Sustainable building reuse

Understanding user preferences for the housing market

C. Vasilache, 0788678
Construction Management & Engineering
Eindhoven University of Technology
16th of July 2013

Graduation committee
Prof. Dr. Ir. W.F. (Wim) Schaefer (Chairman TU/e)
Dr. Ing. B. (Brano) Glumac (Graduation Supervisor TU/e)
Dr. Q. (Qi) Han (Graduation Supervisor TU/e)

Preface

This research represents my graduation thesis as a partial fulfillment of the requirements for the degree of Master of Science in Construction Management and Engineering, provided by Eindhoven University of Technology.

First of all, I would like to thank my parents, Adriana and Ioan Vasilache, for their never ending faith in me and sacrifices to support my dreams. My older sister Raluca and her kind husband, Darren, for giving me a loving and peaceful home during my studies, for being there for me in some of the most challenging moments of my life and for their moral support. I am fortunate to have them beside me. I also want to thank my boyfriend Dragos, for his patience and understanding. Without them, this would not have been possible.

This research would have been impossible without the good guidance of the Eindhoven University staff, Dr. Brano Glumac and Prof. Wim Schaefer (chairman of the dissertation committee). I am deeply grateful for their help and continuous guidance in defining, writing and finishing the dissertation. Brano, I am grateful for your enthusiasm and your comments and advice which shaped this research.

I would also like to thank my colleagues from the CME group, especially Michiel and Niels, for being, during these two years, more than just my project mates and becoming my friends. You've helped me overcome many difficulties of studying in a foreign country. Finally, this research couldn't be done without the contribution of the respondents for the online survey. They provided the data and information required to complete this thesis.

During this research I faced many challenges, from finding a suitable subject, to developing an online survey, finding respondents, handle statistical data and software and many more. Having overcome all these, I am now looking forward for a career start and future challenges that it may bring.

Cristina Vasilache,
Eindhoven, July 2013

Table of contents

1. INTRODUCTION

Due to increased focus on sustainability and the current European Union targets to reduce the carbon footprint, the construction sector, as a major energy consumer, should also explore its options towards more sustainable solutions.

There are ongoing research works to investigate how to significantly reduce the consumption of energy and material flows in the building industry. In residential buildings, embodied energy in the building process represents between 30 and 100% (for passive houses) of total life cycle energy consumption. (Haynes, 2010) That is why, the adaptive reuse of existing building stock that has reached the end of its useful life, but not its physical life, is an important ingredient in the necessary change of the building industry in order to diminish its impact the environment and to conserve valuable resources for the future.

Vacant buildings represent an insufficient exploited “gold mine” for future developments. By finding the future users preferences, vacant buildings can be reused and can generate a significant contribution towards a more sustainable development within the construction industry. Throughout this paper the environmental, social and urban benefits of building reuse are presented and a discrete choice experiment will be used to indicate the preference of the potential future occupants.

When considering sustainability performances, the environmental benefits of building reuse are obvious from waste management and embodied energy perspective, but there are other two major factors that must be taken into account. These are the economic and social development in terms of its life cycle performance. Building vacancy is an emergent problem of our society with repercussions not only on environmental level but on economic and social levels too. This research hopes to elucidate the specific attributes that would lead to success and increased feasibility of a building reuse project. Decreasing vacancy and encouraging developers to consider building reuse, as viable solution prior to demolition and new build, will lead to a more sustainable build environment.

Successful reuse and preventing vacancy in the building’s new life must be ensured by uncovering users’ preferences on specific attributes. Revealing attributes and quantifying their importance according to potential future occupants’ preferences is the key to a sustainable reuse project that will prevent further future vacancy.

1.1. Problem definition

According to statistics by 2030 more than 80% of the global population will live in cities. Inevitably, this puts a substantial pressure on urban land use, especially as, over time, the built environment becomes obsolete and needs replacing. By regenerating previously developed buildings to maximize the use of existing resources, the increasing pressure on urban areas can be answered. Of course this is not sufficient to solve such a great emergent problem, as urban agglomeration, but it makes the best out of the available inner city means. The focus of the adaptive reuse of vacant buildings is on the ones from urban areas, justified by the high land value and the increasing losses caused by their vacancy.

"*The existence of unused buildings represents an underutilization of city resources, a missed opportunity for forms of urban development that might, with simple yet often untried technical solutions, make effective use of physical resources. These buildings represent a negative feature for the idea of the sustainable community*." (Ball, 2010) Reuse of an existing structure may be a project's major sustainable feature. But finding the right structure for reuse that also meets users' preferences in terms of location and attributes is the challenge.

Coping with vacancy by transformation into housing is the main issue of this research as the transformation of structurally vacant buildings may offer a solution to the tight Dutch housing market.

1.2. Research question

The major concern regarding adaptive reuse of buildings, which is common to new build projects as well, is the uncertainty about economic viability. Finding the right structure for reuse that also meets users' preferences in terms of location and attributes is a challenge. In order to guarantee the success rate of the adaptive reuse project, users' preferences must be understood and evaluated. This leads to our main research question:

What type of building is best suited to fulfill customer preferences in a building reuse project developed for the housing market?

During this research the focus will be on building reuse for housing purposes. Both industrial and office buildings will be tested against user preferences in order to asses which one proves to be best fitted for the new use.

In order to better understand vacancy coping possibilities, other sub questions will be answered:

Sub question 1: What are the contributions of building reuse towards sustainability within the construction sector?
Sub question 2: What is the targeted market segment?
Sub question 3: What are the main attributes that future users look for in a reuse building project developed for the housing market?

1.3. Research method

Firstly a comprehensive literature study will be conducted in order to analyze the contributions of building reuse to sustainability. As sustainability performances concerns three major aspects, economic, social and environmental development, all these will be taken into account. Also the level of vacancy in the Netherlands, with the focus on Eindhoven, is researched. There are many ways that owners and developers can cope with vacancy, these will be outlined and a solution will be proposed.

For understanding users preferences a discrete choice experiment will be used. Due to its success in the field of market research, several authors have already used different discrete choice models for land-use assessment.

The discrete-choice-modeling approach requires that a representative sample of customers make choices in simulated situations derived from realistic variations of market offerings. The performing of a discrete choice model experiment typically comprises of three steps. First, using market assessment, customer interviews, case studies, industry data, literature reviews, focus groups, and other information sources, a list of drivers that are believed to influence customers' purchasing decisions is compiled. Once the list of choice drivers is finalized, experimental design techniques are used to develop many realistic versions of service offerings. Next, choice experiments are constructed that ask respondents to select one out of two or more alternatives available to them in a series of choice sets. In the final phase, econometric models based on responses from a representative sample of potential future customers are used to identify empirical key patterns in the survey responses, providing a relative weighting for each driver and, if considered necessary, for interactions among drivers. Developers and managers can then select the optimal combination of attributes to develop a profitable and sustainable value proposition that, under normal competitive constraints, will maximally leverage their available resources. (Verma & al., 2009) A detailed research design is showed in fig. 1.

1.4. Expected results

The findings of this research should indicate the most important attributes and the preference of the potential future building occupants. This will indicate what type of building would be better fitted for the new use and what are the most important changes that need to be undertaken to the building in order to make it more attractive for the current market. Understanding these considerations will help guarantee the success of the building reuse projects. It is also interesting to see if the initial use of the building, office or industrial, has an influence on the users' behavior.

It is expected that users' preferences are highly related to respondents' characteristics. That is why, a few questions about the respondent will be introduced at the beginning of the questionnaire in order to understand the correlation between preferred attributes and possible market segment.

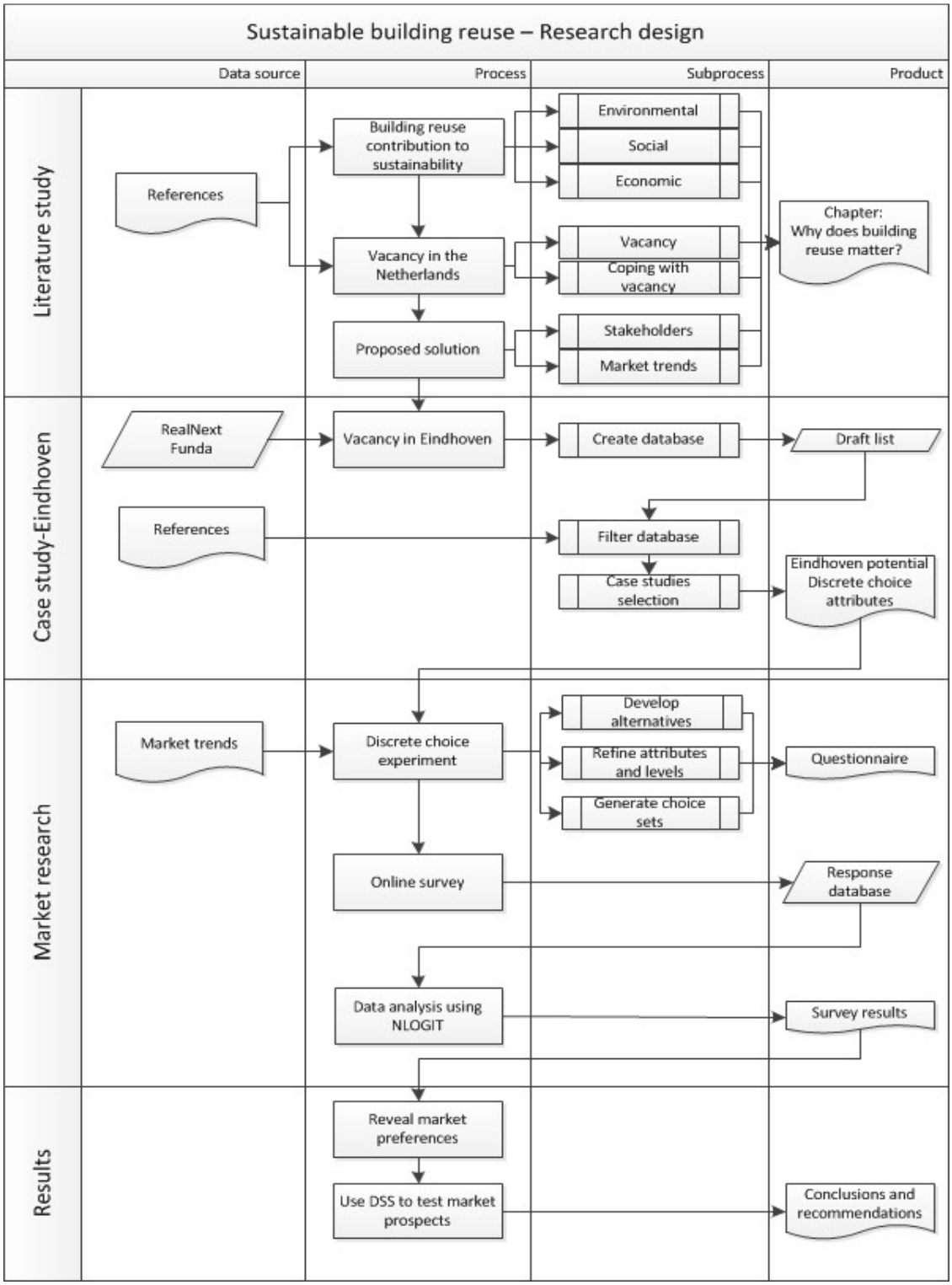


Figure 1. Research design

2. WHY DOES BUILDING REUSE MATTER?

2.1. Buildings reuse contribution to sustainability

2.1.1. Adaptive reuse

'Adaptive reuse is a process that changes a disused or ineffective item into a new item that can be used for a purpose other than which it was built or designed for.' (DEH, 2004) While old buildings become unsuitable for their programmatic requirements, as progress in technology, politics and economics moves faster than the built environment, adaptive reuse comes in as a sustainable option for the reclamation of sites. In many situations, the types of buildings most likely to become subjects of adaptive reuse include industrial buildings, as cities become gentrified and the process of manufacture moves away from city; political buildings, such as palaces and buildings which cannot support current and future visitors of the site; and community buildings such as churches or schools where the use has changed over time.

Adaptive reuse is seen as an effective way of reducing urban sprawl and environmental impact of the build environment. By reusing an existing structure within a site, the energy required to create these spaces is lessened, as is the material waste that comes from destroying old sites and rebuilding using new materials. Through adaptive reuse, old, unoccupied buildings can become suitable sites for many different types of use.

There are often several criteria for deciding whether a building should be conserved and reused or just demolished, these generally concern historical and social value of the site, natural ecological condition of the site and potential for reuse of the structure, as in potential damage, and building's character and fitness for the new use.

