208,966	-€ 213,354	-€ 217,835	-€ 222,409	-€ 227,080
Operating Expenses			**€ 0**	**-€ 226,262**	**-€ 231,013**	**-€ 235,865**	**-€ 240,818**	**-€ 245,875**	**-€ 251,038**	**-€ 256,310**	**-€ 261,693**	**-€ 267,188**	**-€ 272,795**	**-€ 278,528**	**-€ 284,377**	**-€ 290,349**	**-€ 296,446**	**-€ 302,671**	**-€ 309,028**
Net Operating Income			**€ 0**	**€ 685,738**	**€ 700,139**	**€ 714,842**	**€ 729,853**	**€ 745,180**	**€ 760,829**	**€ 776,806**	**€ 793,119**	**€ 809,775**	**€ 826,780**	**€ 844,143**	**€ 861,870**	**€ 879,969**	**€ 898,448**	**€ 917,316**	**€ 936,579**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 8,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 11,000,000**															**€ 15,609,65**	
Debt			€ 7,700,000															-€ 6,622,00	
Equity Investment			**-€ 3,300,000**																
Debt Services																			
Interest Payments			€ 0	-€ 269,500	-€ 269,500	-€ 266,805	-€ 264,110	-€ 261,415	-€ 258,720	-€ 256,025	-€ 253,330	-€ 250,635	-€ 247,940	-€ 245,245	-€ 242,550	-€ 239,855	-€ 237,160	-€ 234,465	
Ammortization			€ 0	-€ 77,000.00	-€ 77,000.	-€ 77,000.00	-€ 77,000.	-€ 77,000.00	-€ 77,000.	-€ 77,000.	-€ 77,000.	-€ 77,000.00	-€ 77,000.	-€ 77,000.	-€ 77,000.00	-€ 77,000.	-€ 77,000.0	-€ 77,000.0	
Total Debt Service			**€ 0**	**-€ 346,500**	**-€ 346,500**	**-€ 343,805**	**-€ 341,110**	**-€ 338,415**	**-€ 335,720**	**-€ 333,025**	**-€ 330,330**	**-€ 327,635**	**-€ 324,940**	**-€ 322,245**	**-€ 319,550**	**-€ 316,855**	**-€ 314,160**	**-€ 311,465**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 382,905	€ 397,305	€ 414,703	€ 432,410	€ 450,432	€ 468,776	€ 487,448	€ 506,456	€ 525,807	€ 545,507	€ 565,564	€ 585,986	€ 606,781	€ 627,955	€ 649,517	
Income Tax			€ 0	-€ 95,726	-€ 99,326	-€ 103,676	-€ 108,103	-€ 112,608	-€ 117,194	-€ 121,862	-€ 126,614	-€ 131,452	-€ 136,377	-€ 141,391	-€ 146,497	-€ 151,695	-€ 156,989	-€ 162,379	
Capital gain Tax																		-€ 2,027,41	
Total Tax Liability			**€ 0**	**-€ 95,726**	**-€ 99,326**	**-€ 103,676**	**-€ 108,103**	**-€ 112,608**	**-€ 117,194**	**-€ 121,862**	**-€ 126,614**	**-€ 131,452**	**-€ 136,377**	**-€ 141,391**	**-€ 146,497**	**-€ 151,695**	**-€ 156,989**	**-€ 2,189,79**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 7,700,000	€ 7,700,000	€ 7,623,00	€ 7,546,000	€ 7,469,00	€ 7,392,000	€ 7,315,00	€ 7,238,00	€ 7,161,00	€ 7,084,000	€ 7,007,00	€ 6,930,00	€ 6,853,000	€ 6,776,00	€ 6,699,00	€ 6,622,000	
Amortization			€ 0	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	
Interest Payments			€ 0	€ 269,500	€ 269,500	€ 266,805	€ 264,110	€ 261,415	€ 258,720	€ 256,025	€ 253,330	€ 250,635	€ 247,940	€ 245,245	€ 242,550	€ 239,855	€ 237,160	€ 234,465	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 8,000,000**	€ 7,966,667	€ 7,933,33	€ 7,900,000	€ 7,866,66	€ 7,833,333	€ 7,800,00	€ 7,766,66	€ 7,733,33	€ 7,700,000	€ 7,666,66	€ 7,633,33	€ 7,600,000	€ 7,566,66	€ 7,533,33	€ 7,500,000	
Total Depreciation				**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**8.50%**	€ 499,332	-€ 11,000,000	€ 685,738	€ 700,139	€ 714,842	€ 729,853	€ 745,180	€ 760,829	€ 776,806	€ 793,119	€ 809,775	€ 826,780	€ 844,143	€ 861,870	€ 879,969	€ 898,448	€ 16,526,96	
Net Equity Cashflow (Before Tax)	**15.99%**	€ 3,050,341	-€ 3,300,000	€ 339,238	€ 353,639	€ 371,037	€ 388,743	€ 406,765	€ 425,109	€ 443,781	€ 462,789	€ 482,140	€ 501,840	€ 521,898	€ 542,320	€ 563,114	€ 584,288	€ 9,593,504	
Net Equity Cashflow (After Tax)	**12.28%**	€ 1,501,418	-€ 3,300,000	€ 243,512	€ 254,312	€ 267,361	€ 280,641	€ 294,157	€ 307,915	€ 321,919	€ 336,175	€ 350,688	€ 365,463	€ 380,507	€ 395,823	€ 411,419	€ 427,299	€ 7,403,712	

PSS	**20.00%**
TCU/TCO	**50.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€77,000

ANNUAL DEPRECIATION	
Initial purchase price property	€8,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€4,000,000
Depreciable basis	€1,000,000
Depreciable Life	30
Annual depreciation	€33,333

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 1,012,27
Terminal value at t=16	€ 16,871,2
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	**Basis**		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 139,587	€ 0	€ 15,000	€ 15,315	€ 15,637	€ 15,965	€ 16,300	€ 16,643	€ 16,992	€ 17,349	€ 17,713	€ 18,085	€ 18,465	€ 18,853	€ 19,249	€ 19,653	€ 20,066	€ 20,487
PSS		-€ 1,069,793	€ 0	-€ 110,841	-€ 113,169	-€ 115,545	-€ 117,972	-€ 120,449	-€ 122,979	-€ 125,561	-€ 128,198	-€ 130,890	-€ 133,639	-€ 136,445	-€ 139,311	-€ 142,236	-€ 145,223	-€ 148,273	-€ 151,387
Operating Expenses			**€ 0**	**-€ 170,841**	**-€ 174,429**	**-€ 178,092**	**-€ 181,832**	**-€ 185,650**	**-€ 189,549**	**-€ 193,529**	**-€ 197,594**	**-€ 201,743**	**-€ 205,980**	**-€ 210,305**	**-€ 214,722**	**-€ 219,231**	**-€ 223,835**	**-€ 228,535**	**-€ 233,334**
Net Operating Income			**€ 0**	**€ 741,159**	**€ 756,723**	**€ 772,614**	**€ 788,839**	**€ 805,405**	**€ 822,318**	**€ 839,587**	**€ 857,218**	**€ 875,220**	**€ 893,600**	**€ 912,365**	**€ 931,525**	**€ 951,087**	**€ 971,060**	**€ 991,452**	**€ 1,012,272**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 8,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 11,000,000**															**€ 16,871,20**	
Debt			€ 7,700,000															-€ 6,622,00	
Equity Investment			**-€ 3,300,000**																
Debt Services																			
Interest Payments			€ 0	-€ 269,500	-€ 269,500	-€ 266,805	-€ 264,110	-€ 261,415	-€ 258,720	-€ 256,025	-€ 253,330	-€ 250,635	-€ 247,940	-€ 245,245	-€ 242,550	-€ 239,855	-€ 237,160	-€ 234,465	
Ammortization			€ 0	-€ 77,000.00	-€ 77,000.	-€ 77,000.00	-€ 77,000.	-€ 77,000.00	-€ 77,000.	-€ 77,000.	-€ 77,000.	-€ 77,000.00	-€ 77,000.	-€ 77,000.	-€ 77,000.00	-€ 77,000.	-€ 77,000.0	-€ 77,000.0	
Total Debt Service			**€ 0**	**-€ 346,500**	**-€ 346,500**	**-€ 343,805**	**-€ 341,110**	**-€ 338,415**	**-€ 335,720**	**-€ 333,025**	**-€ 330,330**	**-€ 327,635**	**-€ 324,940**	**-€ 322,245**	**-€ 319,550**	**-€ 316,855**	**-€ 314,160**	**-€ 311,465**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 438,326	€ 453,890	€ 472,476	€ 491,396	€ 510,657	€ 530,265	€ 550,229	€ 570,555	€ 591,252	€ 612,326	€ 633,787	€ 655,642	€ 677,899	€ 700,566	€ 723,654	
Income Tax			€ 0	-€ 109,581	-€ 113,472	-€ 118,119	-€ 122,849	-€ 127,664	-€ 132,566	-€ 137,557	-€ 142,639	-€ 147,813	-€ 153,082	-€ 158,447	-€ 163,910	-€ 169,475	-€ 175,142	-€ 180,913	
Capital gain Tax																		-€ 2,342,80	
Total Tax Liability			**€ 0**	**-€ 109,581**	**-€ 113,472**	**-€ 118,119**	**-€ 122,849**	**-€ 127,664**	**-€ 132,566**	**-€ 137,557**	**-€ 142,639**	**-€ 147,813**	**-€ 153,082**	**-€ 158,447**	**-€ 163,910**	**-€ 169,475**	**-€ 175,142**	**-€ 2,523,71**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 7,700,000	€ 7,700,000	€ 7,623,00	€ 7,546,000	€ 7,469,00	€ 7,392,000	€ 7,315,00	€ 7,238,00	€ 7,161,00	€ 7,084,000	€ 7,007,00	€ 6,930,00	€ 6,853,000	€ 6,776,00	€ 6,699,00	€ 6,622,000	
Amortization			€ 0	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	€ 77,000	
Interest Payments			€ 0	€ 269,500	€ 269,500	€ 266,805	€ 264,110	€ 261,415	€ 258,720	€ 256,025	€ 253,330	€ 250,635	€ 247,940	€ 245,245	€ 242,550	€ 239,855	€ 237,160	€ 234,465	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 8,000,000**	€ 7,966,667	€ 7,933,33	€ 7,900,000	€ 7,866,66	€ 7,833,333	€ 7,800,00	€ 7,766,66	€ 7,733,33	€ 7,700,000	€ 7,666,66	€ 7,633,33	€ 7,600,000	€ 7,566,66	€ 7,533,33	€ 7,500,000	
Total Depreciation				**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	**€ 33,333**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**9.33%**	€ 1,362,843	-€ 11,000,000	€ 741,159	€ 756,723	€ 772,614	€ 788,839	€ 805,405	€ 822,318	€ 839,587	€ 857,218	€ 875,220	€ 893,600	€ 912,365	€ 931,525	€ 951,087	€ 971,060	€ 17,862,66	
Net Equity Cashflow (Before Tax)	**17.86%**	€ 3,913,852	-€ 3,300,000	€ 394,659	€ 410,223	€ 428,809	€ 447,729	€ 466,990	€ 486,598	€ 506,562	€ 526,888	€ 547,585	€ 568,660	€ 590,120	€ 611,975	€ 634,232	€ 656,900	€ 10,929,19	
Net Equity Cashflow (After Tax)	**13.89%**	€ 2,149,050	-€ 3,300,000	€ 285,077	€ 296,751	€ 310,690	€ 324,880	€ 339,326	€ 354,032	€ 369,005	€ 384,250	€ 399,772	€ 415,578	€ 431,673	€ 448,064	€ 464,757	€ 481,758	€ 8,405,48	

