Business Case Investigation for the Zero Energy Refurbishment of Commercial Buildings

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Working paper series

Centre for Sustainable Entrepreneurship
University of Groningen/Campus Fryslân

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FEBRUARY 2017

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 stock needs to be included, in order to achieve the 2020 EU environmental targets. The main barriers of zero-energy refurbishment of existing non-residential buildings appear to be financial rather than technical, next to a number of other extrinsic factors that do not stimulate such an investment. 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 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. 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 shown that when the design provides additional benefits, such as increasing the rent, or allocating an energy budget to the tenant, the refurbishment can become feasible. Ultimately, a screening-checklist is proposed for a qualitative estimation of the potentials offered by a given building for a feasible energy neutral refurbishment.

INTRODUCTION

Across Europe only 1% of buildings in any given year is newly built, about 70% of buildings are over 30 years old and about 35% are more than 50 years old (Energy Performance of Building Directive, 2013). Given the fact that the building sector is responsible for about 40% of the total greenhouse gases (GHG) emission, massive refurbishment aiming at improving the performance of existing buildings, seems to be the most logical way forward. Moreover, considering the new-constructions rate, it is not difficult to foresee that most of the buildings present in 2050 have already been built (Torgal et al., 2013). These buildings are also the ones supposed to require 80% less energy compared to the 2008 levels (European Commission, 2010). It follows that 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 heating, ventilation and air conditioning (HVAC) systems). Office and retail are amongst the most energy intensive typologies typically accounting for over 50% of the total energy consumption for non-domestic buildings (Pérez-Lombard et al., 2008). 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 analyze 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 (Torcellini et al., 2006).

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 (European Commission, 2010). According to policy-

related researches, aiming to define a strategy towards sustainable building refurbishment of the European building stock, the main barriers appear to be financially related. Economic and technical barriers in deep energy retrofit need to be analyzed, quantified and related to each other. The present study investigated 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 with real estate investors, this 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 results were presented to the formerly interviewed real-estate investors in the form of a roundtable discussion. Finally, a screening-checklist was formulated for a qualitative estimation of the opportunities of a given commercial building for a feasible zero energy refurbishment.

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:

1. Interviewing relevant actors in the decision making phase;

2. Evaluating the business case for a ZE refurbishment case study design;

3. Performing a risk and sensitivity analysis to identify the most influential variables for creating the business case;

In the following sections, the methodologies adopted for each step are summarized.

Interviews

For the scope of this research a general interview guide approach (Gall et al., 2003) was 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, nine 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.

Case study

The Zero Energy refurbishment design was performed 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 m² and hosts the following functions:

- A low basement with parking spaces;
- A ground floor with entrance and restaurant;
- Office floors on the 1st to 19th floor;
- Technical rooms on the 20th floor (extending for two floors).

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. These interventions are independent of the starting energy label performance analysis.

Business Case Analysis

Firstly, the costs of the renovation were estimated, together with the cost of maintenance, comparing the ones occurring before and after the renovation. The estimation was performed by consulting a cost database (Bouwkosten online database, 2105) and contractors. Secondly, the sources of revenues such as increase of rent, change of rentable space, and maintenance cost savings were calculated. Subsequently, the return of investment was 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 were calculated over a 25-year period time, being this a time after which a building usually needs refurbishment.

Risk and Sensitivity Analysis

The risks analysis was 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 was done to identify variables that most affect the business case. Monte Carlo simulations (MCS) were 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 allows tackling uncertainties by using as input for each variable a range of values, rather than a single deterministic value. To perform the simulations, the Excel application Oracle Crystal Ball 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. For the present analysis a beta-PERT distribution was chosen, assigning 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. Table 1 shows the range used as input for the MCS.

Table 1: Variables and related ranges used for the MCS.