An important debate currently running in the buildings area concerns the relative costs and related benefits and constraints of reuse versus new build. Adaptive reuse may not be an economically viable option when the structure of a building requires extensive strengthening to be undertaken. This should be applied on the existing building stock that has reached the end of its useful life, but not its physical life. Several architects suggested that buildings reach a point in their life where they cannot be adapted anymore and demolition is the only solution. Otherwise, the building will generate on-going maintenance costs if, when deciding on the solution, a short term view is taken. Also the presence of contaminations by substances or other materials, such as asbestos, and nonconformance with current governmental health and safety standards can become barriers for adaptive reuse.

In an extensive quantitative research on potential environmental impact reductions associated with building reuse performed by Preservation Green Lab (PreservationGreenLab, 2011), factors like significant emissions reductions in the categories of climate change, human health, ecosystem quality and resource impact were considered. In the above mentioned study it was found that savings from reuse are between 4 and 46 % over new construction when comparing buildings with the same energy performance level.

This variation is due to a combination of factors, including the amount and types of materials used in the reuse project. When comparing buildings with different energy performance the results show that it takes 10 to 80 years for a new building, which is 30 % more efficient than an average performing existing building, to overcome the negative climate change impacts related to the construction process.

2.1.2. *Environmental benefits of adaptive reuse*

The construction industry is a major waste generator and consumer of natural resources. Almost 40% of the world's consumption of materials converts to the built environment, and about 30% of energy use is due to housing (Amponsah, Lacarrière, Jamali-Zghal, & Le Corre, 2012). The building sector is the biggest consumption sector, before transports sector. As a result, there are ongoing research works to investigate how to significantly reduce the consumption of energy and material flows in the building industry. In effect, terms such as low-energy and passive house are used more frequently all over Europe. Life cycle energy analysis clearly identifies optimum strategies for reducing both energy demand and greenhouse gas emissions.

In residential buildings, embodied energy in the building process represents between 30 and 100% (for passive houses) of total life cycle energy consumption. (Haynes, 2010) The total life cycle energy consumption is made up of embodied energy and operational energy. Operational energy is the energy requirement of the building during its life from commissioning to demolition (not including maintenance or renovations). The embodied energy is the energy required to construct and maintain the premises. A brick wall for example, consists of the energy required to make the bricks, transport them to site, lay them, plaster them and (if necessary) paint and replaster over the life of the wall.

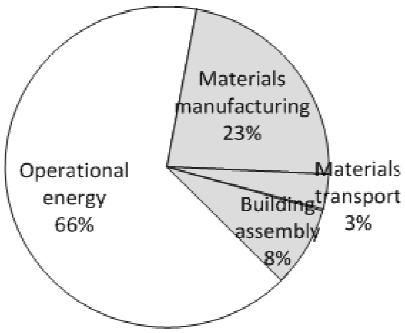


Figure 2. Lifecycle energy use of a typical building

Total life cycle energy use over the typical forty to fifty year life of an office or residential building showing embodied energy to be around 30% of total energy use. These values were supported by Crowther (Crowther, 2000) and later on by Haynes (Haynes, 2010).

The number of occupants or building type must be considered for true comparison between designs and building's embodied energy. Furthermore the life span of a building is critical, as a free standing building with a life span of 50 years and a total embodied energy of 2500GJ has a different percentage ratio compared with a conscientiously designed duplex with a life span of 150 years and the same embodied energy.

As there is an increasing interest in reducing operational energy use, the embodied energy will gain an increasing percentage. Reuse and recycling of building material is a growing area of interest and concern in many parts of the world. The importance of changing traditionally adopted attitudes (such as the discard of used materials for recycling and reuse practices) in order to create a more sustainable production model can be found widely presented in multiple studies. The adoption of these alternatives is critical for the creation of a "closed loop" production model, which is crucial for a sustainable development.

The construction demolition waste stream is one of societies' largest ecological burdens and it is still increasing. For example in the Netherlands, recycling reached 18 million tons per year in 2001 (Ministry of VROM 2001). Additionally, in countries where the building sector already has an increased level of building materials reuse, society might deal with a "next level" phenomenon, which is the increased overload of warehouses with recycled materials stock. (Perera Roderes & Brand, 2006)

The reuse of building components is an alternative for the reduction of construction and demolition waste when renovating and demolishing buildings. By performing building deconstruction, the recovery of building parts as functional components such as bricks, windows, tiles is enabled. This is different from traditional demolitions in which parts are transformed into amorphous materials. The energy used in producing building materials corresponds to a considerable amount of the total energy consumed during the building life cycle, thus reusing and recycling buildings parts result in an energy saving that cannot be ignored.

Designers should design buildings that can easily be dismantled and adapted, not only with new, but also with "second-hand" components and materials. There are four scenarios for materials reuse in the built environment: recycling, reprocessing, relocation and reuse. There are energy costs involved for each of these scenarios described in Figure 3. Energy use during building process, an adaptation of Perera Roderes' article (2006).

Recycling is a process where `waste' materials are (re)processed to fulfill a new function. Three different recycle options are available: downcycling, recycling and upcycling , depending on the end product. It is obvious the energy savings are minimal when producing new construction materials by using recycled materials, as additional energy is still invested in manufacturing the materials. That is why it is considered the lowest level of waste management.

There are still more environmentally friendly solutions. Reprocessing components can lead to even higher energy savings than by recycling building materials. The reprocessing of elements involves reconfiguration of existing elements or systems to restore its condition to "as good as new" (Perera Roderes & Brand, 2006). Similar to recycling it can also be downprocessing, reprocessing and upprocessing, depending on the quality of the remanufactured product: if it should retreat, meet, or surpass the tolerances and capabilities of a new product. Such methods also request additional energy to be spent on remanufacturing the elements into components or systems.

The relocation of components is based on prolonging the life of the building components by dismantling the component at the end of the buildings functional life cycle and relocating it to another (new or existing) building. (Perera Roderes & Brand, 2006) Relocating components can reduce energy use and is more environmentally beneficial than recycling and reprocessing, but energy is still required to disassemble the building and to transport components.

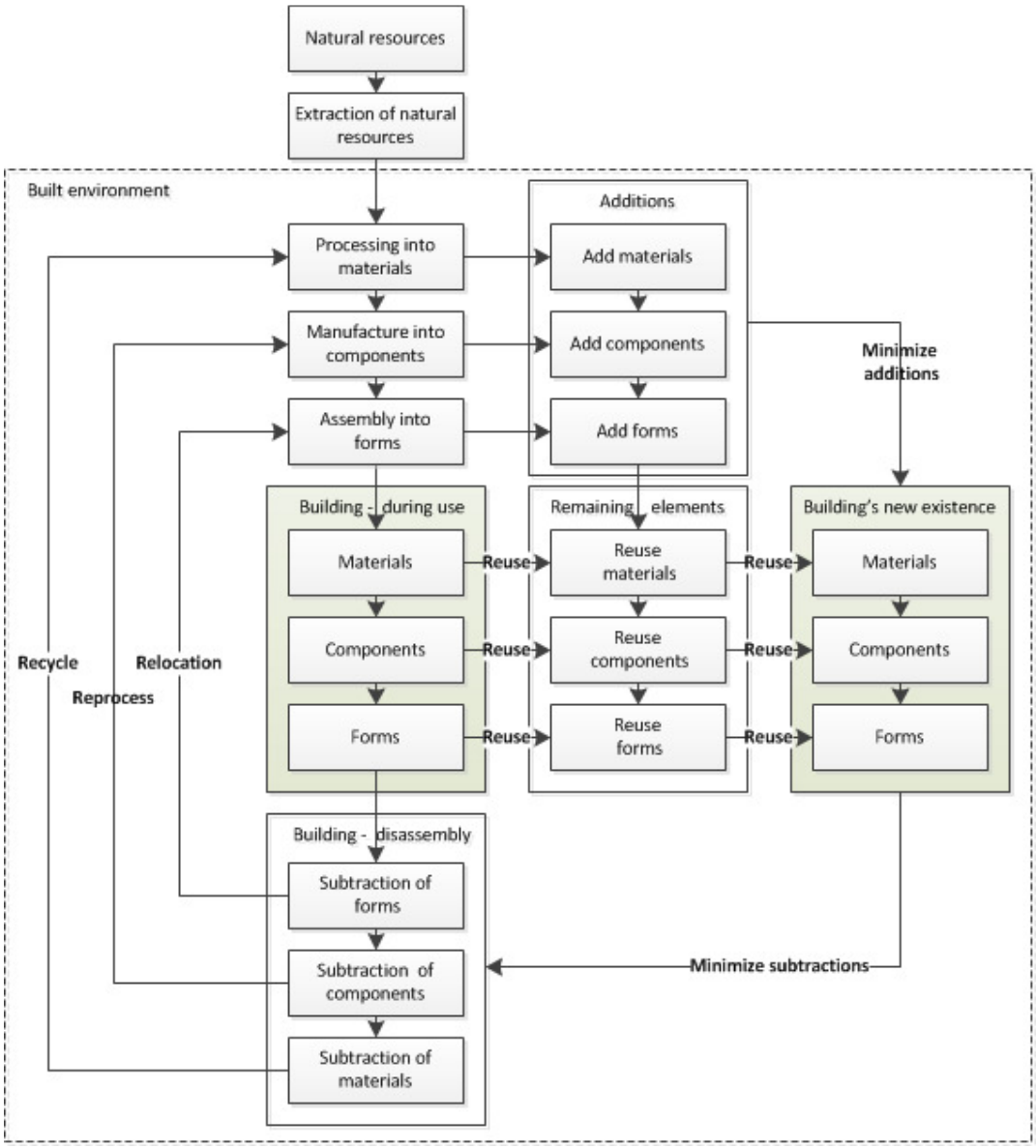


Figure 3. Energy use during building process, adaptation after Perera Roderes & Brand (2006)

There are various examples in Netherlands and all over the world where recycled materials, reprocessed or relocated components are integrated in the design of new or existing buildings. But still, the most energy efficient solution considering the lifecycle of a building, with smallest environmental impact, is the reuse of the building, incorporating reuse of materials, components and forms of the building. The remaining parts of the building can be reused and form a new existence, together with the additions. This way, hardly energy is required to keep the materials in the built environment. With a rehabilitation design, there are always subtractions and additions. This process can be even forward improved by reducing the unnecessary subtractions and by minimizing additions. Further on, by not extracting natural resources for the additions, the designer will be preventing and preserving the natural resources.

2.1.3. Social benefits of adaptive reuse

Next to the obvious environmental benefits of adaptive reuse, there are also economic, social and future oriented urban development benefits. Increasingly, communities, governments and developers are seeking ways to reduce the environmental, social and economic costs of continued urban development and expansion. The reuse of abandoned buildings in established residential areas can provide the community with new housing and commercial property opportunities and increase the value and revitalizing the neighborhood. There are several financial savings and returns to be made from adaptive reuse of buildings. With the predicted rise of energy costs in the future the energy savings, from preserving the embodied energy of the building by not demolishing it, will only increase. When done well, adaptive reuse can restore and maintain the heritage significance of a building and help to ensure its survival. The adaptation of vacant buildings presents a genuine challenge to architects and designers to find innovative solutions. As development pressures increase in urban area, more abandoned buildings are being reused, producing some excellent examples of creative designs.

For society, vacancy presents problems of insecurity and social uncertainty and may bring about criminality ranging from vandalism and graffiti to break-ins, illegal occupancy and fires. Abandoned buildings are often unattractive, and it is not just the building itself, but their surrounding grounds too, and they affect other properties within a neighborhood by lowering property values, having a negative effect on community and neighborhood aesthetics. Other negative impact of vacancy on social level may concern purely economic aspects of well being as they trigger loss in tax revenues for the community as a whole (Setterfield, 1997). By adaptive reuse of these buildings, negative impacts are removed and replaced by the benefits of new developments.

According to statistics by 2030 more than 80% of the global population will live in cities. Inevitably, this puts a substantial pressure on urban land use, especially as, over time, the built environment becomes obsolete and needs replacing. By regenerating previously developed buildings to maximize the use of existing resources, the increasing pressure on urban areas can be answered. Of course this is not sufficient to solve such a great emergent problem, as urban agglomeration, but it makes the best out of the available inner city land.

2.2. Current vacancy state

Vacancy has many possible causes and does not necessarily have to become a social problem, when appropriate measures are taken. Buildings that are vacant for more than three years are considered structurally vacancy. Vacant buildings can have several causes: loss of function by social developments, loss of function by changing policy or technical developments, restrictions by regulation, fluctuations in the economic cycle, by accessibility constraints or prolonged processes of rehabilitation, reconstruction or demolition.

