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BUSINESS CASE STUDY FOR THE ZERO ENERGY REFURBISHMENT OF COMMERCIAL BUILDINGS

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Abstract

Net zero energy is already an ambitious target for several buildings, especially since the DIRECTIVE 2010/31/EU that requires increasing the number of nearly zero energy buildings. The existing commercial building stock needs to be included in order to achieve the 2020 EU environmental targets. The main barriers of zero energy refurbishment of existing nonresidential buildings appear to be financial rather than technical, next to a number of other extrinsic factors that do not stimulate such an investment.

While a business case for new zero energy buildings is believed to exist, controversial opinions can be found with respect to refurbishment of large buildings. The present study aims to identify the factors that affect the feasibility of the zero energy refurbishment of existing commercial buildings, while suggesting ways to create the business case addressing the Dutch market.

Through interviews with real estate investors, the study identified the financial and technical barriers encountered today to undertake deep energy retrofit. Subsequently, the design interventions needed to refurbish a Dutch office building and meeting the net zero energy target were evaluated using a software complying with the Dutch standards NEN 7120. A risk and sensitivity analysis with Monte Carlo simulations showed the influence that design aspects, energy price and landlord-tenant agreements have on the business case.

The study has concluded that a business case considering the energy savings alone is not sufficient to convince investors. However, when the design provides additional benefits, such as increasing the property value, the refurbishment can become feasible. This is an important observation to promote the refurbishment towards a zero energy building stock.

Keywords:

Net-zero energy; refurbishment; commercial buildings; economical evaluation; risk analysis; Monte Carlo simulations

1 INTRODUCTION

The goal of this research is to identify the barriers for the zero energy refurbishment of Commercial Buildings while suggesting a number of ways to create the business case for it. Across Europe, only 1% of buildings in any given year are newly built [1], about 70% of buildings are over 30 years old and about 35% are more than 50 years old [2]. Given the fact that the building sector is responsible for about 40% of the total Greenhouse gases (GHG) emission [3], massive refurbishment aiming at improving the performance of existing buildings, seems to remain the most logical way forward. Moreover, considering the new constructions rate, it is not difficult to imagine that most of the buildings present in 2050 have already been built [4]. These buildings are also the ones supposed to require 80% less energy compared to the 2008

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levels [5]. Aiming at high standards of energy efficiency, such as zero energy, is essential. Looking at all the European building stock, energy consumption in the commercial sector grows at a higher rate than other sectors (due predominantly to the expansion of HVAC systems). Office and retail are amongst the most energy intensive typologies typically accounting for over 50% of the total energy consumption for nondomestic buildings [3]. This makes the energy retrofit of the commercial building stock a priority.

Although the importance of refurbishing existing commercial buildings is widely recognized, it appears that the current refurbishment rate is insufficient to meet the 2020 EU's energy targets. Both the quality and the scale of refurbishment need to improve. This is why this research addresses the **zero energy** refurbishment, as a way to analyse a high, but soon needed, energy goal. Here the term zero energy refers to a building with zero net energy consumption, meaning the total amount of energy used by the building on an annual basis is roughly equal to the amount of renewable energy created on the site [6]. While the business case for *new* zero energy buildings is believed to exist, controversial opinions can be found in literature concerning the zero energy refurbishment. For new buildings, the business case existence is not discussed mainly because it will be a compulsory practice from the year 2020 [5].

The present study aims at identifying the factors that affect the feasibility of the zero energy refurbishment of existing commercial buildings, while suggesting ways to improve the business case. Through interviews to real estate investors, the study identified the financial and technical barriers encountered today to undertake deep energy retrofit. Subsequently, the design interventions needed to refurbish a Dutch office building and meeting the net zero energy target were evaluated using a software complying with the Dutch standards NEN 7120. A risk and sensitivity analysis with Monte Carlo simulations showed the influence that design aspects, energy price and landlord-tenant agreements have on the business case.

2 METHODOLOGY

In order to identify the main barriers for the zero energy refurbishment of commercial buildings and to suggest ways to create the business case, this research was structured as follow:

(i) Interviewing relevant actors in the decision making phase
(ii) Evaluating the business case for a ZE refurbishment case study design
(iii) Performing a risk and sensitivity analysis to identify the most influential variables for creating the business case

Below, the methodology adopted for every step is briefly explained.

2.1 Interviews

For the scope of this research a *general interview guide approach* [7] is chosen. A list of questions was prepared but only used as outline to assure covering the intended topics. Barriers, opportunities and drivers of the zero energy refurbishment were discussed.