PSS	**30.00%**
TCU/TCO	**100.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€70,000

ANNUAL DEPRECIATION	
Initial purchase price property	€7,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€3,500,000
Depreciable basis	€500,000
Depreciable Life	30
Annual depreciation	€16,667

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 719,743
Terminal value at t=16	€ 11,995,71
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	Basis		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 209,380	€ 0	€ 22,500	€ 22,973	€ 23,455	€ 23,947	€ 24,450	€ 24,964	€ 25,488	€ 26,023	€ 26,570	€ 27,128	€ 27,697	€ 28,279	€ 28,873	€ 29,479	€ 30,098	€ 30,730
PSS		-€ 3,209,380	€ 0	-€ 332,523	-€ 339,506	-€ 346,636	-€ 353,915	-€ 361,348	-€ 368,936	-€ 376,684	-€ 384,594	-€ 392,670	-€ 400,917	-€ 409,336	-€ 417,932	-€ 426,708	-€ 435,669	-€ 444,818	-€ 454,160
Operating Expenses			**€ 0**	**-€ 385,023**	**-€ 393,109**	**-€ 401,364**	**-€ 409,793**	**-€ 418,399**	**-€ 427,185**	**-€ 436,156**	**-€ 445,315**	**-€ 454,667**	**-€ 464,215**	**-€ 473,963**	**-€ 483,916**	**-€ 494,079**	**-€ 504,454**	**-€ 515,048**	**-€ 525,864**
Net Operating Income			**€ 0**	**€ 526,977**	**€ 538,043**	**€ 549,342**	**€ 560,878**	**€ 572,657**	**€ 584,682**	**€ 596,961**	**€ 609,497**	**€ 622,296**	**€ 635,365**	**€ 648,707**	**€ 662,330**	**€ 676,239**	**€ 690,440**	**€ 704,939**	**€ 719,743**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 7,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 10,000,000**															**€ 11,995,71**	
Debt			€ 7,000,000															-€ 6,020,00	
Equity Investment			**-€ 3,000,000**																
Debt Services																			
Interest Payments			€ 0	-€ 245,000	-€ 245,000	-€ 242,550	-€ 240,100	-€ 237,650	-€ 235,200	-€ 232,750	-€ 230,300	-€ 227,850	-€ 225,400	-€ 222,950	-€ 220,500	-€ 218,050	-€ 215,600	-€ 213,150	
Ammortization			€ 0	-€ 70,000.00	-€ 70,000.	-€ 70,000.00	-€ 70,000.	-€ 70,000.00	-€ 70,000.(	-€ 70,000.(	-€ 70,000.(	-€ 70,000.00	-€ 70,000.	-€ 70,000.(	-€ 70,000.0(	-€ 70,000.(	-€ 70,000.0	-€ 70,000.0	
Total Debt Service			**€ 0**	**-€ 315,000**	**-€ 315,000**	**-€ 312,550**	**-€ 310,100**	**-€ 307,650**	**-€ 305,200**	**-€ 302,750**	**-€ 300,300**	**-€ 297,850**	**-€ 295,400**	**-€ 292,950**	**-€ 290,500**	**-€ 288,050**	**-€ 285,600**	**-€ 283,150**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 265,310	€ 276,376	€ 290,125	€ 304,111	€ 318,340	€ 332,816	€ 347,544	€ 362,530	€ 377,780	€ 393,298	€ 409,091	€ 425,163	€ 441,522	€ 458,173	€ 475,123	
Income Tax			€ 0	-€ 66,327	-€ 69,094	-€ 72,531	-€ 76,028	-€ 79,585	-€ 83,204	-€ 86,886	-€ 90,633	-€ 94,445	-€ 98,324	-€ 102,273	-€ 106,291	-€ 110,381	-€ 114,543	-€ 118,781	
Capital gain Tax																		-€ 1,311,42	
Total Tax Liability			**€ 0**	**-€ 66,327**	**-€ 69,094**	**-€ 72,531**	**-€ 76,028**	**-€ 79,585**	**-€ 83,204**	**-€ 86,886**	**-€ 90,633**	**-€ 94,445**	**-€ 98,324**	**-€ 102,273**	**-€ 106,291**	**-€ 110,381**	**-€ 114,543**	**-€ 1,430,21**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 7,000,000	€ 7,000,000	€ 6,930,00	€ 6,860,000	€ 6,790,00	€ 6,720,000	€ 6,650,00	€ 6,580,00	€ 6,510,00	€ 6,440,000	€ 6,370,00	€ 6,300,00	€ 6,230,000	€ 6,160,00	€ 6,090,00	€ 6,020,000	
Amortization			€ 0	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	
Interest Payments			€ 0	€ 245,000	€ 245,000	€ 242,550	€ 240,100	€ 237,650	€ 235,200	€ 232,750	€ 230,300	€ 227,850	€ 225,400	€ 222,950	€ 220,500	€ 218,050	€ 215,600	€ 213,150	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 7,000,000**	€ 6,983,333	€ 6,966,66	€ 6,950,000	€ 6,933,33	€ 6,916,667	€ 6,900,00	€ 6,883,33	€ 6,866,66	€ 6,850,000	€ 6,833,33	€ 6,816,66	€ 6,800,000	€ 6,783,33	€ 6,766,66	€ 6,750,000	
Total Depreciation				**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**6.78%**	-€ 1,048,415	-€ 10,000,000	€ 526,977	€ 538,043	€ 549,342	€ 560,878	€ 572,657	€ 584,682	€ 596,961	€ 609,497	€ 622,296	€ 635,365	€ 648,707	€ 662,330	€ 676,239	€ 690,440	€ 12,700,65	
Net Equity Cashflow (Before Tax)	**12.04%**	€ 1,270,684	-€ 3,000,000	€ 211,977	€ 223,043	€ 236,792	€ 250,778	€ 265,007	€ 279,482	€ 294,211	€ 309,197	€ 324,446	€ 339,965	€ 355,757	€ 371,830	€ 388,189	€ 404,840	€ 6,397,505	
Net Equity Cashflow (After Tax)	**8.71%**	€ 206,166	-€ 3,000,000	€ 145,649	€ 153,949	€ 164,261	€ 174,750	€ 185,422	€ 196,278	€ 207,325	€ 218,564	€ 230,001	€ 241,640	€ 253,485	€ 265,539	€ 277,808	€ 290,297	€ 4,967,295	

PSS	**30.00%**
TCU/TCO	**75.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€70,000