Vacancy by loss of function is often associated with aging of the building; the building is no longer suitable for the original function. Technical ageing occurs when the nature of the building is no longer fitted for the type and/or the scale of the business. Examples of buildings where it plays a role are: companies, hospitals, healthcare facilities, schools, offices and stores. Churches are a special case of loss of function as it is caused by changing

views in the society. As an example of situations where buildings vacancy is due to regulations, consider old water towers due to their monumental status. Also, in many cases environmental regulations, increased safety and similar regulations may support vacancy upsurge. There is also a strong relationship between the economy and vacancy rates, particularly in regard to business and office space.

2.2.1. Vacancy in the Netherlands

Vacant buildings can be found all around the world, both in urban and rural areas. Even if in the last two decades the number of farmers in the European Union as a whole has halved, from 12.7 million to just over 6 million (Candura, Dal Sasso, & Marinell, 2008), the focus of the adaptive reuse of vacant buildings is on the ones from urban area. This is justified by the high land value and the increasing financial losses caused by their vacancy. In rural areas the problem seems to be caused by the slow but continuous flight from the countryside, leading to the abandonment and consequent deterioration of rural constructions. (Candura, Dal Sasso, & Marinell, 2008)

For a densely populated country like Netherlands, vacancy might not seem realistic, but unfortunately it is growing more vacant by the day. Millions of square meters to which little attention is played to are at stake. These are very diverse buildings: lighthouses, hospitals, water towers, factory buildings, airports, hangars, offices, forts, bunkers, schools, swimming pools and many more. (Bouman, 2010)

Thousands of vacant buildings are not privately owned but are state property. These vacant buildings are costing society a lot of money at the moment (e.g. Radio Kootwijk in Apeldoorn cost around €200,000 a year). There are thousands of vacant buildings from the 17th, 18th, 19th, 20th and 21st, large variety of empty heritage buildings with even more to come. (Bouman, 2010) Adaptive reuse of heritage buildings must consider its historic value and add a contemporary layer that provides value for the future. It can restore and maintain the heritage significance of a building and help to ensure its survival, rather than falling into disrepair through neglect or being rendered unrecognizable. Built heritage that through adaptive reuse has a new function for some socially useful purpose, appears to be the most effective approach for a self-financing and sustainable form of conservation. (Yung & Chan, 2012)

Except government owned and heritage buildings, there are also privately owned industrial, office and retail buildings that face vacancy. Each of these has its own characteristics and social, economic, environmental, urban and political context.

Vacancy of office buildings has risen worldwide since the year 2000. Driven by the growth of the new economy, high-risk investments in real estate property increased at the end of last century. As a result of the cyclic behavior of the real estate market, a huge number of buildings were at that moment being developed or built, and even now, buildings which were initiated before 2001 are being finished. Vacancy thus derives from market and economic changes, but from location and building preferences as well. (Remøy & Voordt, 2006) By the end of 2007, the Dutch office market comprised approximately 45 million square meters office space, of which 6 million square metres were vacant. As older buildings are left for preferred new buildings, the vacancy concentrates in the older stock and structural vacancy occurs. Estimates consider up to 2 million square meters structurally

vacant. Dynamis, the largest Dutch commercial real estate broker cooperation, considers 500 000 m² as prospectless, and adds 1,5 million sqm as deteriorated. (REMØY, 2010)

The vacancy rate of retail space over the past years has increased. The increase in numbers of vacant retail premises in 2009 and 2010 was by 9% and in 2011 rose even by 10%. (Zandbergen, 2012) More and more buildings face structural vacancy. In 2012, of the 220,000 retail properties in the Netherlands there are currently 13,259 empty (5.96%) thus the number of vacant properties increased by 20% in two years. There are 29.45 million square meters of retail surface out of which almost 1,750,000 sqm are empty (5.94%). Due to increasing vacancy there is a substantial withdrawal of the existing stock and more than ever shopping areas are converted into dwellings or office space. (Zandbergen, 2012)

The industrial built environment with its wide range of building qualities, ages and potentials is an important element to be considered in sustainable urban redevelopment. In Netherlands, according to DTZ Zadelhoff, at the moment there is a stock of 52,316 ha of industrial real-estate developed plots, a decrease of 1.2% from previous year. The stock of industrial buildings (in sqm) is calculated by reducing the stock of business parks by a plot ratio (permissible building area) of 50%. This leads to 261,580,000 sqm of industrial built area, out of which 9,274,000 sqm are vacant, that makes a total of 3.5%. (DTZ, 2013) Not all vacancy represents prospectless or deteriorated industrial parks or other type of industrial building stock, but there is still high percentage of suitability for adaptive reuse within these numbers. In the Netherlands, however, regeneration often takes place on industrial sites which are still in use, without its use being changed. Although still utilized by firms, these sites are characterized by obsolete and deteriorated properties, high crime rates and outdated infrastructure and they might suffer from contamination issues.

In general, and not surprisingly, persistently vacant buildings tend to be in poorer condition than both newly vacant and, most significantly, reoccupied ones. As premises are left in a state of disuse they tend to deteriorate, rendering them less likely to be taken on as a working building, although eventually they may be considered for redevelopment.

2.2.2. Vacancy in Eindhoven

Eindhoven has grown from a little village in 1232 to one of the biggest cities in the Netherlands with around 212,000 inhabitants. Much of its growth is due to Philips and DAF Trucks. Philips' presence is probably the largest contributing factor to the major growth of Eindhoven in the 20th century. It attracted and spun off many hi-tech companies, making Eindhoven a major technology and industrial hub. Generally, according to the current trend of urban development, the city is shifting from the industrial society to the information era. This phenomenon is known as “deindustrialization”, in which, post-industrial society is rapidly rising, whereas, industrial society is declining. In the course of urban development, because of the land expansion, the industrial land originally on the edge of city is gradually within the city, leading to an increasing demand for better urban function. Thus a large number of old districts have to be renovated, especially the industrial land. This does not leave the city only with a large stock of abandoned industrial buildings, but offices as well, as they are left behind for newer estates that are better fitted for the current market demands.

According to the DTZ's property market overview for 2012 (DTZ, 2013), Eindhoven is in top ten cities facing vacancy on the industrial property marked and above average on the office market.

Figure 4. Eindhoven and surroundings industrial property overview (DTZ, 2013)

Concerning industrial estate, the average vacancy percentage on national level is at 3.5%, but Eindhoven area has values above this average, being among the top 10 cities with highest vacancy. Strictly on city level, Eindhoven faces a vacancy rate of 9%, with 292.000 sqm of industrial space (including the associated office space) for sale or letting, among the highest in the region, after Veldhoven. In 2012, 196.000 sqm of industrial property were leased or sold, a significant increase compared to 2011, but still not sufficient to redeem a balance for all these underutilized resources.

Figure 5. Eindhoven and surroundings office property overview (DTZ, 2013)

On the office property market Eindhoven's level of vacancy is below the national level of 14.6%, with a vacancy rate of 13%, higher than the upper limit of 8% considered normal in a healthy market environment. (REMØY, 2010) As seen in the DTZ data, even though in the previous year the number of office jobs have increased, take-ups, as in property being rented or sold, are decreasing drastically thus leading to more imbalance and lower renting prices. Within the city, there are 185.000 sqm of unused build office space, 30% consisting of buildings with net internal floor area (NIA) between 1000-2500 sqm and 30% consisting of buildings with NIA between 2500-5000 sqm. (DTZ, 2013)

2.3. Proposed solution

"*The existence of unused buildings represents an underutilization of city resources, a missed opportunity for forms of urban development that might, with simple yet often untried technical solutions, make effective use of physical resources, and a negative feature for the idea of the sustainable community*." (Ball, 2010) Reuse of an existing structure may be a project's major sustainable feature. But finding the right structure for reuse that also meets users' preferences in terms of location and attributes is the challenge.

Considering the tight Dutch housing market and the continuous migration toward urban areas, vacant buildings are proposed for reuse to support the increasing housing demand and as an adjoining solution to urban sprawl. As shown in the previous paragraph (*2.2.1 Vacancy in the* Netherlands) most of the vacant built surface is within office or industrial

estates, therefore the focus will be on these type of structures. Governmental buildings will not be discussed as they vary widely in size and shape (from water tower to factories and military bases) and it is difficult to generate a typology and must be considered as individual case studies.

As suggested in literature (REMØY, 2010) buildings can be seen as processes and not as completed products. Though they are static, or immobile, strategies are necessary in order for them to meet a specified future match at certain points in time and this may lead to decisions of selling, demolishing, adapting or transforming a building in order to achieve a new match between demand and supply. The shortage of dwellings is approximately 2.5% of the total housing stock and with the increasing number of households (CBS, 2010) and a large part of the housing stock that needs to be replaced, will lead to an increase of demand if the production of housing is not speeded. According to CBS, Central Statistical Office , the number of persons per household is changed, from an average of 3.93 person/household in 1950 to 2.22 person/household nowadays and a predicted further decrease to 2.09 persons by the year 2040 (CBS, 2005). Following this trend, the demand for single occupancy dwellings (like e.g. apartments) will increase.

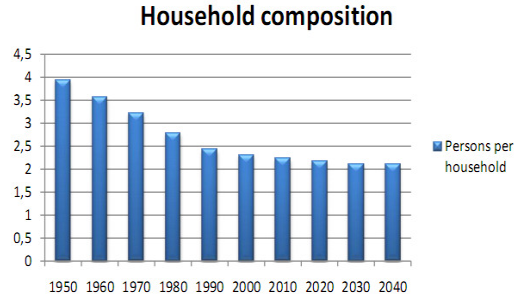


Figure 6. Variation in household composition (CBS)

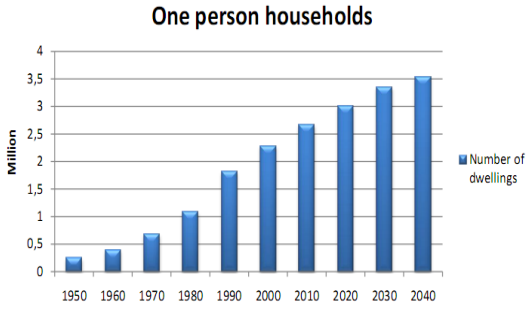


Figure 7. Variation in number of single person households (CBS)

Transformation of structurally vacant buildings into housing can help balance the housing supply and at the same time create redevelopment possibilities for these buildings of which the current function no longer satisfies market demands. The location of the buildings is an important factor to consider. If located in the city centre, in housing areas or on the edges of such areas, they have high possibility of suitability for transformation into housing, while transformation of buildings in mono-functional parks will need further consideration, as they need to be considered on a large scale urban area development.

Considering the possible functionally of the apartment types that can be adapted to the existent structure, and the location of the buildings, interesting target groups (buyers or renters) can be found. One of the most important differences between target groups is the difference in income. The price that a target group is willing to pay for an apartment decides the sum of the expenses, building costs plus the purchasing costs of the existing building, which can be made. Typically, these buildings were purchased for a lower price, are selected according to a structural plan that facilitates adaptation into apartments and subsidy from the government may be possible. In most cases, investors that take these type of solutions into account, work with long-term investment scenarios and do not require profit-maximization.

2.3.1. Stakeholders

Clearly it is in the interests of all stakeholders, investors, owners, occupiers and the wider community to ensure that the commercial building stock is well utilized, well maintained and continues to meet the ever changing needs. (Bullen, 2007)

Owners - The drive for sustainable buildings will come from the building owners instead of the more traditional area of design. (Bullen, 2007) They are mainly driven by economic viability of the investment, but as sustainability issues gain interest it is now establishing as an important element in the feasibility study. Important elements like environmental sustainability, cultural or heritage significance of the building are considered next to the obvious practical aspects of various use options. It was generally considered more difficult to estimate the costs of adapting a building than constructing a new one. But it was even more difficult to provide a value of the social and environmental factors of sustainability. (Bullen, 2007). User demand is also vital.

Future users – As any other development project, the investment is driven my market demand, which is why future users represent a major stakeholder. The new building use must fulfill future users' requirements in order to be estimated as a feasible investment. Emotional or cultural bond of the neighboring inhabitants to the existing building, may attract future residents easier than a new structure.

Building industry - Obviously, the role of the building industry -developers, construction firms and so on- in the reuse process is vital. They have great power of influence over local economies. Decisions made by development companies to build, adapt and develop vacant areas will have a huge influence on the capacity of the local economy to attract investment and, given research findings from around the world, to supply new or existing businesses. The willingness of key players, like developers and related firms, to initiate active change has proved vital in the re-use process. (Ball, 2002) More significant, without the influence and involvement of the private development sector, there will be only limited movement. (Ball, 2010)

The property market and its actors - The activities of local property market, estate agents and actors, play an important role in the immediate potential reuse of abandoned structures. In a specific area, 75% of reoccupations occurred where premises were being actively marketed. (Ball, 2002) These decisions to actively promote a building or complex often generate successful re-use. Whether reoccupation is a success of marketing or a result of preselection, clearly follows from the attitude and involvement of those with the power to initiate.