In total, 9 interviews are shown in the result section, reporting at least one interviewee per the following categories:

- Investors
- Designers
- Real Estate Experts
- Energy Service Companies (ESCOs')
- Tenants

2.2 Business Case Analysis

The Zero Energy refurbishment was designed for De Groene Toren, an office building from the 1980s in The Hague, the Netherlands, already refurbished in 2011. The building occupies a gross floor area of approximately 35,000 m^2.

The software ENORM was used to identify the interventions needed to reach the zero energy target, as it allows carrying energy calculation according to the Dutch regulation NEN 7120 (The NEN 7120 specifies terms, definitions and methodologies for the determination of the energy performance.).

Firstly, the costs of the renovation are estimated, together with the cost of maintenance, comparing the ones occurring before and after the renovation. The costs were estimated by consulting a cost database [8] and contractors. Secondly, the sources of revenues such as increase of rent, change of rentable space, and maintenance cost savings are calculated. Subsequently, the return of investment is determined and expressed in terms of economic indicators such as *Net Present Value (NPV)*, *Internal Rate of Return (IRR)* and *Payback Time*. The NPV and IRR are calculated over a 25-year period time, being this a time after which a building usually needs refurbishment.

2.3 Risk and Sensitivity Analysis

The risks analysis is performed to deal with the uncertainties and errors of the business case evaluation. For instance, costs may vary considerably depending on the contractor consulted for the estimation or on the specific supply choice. The sensitivity analysis is done to identify variables that most affect the business case. A **Monte Carlo Simulation** (MCS) was performed, achieving the intended overview of the parameters that play the most important role compared to others in defining the business case. The MCS is a probabilistic method that can overcome uncertainties or mistakes in the

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analysis when a 'safe' range of variables is used as input. To perform the simulation, the Excel application Oracle Crystal Ball [9] was used. By defining variable inputs in terms of realistic range of possible values, Crystal Ball generates thousands of calculations, each time using a different randomly selected value. In this case a beta-PERT distribution was chosen which allows giving a minimum, most likely and maximum value. Changing the forecasted variables, the probability of the IRR to be greater than 10% is given, together with the probability of the NPV to be greater than 0 and of the Payback time to be less than 15 years.

2.4 Strategies

To analyse the influence and the weight that each parameter has on the business case (with the MCS), four different strategies were defined:

- Base-Case (A)
- Budget allocation (B)
- Increase of rentable space (C)
- Combination (D)

All the strategies describe a renovation consisting of the minimum interventions needed to reach zero energy with a rent within the market range (from 150 to 200 €/m2) for that specific location.

Table 1 summarizes the assumptions made for each strategy.

	A	B	C	D
Increase of floor area with the renovation			✓	✓
Owner does not pay for energy bills	✓		✓	
Energy budget allocation to tenant, owner officially pays for energy		✓		✓

Table 1: *Assumptions* for strategy A, B, C, and D.

3 RESULTS

3.1 Interviews

The results of the interview are summarized in *Table 2*. The main barriers for the business case of the zero energy refurbishment of commercial buildings appear to be financial rather than technical. In particular, the increase of value of refurbished zero energy building is considered to be too low. Lack of financial attractiveness seems to be the main reason why zero energy refurbishment does not belong to the current practice.

3.2 Business Case Evaluation

For the chosen building the refurbishment designed to reach the zero energy target includes measures such as the addition of a geothermal heat pump, the replacement of all the existing light bulbs with LED lights and mechanical demand-controlled ventilation (CO2 control). Interventions on the building envelope were also necessary, replacing the existing elements with triple insulated glazing (U value of 0.25 W/m^{2}K) and with insulated façade panels (Rc value of 7 m^{2}K/W). Concerning the energy production, PV cells are placed on the roof (1400 m^2) and on the Southeast and Southwest façades (2386 and 1481 m^2, respectively).

With these energy measures, the energy demand of the building is 2.5 mln MJ. In order to fully achieve zero energy an additional 3120 m2 of PV panels need to be installed off-site.

The total renovation was estimated to cost about 12 mln €, with a Payback time of 18 years and a NPV equal to 3.27 mln €.

3.3 Risk and Sensitivity Analysis

Table 3 shows the range used as input for the MCS while *Table 4* summarizes the outcomes for each strategy. It can be seen that the probability for the NPV to be positive goes from 39.6% with the base case strategy (A) to 90.9% with the combination strategy (D). The sensitivity analysis for the NPV is shown from Figure 1 to Figure 4.