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	€/m²	*DTZ*
Occupancy rate after renovation	50	75	100	%	*DTZ*
Total surface before renovation		30,000		m²	*Building*
Total surface after renovation	30,000	32,000	34,000	m²	*Design strategies*
Electricity price	0.05	0.15	0.25	€/kWh	*EUROSTAT*
Gas price	0.20	0.40	0.60	€/m³	*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 Expenditure

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;

- Budget allocation;

- Increase of rentable space;

- Combination.

All the strategies describe a renovation consisting of the minimum interventions needed to reach zero energy with a rent within the market range for that specific location. The *base case* represents today's common practice, where the owner pays for the renovation and the tenant for the energy bills. In the *budget allocation* strategy 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 and allowing the owner benefitting from renovation. The *increase of surface* strategy aims at increasing the rentable space with the renovation, allowing increasing the rent within market range. The *combination* strategy couples the two strategies above mentioned. Table 2 summarizes the assumptions made for each strategy.

Table 2: Summary of the strategies.

	Increase of floor area	Owner does not pay for energy	Owner pays for energy
Base Case		✓	
Budget allocation			✓
Increase of surface	✓	✓	
Combination	✓		✓

RESULTS

Interviews

The results of the interviews are summarized in Table 3. 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.

Case study

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 €, calculated with a discount rate of 5%. For the chosen building, the measures applied to reach the zero energy target are summarized below:

- Cooling: Air-cooled compression-refrigeration machine and geothermal heat pump. Distributed by means of water (induction units) and air handling unit.

- Heating: High temperature geothermal heat pump, air source heat pump. Transferred by means of water (induction units) and air handling unit.

- Warm tap water: Electrical heat pump, electrical boiler (backup).

- Ventilation: Mechanical demand-controlled ventilation (CO_2 control)

- Lighting: Only LED bulbs.

- Building envelope: Triple insulated glazing 36 mm with Argon filling and U value of 0.25 W/m²K. Insulated façade panels with an Rc value of 7 m²K/W.

- Energy production: PV cells are placed on the roof (1400 m2) and on the South-East and South-West façades.

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

Table 3: Summary of the interviews outcome.

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 economic 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

Risk and Sensitivity Analysis

Table 1 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 to 90.9% with the combination strategy. The sensitivity analysis for the NPV is shown from Figure 1 to Figure 4. It can be seen that the capital expenditures (CAPEX), the rent after renovation and the occupancy rate are the most influential factors in determining the business case.

Table 4: Overview of economic indicators outcomes per strategy calculated with MCS.

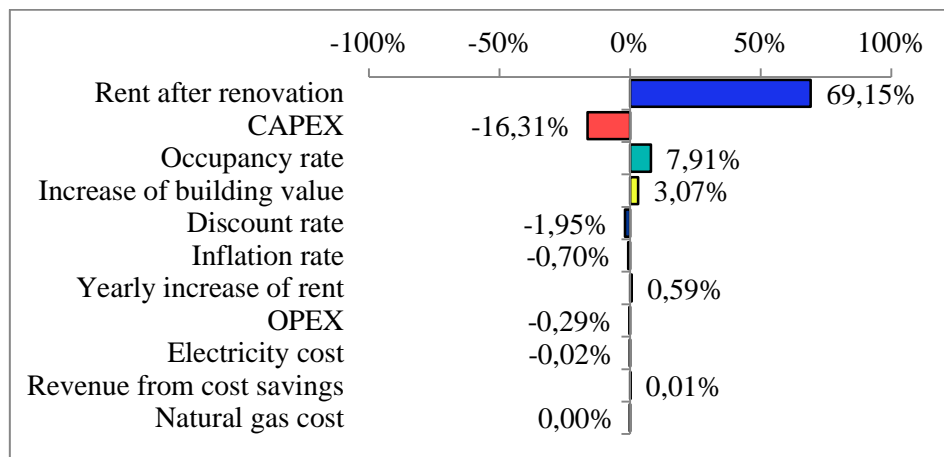|	Base Case	Budget allocation	Increase of floor area	Combination
IRR>10% [%]	4.23	23.5	22.0	53.2
NPV>0 [%]	31.6	69.7	65.0	90.9
Payback<15 y [%]	6.34	30.6	27.7	61.1