Government, regional or urban policy machine - The political-institution sphere may influence the decision of developers where to reuse or new build. The political sphere acts as the regulating agent who balances the tradeoffs and resolves the conflicts between the other spheres of sustainability - environmental, economical and socio-cultural. The importance of local political governance in constructing strategies of sustainable urban development is high. (Yung & Chan, 2012) Local policy is highly important, with obvious influence on reuse. There is an undoubted effect of local policy that has targeted specific parts of the city and which has, in effect, created 'quiet' and 'busy' zones in terms of vacancy area changes. (Ball, 2002)

It is argued that the interferences of all the four spheres- environmental, economical, social and political- become the fundamentals to achieve the goal of sustainable cities. (Yung & Chan, 2012) Other stakeholders like academic investigators, housing association representatives, architects, surveyors, heritage consultants and nongovernmental organization can facilitate the connection and strong collaboration within these spheres. Companies or individuals who instigate reuse processes and whose decisions lead to reuse are probably some of the most significant stakeholders as they decide the fate of a building.

2.3.2. Owners' perspective on adaptive reuse

When faced with vacancy, property owners have different options of coping with this problem: preservation, renovation or upgrading, demolishment and new build, and transformation or adaptation.

Most owners of vacant buildings choose a form of preservation, to do nothing and wait for better times, or searching for new tenants. Disposal (or selling) of the property is also an option, but it faces great challenges as property value perspective varies greatly between seller and buyer. The market value of a building is based on rent value; hence the sale of a vacant building yields less than the sale of an occupied building. The building will not be sold in accordance with its book value, which is often based on a presumed 100% rent for the entire investment period and thus owners regard selling a vacant building as facial loss. Yet leaving the building vacant for a longer period of time will only contribute to the degradation and financial depreciation of the building.

Another alternative for coping with structural vacancy is upgrading and renovation of the property in order to fit the current market demand. However, in situations with high levels of vacancy or with vacancy caused by location characteristics, there is a risk that the positive effect of this solution will be less than the costs of intervention.

Demolishment and new built is an intervention that creates possibilities for developing a new building fit to future market demand. However, redevelopment takes time and leads to a delay of income and if the building is technically in a good state, redevelopment is a waste of resources.

Finally, structural vacancy can be coped with by adaptive reuse. This process may be expensive and disrupt incomes flows and use of the building. If it works out successfully, the building's future market value accommodating the new function must be higher than its initial use and leads to beneficial and durable use of the location and building. This solution also implies less income disruption than redevelopment and has higher social and financial benefits.

In Table 1., options that property owners have in order to cope with vacancy are presented schematically, outlining the advantages and disadvantages of each option: preservation, renovation and upgrading, selling, demolishment and new built or adaptive reuse.

Option	Advantages	Disadvantages
Preservation	Preserves the property, sustains existing use, ensures ongoing service and lifespan.	Requires maintenance costs, finding new users might be time consuming, little or no incomes are generated. If left vacant it is vulnerable to vandalism, squatting and degradation
Renovation & upgrading	Enhances the physical and economic characteristics of the building, delays deterioration and obsolescence, reduces the likelihood of redundancy and increases building's lifespan. Short-term disuse of building.	Disruptive and expensive, extended lifespan, performance and match with market demand is not as adequate as a new building, problems caused by location characteristics cannot be influenced.
Selling	Realizes asset/site value, clears management and operating costs.	Loss of potential and price may not correspond to expected value.
Demolish & new built	New building tailored to meet users' preferences, make use of current building location.	Disruptive and expensive, long term delay of income, location characteristics cannot be influenced.
Adaptive reuse	Alters and improves physical and economic characteristics of the building, prevents deterioration and obsolescence, prolongs building's lifespan, added social and environmental benefits. Short-term disuse of building.	Disruptive and expensive, location characteristics may not suit new function, high risks related to building costs, regulations and market uncertainty.

Table 1 Coping with vacancy-advantages and disadvantages of options, adaptation after RemØy (2010)

As in any building project, risks have to be identified as they are substantial in assessing the feasibility of the project. When risks are analyzed, ways of avoiding them and diminishing their impact can be revealed. In adaptive reuse building projects the main risks and unforeseen problems that might surface during the building phase of the project are grouped in four categories: legal, financial, technical, and architectural. These risks are either related to the building itself or to the location and market aspect. (Douglas, 2006) (REMØY, 2010)

As the requirements for residential buildings are stricter than for other functions, such as offices or industrial buildings, in some cases adaptation of the buildings structure, stairways and facade is needed. Most of the above mention risks, technical, architectural and the ones related to compliance with fire regulations, thermal and acoustic insulation requirements can be solved, but they can seriously increase the financial burden of the project. So it can be concluded that all risks are actually financial. One of the risks that can not be easily solved by increasing the investment costs, is the legal risk related to the municipalities' flexibility on the zoning plan changes. In RemØy study 'Out of office' (2010) 14 building reuse projects across Netherlands were analyzed and it was concluded that in all cases municipalities were found cooperative with both zoning plan changes and building code exemptions.

Risk category	Details
Legal	Zoning law Soil pollution or presence of asbestos Monumental status Dutch building decree (noise and fire regulations)
Financial	Purchasing costs of vacant building Investment, financial feasibility and revenues of the new function
Technical	Incorrect technical assessment of building Inadequate / poor state of main structure or foundation Inadequate pipes, ducts, electricity system and water supply for new function Inadequate acoustic and thermal insulation (floors, facade, openings and roof) Insufficient daylight for housing
Architectural	Amount of parking places and facilities in the area Accessibility by car and public transport Building too slender or too deep, with no basement, floors too high Poor quality of interior walls, few points for attaching interior walls to the facade No balconies or roof terraces Not enough elevators and staircases

Table 2 Risks in building reuse projects, adaptation after RemØy (2010)

In assessing the feasibility of transformation projects four key decision criteria were found: the relative costs of options (comparing the adaptation to new build costs), the relative value of options (cash-flow analysis), the probable risk of options (business and technical risks) and the relative robustness of options (changes in market conditions, like demand or rental levels). (Douglas, 2006)

2.3.3. Market trends

With over 217,000 inhabitants, Eindhoven is the fifth city in the country, in terms of population, with numbers that are continuously increasing. This increase is mostly due to positive net migration of population. As 40% of all R&D activities in the Netherlands take place in the Eindhoven region (Gemeente Eindhoven, 2011), this is attracting more and more young professionals to the area.

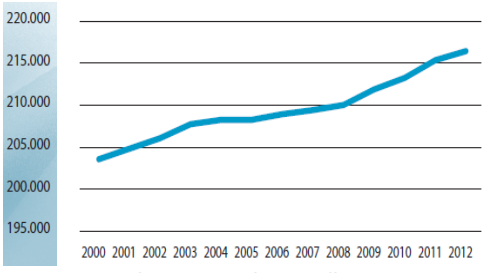


Figure 8. Population growth in Eindhoven

The so-called 'productive age' of 20-65 years in Eindhoven is relatively higher (64%) than the average Netherlands (61%). Especially the age group between 20 and 40 years is significantly greater in Eindhoven, in particular due to the teaching function that the city holds. (Gemeente Eindhoven, 2011)

Considering the functionally realizable apartment types as well as the location of the buildings, interesting target groups (buyers or renters) may be found. One of the most important differences between target groups is the difference in income. The price that a target group is willing to pay for an apartment residually decides the sum of the building costs plus the purchasing costs of the existing building.

As mentioned earlier (2.3. Proposed solution), the Dutch housing market is really tight, so poorer groups of the population face the biggest challenges when faced with finding a dwelling that fulfils their needs. Especially students and other newcomers on the housing

market experience problems finding a suitable dwelling. Senior citizens with a low income also belong to the group that needs special consideration, although this group is often prioritized to other groups by housing associations.

Considering the above mentioned market situation and population distribution in Eindhoven, a suitable target market for the adaptive reuse of buildings into housing could be students and starters. Investors also see potential growth in housing for senior citizens, for whom quality and comfort is important, thus demanding more budget for the investment. As the financial feasibility of the transformation projects varies greatly depending on the targeted market segment and the quality of the amenities that future users look for, the type of housing facilities should be selected with great caution. For example there are many cases of transformation of office buildings into student housing where the financial targets were met because the facade could be retained. (REMØY, 2010) When office buildings are transformed into more expensive housing, more expensive interventions to the building might be needed.

Developing small housing units, typically for students or starters, the new layout of the existing building is changeable. Also, a lower status appearance of interior and exterior is less important for this target group and less money is therefore invested in upgrading the appearance of the building and in finishes. In some of the existing cases, municipalities made exception from the building code, like sound proofing, since students (the expected occupants of the transformed building) are considered to have higher tolerance to noise. If the relevant user groups had been seniors, the acoustic insulation would probably have had to be improved.

Due to the location of many vacant buildings, vicinity to the city centre and universities and the time saved due to the fact that these buildings are already developed, transformation is in many cases found to be financially feasible.

Young couples could also represent a good market niche. In Eindhoven, the average age when inhabitants make their first child is above 30 (33 for men, 30 for women) (Gemeente Eindhoven, 2011), but more and more people have children at older ages, reaching 40. Thus by addressing young starter couples, the market segment could be greatly extended.

Inspired also by the study ‘New transformation meter’ by Rob Geraedts and Theo van der Voordt (2007), which describes five target-group profiles with dwelling preferences for inner-city transformations, the following target groups are selected:

- Students: low-income singles
- Starters: young, medium and low-income singles
- Young two income: young couples with two incomes
- Senior citizens 65+: low to modal income

Each of these target groups has different preferences in terms of location and size of the facilities. In order to meet the housing demand for these target groups, one room apartments and loft type studios will be considered. The type of tenure for the proposed housing units is renting.

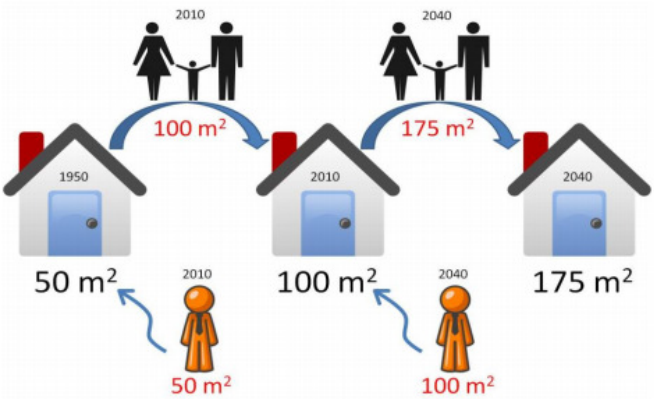


Figure 9. Change in dwelling floor space according to household size (der Weerdt, 2011)

In line with changes in household composition, increase in demand for dwellings for single households (2.3. Proposed solution), also the demand for average dwelling floor space has changed. As an example, post-war dwellings that used to have a floor space between 50 (for multifamily dwellings) and 70 sqm (single-family dwellings), nowadays have a minimum floor space of 90 to 100 sqm in new estates. While in contrast to the average household composition, that is decreasing, the average floor space is rising. This trend is only predicted to continue, reaching in 2050 an average of 108 sqm per person, respectively 195 sqm per household. This means that by 2040, the floor space demand per person will be equal to the average dwelling floor space of today, the same as the average floor space demand per person today equals the floor space per dwelling in 1950. (der Weerdt, 2011). As the current floor space no longer satisfies users' necessities, these move to newer, larger dwellings that satisfy the current demand, thus allowing single persons to move to the recently smaller, vacant residencies. This process is depicted in the above picture (Fig.4), change in supply and demand with regard to the floor space. In order to offer viable solutions to the redevelopments related to the housing market, these aspects concerning changes in users demand over time need to be taken into account.

3. BULDING REUSE POTENTIAL IN EINDHOVEN

As shown in the previous paragraphs (2.2.2 Vacancy in Eindhoven), there is a wide variety of vacant properties in Eindhoven. From the database of RealNext (2013) and Funda-in-Business (2013) a list of vacant buildings was created. Unfortunately, a great number of exclusion of buildings had to be made, as most of the vacant office and industrial buildings are located in mono-functional areas. These locations are not found suitable for housing because of their intrinsic mono-functionality, (often) isolated location and low quality of the public space. In these areas a functional transformation of one building will not be successful, as it will not generate enough demand for facilities and services that are needed in or near a housing location. The effect of one transformation is not significant and a large scale intervention is needed to redevelop the entire area. Geraedts and Van Der Voordt brought up the idea of starting a transformation of the location from its edges; if the mono-functional location is located near a mix-use or housing location with the facilities and services needed for housing, transformation may take place next to these locations. (REMØY, 2010)

A draft list was created with buildings that have a high level of vacancy, mostly 100%, and are located within a 5 to 7 km radius to city center (Appendix B.1. Draft list). Properties that do not have any residential buildings in their surroundings are excluded from the list as they do not match the demands required for housing transformation. Still, this leaves 22 office buildings and 9 industrial ones. Some of these office buildings coincide with the ones found in the study of Martin Kraaij – Greening of gray buildings (2010) showing that they are vacant for at least three years. Two of the buildings found in the above mentioned study were no longer available on the office property market as they were already transformed into housing for students. This comes only to support the suitability of this type of structures for transformation into housing.