ANNUAL DEPRECIATION	
Initial purchase price property	€7,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€3,500,000
Depreciable basis	€500,000
Depreciable Life	30
Annual depreciation	€16,667

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 833,283
Terminal value at t=16	€ 13,888,04
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	**Basis**		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 209,380	€ 0	€ 22,500	€ 22,973	€ 23,455	€ 23,947	€ 24,450	€ 24,964	€ 25,488	€ 26,023	€ 26,570	€ 27,128	€ 27,697	€ 28,279	€ 28,873	€ 29,479	€ 30,098	€ 30,730
PSS		-€ 2,407,035	€ 0	-€ 249,393	-€ 254,630	-€ 259,977	-€ 265,437	-€ 271,011	-€ 276,702	-€ 282,513	-€ 288,445	-€ 294,503	-€ 300,687	-€ 307,002	-€ 313,449	-€ 320,031	-€ 326,752	-€ 333,614	-€ 340,620
Operating Expenses			**€ 0**	**-€ 301,893**	**-€ 308,232**	**-€ 314,705**	**-€ 321,314**	**-€ 328,062**	**-€ 334,951**	**-€ 341,985**	**-€ 349,167**	**-€ 356,499**	**-€ 363,986**	**-€ 371,629**	**-€ 379,433**	**-€ 387,402**	**-€ 395,537**	**-€ 403,843**	**-€ 412,324**
Net Operating Income			**€ 0**	**€ 610,107**	**€ 622,920**	**€ 636,001**	**€ 649,357**	**€ 662,993**	**€ 676,916**	**€ 691,132**	**€ 705,645**	**€ 720,464**	**€ 735,594**	**€ 751,041**	**€ 766,813**	**€ 782,916**	**€ 799,357**	**€ 816,144**	**€ 833,283**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 7,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 10,000,000**															**€ 13,888,04**	
Debt			€ 7,000,000															-€ 6,020,00	
Equity Investment			**-€ 3,000,000**																
Debt Services																			
Interest Payments			€ 0	-€ 245,000	-€ 245,000	-€ 242,550	-€ 240,100	-€ 237,650	-€ 235,200	-€ 232,750	-€ 230,300	-€ 227,850	-€ 225,400	-€ 222,950	-€ 220,500	-€ 218,050	-€ 215,600	-€ 213,150	
Ammortization			€ 0	-€ 70,000.00	-€ 70,000.	-€ 70,000.00	-€ 70,000.	-€ 70,000.00	-€ 70,000.(	-€ 70,000.(	-€ 70,000.(	-€ 70,000.00	-€ 70,000.	-€ 70,000.(	-€ 70,000.00	-€ 70,000.(	-€ 70,000.0	-€ 70,000.0	
Total Debt Service			**€ 0**	**-€ 315,000**	**-€ 315,000**	**-€ 312,550**	**-€ 310,100**	**-€ 307,650**	**-€ 305,200**	**-€ 302,750**	**-€ 300,300**	**-€ 297,850**	**-€ 295,400**	**-€ 292,950**	**-€ 290,500**	**-€ 288,050**	**-€ 285,600**	**-€ 283,150**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 348,441	€ 361,253	€ 376,784	€ 392,590	€ 408,677	€ 425,050	€ 441,715	€ 458,679	€ 475,947	€ 493,527	€ 511,424	€ 529,646	€ 548,199	€ 567,091	€ 586,327	
Income Tax			€ 0	-€ 87,110	-€ 90,313	-€ 94,196	-€ 98,148	-€ 102,169	-€ 106,262	-€ 110,429	-€ 114,670	-€ 118,987	-€ 123,382	-€ 127,856	-€ 132,412	-€ 137,050	-€ 141,773	-€ 146,582	
Capital gain Tax																		-€ 1,784,51	
Total Tax Liability			**€ 0**	**-€ 87,110**	**-€ 90,313**	**-€ 94,196**	**-€ 98,148**	**-€ 102,169**	**-€ 106,262**	**-€ 110,429**	**-€ 114,670**	**-€ 118,987**	**-€ 123,382**	**-€ 127,856**	**-€ 132,412**	**-€ 137,050**	**-€ 141,773**	**-€ 1,931,09**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 7,000,000	€ 7,000,000	€ 6,930,00	€ 6,860,000	€ 6,790,00	€ 6,720,000	€ 6,650,00	€ 6,580,00	€ 6,510,00	€ 6,440,000	€ 6,370,00	€ 6,300,00	€ 6,230,000	€ 6,160,00	€ 6,090,00	€ 6,020,000	
Amortization			€ 0	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	
Interest Payments			€ 0	€ 245,000	€ 245,000	€ 242,550	€ 240,100	€ 237,650	€ 235,200	€ 232,750	€ 230,300	€ 227,850	€ 225,400	€ 222,950	€ 220,500	€ 218,050	€ 215,600	€ 213,150	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 7,000,000**	€ 6,983,333	€ 6,966,66	€ 6,950,000	€ 6,933,33	€ 6,916,667	€ 6,900,00	€ 6,883,33	€ 6,866,66	€ 6,850,000	€ 6,833,33	€ 6,816,66	€ 6,800,000	€ 6,783,33	€ 6,766,66	€ 6,750,000	
Total Depreciation				**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**8.27%**	€ 246,851	-€ 10,000,000	€ 610,107	€ 622,920	€ 636,001	€ 649,357	€ 662,993	€ 676,916	€ 691,132	€ 705,645	€ 720,464	€ 735,594	€ 751,041	€ 766,813	€ 782,916	€ 799,357	€ 14,704,19	
Net Equity Cashflow (Before Tax)	**15.48%**	€ 2,565,949	-€ 3,000,000	€ 295,107	€ 307,920	€ 323,451	€ 339,257	€ 355,343	€ 371,716	€ 388,382	€ 405,345	€ 422,614	€ 440,194	€ 458,091	€ 476,313	€ 494,866	€ 513,757	€ 8,401,041	
Net Equity Cashflow (After Tax)	**11.74%**	€ 1,177,615	-€ 3,000,000	€ 207,997	€ 217,606	€ 229,255	€ 241,109	€ 253,174	€ 265,454	€ 277,953	€ 290,676	€ 303,627	€ 316,812	€ 330,235	€ 343,901	€ 357,816	€ 371,985	€ 6,469,947	

PSS	**30.00%**
TCU/TCO	**50.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€70,000

ANNUAL DEPRECIATION	
Initial purchase price property	€7,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€3,500,000
Depreciable basis	€500,000
Depreciable Life	30
Annual depreciation	€16,667