4 DISCUSSION

In commercial buildings it is usually the tenant who pays for energy bills and the owner who pays for the refurbishment. This reality brings to a paradox: the owner invests in energy saving measures while the tenant benefits from them. The only way for the owner to get back the investment would be increasing the rent, which is not always possible. Rental increase depends on location and other parameters, and has market rules to follow. To remove the paradox and improve the business case, the budget allocation strategy was made: the tenant pays a quota that is equal or smaller than the previous energy bill, which is added to the competitive market rent.

The owner officially pays for energy, but with zero energy buildings the only energy to be paid is for backup system (lack of renewable energy supply) and grid connection.

Should the tenant demand too much energy, he would need to pay for it. Such a measure seems to offer a win-win situation for tenant and owner solving the typical user-behaviour problem of all-inclusive contracts.

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Category	Interviewee's role	Zero Energy Refurbishment Main Drivers	Opportunities	Barriers
Investor	Senior Real Estate Development (*BREEVAST)*	• Strategic location • Local regulation • Local incentives	• Certification seen as added value for property evaluation	• Inefficient certification systems in The Netherlands • Lack of sustainable mind-set and knowledge by building owners • Attractive new building options • Lobbying of current providers • Economic crisis
	Owner (*DTZ Zadelhoff)*	• Strategic location • Tenants' requests • Local incentives • Age of the building	• Market increase in the coming years	• Balance between investment and return
	Technical Project Manager Offices (*CBRE Global Investors)*	• Strategic location • Tenants' requests and alternatives • Vacancy rate • Return of investment	• Increasing rent-ability • Decreasing vacancy • Corporate image	• Non-existing economical technical solutions • Bureaucracy of external renewable sources
Designer	Sustainability and Life Cycle Performance Engineer (*RHDHV)*	• Location • Budget • Life cycle costs • Type of contract	• Technological Improvements • NZEB technically possible	• Impossibility to predict the real energy demand • Significant uncertainties of users' behaviour • Investors are not enough interested in energy
	Sustainability and Innovation Engineer (*Techniplan Adviseurs)*	• Business case • Current building performance • Technical Life Cycle of building services • User requirements	• Technological Improvements • BIM for building management	• Research phase more risky and costly • Uncertainty of existing building data and modelling
Real Estate Expert	Assistant Professor Real Estate Finance *(TU Delft)*	• Increase of property value (IRR, NPV) • Decrease of vacancy rate • Depreciation	• Not discussed	• Uncertainty of return of Investment • Economic crisis
	Assistant Professor Real Estate & Housing *(TU Delft)*	• Rental market • Location • Adaptability of the building architecture • Tenants requests • Building importance	• Increasing corporate image	• Current refurbishment to meet lower energy labels • Initial costs too high
ESCO	Product Manager (ENECO)	• Technological innovation • Regulations	• New business	• Non-Intelligent Appliances • Complex systems to be developed • Absence of business case
Tenant	Facility Manager (PostNL)	• Energy Savings • Corporate Image	• Not tangible opportunities could be identified	• Too high investment • Technical impossibilities

Table 2: Summary of the outcome of the interviews.

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Variable	Low	Mid	High	Unit	Source
CAPEX *)	12,000,000	17,000,000	22,000,000	€	*Database and contractors*
OPEX **)	30,000	65,000	100,000	€	*Database and contractors*
Rent after renovation	150	175	200	€/m^2	*DTZ*
Occupancy rate after renovation	50	75	100	%	*DTZ*
Total surface before renovation		30,000		m^2	*Building*
Total surface after renovation	30,000	32,000	34,000	m^2	*Design strategies*
Electricity price	0.05	0.15	0.25	€/kWh	*EUROSTAT*
Gas price	0.20	0.40	0.60	€/m^3	*EUROSTAT*
OPEX savings after renovation	0	7,500	15,000	€	*Database and contractors*
Discount rate	2	4	6	%	*Interviews*
Inflation rate	0	1	2	%	*EUROSTAT*
Annual rent increase	1	2	3	%	*Interviews*
Building value increase	5	8	11	%	*Evaluator*

*) Capital Expenditures **) Operational Expenditures

Table 3: Variables and related ranges used for the Monte Carlo simulation.

A common argument against the business case for energy retrofit is that the energy price is too low. Assuming the owner would take advantage from an improved energy performance, looking at the budget allocation strategy, the business case does improve, suggesting that higher energy prices favour energy refurbishment. Nonetheless, looking at Fig. 1 to Fig. 4, the electricity and gas prices are never in the top 3 influencing variables. Other parameters such as the Capital Expenditures (CAPEX), the increase of rent after renovation and the occupancy rate play a much more important role in determining the business case.