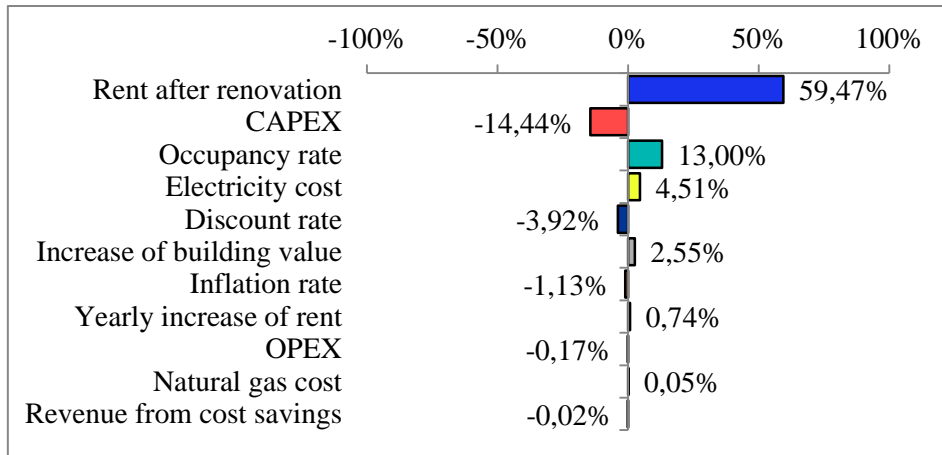Figure 1: Sensitivity for the NPV for the base case strategy.

Figure 2: Sensitivity for the NPV for the budget allocation strategy.

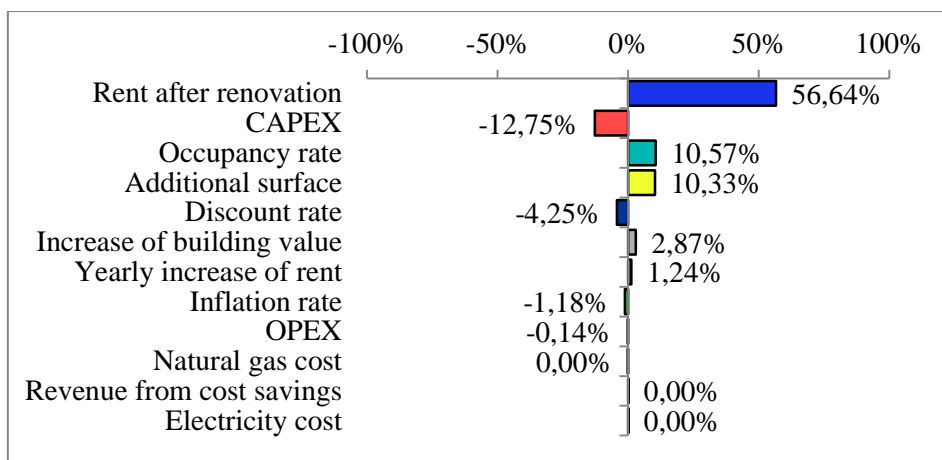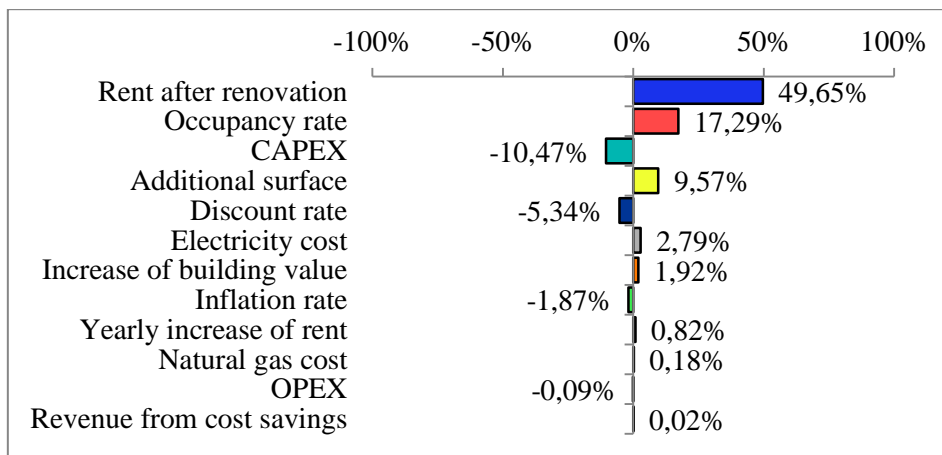**Figure 3: Sensitivity for the NPV for the increase of rental space strategy.**