3.1. Transformation potential of buildings

In order to select the case studies, the buildings' transformation potential must be analyzed. A wide variety of tools and instruments have been developed in order to analyze buildings' transformation potential and feasibility using a range of criteria. Wilkinson, James and Reed (2009) made an extensive literature study about the attributes identified in previous researches considering risks which need to be acknowledged and managed in reuse projects. These building adaptation criteria are summarized as age, condition, depth of the building, envelope and cladding, structure, building services, internal layout, flexibility for a range of differing uses and functional equipment, purpose of the built buildings, location, perceived heritage value, size, accessibility, proactive policy making/legislation (planning and building codes including fire), acoustic separation, user demand and site conditions. (Wilkinson, James, & Reed, 2009)

The adaptive reuse potential (ARP) is a conceptual framework described in Langston et al. (2007). The model requires an estimate of the expected physical life of the building and the current age of the building, both reported in years. It also requires an assessment of physical, economic, functional, technological, social and legal obsolescence. Here the economic variable is tightly related to the geographic location of the building relative to a major city, central business district or other primary market or business hub. (Langston, 2012) (Conejos, Langston, & Smith, 2013)

There is also a 10 performance criteria tool developed and used to assess the level of satisfaction that a residential building can offer to its users, developed by Ilesanmi (2010). These criteria concern: external visual quality of buildings, maintenance quality of buildings, structural quality of buildings, detailing quality of buildings (doors, windows, ceilings, roofing members), quality of building services and, quality of estate roads, quality of landscaping, quality of semi-public open spaces, quality of environmental layout, quality of the location. The first five criteria relate to the buildings, while the next five deal with their location. They cover aesthetic, functional and technical quality. (Ilesanmi, 2010)

In its book on building adaptation, James Douglas (2006) published a series of checklists developed by Building Research Establishment (BRE), BRE Good Building Guides. These checklists focus mainly on the buildings characteristics and their potential of transformation, and do not approach the location or neighborhood characteristics. Still, building conversion as any other property development, has a number of risks depending on variables such as: location, condition of the building and the extent of works required to repair any defects, length of time the conversion work will take, the general state of the economy, demand for the use proposed at the time the property is marketed, degree of legal and planning restraints operating over the property, cost of the change of use and the projected value of the converted building. (Douglas, 2006)

For this study only a quick-scan is used to select the case studies, using an adaptation of the "transformation meter" developed by Geraedts and Van der Voordt (2003) (2007) (Remøy & Voordt, 2007). This tool, initially developed for office buildings, uses physical aspects of buildings and their location in order to estimate their value and suitability for housing, also considering organizational and market aspects. While most of the aspects related to the internal building characteristics can be modified, the location criteria can be the source to a negative transformation advice. For transformation to be a feasible way of coping with structural vacancy, location criteria should be met. It must also be taken into consideration that the financial feasibility of the transformation projects varies greatly depending on the targeted market segment.

The transformation meter is a five steps process that follows a five step scheme (Table. 3).

Step	Action	Level	Result
Step 0	Inventory vacant buildings on market availability	Market	Gain insights on location and characteristics of vacant buildings stock
Step 1	Asses vacant buildings using veto criteria	Location Building	Fast selection of building; determine suitability for further research
Step 2	Asses vacant buildings using gradual criteria	Location Building	Gradual assessment of building's transformation potential
Step 3	Determine transformation class	Location Building	Transformation class of the building
Step 4	Detailed assessment of building	Building	Indicates financial/economic feasibility Sketch and cost-benefit analysis
Step 5	Investment risk assessment	Location Building	Highlights areas of concern in the development and construction phase

Table 3. Steps in the transformation meter (Geraedts & der Voordt, 2007)

There are many aspects related to location that must be considered, these include noise (from airplanes, railroads and highways), air-quality, travel time to the highway and parking possibilities, distance to the railway station or nearest public transportation stop, the accessibility to the city center, level of facilities and services in or near the location, accessibility to water (the river, ponds) and green area and the mix of functions are the most important characteristics. (Bryson, 1997) (Kryvobokov & Wilhelmsson, 2007) (REMØY, 2010) That is why, the preliminary building selection will be on location criteria. Also buildings without 100% vacancy rate will be excluded, as handling current residents may prove to be a long and difficult process. (Appendix B.2 Preliminary case study selection)

3.2. Case study selection

In order to assess the transformation potential of a building for housing purposes, some of the important criteria to be considered include: demand for housing, urban location (zoning plan, pollution, noise, odors), dimension of the building structure (2.60 m free height of the floors-minimum requirement for dwellings) and organizational aspects considering the developer. The financial feasibility depends on the necessary level of intervention on the building. Interior walls, ceilings and electrical installations are considered costs that are always made, whereas changes in the structure, facade and mechanical installations depend on the state of the original building.

The table found in Appendix C. Gradual criteria for building transformation potential reveals all the criteria considered in the transformation meter. This is a quite comprehensive tool, offering a well rounded approach of the criteria discussed in the related literature (Douglas, 2006; Ilesanmi, 2010; ARP -Langston et al., 2007; Wilkinson, James & Reed, 2009; Conejos, Langston & Smith, 2013). Though some of these studies focus strictly on the buildings characteristics, there are many reasons to why location characteristics should not be neglected and actually considered as decisive. Firstly, this is the only aspect that can not be changed, while building characteristics can be changed with a certain level of costs incurred. (REMØY, 2010) Secondly, importance of location characteristics have great impact on housing prices, as marginal prices of key housing attributes are not constant throughout the

market, but vary with location context. (Bitter, Mulligan, & Dall'erba, 2007) (Fik, Ling, & Mulligan, 2003) (Kauko, 2007) (Bryson, 1997)

As this study does not focus on assessing buildings transformation potential, a simplified tool will be developed to select de case studies, which will later on be used to reveal the attributes necessary for the discrete choice experiment. The buildings are assessed focusing on location characteristics, as they were found to be essential and some of the structural criteria discussed earlier (3.1. Transformation potential of buildings & Appendix C.). The location must be easily accessible both by car and public transport and parking places must be available at least one per 50sqm of rentable floor area. When assessing accessibility by public transport frequency and distance to the closest bus stop are considered. Also the fitness of the surroundings for housing purposes are assessed. All buildings that can be selected must at least neighbor housing facilities. If the building is located in a mono-functional industrial or office area it must not be deep within the premises, it must be located on the edge so it can neighbor houses and provide easy access to the necessary facilities.

When assessing transformation potential, one must also consider structural characteristics like floor height, building's depth and facade. These characteristics are also considered when assessing the buildings in the 'Adaptability for housing' column. Table. 4 presents the scoring of the buildings that are selected to be further used in the analysis of the building's characteristics. Each criteria/column has scoring from ++ being the best, to -- being the worst. Buildings that had unsatisfactory scoring or more – in their final score, were removed from the table. All tables used to filter information in order to reach the current table, can be found in the Appendices B.1 to B.3.

The location of the buildings that are thus selected are presented on the map below (fig. 10).

Figure 10. Eindhoven map-case studies location

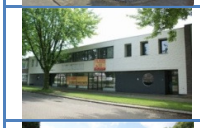
Building			Location					Structure	Final score		
Picture	Address										
	Street	no	Accessibility: car	Accessibility: OV	Parking	Visual image	Services in the surroundings	Adaptability for housing	Total +	Total 0	Total -
	Vonderweg	11	++	0	+	+	++	++	8	1	0
	Begijnenhof	35	+	++	++	0	+	++	8	1	0
	Frederik van Eedenplein	1	0	0-	+	+	+	++	5	2	1
	Beukenlaan	77	++	++	++	0	+	++	9	1	0
	Byrdstraat	21	++	+	++	+	++	++	10	0	0
	Zwaanstraat Gebouw	1	++	0	0+	0	+	++	6	3	0
	Limburglaan	36	++	0	++	0	0	+	5	3	0
	Fuutlaan	21	++	++	+	-	+	0-	6	1	2
	Thorvaldsenlaan	2c	++	++	++	0	+ 0	0	7	3	0
	Hondsruglaan	87	+	+	++	+	+	0	6	1	0
	Zwaanstraat Pomphuis	1	++	0	0+	0	+	0	4	4	0

Table 4. Selected case studies in Eindhoven

3.3. Conclusion

Transformation potential of buildings is mainly a matter of the financial investment necessary in the conversion of the structure itself. The only limitations are concerning the floor height and width of the building. Structures that respects these minimum criteria and are located in suitable area for housing, can be transformed with various levels of investments.

Eindhoven offers a high availability of vacant buildings that can be transformed. This, along with the increasing demand for housing for students and starters, generates suitable market situations for adaptive reuse of these buildings.

The selected buildings vary in height, possibility of offering private outdoors and building types, office and industrial. As seen, most of the office buildings are located within the Eindhoven ring and 3 of them right in the heart of the city center. The industrial buildings are located right outside the ring and one of them even farther by almost 4 km. These location aspects will be highly influential in the selection of renting prices per sqm. These characteristics will be incorporated in defining the attributes for the discrete choice experiment.

By studying users preferences it will become clear which of these buildings' characteristics offer more utility to future users, if people reject or accept the idea of living in reused buildings or in former offices or industrial structures.

By understanding what is actively sought by future residents, developers and investors will have a better understanding on what to look for in the selection process of the buildings, other than the ease of transformation. If the idea of living in a former industrial or office building is generally rejected by future users, it means that a different use needs to be found for these buildings.

4. DISCRETE CHOICE EXPERIMENT

''*What business thinks it produces is not of first importance. What the customer thinks he is buying, what he considers value, is decisive. And what the customer buys and considers value is never a product. It is always utility, that is, what a product does for him.*'' - P. Drucker (1974)

In order to derive the utility perceived by consumers, a multinomial logit model (MNL) will be used to predict the probabilities that an alternative, i, is chosen from set of choices.

$$Prob(choice\ i) = Prob(Ui > Uq),\ \forall q \neq i \quad (4.1)$$

$$Prob(choice\ i) = \frac{exp\ (\beta_j * x_{ji})}{\sum_{k=0}^{j} exp\ (\beta_k * x_{ki})} \quad (4.2)$$

where i indexes the observation, or individual, k and j index the choices.

An individual is assumed to have preferences defined over a set of alternatives based on utility maximization. The MNL model, which falls within the standard random utility approaches, treats observations coming from the same respondent as independent observations and derives utility based on the chosen alternatives, as follows:

$$U_i = V_i + \varepsilon_i \quad (4.3)$$

Where: U_i is the utility provided by product/alternative i
V_i is the representative component of utility
ε_i is the error component due to unobserved influences.

The representative component of utility for k attributes can be defined as:

$$V_i = \beta_{0i} + \beta_{1i} f(x_{1i}) + \beta_{2i} f(x_{2i}) + \cdots + \beta_{ki} f(x_{ki}) \quad (4.4)$$

Where: $\beta_{1i}$is the weight associated with attribute x_1 and alternative i, which establishes the relative contribution of the attribute to the observed sources of relative utility.
β_{oi} is called the alternative-specific constant, which represents on average the role of all the unobserved sources of utility.

The model's performance can be assessed by employing the goodness of fit. Because each model performs differently, their goodness of fit can be tested using the McFadden's *pseudo-R^2*:

$$Pseudo\text{-}R^2 = \frac{LL_M}{LL_0} \quad (4.5)$$

Where: LL_M is the likelihood function for the estimated model
LL_0 is the likelihood function for the model estimated with no coefficients, also known as the base model.

The value of *pseudo* R^2 from a model can't be evaluated as good or bad in singularity, but it can be judged relative to other models that have been estimated similarly. The values of McFadden's *pseudo*-R^2 tends to be smaller than R^2 (the coefficient of determination), but values of 0.2 to 0.4 are considered highly satisfactory and that the model has an excellent fit. However models with values of *pseudo*-R^2 below 0.1 are considered weak.