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 946,823
Terminal value at t=16	€ 15,780,37
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	Basis		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 209,380	€ 0	€ 22,500	€ 22,973	€ 23,455	€ 23,947	€ 24,450	€ 24,964	€ 25,488	€ 26,023	€ 26,570	€ 27,128	€ 27,697	€ 28,279	€ 28,873	€ 29,479	€ 30,098	€ 30,730
PSS		-€ 1,604,690	€ 0	-€ 166,262	-€ 169,753	-€ 173,318	-€ 176,958	-€ 180,674	-€ 184,468	-€ 188,342	-€ 192,297	-€ 196,335	-€ 200,458	-€ 204,668	-€ 208,966	-€ 213,354	-€ 217,835	-€ 222,409	-€ 227,080
Operating Expenses			**€ 0**	**-€ 218,762**	**-€ 223,356**	**-€ 228,046**	**-€ 232,835**	**-€ 237,725**	**-€ 242,717**	**-€ 247,814**	**-€ 253,018**	**-€ 258,331**	**-€ 263,756**	**-€ 269,295**	**-€ 274,950**	**-€ 280,724**	**-€ 286,620**	**-€ 292,639**	**-€ 298,784**
Net Operating Income			**€ 0**	**€ 693,238**	**€ 707,796**	**€ 722,660**	**€ 737,836**	**€ 753,330**	**€ 769,150**	**€ 785,303**	**€ 801,794**	**€ 818,632**	**€ 835,823**	**€ 853,375**	**€ 871,296**	**€ 889,593**	**€ 908,275**	**€ 927,348**	**€ 946,823**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 7,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 10,000,000**															**€ 15,780,37**	
Debt			€ 7,000,000															-€ 6,020,00	
Equity Investment			**-€ 3,000,000**																
Debt Services																			
Interest Payments			€ 0	-€ 245,000	-€ 245,000	-€ 242,550	-€ 240,100	-€ 237,650	-€ 235,200	-€ 232,750	-€ 230,300	-€ 227,850	-€ 225,400	-€ 222,950	-€ 220,500	-€ 218,050	-€ 215,600	-€ 213,150	
Ammortization			€ 0	-€ 70,000.00	-€ 70,000.	-€ 70,000.00	-€ 70,000.	-€ 70,000.00	-€ 70,000.(	-€ 70,000.(	-€ 70,000.(	-€ 70,000.00	-€ 70,000.	-€ 70,000.(	-€ 70,000.0(	-€ 70,000.(	-€ 70,000.0	-€ 70,000.0	
Total Debt Service			**€ 0**	**-€ 315,000**	**-€ 315,000**	**-€ 312,550**	**-€ 310,100**	**-€ 307,650**	**-€ 305,200**	**-€ 302,750**	**-€ 300,300**	**-€ 297,850**	**-€ 295,400**	**-€ 292,950**	**-€ 290,500**	**-€ 288,050**	**-€ 285,600**	**-€ 283,150**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 431,572	€ 446,130	€ 463,443	€ 481,069	€ 499,014	€ 517,284	€ 535,886	€ 554,827	€ 574,115	€ 593,756	€ 613,758	€ 634,129	€ 654,876	€ 676,008	€ 697,532	
Income Tax			€ 0	-€ 107,893	-€ 111,532	-€ 115,861	-€ 120,267	-€ 124,753	-€ 129,321	-€ 133,971	-€ 138,707	-€ 143,529	-€ 148,439	-€ 153,440	-€ 158,532	-€ 163,719	-€ 169,002	-€ 174,383	
Capital gain Tax																		-€ 2,257,59	
Total Tax Liability			**€ 0**	**-€ 107,893**	**-€ 111,532**	**-€ 115,861**	**-€ 120,267**	**-€ 124,753**	**-€ 129,321**	**-€ 133,971**	**-€ 138,707**	**-€ 143,529**	**-€ 148,439**	**-€ 153,440**	**-€ 158,532**	**-€ 163,719**	**-€ 169,002**	**-€ 2,431,97**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 7,000,000	€ 7,000,000	€ 6,930,00	€ 6,860,000	€ 6,790,00	€ 6,720,000	€ 6,650,00	€ 6,580,00	€ 6,510,00	€ 6,440,000	€ 6,370,00	€ 6,300,00	€ 6,230,000	€ 6,160,00	€ 6,090,00	€ 6,020,000	
Amortization			€ 0	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	€ 70,000	
Interest Payments			€ 0	€ 245,000	€ 245,000	€ 242,550	€ 240,100	€ 237,650	€ 235,200	€ 232,750	€ 230,300	€ 227,850	€ 225,400	€ 222,950	€ 220,500	€ 218,050	€ 215,600	€ 213,150	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 7,000,000**	€ 6,983,333	€ 6,966,66	€ 6,950,000	€ 6,933,33	€ 6,916,667	€ 6,900,00	€ 6,883,33	€ 6,866,66	€ 6,850,000	€ 6,833,33	€ 6,816,66	€ 6,800,000	€ 6,783,33	€ 6,766,66	€ 6,750,000	
Total Depreciation				**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	**€ 16,667**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**9.65%**	€ 1,542,116	-€ 10,000,000	€ 693,238	€ 707,796	€ 722,660	€ 737,836	€ 753,330	€ 769,150	€ 785,303	€ 801,794	€ 818,632	€ 835,823	€ 853,375	€ 871,296	€ 889,593	€ 908,275	€ 16,707,72	
Net Equity Cashflow (Before Tax)	**18.55%**	€ 3,861,215	-€ 3,000,000	€ 378,238	€ 392,796	€ 410,110	€ 427,736	€ 445,680	€ 463,950	€ 482,553	€ 501,494	€ 520,782	€ 540,423	€ 560,425	€ 580,796	€ 601,543	€ 622,675	€ 10,404,57	
Net Equity Cashflow (After Tax)	**14.38%**	€ 2,149,064	-€ 3,000,000	€ 270,345	€ 281,264	€ 294,249	€ 307,469	€ 320,927	€ 334,629	€ 348,581	€ 362,787	€ 377,253	€ 391,984	€ 406,985	€ 422,264	€ 437,824	€ 453,673	€ 7,972,599	

PSS	**40.00%**
TCU/TCO	**100.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€63,000

ANNUAL DEPRECIATION	
Initial purchase price property	€6,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€3,000,000
Depreciable basis	€0
Depreciable Life	30
Annual depreciation	€0

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 578,600
Terminal value at t=16	€ 9,643,33
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	**Basis**		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 279,174	€ 0	€ 30,000	€ 30,630	€ 31,273	€ 31,930	€ 32,600	€ 33,285	€ 33,984	€ 34,698	€ 35,426	€ 36,170	€ 36,930	€ 37,705	€ 38,497	€ 39,306	€ 40,131	€ 40,974
PSS		-€ 4,279,174	€ 0	-€ 443,365	-€ 452,675	-€ 462,181	-€ 471,887	-€ 481,797	-€ 491,915	-€ 502,245	-€ 512,792	-€ 523,561	-€ 534,555	-€ 545,781	-€ 557,242	-€ 568,945	-€ 580,892	-€ 593,091	-€ 605,546
Operating Expenses			**€ 0**	**-€ 488,365**	**-€ 498,620**	**-€ 509,091**	**-€ 519,782**	**-€ 530,698**	**-€ 541,842**	**-€ 553,221**	**-€ 564,839**	**-€ 576,700**	**-€ 588,811**	**-€ 601,176**	**-€ 613,801**	**-€ 626,690**	**-€ 639,851**	**-€ 653,288**	**-€ 667,007**
Net Operating Income			**€ 0**	**€ 423,635**	**€ 432,532**	**€ 441,615**	**€ 450,889**	**€ 460,357**	**€ 470,025**	**€ 479,896**	**€ 489,973**	**€ 500,263**	**€ 510,768**	**€ 521,494**	**€ 532,446**	**€ 543,627**	**€ 555,043**	**€ 566,699**	**€ 578,600**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 6,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 9,000,000**															**€ 9,643,332**	
Debt			€ 6,300,000															-€ 5,418,00	
Equity Investment			**-€ 2,700,000**																
Debt Services																			
Interest Payments			€ 0	-€ 220,500	-€ 220,500	-€ 218,295	-€ 216,090	-€ 213,885	-€ 211,680	-€ 209,475	-€ 207,270	-€ 205,065	-€ 202,860	-€ 200,655	-€ 198,450	-€ 196,245	-€ 194,040	-€ 191,835	
Ammortization			€ 0	-€ 63,000.00	-€ 63,000.	-€ 63,000.00	-€ 63,000.	-€ 63,000.00	-€ 63,000.(	-€ 63,000.(	-€ 63,000.(	-€ 63,000.00	-€ 63,000.	-€ 63,000.(	-€ 63,000.00	-€ 63,000.(	-€ 63,000.0	-€ 63,000.0	
Total Debt Service			**€ 0**	**-€ 283,500**	**-€ 283,500**	**-€ 281,295**	**-€ 279,090**	**-€ 276,885**	**-€ 274,680**	**-€ 272,475**	**-€ 270,270**	**-€ 268,065**	**-€ 265,860**	**-€ 263,655**	**-€ 261,450**	**-€ 259,245**	**-€ 257,040**	**-€ 254,835**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 203,135	€ 212,032	€ 223,320	€ 234,799	€ 246,472	€ 258,345	€ 270,421	€ 282,703	€ 295,198	€ 307,908	€ 320,839	€ 333,996	€ 347,382	€ 361,003	€ 374,864	
Income Tax			€ 0	-€ 50,784	-€ 53,008	-€ 55,830	-€ 58,700	-€ 61,618	-€ 64,586	-€ 67,605	-€ 70,676	-€ 73,799	-€ 76,977	-€ 80,210	-€ 83,499	-€ 86,846	-€ 90,251	-€ 93,716	
Capital gain Tax																		-€ 910,833	
Total Tax Liability			**€ 0**	**-€ 50,784**	**-€ 53,008**	**-€ 55,830**	**-€ 58,700**	**-€ 61,618**	**-€ 64,586**	**-€ 67,605**	**-€ 70,676**	**-€ 73,799**	**-€ 76,977**	**-€ 80,210**	**-€ 83,499**	**-€ 86,846**	**-€ 90,251**	**-€ 1,004,54**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 6,300,000	€ 6,300,000	€ 6,237,00	€ 6,174,000	€ 6,111,00	€ 6,048,000	€ 5,985,00	€ 5,922,00	€ 5,859,00	€ 5,796,000	€ 5,733,00	€ 5,670,00	€ 5,607,000	€ 5,544,00	€ 5,481,00	€ 5,418,000	
Amortization			€ 0	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	
Interest Payments			€ 0	€ 220,500	€ 220,500	€ 218,295	€ 216,090	€ 213,885	€ 211,680	€ 209,475	€ 207,270	€ 205,065	€ 202,860	€ 200,655	€ 198,450	€ 196,245	€ 194,040	€ 191,835	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 6,000,000**	€ 6,000,000	€ 6,000,00	€ 6,000,000	€ 6,000,00	€ 6,000,000	€ 6,000,00	€ 6,000,00	€ 6,000,00	€ 6,000,000	€ 6,000,00	€ 6,000,00	€ 6,000,000	€ 6,000,00	€ 6,000,00	€ 6,000,000	
Total Depreciation				**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**5.67%**	-€ 1,732,652	-€ 9,000,000	€ 423,635	€ 432,532	€ 441,615	€ 450,889	€ 460,357	€ 470,025	€ 479,896	€ 489,973	€ 500,263	€ 510,768	€ 521,494	€ 532,446	€ 543,627	€ 555,043	€ 10,210,03	
Net Equity Cashflow (Before Tax)	**9.35%**	€ 354,537	-€ 2,700,000	€ 140,135	€ 149,032	€ 160,320	€ 171,799	€ 183,472	€ 195,345	€ 207,421	€ 219,703	€ 232,198	€ 244,908	€ 257,839	€ 270,996	€ 284,382	€ 298,003	€ 4,537,196	
Net Equity Cashflow (After Tax)	**6.17%**	-€ 441,453	-€ 2,700,000	€ 89,352	€ 96,024	€ 104,490	€ 113,099	€ 121,854	€ 130,759	€ 139,815	€ 149,027	€ 158,398	€ 167,931	€ 177,630	€ 187,497	€ 197,537	€ 207,752	€ 3,532,647	