	A	B	C	D
IRR>10% [%]	4.23	23.5	22.0	53.2
NPV>0 [%]	31.6	69.7	65.0	90.9
Payback<15 y [%]	6.34	30.6	27.7	61.1

Table 4: Probability of economic indicators for different strategies of the MCS.

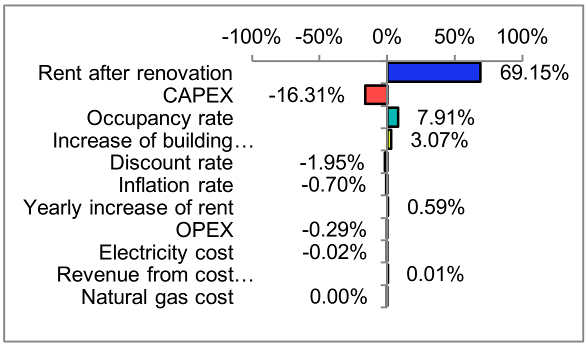

Fig. 1: Sensitivity for the NPV for the base case strategy (A).

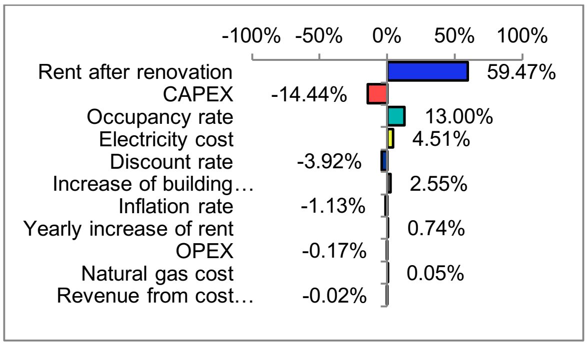

Fig. 2: Sensitivity for the NPV for the budget allocation strategy (B).

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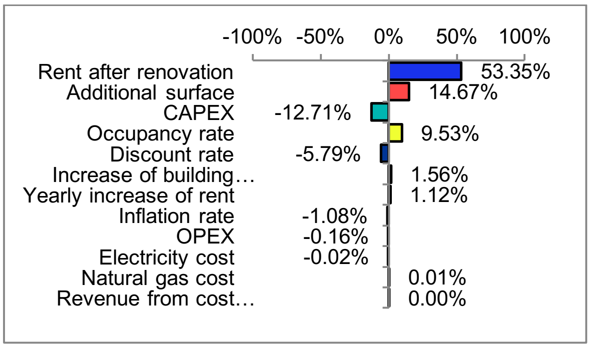

Fig. 3: Sensitivity for the NPV for the increase of rental space strategy (C).

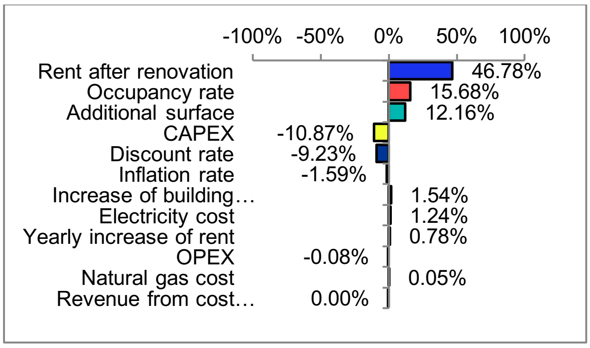

Fig. 4: Sensitivity for the NPV for the combination strategy (D).

5 CONCLUSIONS

This study concludes that when the design provides additional benefits, such as increasing the property value, the refurbishment can become feasible. The most relevant conclusions reached with this research are:

- Interviewing stakeholders provided a direct overview of barriers and opportunities of the ZE refurbishment.
- Investors agree that the barriers for the zero energy refurbishment of commercial buildings are financial: the value increase of the building after renovation is not high enough with respect to the initial investment required (CAPEX).
- The evaluation of the business case by means of Monte Carlo simulations allows overcoming uncertainties in the input variables and identifying the most influencing ones.
- As long as the owner pays for energy retrofit and tenant pays for energy bills the energy performance does not influence the business case. This way the energy price and energy savings do not impact the business case. Allocating a budget for energy to the tenant can easily improve the business case for the owner who invests in energy retrofit, while helping to control the user behaviour.
- Adding surface with the refurbishment increases the rentable space hence increases the revenue and improves the business case.

The model used for this study could be tested on more existing buildings to decide if a ZE refurbishment would present a good business case. It could also be used for assessing already refurbished buildings for which a lower energy target was chosen.

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