When conducting a discrete choice experiment, in order to evaluate the utility of several attributes, the following steps are performed (fig. 11):

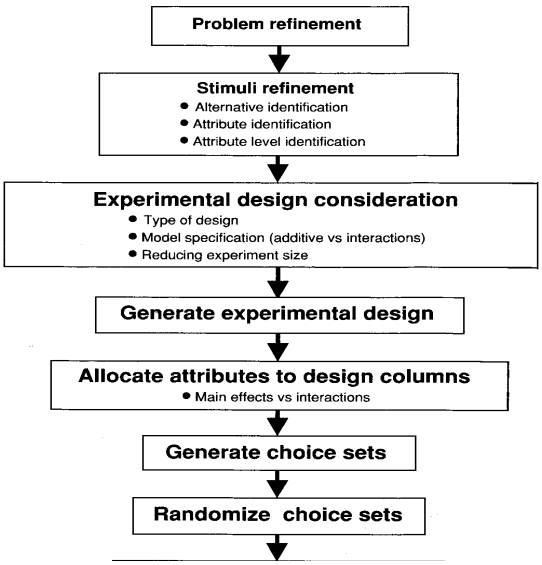


Figure 11. Design process for a discrete choice experiment. (Hensher, Rose, & Greene, 2005)

The research problem has to be defined and refined. In our case, this resumes to defining the building type(s) that are approached and the market segment suitable for the research. This part was widely discussed in the 2nd chapter of this study: 2.3. Proposed solution

Once the problem is well understood, the next step is determining through literature and case studies the alternatives and the attributes that will be later on used. Buildings facing vacancy in the area of Eindhoven that were selected, are used to determine the alternatives and the attributes that will be later on tested in the discrete choice experiment.

In order for the questionnaire to be short enough for respondents not to lose interest, not all attributes will be considered. Only the most relevant attributes will be selected and thoroughly defined. Having identified the attributes to be used in the experiment, attribute levels and attribute level labels must be established.

In conducting a discrete choice experiment, several design characteristics must be considered as: class of design – combination of attribute levels (full factorial or fractional factorial design), coding format (orthogonal dummy or effects coding), labeled or unlabeled experiments, main effects with or without interactions between attributes and so on. These aspects will be discussed in design considerations subchapter.

Once all data has been established, generating the experimental design (attribute levels combinations), allocate attributes to design columns and generating choice sets will be performed in order to have an experimental design that delivers reliable data.

Elaborating a questionnaire for the collection of choice data is a complex in-depth process and the researcher has to empathize with the respondents, in order to make the requirements and alternatives as understandable as possible. Also the data collected through the survey has to deliver the necessary information, with the appropriate format, to answer the research question.

Once data has been collected, introduced in the statistical program (NLOGIT) and cleaned, the final step is to use statistical techniques in order to analyze and quantify user

preferences, by providing a relative weighting for each attribute. When market preferences are revealed, willingness to pay can be quantified. The price that a target group is willing to pay for the new redevelopment, decides the sum that will be invested in the project. These expenses comprise of purchasing costs of the existing building plus the construction costs to be made in order to adapt the building to its new use. The results of this study can be used by developers to test reuse project feasibility and select the optimal combination of attributes to generate a profitable and sustainable value proposition that, under normal competitive constraints, will maximally leverage their available resources.

4.1. Goal of the discrete choice experiment

In order to maximize the use of inner-city resources, the reuse of existing vacant buildings has to be approached. In the previously presented chapters of this research, it was concluded that a suitable reuse of these buildings should be for housing functions. But finding the right structure for reuse that also meets users' preferences in terms of location and attributes is a challenge.

The aim of the discrete choice experiment is understanding future users preferences for dwellings. Knowing the desired mix of attributes that an individual or a targeted group is looking for, might guarantee the success of the reuse project.

After establishing the targeted market segment, their preferences must be analyzed. It is interesting to know what type of housing unit they prefer, how important is the relative distance to the city center and if the initial use of the building has any influence on their choice behavior.

When performing discrete choice experiments, both revealed preference and stated preference data collections can be used. While revealed preference (RP) data is better suited when data is collected on choices that are made in an actual market situation, choices that have actually occurred; stated preference (SP) data represents choices stated in given hypothetical situations. As this study aims at revealing possible future use of vacant buildings, the best approach would be the use of SP.

4.2. Stimuli refinement

4.2.1. Alternative identification and refinement

The first stage involves defining all possible alternatives available to decision makers within the context being studied. In defining such a list, every possible alternative (even if a number of alternatives are available to only a small sub-set of the total number of decision makers) must be identified in order to meet the global utility maximizing rule. It is considered that failure to identify all alternatives results in a constraint, a threshold on the utility maximizing outcome.

The type of housing units that can be adapted into the studied reused buildings, that might also be found suitable for the targeted market segment are either studios, apartments, row-houses (for some of the industrial buildings) or condominium. Studios are large, usually

unpartitioned floor over an industrial space, with high ceilings and few finishes, converted into an apartment. Apartments are individual units in a multi-unit building, often in multi-story apartment buildings. Row-houses (terraced houses or townhouses) are single or multi-unit buildings in a continuous row, with shared walls and no intervening space. Condominium is a building or complex, similar to apartments, with common grounds and common areas within the complex. There can be row-house style condominiums as well or garden apartments, with their own building entrance and direct access to a garden from the apartment.

The second stage involves the refining of alternatives from the list. While this breaks with the global utility maximizing rule, in order to reach a manageable number, reducing the alternatives by excluding "insignificant" alternatives is performed. By doing so more weight is placed on practical, as opposed to theoretical, considerations. Another approach is to use experiments that do not name the alternatives by defining generic or unlabeled alternatives.

Considering the targeted groups, the market will be tested only for apartments and studios. As the decision to use generic alternatives (discussed later in 4.3 Experimental design considerations) is taken, these variables will be introduced as attributes.

4.2.2. Attribute identification and attribute levels

Even if the study focuses on a selected market segment, in the end, the individual's preferences for specific alternatives (goods or services) best determine what product is chosen. Preferences are the desires of each individual for the consumption of goods and services that translate into choices. Choices are based on income combined with the degree of satisfaction, utility, that the product offers. Each alternative/product that a decision maker is presented with incorporates a mix of different attributes.

Many of the criteria revealed in the 3.1.Transformation potential of buildings and Appendix C. Gradual criteria, coincide with requirements that the selected market segment is looking for. Of course, the attributes that are of interest for the developer differ from the ones regarded through the eyes of the consumer. Criteria regarding subjects like land ownership or compliance with Dutch building decree and other necessary permits are only concerns of the developer. The attributes checked in the Appendix C. Gradual criteria are relevant as they check the building's potential to be transformed into products that offer sufficient utility to be considered by the targeted group.

When tenants, future users, are searching for a new residence, there are certain features that they are looking for. A property that contains these desirable features will be distinguished from the competition. Obviously these characteristics depend on the targeted group, but they always concern location, building characteristics and price.

Housing attributes range from intrinsic housing attributes such as cost and size to extrinsic attributes such as exterior design and other location factors. (Opoku & Abdul-Muhmin, 2010) (Ilesanmi, 2010) The relative importance of different housing attributes is a function of national and/or social context. For example, for consumers from highly developed countries, features of the house, economic and location factors are the most important factors. (Opoku & Abdul-Muhmin, 2010)

Location is the most important feature of a property, while other characteristics can be changed through renovations, the location aspects cannot be influenced. A highly desirable location can command higher prices and renovations and square footage become secondary concerns. People are much more willing to compromise on other amenities if they are in a location that is desirable to them. Similar, in areas close to a large city center, users are willing to pay much higher prices in order to be closer to transportation, shopping, food and entertainment, even if that means having less square meters. (Bryson, 1997) Characteristics concerning location are either functional or cultural and are influenced by accessibility, services and greenery in the area, neighborhood reputation and so on (Appendix C.).

Unlike developers, tenants are not interested in technical characteristics from the Gradual criteria, concerning matters like year of construction, vacancy, expendability, dimensions and type of the structural support. They might however be concerned about how recent the building has been renovated, the quality and functionality of the installations and presence of thermal and acoustic insulation.

In what concerns the building itself, the type of building and number of floor, the visual aspect of the façade, safe entrance and ease of access to the housing unit are also considered by future tenants. Type of heating or air conditioning, whether they are individual units or collective are factors that might be considered. Natural daylight that the housing unit gets an important feature, as it makes the dwelling more welcoming and it also lowers the electricity bill.

Housing unit's visual aspect, surface, private outdoor space (balconies, individual or shared gardens), level and quality of provided appliances (washing machine, stove, dishwasher and so on) and storage space (basement, garage or storage shed) are aspects that are considered by future tenants.

Not all the above mentioned characteristics will be taken into account as the questionnaire would be too long, only the ones considered highly relevant will be selected. Also attributes that remain constant for all alternatives will be mentioned in the scenario description and will not be introduced in the questionnaire.

4.2.2.a) Scenario

Some of the attributes will be constant throughout the entire survey. These will be presented as a scenario under which the rest of the attributes will vary.

The reasoning for choosing these attributes as constant is that they either represent minimum requirements or are derived by the needs of the targeted market segment. The lower income targeted segment will influence the level of quality delivered. As previously mentioned, the amount of money that future tenants are able to spend on housing influences greatly the level of the investment. In order to keep costs under reasonable levels and to reach financial feasibility, the building's transformations will target a B energy label. The energy label shows the energetic quality of a dwelling. Introduced in 2008 (renewed by 2010), it shows the presence of insulation, e.g. wall insulation or double glazing, building type and a prediction of the annual energy consumption, divided in gas, electricity and (district) heat, depending on the installations types, needed for heating and ventilation (VROM, 2009). In order to comply with current regulation on energy efficiency and WWS (WoningWaarderingsStelsel), the buildings will be transformed to a B energy label. Also the

level of wall finishing will be kept to a minimum, in order to lower the costs and to allow easier future redevelopments. All these will lead to a second quality level.

The tenure possibilities are rent or buy, given that the targeted market segment is characterized by starters on the housing market and lower incomes, the dwellings will be made available for rent.

The wide variety of vacant buildings available, allows a scrutinous selection in order to only consider buildings within good accessibility, not only by car, but by public transport as well. When considering easily accessible buildings' location, frequency of public transport and distance to the nearest bus stop are considered. Also, all buildings have parking facilities, at least an average of one parking place per 50 sqm.

Scenario				Explanation
Tenure	Rent	Buy		Dwellings for rent
Quality	I	II	III	B energy label
Parking	Yes	No		All have at least 1 parking space per 50 sqm of rentable area
Accessibility	Easy	Difficult		Easy access by car or public transport

Table 5. Research scenario

4.2.2.b Discrete choice attributes

Price-location

While location and price are strictly correlated (also due to land prices) they cannot be both introduced into the questionnaire as the attributes must not be correlated. By introducing correlated attributes, will result in confusion and it will be impossible to establish the role of each term. In such cases, in order to respect the IID condition of (independently and identically distributed) only one attribute will be selected and used as a proxy for the other. (Hensher, Rose, & Greene, 2005)

The price attribute will be used as it is always an important criteria in any product selection. Price alternatives will be defined also in regard to the distance to city center as a defining characteristic.

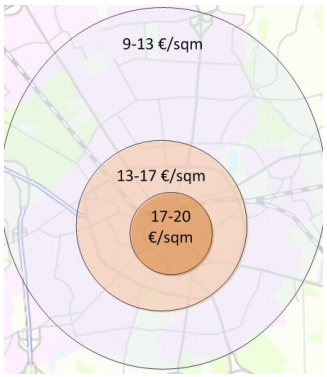


Figure 12. Price-location map

Prices will be presented in value per sqm. As the study focuses on similar types of housing, the price range between studios and one room apartments is similar. Using data from the current real estate market in Eindhoven (Funda-in-Business, 2013) (RealNext, 2013) (Numbeo, 2013), an average price range per sqm was calculated and 3 zones with similar housing prices were identified (Fig 12. Price-location map).

The levels that were found are:

- 9-12 €/sqm for 2.5-4.5 km to city center
- 13-16 €/sqm for 1.1-2.4 km to city center
- 17-20 €/sqm for 0-1 km to city center

Surface

Size of the dwelling is a very important factor. Considering smaller individual dwellings (studios or one room apartments) on the current market in Eindhoven, these vary from 30 to 80 and even 86 sqm. In line with the changes in household composition, increase in demand for dwellings for single households (2.3 Proposed solution), also the demand for average dwelling floor space has changed. Nowadays singles are looking for dwellings with an average of 50 sqm and it is prognosed that this will continue to increase to 100 sqm by 2040. So the attributes levels for surface should have a level with values also below 50sqm, in line with the current market, and others above 50 sqm. The ones above 50 sqm should be one in line with the current market and one in respect to the prognosed demand. These will be:

- 30-49sqm
- 50-75 sqm
- 76-100 sqm

Housing unit

Floor layout is relevant as it defines the amount of privacy the dwelling has to offer. With respect to the targeted group, smaller housing units were considered either with one open floor space or with a separate bedroom, with no shared facilities. This will result in either studio-apartments (living, dining and bedroom combined) or one room apartments.