Figure 4: Sensitivity for the NPV for the combination strategy.

SUMMARY

Thanks to the initial dialogue with real estate investors, it was possible to identify the main barriers for the zero energy refurbishment of commercial buildings, confirming the relevance of the lack of business case. The case study design allowed reflecting upon the technical challenges of deep energy retrofit and the approaches of design methodologies adopted today to tackle refurbishment.

When evaluating the business case, it became clear that a deterministic approach was not sufficient to thoroughly analyse the potentials for building value increase. It was not only impossible to draw general conclusions, but also the uncertainties of the analysis would have most probably lead to false results. A risk and sensitivity analysis allowed for a more objective study, freed from the intrinsic uncertain nature of design choices and cost evaluation, which unavoidably come with a high error probability.

Thanks to the study of the variables with the Monte Carlo simulations, it was possible to draw different strategies by playing with the most influential variables, finally leading to a strategy that presents a good business case for the investor. The strategies developed were then presented to relevant real estate investors during a roundtable discussion. This allowed to get feedback about the methodology and the assumptions, and to discuss the future visions about zero energy refurbishment with actors involved in decision-making process.

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. 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 Figure 1 to Figure 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.

As mentioned before, the first two factors are user dependent and only the last one is intrinsically related to the problem itself. In an effort to have more insights on the real weight of the variables used in the MCS, one could calculate the partial derivative of the NPV, IRR and payback time with respect to each variable. Since all the equations used to calculate these economic indicators are explicit, it is a relatively simple problem to solve, yet a tedious procedure. Furthermore, it would present a strong limitation in comparing the different derivatives, as each of them would have different units. A faster and more generic approach would be to run a MCS where the other two factors influencing the sensitivity are the same for each variable. In this way the resulting sensitivity would be only influenced by the real weight of the different variables.

Figure 5 shows the NPV sensitivity for a simulation where all variables have a range of +/- 20% from the mean value used in Table 1, and all distributions are beta Pert (as in all previous simulations as well).
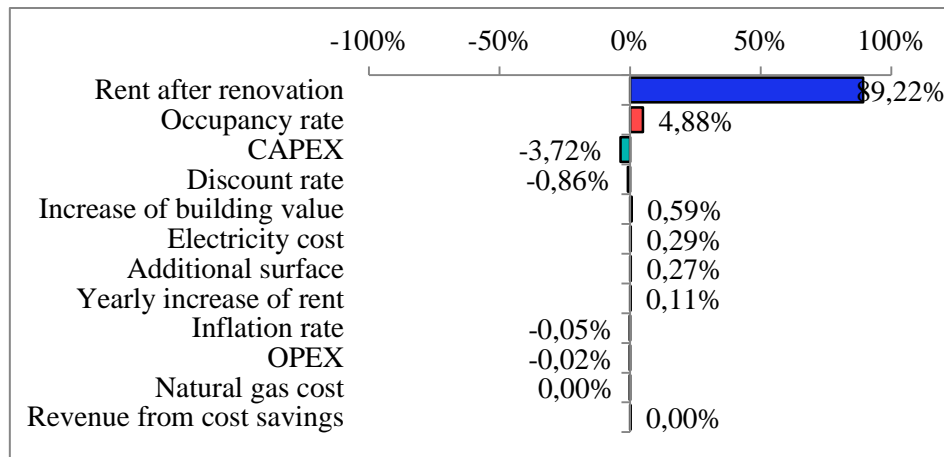
Figure 5: Sensitivity for the NPV when all variables have a range of +/- 20% from the mean value.