PSS	**40.00%**
TCU/TCO	**75.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€63,000

ANNUAL DEPRECIATION	
Initial purchase price property	€6,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€3,000,000
Depreciable basis	€0
Depreciable Life	30
Annual depreciation	€0

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 729,986
Terminal value at t=16	€ 12,166,44
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	Basis		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 279,174	€ 0	€ 30,000	€ 30,630	€ 31,273	€ 31,930	€ 32,600	€ 33,285	€ 33,984	€ 34,698	€ 35,426	€ 36,170	€ 36,930	€ 37,705	€ 38,497	€ 39,306	€ 40,131	€ 40,974
PSS		-€ 3,209,380	€ 0	-€ 332,523	-€ 339,506	-€ 346,636	-€ 353,915	-€ 361,348	-€ 368,936	-€ 376,684	-€ 384,594	-€ 392,670	-€ 400,917	-€ 409,336	-€ 417,932	-€ 426,708	-€ 435,669	-€ 444,818	-€ 454,160
Operating Expenses			**€ 0**	**-€ 377,523**	**-€ 385,451**	**-€ 393,546**	**-€ 401,810**	**-€ 410,248**	**-€ 418,864**	**-€ 427,660**	**-€ 436,641**	**-€ 445,810**	**-€ 455,172**	**-€ 464,731**	**-€ 474,490**	**-€ 484,454**	**-€ 494,628**	**-€ 505,015**	**-€ 515,620**
Net Operating Income			**€ 0**	**€ 534,477**	**€ 545,701**	**€ 557,160**	**€ 568,861**	**€ 580,807**	**€ 593,004**	**€ 605,457**	**€ 618,171**	**€ 631,153**	**€ 644,407**	**€ 657,940**	**€ 671,756**	**€ 685,863**	**€ 700,266**	**€ 714,972**	**€ 729,986**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 6,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 9,000,000**															**€ 12,166,44**	
Debt			€ 6,300,000															-€ 5,418,00	
Equity Investment			**-€ 2,700,000**																
Debt Services																			
Interest Payments			€ 0	-€ 220,500	-€ 220,500	-€ 218,295	-€ 216,090	-€ 213,885	-€ 211,680	-€ 209,475	-€ 207,270	-€ 205,065	-€ 202,860	-€ 200,655	-€ 198,450	-€ 196,245	-€ 194,040	-€ 191,835	
Ammortization			€ 0	-€ 63,000.00	-€ 63,000.	-€ 63,000.00	-€ 63,000.	-€ 63,000.00	-€ 63,000.	-€ 63,000.(	-€ 63,000.(	-€ 63,000.00	-€ 63,000.	-€ 63,000.(	-€ 63,000.00	-€ 63,000.(	-€ 63,000.0	-€ 63,000.0	
Total Debt Service			**€ 0**	**-€ 283,500**	**-€ 283,500**	**-€ 281,295**	**-€ 279,090**	**-€ 276,885**	**-€ 274,680**	**-€ 272,475**	**-€ 270,270**	**-€ 268,065**	**-€ 265,860**	**-€ 263,655**	**-€ 261,450**	**-€ 259,245**	**-€ 257,040**	**-€ 254,835**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 313,977	€ 325,201	€ 338,865	€ 352,771	€ 366,922	€ 381,324	€ 395,982	€ 410,901	€ 426,088	€ 441,547	€ 457,285	€ 473,306	€ 489,618	€ 506,226	€ 523,137	
Income Tax			€ 0	-€ 78,494	-€ 81,300	-€ 84,716	-€ 88,193	-€ 91,730	-€ 95,331	-€ 98,995	-€ 102,725	-€ 106,522	-€ 110,387	-€ 114,321	-€ 118,327	-€ 122,405	-€ 126,557	-€ 130,784	
Capital gain Tax																		-€ 1,541,61	
Total Tax Liability			**€ 0**	**-€ 78,494**	**-€ 81,300**	**-€ 84,716**	**-€ 88,193**	**-€ 91,730**	**-€ 95,331**	**-€ 98,995**	**-€ 102,725**	**-€ 106,522**	**-€ 110,387**	**-€ 114,321**	**-€ 118,327**	**-€ 122,405**	**-€ 126,557**	**-€ 1,672,39**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 6,300,000	€ 6,300,000	€ 6,237,00	€ 6,174,000	€ 6,111,00	€ 6,048,000	€ 5,985,00	€ 5,922,00	€ 5,859,00	€ 5,796,000	€ 5,733,00	€ 5,670,00	€ 5,607,000	€ 5,544,00	€ 5,481,00	€ 5,418,000	
Amortization			€ 0	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	
Interest Payments			€ 0	€ 220,500	€ 220,500	€ 218,295	€ 216,090	€ 213,885	€ 211,680	€ 209,475	€ 207,270	€ 205,065	€ 202,860	€ 200,655	€ 198,450	€ 196,245	€ 194,040	€ 191,835	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 6,000,000**	€ 6,000,000	€ 6,000,00	€ 6,000,000	€ 6,000,00	€ 6,000,000	€ 6,000,00	€ 6,000,00	€ 6,000,00	€ 6,000,000	€ 6,000,00	€ 6,000,00	€ 6,000,000	€ 6,000,00	€ 6,000,00	€ 6,000,000	
Total Depreciation				**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**7.99%**	-€ 5,631	-€ 9,000,000	€ 534,477	€ 545,701	€ 557,160	€ 568,861	€ 580,807	€ 593,004	€ 605,457	€ 618,171	€ 631,153	€ 644,407	€ 657,940	€ 671,756	€ 685,863	€ 700,266	€ 12,881,41	
Net Equity Cashflow (Before Tax)	**14.84%**	€ 2,081,558	-€ 2,700,000	€ 250,977	€ 262,201	€ 275,865	€ 289,771	€ 303,922	€ 318,324	€ 332,982	€ 347,901	€ 363,088	€ 378,547	€ 394,285	€ 410,306	€ 426,618	€ 443,226	€ 7,208,577	
Net Equity Cashflow (After Tax)	**11.06%**	€ 853,813	-€ 2,700,000	€ 172,482	€ 180,900	€ 191,149	€ 201,578	€ 212,191	€ 222,993	€ 233,986	€ 245,176	€ 256,566	€ 268,160	€ 279,964	€ 291,980	€ 304,214	€ 316,670	€ 5,536,183	

PSS	**40.00%**
TCU/TCO	**50.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€63,000

ANNUAL DEPRECIATION	
Initial purchase price property	€6,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€3,000,000
Depreciable basis	€0
Depreciable Life	30
Annual depreciation	€0