Private outdoor

The Dutch building code requires that dwellings should be equipped with private outdoor space. Depending on the building, balconies can be created or in some cases even a private garden. Sometimes the building's structure does not allow the possibility of creating any of the above mentioned and building code exemptions might be obtained. Still it is of importance to be able to estimate how does the private outdoor availability influence users decision. The levels for this attribute are:

- None
- Balcony
- Garden

Furnishing

Most of the starters on the housing market are looking for furnished properties to rent, as they do not own their own furniture and providing it themselves will dramatically increase their expenses. Of course renting a furnished property increases the monthly rent and also diminishes the possibility of personalizing the property according to individual preferences, so the possibility of unfurnished dwellings will also be tested. For testing the furnishing attribute three levels were selected:

- Unfurnished (only with kitchen furniture)
- Semi-furnished (with only the basic amenities)
- Fully furnished (with all the amenities including microwave, washing machine, dishwasher and others, that for some people might be basic necessities and for others considered a luxury)

Building type

It is also interesting to see how the initial use of the building will affect the decision of the respondents, as the building type can influence not only the exterior appearance of the

building but also the internal layout and the character of the housing unit. The choices for this attribute will be:

- Office
- Industrial

"Attribute levels" represent the levels assigned to an attribute as part of the experimental design process. These are represented by numbers that will have no meaning to the decision maker being surveyed. That is why, "attribute-level labels" are assigned. Attribute-level labels are meant to provide meaning to the decision maker and they may be numbers (quantitative) or as words (qualitative). For any given decision maker, there will exist for this attribute different quantities of utility associated with the various levels that may be taken. (Hensher, Rose, & Greene, 2005)

Attribute	Level	Labels	Explanation
Housing unit	0 1	Studio One bedroom	Partitioning of floor space: Living, dining and bedroom combined (open floor plan) Apartment with separate bedroom
Surface (in sqm)	0 1 2	30-49 sqm 50-75 sqm 76-100 sqm	Total surface of the housing unit
Price (€/sqm)	0 1 2	9-12 €/sqm 13-16 €/sqm 17-20 €/sqm	Rent price according to distance to city center: 9-12 €/sqm for 2.5-4.5 km to city center 13-16 €/sqm for 1.1-2.4 km to city center 17-20 €/sqm for 0-1 km to city center
Private outdoor	0 1 2	None Balcony Garden	Availability of private outdoor: none, balcony or garden
Furnishing	0 1 2	Unfurnished Semi-furnished Fully furnished	Only kitchen furniture Kitchen plus basics (bed, table with chairs and wardrobe) All amenities (washing machine, microwave and so on)
Building type	0 1	Office Industrial	The initial use of the building

Table 6. Discrete choice experiment attributes and levels

4.3. Experimental design considerations

Having identified the alternatives, attributes, the number of attribute levels, and the attribute-level labels, the analyst must now make decisions as to the design to be used.

One of the decisions that must be made when performing a discrete choice survey is weather to use labeled or unlabeled experiment. This design will use unlabeled alternatives and one of the benefits of using this type of design is that it does not require the identification and use of all alternatives within the universal set of alternatives, thus decreasing the number of treatment combination and diminishing the cognitive burden on respondents. (Henshe, Rose, & Greene, 2005)

A full factorial design in which all possible treatment combinations are enumerated, implies that a total of L^A combinations, where L are the number of attributes levels and A number of attributes. This results in: $L^A=3^4x2^2=324$ treatment combinations. One benefit of using full factorial designs is that all the main effects and all the interaction effects may be estimated

independent of one another. This way, parameters for all main effects and interaction effects may be estimated. As this would generate a questionnaire too long to handle by the respondents, a fractional factorial design must be considered.

To determine the minimum number of treatment combinations necessary for a fractional factorial design, the degrees of freedom that are required must be found. These depend on the number of parameters to be estimated. The more parameters an analyst desires to estimate, the greater the number of degrees of freedom required for estimation purposes. That is, the more complex non-linear relationships that must be found, the more parameters are required to be estimated and in turn the more degrees of freedom are required for model estimation and the larger the design will be.

An effect is the impact a particular attribute level has on choice. The design will test for non linear effects, by using dummy or effects coding. This type of coding will be used as it is unlikely that the difference in utility between, as an example, no private outdoor space and balcony, is the same as between balcony and garden. In order to test for such non-linear effects, effects coding is chosen, as it does not confound the base attribute level with the grand mean of the utility function. (Hensher, Rose, & Greene, 2005)

A main effect is defined as the direct independent effect of each attribute, or attribute level, upon the response variable, choice. An interaction effect is an effect upon a choice, obtained by combining two or more attributes. An interaction occurs when the preference for the level of one attribute is dependent upon the level of a second attribute or the impact two attributes are having when acting in concert. The experiment will only estimate the main effects as no interactions between the chosen attributes are considered to be relevant. This type of design is called orthogonal main effects only design. The degrees of freedom required of the design depend upon the types of effects to be estimated and whether the design is labeled or unlabeled and they can be computed using the formula:

$$(L-1)xA+1 \qquad (4.6)$$

Where: L represents the number of attributes levels and A number of attributes.

Thus the design requires a minimum of (3-1)x4+(2-1)x2+1=11 degrees of freedom. Over the six attributes, the number of parameters to be estimated is 10, however in order to estimate the model, one additional degree of freedom is required, called the random error component of the model. Thus, a minimum of 11 degrees of freedom would be required for the design used to estimate all of the parameters. This number of treatment combinations is significantly smaller than the 324 combinations initially proposed by using full factorial design and it is manageable by respondents.

The last aspect to be considered here concerns the introduction of the no choice alternative. As the objective of the experiment is to estimate the demand for various alternatives, then the inclusion of a non-choice alternative is needed, thus decision makers will not be forced to select among the available alternatives. Forcing respondents to select only from the presented alternatives would lead to over estimated results. (Hensher, Rose, & Greene, 2005)

4.4. Generated experimental design

Unfortunately 11 treatments combinations are not sufficient in order to create an orthogonal uncorrelated design and 16 treatment combinations are necessary. Thus a 6 columns, representing the attributes, and 16 rows matrix is revealed. Once the matrix is generated attributes are allocated to its columns, respecting the number of levels of each attribute. (Appendix D. Design matrix). This design is selected according to the number of attributes and their levels, using a predefined design plan from catalog of experimental design plans.

Treatment combinations	Design matrix					
	H	S	P	PO	F	BT
1	0	0	0	0	0	0
2	1	0	1	1	2	0
3	1	0	2	2	1	1
4	0	0	1	1	1	1
5	1	1	0	1	1	1
6	0	1	1	0	1	1
7	0	1	2	1	2	0
8	1	1	1	2	0	0
9	0	2	0	2	2	1
10	1	2	1	1	0	1
11	1	2	2	0	1	0
12	0	2	1	1	1	0
13	1	1	0	1	1	0
14	0	1	1	2	1	0
15	0	1	2	1	0	1
16	1	1	1	0	2	1

Symbol	Explanation
H	Housing unit
S	Surface
P	Price
PO	Private outdoor
F	Furnishing
BT	Building type

Table 7. a) Design matrix; b) Labels

The matrix is tested for correlations. Orthogonal fractional factorial designs are generated so that the attributes of the design are statistically independent (uncorrelated). Orthogonality between the design attributes represents the basic criterion in the generation process, while the statistical efficiency of the design is rarely considered. On the other hand, optimal designs optimize the amount of information obtained from a design and are considered statistically efficient. By using the predefined orthogonal fractional factorial design, the amount of information obtained from a design is optimized and correlations within the design are minimized to zero. (Hensher, Rose, & Greene, 2005)

4.5. Generated and randomized choice sets

A choice set represents the basic technique of delivering information to decision makers about the alternatives, attributes and attribute levels that exist within the hypothetical scenarios of the study. It represents the way by which information on the choices made by sampled decision makers is gathered.

A treatment combination consists of attribute levels that are related directly to a set of attributes, which are in turn related specifically to a set of alternatives. As there are 16 treatment combinations, the respondents will be presented with 8 choice sets of 2 alternatives, hypothetical scenarios, each. By changing the attribute levels observed between the rows, the underlying experimental design forces each treatment combination to act as a separate and independent hypothetical scenario.

Each treatment combination has to be rearranged into choice sets that not only provide information on the attribute levels of the various alternatives, but also allows the decision maker the possibility of selecting one of the alternatives available.

Choice set	Set	Alt I	Alt II
1	1	8	2
2	1	7	6
3	1	9	4
4	1	13	15
5	1	1	10
6	1	14	5
7	1	16	12
8	1	11	3
9	2	4	13
10	2	14	12
11	2	11	9
12	2	3	15
13	2	2	10
14	2	16	7
15	2	6	5
16	2	1	8
17	3	5	2
18	3	12	13
19	3	7	10
…	…	…	…

Table 8. Generated choice sets

Taking two treatment combinations from table 7, two possible alternatives are presented. From the 16 available treatment combinations, 8 choice sets can be made, each with 2 alternatives. By randomizing the pairs of treatment combinations used to create a choice set, various sets can be created. Preferably each respondent should be presented with a different set of 8 choices.

Microsoft Excel was used for randomizing pairs of treatment combinations and generating each set of choice sets. After all choice sets are generated, labels are assigned. A detailed version of the tables used to generate the choice sets as presented to the respondent are presented in the Appendix E. Generate and randomize choice sets.

An example of choice set as seen by respondents is presented in figure 13:

Features	Alternative I	Alternative II	None
Housing unit	*One bedroom*	*Studio*	
Surface	*50-75 sqm*	*50-75 sqm*	
Price	*13-16 euro/sqm*	*13-16 euro/sqm*	
Private outdoor	*None*	*Garden*	
Furnishing	*Fully furnished*	*Semi-furnished*	
Building type	*Industrial*	*Office*	
Your choice	◉	○	○

Figure 13. Example of choice set

4.6. Questionnaire construction

The discrete choice experiment is dependent on the integrity of the data collected from respondents, who may face some limits in their ability to process information. If the tasks are too long, too difficult, or if they lack sufficient reality, data quality will suffer and not contain the information sought. Therefore, it is important to make the instructions for the

respondents simple and straightforward. To avoid differences in interpretation, task uniformity is sought and respondents are given examples of choice tasks and attribute combinations. To stimulate respondents' involvement, they are given information to set the domain of the experiment and to inform about the objectives of the experiment. (Kemperman, 2000)

The survey will be conducted online, it will be one-time (cross-sectional) survey and responses will be anonymous. Using web-based surveys has many advantages as ease of access and automatic notice if a question is skipped. Also, computer based surveys have the advantage of facilitating the process of data recording and creating a correct database that will be later on analyzed using NLOGIT software.

As the survey is focused on the housing market in Eindhoven, any inhabitant of Eindhoven, or anyone planning to move to the city in the near future, is a potential future user. The respondents are informed about the context of this survey in an introduction page. This page contains information about who is performing the study and the scope of the research. Also information about the length and structure of the survey is given. If the respondent is satisfied with the purpose of the study, he can continue to the actual questionnaire. Though the survey responses will be anonymous, the demographic questions that are asked, will be useful for comparing respondents preference by socio-demographic groups.

The decision of selecting or not a product depends on the characteristics of the person and the attributes of the alternatives available to the person. When studying the choice behavior of a specific target group this ensures that the individuals within the group have similar needs and benefits sought by them on purchase of a product. The target group is selected based on psychographic influences (similar attitudes, values, and lifestyles), demographic/socioeconomic influences (gender, age, income, occupation, education, household size and stage in the family life cycle) and product-related influences (similar relationship to a product).

Given that the choice behavior of the respondents varies according to their demographic profile**,** in the first part of the questionnaire questions about age group and household size are introduced.

Respondent's age

As the targeted market segment is highly related to age (starters and elderly) it is important to know the age of the respondents. The respondent has to pick an answer from a given number of options. These options were selected according to the age groups used also by the municipality of Eindhoven: 18-23, 24-54, 55-64, 65+. The age range of 18-23 will be mostly representative for student and ages between 24 to 64 are known as the productive ages so these will form one single segment. Because the average age for having the first child is above 30 (33 for men, 30 for women) and still increasing, the productive age will be divided from this consideration into 24-32 and 33-64. The respondent's choice options will be:

- 18-23
- 24-32
- 33-64
- 65+

Household size
Household size is also relevant from the point of view of the targeted market segment, as couples with children are highly doubtful to select for a studio or even a one bedroom apartment as a possible housing solution. The respondents will have to choose between the following options:

- Single household
- Two persons household
- Couple/family with children(s)

After the multiple-choice demographic questions are asked, the respondent is presented with a descriptive story which explains to the decision maker the context in which to consider their choice of alternative within each choice set. He is informed about the attributes that will be constant throughout the entire survey, those formally presented as a scenario under which the rest of the attributes will vary.