The first three variables in the sensitivity analysis are the same as in all the previous strategies (rent after renovation, occupancy rate and CAPEX). The rent after renovation, with an 89% influence, has a much heavier weight on the problem than any other variable (occupancy rate follows with a mere 5%).

To further verify the conclusion drawn from this sensitivity analysis, several other MCS were run including a change in fixed range (+/- 10% and +/- 50%) and a change in mean value (these are not reported here for simplicity). The effect is always the same: rent after renovation is by far the most important variable, followed by CAPEX and occupancy rate.

CONCLUSIONS

This study concludes that when the design provides additional benefits, such as increasing the property value, the energy neutral 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.

RECOMMENDATION FOR FUTURE RESEARCH

This research identified the key aspects that play a role in the business case evaluation for the zero energy refurbishment of commercial buildings. The model used for this study could be tested on other 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.

This would not only help to build a more general theory but also to improve the model, where for instance the ranges are limited to a span, which is proved to be valid for more situations. The case studies could be both already renovated buildings (for which the business case was considered attractive; this could help define a certain range limit for the MCS input) and renovations yet to be made, helping the real estate industry in decision-making.

In addition, it would be needed to perform a similar research focusing on the residential sector, which presents a very different business case definition. The residential building stock is also highly energy consuming and its refurbishment is a priority in the European political agenda.

Finally, this research addressed the energy performance, this being very relevant in the GHG emission of the built environment. However, there are other aspects, which label a building "green", that are also believed to lack of business case, brining none to little economic value in the refurbishment. This belief among developers should be further explored and perhaps a similar research could confute the practice that defines the refurbishment of green buildings, as being not economically feasible.

REFERENCES

Bouwkosten, (2015). Online database, available at: http://www.bouwkosten.nl/. Accessed July 2015

Commission of the European Communities (2008). Summary of the Impact Assessment accompanying the proposal for a recast of the Energy Performance of Buildings Directive (2002/91/EC).

Energy Performance of Building Directive (2013). Assistance Documents for EU Member States in developing long term strategies for mobilizing investment in building energy renovation (per Energy Efficiency Directive Article 4) - COMPOSITE DOCUMENT

European Commission (2010). Energy 2020: A strategy for competitive, sustainable and secure energy. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

Gall, M.D., Borg, W.R., Gall, J.P. (2003). Educational Research: An Introduction. 7th ed. Boston: Pearson

Meijer, F., Itard, L., Sunikka-Blank, M. (2009). Comparing European residential building stocks: performance, renovation and policy opportunities, Building Research & Information, vol. 37(5-6), p. 533–551.

Pacheco Torgal, F., Artkras Kaklauskas, M.M., Granqvist, C.G., Cabeza, L.F. (2013). Nearly Zero Energy Building Refurbishment, A Multidisciplinary Approach. London: Springer

Pérez-Lombard, L., Ortiz, J., Pout., C. (2008). A review on buildings energy consumption information, Energy and Buildings, 40 (3), p. 394–398

Poel, B., Van Cruchten, G., Balaras, C.A., (2007). Energy Performance Assessment of Existing Dwellings & Non Residential Buildings, Energy and Buildings 39, p. 393–403.

Oracle, (2011). Crystal Ball, Release 2.4, for Microsoft Office.

Torcellini, P., Pless, S., Deru., M. (2006). Zero Energy Buildings: A Critical Look at the

Definition, U.S. Department of Energy. National Renewable Energy Laboratory

report.

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