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 881,373
Terminal value at t=16	€ 14,689,54
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	**Basis**		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 279,174	€ 0	€ 30,000	€ 30,630	€ 31,273	€ 31,930	€ 32,600	€ 33,285	€ 33,984	€ 34,698	€ 35,426	€ 36,170	€ 36,930	€ 37,705	€ 38,497	€ 39,306	€ 40,131	€ 40,974
PSS		-€ 2,139,587	€ 0	-€ 221,682	-€ 226,338	-€ 231,091	-€ 235,944	-€ 240,898	-€ 245,957	-€ 251,122	-€ 256,396	-€ 261,780	-€ 267,278	-€ 272,891	-€ 278,621	-€ 284,472	-€ 290,446	-€ 296,546	-€ 302,773
Operating Expenses			**€ 0**	**-€ 266,682**	**-€ 272,283**	**-€ 278,001**	**-€ 283,839**	**-€ 289,799**	**-€ 295,885**	**-€ 302,099**	**-€ 308,443**	**-€ 314,920**	**-€ 321,533**	**-€ 328,285**	**-€ 335,179**	**-€ 342,218**	**-€ 349,405**	**-€ 356,742**	**-€ 364,234**
Net Operating Income			**€ 0**	**€ 645,318**	**€ 658,869**	**€ 672,706**	**€ 686,832**	**€ 701,256**	**€ 715,982**	**€ 731,018**	**€ 746,369**	**€ 762,043**	**€ 778,046**	**€ 794,385**	**€ 811,067**	**€ 828,099**	**€ 845,490**	**€ 863,245**	**€ 881,373**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 6,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 9,000,000**															**€ 14,689,54**	
Debt			€ 6,300,000															-€ 5,418,00	
Equity Investment			**-€ 2,700,000**																
Debt Services																			
Interest Payments			€ 0	-€ 220,500	-€ 220,500	-€ 218,295	-€ 216,090	-€ 213,885	-€ 211,680	-€ 209,475	-€ 207,270	-€ 205,065	-€ 202,860	-€ 200,655	-€ 198,450	-€ 196,245	-€ 194,040	-€ 191,835	
Ammortization			€ 0	-€ 63,000.00	-€ 63,000.	-€ 63,000.00	-€ 63,000.	-€ 63,000.00	-€ 63,000.(	-€ 63,000.(	-€ 63,000.(	-€ 63,000.00	-€ 63,000.	-€ 63,000.(	-€ 63,000.00	-€ 63,000.(	-€ 63,000.0	-€ 63,000.0	
Total Debt Service			**€ 0**	**-€ 283,500**	**-€ 283,500**	**-€ 281,295**	**-€ 279,090**	**-€ 276,885**	**-€ 274,680**	**-€ 272,475**	**-€ 270,270**	**-€ 268,065**	**-€ 265,860**	**-€ 263,655**	**-€ 261,450**	**-€ 259,245**	**-€ 257,040**	**-€ 254,835**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 424,818	€ 438,369	€ 454,411	€ 470,742	€ 487,371	€ 504,302	€ 521,543	€ 539,099	€ 556,978	€ 575,186	€ 593,730	€ 612,617	€ 631,854	€ 651,450	€ 671,410	
Income Tax			€ 0	-€ 106,204	-€ 109,592	-€ 113,603	-€ 117,686	-€ 121,843	-€ 126,076	-€ 130,386	-€ 134,775	-€ 139,245	-€ 143,796	-€ 148,432	-€ 153,154	-€ 157,964	-€ 162,862	-€ 167,852	
Capital gain Tax																		-€ 2,172,38	
Total Tax Liability			**€ 0**	**-€ 106,204**	**-€ 109,592**	**-€ 113,603**	**-€ 117,686**	**-€ 121,843**	**-€ 126,076**	**-€ 130,386**	**-€ 134,775**	**-€ 139,245**	**-€ 143,796**	**-€ 148,432**	**-€ 153,154**	**-€ 157,964**	**-€ 162,862**	**-€ 2,340,24**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 6,300,000	€ 6,300,000	€ 6,237,00	€ 6,174,000	€ 6,111,00	€ 6,048,000	€ 5,985,00	€ 5,922,00	€ 5,859,00	€ 5,796,000	€ 5,733,00	€ 5,670,00	€ 5,607,000	€ 5,544,00	€ 5,481,00	€ 5,418,000	
Amortization			€ 0	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	€ 63,000	
Interest Payments			€ 0	€ 220,500	€ 220,500	€ 218,295	€ 216,090	€ 213,885	€ 211,680	€ 209,475	€ 207,270	€ 205,065	€ 202,860	€ 200,655	€ 198,450	€ 196,245	€ 194,040	€ 191,835	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 6,000,000**	€ 6,000,000	€ 6,000,00	€ 6,000,000	€ 6,000,00	€ 6,000,000	€ 6,000,00	€ 6,000,00	€ 6,000,00	€ 6,000,000	€ 6,000,00	€ 6,000,00	€ 6,000,000	€ 6,000,00	€ 6,000,00	€ 6,000,000	
Total Depreciation				**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	**€ 0**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**10.02%**	€ 1,721,389	-€ 9,000,000	€ 645,318	€ 658,869	€ 672,706	€ 686,832	€ 701,256	€ 715,982	€ 731,018	€ 746,369	€ 762,043	€ 778,046	€ 794,385	€ 811,067	€ 828,099	€ 845,490	€ 15,552,79	
Net Equity Cashflow (Before Tax)	**19.38%**	€ 3,808,578	-€ 2,700,000	€ 361,818	€ 375,369	€ 391,411	€ 407,742	€ 424,371	€ 441,302	€ 458,543	€ 476,099	€ 493,978	€ 512,186	€ 530,730	€ 549,617	€ 568,854	€ 588,450	€ 9,879,959	
Net Equity Cashflow (After Tax)	**14.98%**	€ 2,149,078	-€ 2,700,000	€ 255,613	€ 265,777	€ 277,808	€ 290,057	€ 302,528	€ 315,227	€ 328,157	€ 341,324	€ 354,734	€ 368,389	€ 382,297	€ 396,463	€ 410,891	€ 425,587	€ 7,539,719	

PSS	**50.00%**
TCU/TCO	**100.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€56,000

ANNUAL DEPRECIATION	
Initial purchase price property	€5,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€2,500,000
Depreciable basis	-€500,000
Depreciable Life	30
Annual depreciation	-€16,667

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 437,457
Terminal value at t=16	€ 7,290,948
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	Basis		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 348,967	€ 0	€ 37,500	€ 38,288	€ 39,092	€ 39,912	€ 40,751	€ 41,606	€ 42,480	€ 43,372	€ 44,283	€ 45,213	€ 46,162	€ 47,132	€ 48,122	€ 49,132	€ 50,164	€ 51,217
PSS		-€ 5,348,967	€ 0	-€ 554,206	-€ 565,844	-€ 577,727	-€ 589,859	-€ 602,246	-€ 614,893	-€ 627,806	-€ 640,990	-€ 654,451	-€ 668,194	-€ 682,226	-€ 696,553	-€ 711,181	-€ 726,115	-€ 741,364	-€ 756,933
Operating Expenses			**€ 0**	**-€ 591,706**	**-€ 604,132**	**-€ 616,818**	**-€ 629,772**	**-€ 642,997**	**-€ 656,500**	**-€ 670,286**	**-€ 684,362**	**-€ 698,734**	**-€ 713,407**	**-€ 728,389**	**-€ 743,685**	**-€ 759,302**	**-€ 775,248**	**-€ 791,528**	**-€ 808,150**
Net Operating Income			**€ 0**	**€ 320,294**	**€ 327,020**	**€ 333,888**	**€ 340,899**	**€ 348,058**	**€ 355,368**	**€ 362,830**	**€ 370,450**	**€ 378,229**	**€ 386,172**	**€ 394,282**	**€ 402,562**	**€ 411,015**	**€ 419,647**	**€ 428,459**	**€ 437,457**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 5,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 8,000,000**															**€ 7,290,948**	
Debt			€ 5,600,000															-€ 4,816,00	
Equity Investment			**-€ 2,400,000**																
Debt Services																			
Interest Payments			€ 0	-€ 196,000	-€ 196,000	-€ 194,040	-€ 192,080	-€ 190,120	-€ 188,160	-€ 186,200	-€ 184,240	-€ 182,280	-€ 180,320	-€ 178,360	-€ 176,400	-€ 174,440	-€ 172,480	-€ 170,520	
Ammortization			€ 0	-€ 56,000.00	-€ 56,000.	-€ 56,000.00	-€ 56,000.	-€ 56,000.00	-€ 56,000.(	-€ 56,000.(	-€ 56,000.(	-€ 56,000.00	-€ 56,000.	-€ 56,000.(	-€ 56,000.00	-€ 56,000.(	-€ 56,000.0	-€ 56,000.0	
Total Debt Service			**€ 0**	**-€ 252,000**	**-€ 252,000**	**-€ 250,040**	**-€ 248,080**	**-€ 246,120**	**-€ 244,160**	**-€ 242,200**	**-€ 240,240**	**-€ 238,280**	**-€ 236,320**	**-€ 234,360**	**-€ 232,400**	**-€ 230,440**	**-€ 228,480**	**-€ 226,520**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 140,961	€ 147,687	€ 156,515	€ 165,486	€ 174,605	€ 183,874	€ 193,297	€ 202,876	€ 212,616	€ 222,519	€ 232,588	€ 242,828	€ 253,242	€ 263,833	€ 274,606	
Income Tax			€ 0	-€ 35,240	-€ 36,922	-€ 39,129	-€ 41,372	-€ 43,651	-€ 45,969	-€ 48,324	-€ 50,719	-€ 53,154	-€ 55,630	-€ 58,147	-€ 60,707	-€ 63,311	-€ 65,958	-€ 68,651	
Capital gain Tax																		-€ 510,237	
Total Tax Liability			**€ 0**	**-€ 35,240**	**-€ 36,922**	**-€ 39,129**	**-€ 41,372**	**-€ 43,651**	**-€ 45,969**	**-€ 48,324**	**-€ 50,719**	**-€ 53,154**	**-€ 55,630**	**-€ 58,147**	**-€ 60,707**	**-€ 63,311**	**-€ 65,958**	**-€ 578,889**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 5,600,000	€ 5,600,000	€ 5,544,00	€ 5,488,000	€ 5,432,00	€ 5,376,000	€ 5,320,00	€ 5,264,00	€ 5,208,00	€ 5,152,000	€ 5,096,00	€ 5,040,00	€ 4,984,000	€ 4,928,00	€ 4,872,00	€ 4,816,000	
Amortization			€ 0	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	
Interest Payments			€ 0	€ 196,000	€ 196,000	€ 194,040	€ 192,080	€ 190,120	€ 188,160	€ 186,200	€ 184,240	€ 182,280	€ 180,320	€ 178,360	€ 176,400	€ 174,440	€ 172,480	€ 170,520	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 5,000,000**	€ 5,016,667	€ 5,033,33	€ 5,050,000	€ 5,066,66	€ 5,083,333	€ 5,100,00	€ 5,116,66	€ 5,133,33	€ 5,150,000	€ 5,166,66	€ 5,183,33	€ 5,200,000	€ 5,216,66	€ 5,233,33	€ 5,250,000	
Total Depreciation				**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**4.14%**	-€ 2,416,889	-€ 8,000,000	€ 320,294	€ 327,020	€ 333,888	€ 340,899	€ 348,058	€ 355,368	€ 362,830	€ 370,450	€ 378,229	€ 386,172	€ 394,282	€ 402,562	€ 411,015	€ 419,647	€ 7,719,407	
Net Equity Cashflow (Before Tax)	**5.26%**	-€ 561,610	-€ 2,400,000	€ 68,294	€ 75,020	€ 83,848	€ 92,819	€ 101,938	€ 111,208	€ 120,630	€ 130,210	€ 139,949	€ 149,852	€ 159,922	€ 170,162	€ 180,575	€ 191,167	€ 2,676,887	
Net Equity Cashflow (After Tax)	**2.21%**	-€ 1,089,072	-€ 2,400,000	€ 33,054	€ 38,099	€ 44,719	€ 51,448	€ 58,287	€ 65,239	€ 72,306	€ 79,491	€ 86,795	€ 94,222	€ 101,775	€ 109,454	€ 117,265	€ 125,208	€ 2,097,995	

PSS	**50.00%**																			
TCU/TCO	**75.00%**																			
INDEXES																				
Inflation	2.1%																			
Vacancy (loss of rent)	5.0%																			
RATE OF RETURN																				
Internal Rate of Return	8.00%																			
Gross Exit Yield	6.00%																			

EXPENSES / BUILDING																				
Mgmt./Maint. costs/apartment	-€1,500																			
Annual Mgmt./Maint. costs	-€75,000																			
DEBT SERVICE																				
Loan-to-value	70.00%																			
Interest Rate	3.50%																			
Ammortization	1.00%																			
Annual Ammortization	€56,000																			

ANNUAL DEPRECIATION																				
Initial purchase price property	€5,000,000																			
Land value	€3,000,000																			
Risidual Value % (of Purchase Price)	50%																			
Residual value	€2,500,000																			
Depreciable basis	-€500,000																			
Depreciable Life	30																			
Annual depreciation	-€16,667																			

TERMINAL VALUE																				
Potential NOI (PGI t=16)	€ 626,690																			
Terminal value at t=16	€ 10,444,83																			
PSS																				
Cost Indexation	2.1%																			
Periods (Terms in Months)	15																			
Residual Value to Manufacturer	30.0%																			

TAXES																				
Income	25%																			
Capital gain	25%																			

Period	**Basis**		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 348,967	€ 0	€ 37,500	€ 38,288	€ 39,092	€ 39,912	€ 40,751	€ 41,606	€ 42,480	€ 43,372	€ 44,283	€ 45,213	€ 46,162	€ 47,132	€ 48,122	€ 49,132	€ 50,164	€ 51,217
PSS		-€ 4,011,725	€ 0	-€ 415,654	-€ 424,383	-€ 433,295	-€ 442,394	-€ 451,685	-€ 461,170	-€ 470,855	-€ 480,742	-€ 490,838	-€ 501,146	-€ 511,670	-€ 522,415	-€ 533,385	-€ 544,587	-€ 556,023	-€ 567,699
Operating Expenses			**€ 0**	**-€ 453,154**	**-€ 462,671**	**-€ 472,387**	**-€ 482,307**	**-€ 492,435**	**-€ 502,776**	**-€ 513,335**	**-€ 524,115**	**-€ 535,121**	**-€ 546,359**	**-€ 557,832**	**-€ 569,547**	**-€ 581,507**	**-€ 593,719**	**-€ 606,187**	**-€ 618,917**
Net Operating Income			**€ 0**	**€ 458,846**	**€ 468,481**	**€ 478,320**	**€ 488,364**	**€ 498,620**	**€ 509,091**	**€ 519,782**	**€ 530,697**	**€ 541,842**	**€ 553,221**	**€ 564,838**	**€ 576,700**	**€ 588,811**	**€ 601,176**	**€ 613,800**	**€ 626,690**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 5,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 8,000,000**															**€ 10,444,83**	
Debt			€ 5,600,000															-€ 4,816,00	
Equity Investment			**-€ 2,400,000**																
Debt Services																			
Interest Payments			€ 0	-€ 196,000	-€ 196,000	-€ 194,040	-€ 192,080	-€ 190,120	-€ 188,160	-€ 186,200	-€ 184,240	-€ 182,280	-€ 180,320	-€ 178,360	-€ 176,400	-€ 174,440	-€ 172,480	-€ 170,520	
Ammortization			€ 0	-€ 56,000.00	-€ 56,000.	-€ 56,000.00	-€ 56,000.	-€ 56,000.00	-€ 56,000.(	-€ 56,000.(	-€ 56,000.(	-€ 56,000.00	-€ 56,000.	-€ 56,000.(	-€ 56,000.00	-€ 56,000.(	-€ 56,000.0	-€ 56,000.0	
Total Debt Service			**€ 0**	**-€ 252,000**	**-€ 252,000**	**-€ 250,040**	**-€ 248,080**	**-€ 246,120**	**-€ 244,160**	**-€ 242,200**	**-€ 240,240**	**-€ 238,280**	**-€ 236,320**	**-€ 234,360**	**-€ 232,400**	**-€ 230,440**	**-€ 228,480**	**-€ 226,520**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 279,512	€ 289,148	€ 300,946	€ 312,951	€ 325,167	€ 337,598	€ 350,249	€ 363,124	€ 376,229	€ 389,567	€ 403,145	€ 416,966	€ 431,037	€ 445,362	€ 459,947	
Income Tax			€ 0	-€ 69,878	-€ 72,287	-€ 75,237	-€ 78,238	-€ 81,292	-€ 84,399	-€ 87,562	-€ 90,781	-€ 94,057	-€ 97,392	-€ 100,786	-€ 104,242	-€ 107,759	-€ 111,341	-€ 114,987	
Capital gain Tax																		-€ 1,298,70	
Total Tax Liability			**€ 0**	**-€ 69,878**	**-€ 72,287**	**-€ 75,237**	**-€ 78,238**	**-€ 81,292**	**-€ 84,399**	**-€ 87,562**	**-€ 90,781**	**-€ 94,057**	**-€ 97,392**	**-€ 100,786**	**-€ 104,242**	**-€ 107,759**	**-€ 111,341**	**-€ 1,413,69**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 5,600,000	€ 5,600,000	€ 5,544,00	€ 5,488,000	€ 5,432,00	€ 5,376,000	€ 5,320,00	€ 5,264,00	€ 5,208,00	€ 5,152,000	€ 5,096,00	€ 5,040,00	€ 4,984,000	€ 4,928,00	€ 4,872,00	€ 4,816,000	
Amortization			€ 0	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	
Interest Payments			€ 0	€ 196,000	€ 196,000	€ 194,040	€ 192,080	€ 190,120	€ 188,160	€ 186,200	€ 184,240	€ 182,280	€ 180,320	€ 178,360	€ 176,400	€ 174,440	€ 172,480	€ 170,520	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 5,000,000**	€ 5,016,667	€ 5,033,33	€ 5,050,000	€ 5,066,66	€ 5,083,333	€ 5,100,00	€ 5,116,66	€ 5,133,33	€ 5,150,000	€ 5,166,66	€ 5,183,33	€ 5,200,000	€ 5,216,66	€ 5,233,33	€ 5,250,000	
Total Depreciation				**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	
Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**7.63%**	-€ 258,113	-€ 8,000,000	€ 458,846	€ 468,481	€ 478,320	€ 488,364	€ 498,620	€ 509,091	€ 519,782	€ 530,697	€ 541,842	€ 553,221	€ 564,838	€ 576,700	€ 588,811	€ 601,176	€ 11,058,63	
Net Equity Cashflow (Before Tax)	**14.03%**	€ 1,597,166	-€ 2,400,000	€ 206,846	€ 216,481	€ 228,280	€ 240,284	€ 252,500	€ 264,931	€ 277,582	€ 290,457	€ 303,562	€ 316,901	€ 330,478	€ 344,300	€ 358,371	€ 372,696	€ 6,016,114	
Net Equity Cashflow (After Tax)	**10.18%**	€ 530,010	-€ 2,400,000	€ 136,968	€ 144,194	€ 153,043	€ 162,047	€ 171,208	€ 180,532	€ 190,020	€ 199,676	€ 209,505	€ 219,509	€ 229,692	€ 240,058	€ 250,611	€ 261,355	€ 4,602,419	

PSS	**50.00%**
TCU/TCO	**50.00%**

INDEXES	
Inflation	2.1%
Vacancy (loss of rent)	5.0%
RATE OF RETURN	
Internal Rate of Return	8.00%
Gross Exit Yield	6.00%

EXPENSES / BUILDING	
Mgmt./Maint. costs/apartment	-€1,500
Annual Mgmt./Maint. costs	-€75,000
DEBT SERVICE	
Loan-to-value	70.00%
Interest Rate	3.50%
Ammortization	1.00%
Annual Ammortization	€56,000

ANNUAL DEPRECIATION	
Initial purchase price property	€5,000,000
Land value	€3,000,000
Risidual Value % (of Purchase Price)	50%
Residual value	€2,500,000
Depreciable basis	-€500,000
Depreciable Life	30
Annual depreciation	-€16,667

TERMINAL VALUE	
Potential NOI (PGI t=16)	€ 815,923
Terminal value at t=16	€ 13,598,7
PSS	
Cost Indexation	2.1%
Periods (Terms in Months)	15
Residual Value to Manufacturer	30.0%

TAXES	
Income	25%
Capital gain	25%

Period	**Basis**		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Operating income and expenses																			
Yearly rent	€ 960,000		€ 0	€ 960,000	€ 980,160	€ 1,000,743	€ 1,021,75	€ 1,043,216	€ 1,065,12	€ 1,087,49	€ 1,110,32	€ 1,133,645	€ 1,157,45	€ 1,181,75	€ 1,206,575	€ 1,231,91	€ 1,257,78	€ 1,284,197	€ 1,311,165
Loss of rent (vacancy)			€ 0	-€ 48,000	-€ 49,008	-€ 50,037	-€ 51,088	-€ 52,161	-€ 53,256	-€ 54,375	-€ 55,516	-€ 56,682	-€ 57,873	-€ 59,088	-€ 60,329	-€ 61,596	-€ 62,889	-€ 64,210	-€ 65,558
Potential Gross Income			**€ 0**	**€ 912,000**	**€ 931,152**	**€ 950,706**	**€ 970,671**	**€ 991,055**	**€ 1,011,86**	**€ 1,033,11**	**€ 1,054,81**	**€ 1,076,963**	**€ 1,099,57**	**€ 1,122,67**	**€ 1,146,246**	**€ 1,170,31**	**€ 1,194,89**	**€ 1,219,987**	**€ 1,245,607**
		NPV																	
Annual Management/Maintenance expenses			€ 0	-€ 75,000	-€ 76,575	-€ 78,183	-€ 79,825	-€ 81,501	-€ 83,213	-€ 84,960	-€ 86,744	-€ 88,566	-€ 90,426	-€ 92,325	-€ 94,264	-€ 96,243	-€ 98,264	-€ 100,328	-€ 102,435
Reduction (due to outsourcing)		€ 348,967	€ 0	€ 37,500	€ 38,288	€ 39,092	€ 39,912	€ 40,751	€ 41,606	€ 42,480	€ 43,372	€ 44,283	€ 45,213	€ 46,162	€ 47,132	€ 48,122	€ 49,132	€ 50,164	€ 51,217
PSS		-€ 2,674,484	€ 0	-€ 277,103	-€ 282,922	-€ 288,863	-€ 294,930	-€ 301,123	-€ 307,447	-€ 313,903	-€ 320,495	-€ 327,225	-€ 334,097	-€ 341,113	-€ 348,277	-€ 355,590	-€ 363,058	-€ 370,682	-€ 378,466
Operating Expenses			**€ 0**	**-€ 314,603**	**-€ 321,210**	**-€ 327,955**	**-€ 334,842**	**-€ 341,874**	**-€ 349,053**	**-€ 356,383**	**-€ 363,867**	**-€ 371,508**	**-€ 379,310**	**-€ 387,276**	**-€ 395,408**	**-€ 403,712**	**-€ 412,190**	**-€ 420,846**	**-€ 429,684**
Net Operating Income			**€ 0**	**€ 597,397**	**€ 609,942**	**€ 622,751**	**€ 635,829**	**€ 649,181**	**€ 662,814**	**€ 676,733**	**€ 690,945**	**€ 705,455**	**€ 720,269**	**€ 735,395**	**€ 750,838**	**€ 766,606**	**€ 782,704**	**€ 799,141**	**€ 815,923**
Investment																			
Traditional Development Costs (No PaaS)			-€ 10,000,000																
Development Costs with PaaS			-€ 5,000,000																
Land Cost			-€ 3,000,000																
Investment			**-€ 8,000,000**															**€ 13,598,71**	
Debt			€ 5,600,000															-€ 4,816,00	
Equity Investment			**-€ 2,400,000**																
Debt Services																			
Interest Payments			€ 0	-€ 196,000	-€ 196,000	-€ 194,040	-€ 192,080	-€ 190,120	-€ 188,160	-€ 186,200	-€ 184,240	-€ 182,280	-€ 180,320	-€ 178,360	-€ 176,400	-€ 174,440	-€ 172,480	-€ 170,520	
Ammortization			€ 0	-€ 56,000.00	-€ 56,000.	-€ 56,000.00	-€ 56,000.	-€ 56,000.00	-€ 56,000.(	-€ 56,000.(	-€ 56,000.(	-€ 56,000.00	-€ 56,000.(	-€ 56,000.(	-€ 56,000.00	-€ 56,000.(	-€ 56,000.0	-€ 56,000.0	
Total Debt Service			**€ 0**	**-€ 252,000**	**-€ 252,000**	**-€ 250,040**	**-€ 248,080**	**-€ 246,120**	**-€ 244,160**	**-€ 242,200**	**-€ 240,240**	**-€ 238,280**	**-€ 236,320**	**-€ 234,360**	**-€ 232,400**	**-€ 230,440**	**-€ 228,480**	**-€ 226,520**	
Income and Capital Gain																			
Taxable Income			€ 0	€ 418,064	€ 430,609	€ 445,378	€ 460,416	€ 475,728	€ 491,321	€ 507,200	€ 523,371	€ 539,841	€ 556,616	€ 573,701	€ 591,105	€ 608,832	€ 626,891	€ 645,288	
Income Tax			€ 0	-€ 104,516	-€ 107,652	-€ 111,344	-€ 115,104	-€ 118,932	-€ 122,830	-€ 126,800	-€ 130,843	-€ 134,960	-€ 139,154	-€ 143,425	-€ 147,776	-€ 152,208	-€ 156,723	-€ 161,322	
Capital gain Tax																		-€ 2,087,18	
Total Tax Liability			**€ 0**	**-€ 104,516**	**-€ 107,652**	**-€ 111,344**	**-€ 115,104**	**-€ 118,932**	**-€ 122,830**	**-€ 126,800**	**-€ 130,843**	**-€ 134,960**	**-€ 139,154**	**-€ 143,425**	**-€ 147,776**	**-€ 152,208**	**-€ 156,723**	**-€ 2,248,50**	
Debt schedule: calculations (non-cash flows)																			
Loan Balance			€ 5,600,000	€ 5,600,000	€ 5,544,00	€ 5,488,000	€ 5,432,00	€ 5,376,000	€ 5,320,00	€ 5,264,00	€ 5,208,00	€ 5,152,000	€ 5,096,00	€ 5,040,00	€ 4,984,000	€ 4,928,00	€ 4,872,00	€ 4,816,00	
Amortization			€ 0	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	€ 56,000	
Interest Payments			€ 0	€ 196,000	€ 196,000	€ 194,040	€ 192,080	€ 190,120	€ 188,160	€ 186,200	€ 184,240	€ 182,280	€ 180,320	€ 178,360	€ 176,400	€ 174,440	€ 172,480	€ 170,520	
Fiscal balance sheet (non-cash flows)																			
Book Value property			**€ 5,000,000**	€ 5,016,667	€ 5,033,33	€ 5,050,000	€ 5,066,66	€ 5,083,333	€ 5,100,00	€ 5,116,66	€ 5,133,33	€ 5,150,000	€ 5,166,66	€ 5,183,33	€ 5,200,000	€ 5,216,66	€ 5,233,33	€ 5,250,00	
Total Depreciation				**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	**-€ 16,667**	

Net cash flows	**IRR**	**NPV**																	
Net Investment Cashflow	**10.47%**	€ 1,900,663	-€ 8,000,000	€ 597,397	€ 609,942	€ 622,751	€ 635,829	€ 649,181	€ 662,814	€ 676,733	€ 690,945	€ 705,455	€ 720,269	€ 735,395	€ 750,838	€ 766,606	€ 782,704	€ 14,397,86	
Net Equity Cashflow (Before Tax)	**20.40%**	€ 3,755,942	-€ 2,400,000	€ 345,397	€ 357,942	€ 372,711	€ 387,749	€ 403,061	€ 418,654	€ 434,533	€ 450,705	€ 467,175	€ 483,949	€ 501,035	€ 518,438	€ 536,166	€ 554,224	€ 9,355,340	
Net Equity Cashflow (After Tax)	**15.70%**	€ 2,149,092	-€ 2,400,000	€ 240,881	€ 250,290	€ 261,367	€ 272,645	€ 284,129	€ 295,824	€ 307,733	€ 319,862	€ 332,214	€ 344,795	€ 357,609	€ 370,662	€ 383,958	€ 397,502	€ 7,106,839