"As dwelling size, price and other characteristics change along the survey, please consider that:

- *All dwellings are for rent.*
- *All dwellings have B energy label.*
- *All dwellings have at least 1 parking space per 50 sqm of rentable area.*
- *All dwellings are easily accessible by car or public transport (bus frequency and distance to bus stop)"*

Also the attributes and their levels are depicted and the choice task is explained. For reliability purposes an example of the choice task is provided, explaining exactly what is it that the analyst requires from the decision maker to do. After this descriptive part, the main survey is accessed and decision makers have to respond to eight consecutive independent choice sets, by choosing one of the either two proposed alternatives or a no-choice alternative.

The questionnaire is ended with some finishing words, thanking the respondents for their participation. Contact details of the researcher are given and respondents can leave their email address if they desire to be informed on the outcome of the survey. The possibility of receiving the research results is the tradeoff for their participation. The survey content can be found in the Appendix F. Questionnaire.

4.7. Sample choice

The choice of sample population is easily determined, as it is related to the research problem. The sampling frame represents the universal but finite set of decision makers to whom the survey may be presented. Since the research focuses on housing preferences in Eindhoven, the sampling frame consists of any inhabitant of the city.

There are three possible sampling strategies that can be used: simple random samples (SRS), stratified random samples, and a choice-based sample (CBS mostly used in RP experiments). Non-random samples are also possible; however, the results of the analysis may not be readily transferable to the larger population of interest and will often produce highly

dubious market share or market demand estimates. With regard to SRS, if the sampling procedure is conducted properly, the proportions of those sampled should equal the proportions of those observed who actually have selected or are likely to select each of the available alternatives. That is, if an SRS to the population is aggregated, the true market shares should be reproduced.

Though most of the principles that influence sample size determination are based on statistics, successful researchers develop heuristics for quickly determining sample sizes based on experience, rules-of-thumb, and budget or time constraints.

While in RP experiments the rule of thumb suggests that at least 50 decision makers must be sampled for each alternative (Hensher, Rose, & Greene, 2005), for SP choice data, experience suggests that the most commonly used criteria for establishing a minimum sample size is the number of choice sets required to estimate robust models. There appear to be no practical well defined rules to guide the analyst. Since decision makers are presented with 8 choice sets and the alternatives are not labels, thus all parameters will be generic across all alternatives, the minimum can be relaxed since the variability required is far less. There is no magic number, but authors (Hensher, Rose, & Greene, 2005) suggest a total sample of 100 individuals, each with 8 choice sets and fully generic parameter specification for design attributes and no contextual or covariate effects, might just be acceptable.

The most cited rule of thumb (Rose & Bliemer, 2013) is developed by Johnson and Orme (2003) (Orme, 2010):

$n \geq 500 \frac{L}{Sa}$, where L represent the highest number of level of attributes, S-number of choice sets and a-number of alternatives.

500 is intended to be a minimum threshold when researchers cannot afford to do better. It would be better, when possible, to have 1000 or more representations per main-effect level.

Considering Orme's rule of thumb the minimum number of respondents is $n \geq 1000 \frac{3}{8*6} \geq 62.5$

Orme (2010) suggests that a minimum sample size of 200 respondents for studies involving an analysis of differences between sample segments can suffice. (Orme, 2010)

Another rule of thumb to consider is that "sample sizes which yield less than thirty responses per alternative produce estimators which cannot be analyzed reliably by asymptotic methods." McFadden (1984) (Rose & Bliemer, 2013)

For the current study, the minimum sample of respondents is set at 200, with no less than 30 respondents per socio-demographic group.

5. IDENTIFYING GROUP PREFERENCES FROM DISCRETE CHOICE EXPERIMENT RESULTS

5.1. Data collection

The data was gathered using Berg Enquête System © 2007, an on-line survey tool. The survey was open to the public from the 29/04/2013 to 31/05/2013 and was promoted on social media like Facebook and LinkedIn. The questionnaires, both Dutch and English versions, were accessed by 464 persons leading to a total of 233 complete responses. The result is satisfactory as it is above the settled threshold of 200 respondents

5.1.1. Response rate

The Dutch questionnaire had a 59% of completed questionnaires while the English one had a 44% success rate, leading to an overall above 50%. The response rate is satisfactory considering the short data collection period and the lack of financial tradeoffs offered to respondents.

5.1.2. Data cleaning

All incomplete questionnaires were rejected and after a data consistency check, out of the 233 complete questionnaires, 3 more had to be rejected. Considering data quality, the respondents that chose only the "no choice" alternative were not rejected as they were either part of the 33-64 age group or families with children, and their lack of interest for small housing units is easily justified.

5.1.3. Data preparation

As previously mentioned (4.3.Experimental design considerations), in order to test for non-linear effects, effects coding is used. Thus the attributes are recoded as follows:

Levels	3 levels		2 levels
High	1	0	1
Medium	0	1	
Low	-1	-1	-1

Table 9. Effects coding

After data is cleaned and coded accordingly, it still needs to be formatted in order to be later on analyzed using NLOGIT 4.0. For best result, in NLOGIT, each alternative within a choice set is allocated to a separate row of data. Considering this, each respondent will be represented by 8 blocks, representing an individual choice set. Each block consists of 3 rows, corresponding to an alternative within the choice set. Thus, for each respondent there will be 24 rows of data.

5.2. Respondents characteristics

All respondents were asked to answer some questions regarding their socio-demographic characteristics (SDC), stating their age and size of the household, in order to generate interest groups. Though our target group consisted of singles or couples, many respondents with households with children took part in the survey.

Age group	Total respondents	Single	Couple	With children
65+	2*	1*	1*	0*
33-64	87	11*	33	43
24-32	110	59	45	6*
18-23	31	24	5*	2*
Total	230	95	84	51

*socio-demographic groups unable to be modeled due to very low respondents rate

Table 10. Respondents socio-demographic characteristics

The representative group of respondents with children (between the ages of 33 and 64) also has the biggest percentage of "no choice" responses: 16,4% of their total answers. But, as expected, they are the least probable to be interested in the small housing units.

The minimum number of respondents of 30 was reached for all age cathegories except the 65+ group, where only 2 respondents addressed the questionnaire. As an extemption from the 30 respondents rule, the 18-23 single group will be modeled though it has only 24 respondents, as it it one of the interest groups for this study.

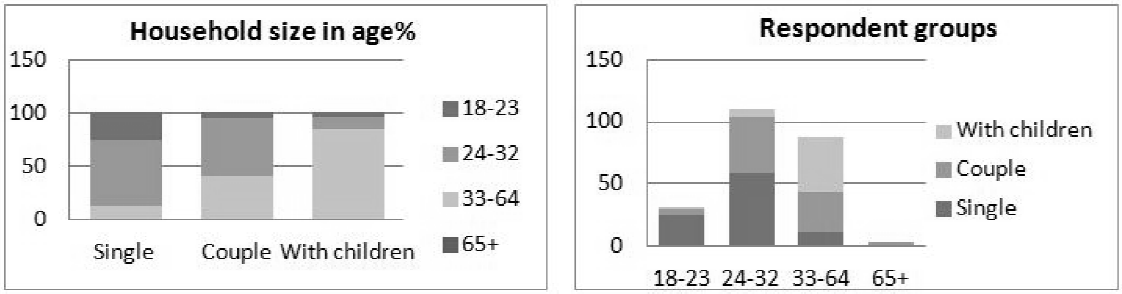


Figure 14. Graphic representations of respondents by age and household size

5.3. Descriptive statistics

A quick data check is performed by analyzing the descriptive statistics output, which suggests that all variables are within expected parameters. The number of cases, 5520, show that all observations were read: 230*24=5520. Other parameters to be checked are: alti is expected to be between 1 and 3, cset equal to 3, all attributes are between -1 and 1, AGE is between 1 and 4 and HS between 1 and 3.

```
Descriptive Statistics
All results based on nonmissing observations.
=============================================================================
Variable      Mean         Std.Dev.      Minimum       Maximum       Cases Missing
=============================================================================
-----------------------------------------------------------------------------
All observations in current sample
-----------------------------------------------------------------------------
ID        |  72558.5       2644.43       70150.0       87634.0          5520        0
ALTI      |  2.00000       .816571       1.00000       3.00000          5520        0
CSET      |  3.00000       .000000       3.00000       3.00000          5520        0
CHOICE    |  .333333       .471447        .000000       1.00000          5520        0
H         |  .869565E-02  1.00010      -1.00000       1.00000          3680     1840
S1        |  .000000       .707203      -1.00000       1.00000          3680     1840
S2        |  .250000       .829269      -1.00000       1.00000          3680     1840
P1        |  .000000       .707203      -1.00000       1.00000          3680     1840
P2        |  .250000       .829269      -1.00000       1.00000          3680     1840
PO1       |  .434783E-02   .707190      -1.00000       1.00000          3680     1840
PO2       |  .252174       .827297      -1.00000       1.00000          3680     1840
F1        |  .000000       .710271      -1.00000       1.00000          3680     1840
F2        |  .243478       .829899      -1.00000       1.00000          3680     1840
BT        |  .434783E-02  1.00013      -1.00000       1.00000          3680     1840
AGE       |  2.26087       .692719       1.00000       4.00000          5520        0
HS        |  1.80870       .773494       1.00000       3.00000          5520        0
```

Figure 15. Descriptive statistics (NLOGIT)

The descriptive output highlights that, in spite of all efforts to make an optimal design, an orthogonal array could not be generated. This results from the averages of S2, P2, PO2 and F2 that are not equal to 0. From the age parameter value, it is suggested that most respondents are representing the first two groups of age (18-23, 24-32 years) as AGE=2.26, an average closer to 1 than to 4.

Also the correlation matrix was generated and analyzed in order to check for correlations (Appendix G.). This ascertainment is relevant, as significant correlations may result in multi-collinearity at the time of modeling, which has implications for both model estimation and prediction. No significant correlations were observed, thus orthogonality is not seriously compromised and data analysis can be pursued

5.4. Model estimates

Data analysis is based on the multinomial logit model (MNL) where, for current choice experiment with two unlabeled alternatives and a 'no choice' option, the utility used in NLOGIT 4.0 software package for choice model estimation, is:

$U_{(1)}=U_{(2)}=B_0+H*H+S1*S1+S2*S2+P1*P1+P2*P2+PO1*PO1+PO2*PO2+F1*F1+F2*F2+BT*BT$ (6.1)

$U_{(3)}=0$ for the 'no choice' alternative,

B_0 is a constant defined as the base alternative, representing the utility of undefined attributes. A series of zero's are used for the coding of the 'no choice' alternative, because nothing is known by definition of its attributes and levels. Thus in examining the 'no choice' utility perceived by respondents, it is equal to $-B_0$. (Haaijer, Kamakura, & Wedel, 2001)

B_0 indicates the general attitude toward the proposed housing type. This attitude can be positive or negative and it is indicated by the sign of the variables' coefficient. When B_0's value is positive, the utility offered by the proposed alternative starts from a value above 0, indicating that the alternative is of interest and that the respondents or socio-demographic groups are positive toward this type of housing. On the other side, when the value of B_0 is negative, it suggests that the respondent or group of respondents is not interested in the proposed type of housing. Similar to any other variable, the bigger the value of the B_0 coefficient, the more influence it has on the overall preference of a certain group.

5.4.1. Finding the optimal MNL model

MNL models were generated and parameters were estimated for each of the above mentioned socio demographic groups, excluding the ones that are very low represented (all groups aged 65+, 33-64 singles, 24-32 with children and 18-23 couples and families with children). This resulted in four main blocks of MNL models. The first block consists of one MNL model, the basic MNL, generated for all respondents as a group (230 respondents). The second block, MNL by age, consists of 3 models, one for each age group (18-23, 24-32, 33-64), no matter the household size. This block does not consider the 65+ age group, as the number of respondents, only 2, is too low. The third block, MNL by age and household size, consists of 5 models for each representative group generated by the combination of age and household size (18-23 single, 24-32 single, 24-32 couple, 33-64 couple, 33-64 with children).

The last block, MNL by household size, consists of 3 models, one for each household size, no matter the age group the respondents come from.

Obviously each of these models performs differently and their goodness of fit is tested using the McFadden's pseudo-R^2: $pseudo\text{-}R^2=LL_M/LL_0$, where LL_M is the likelihood function for the estimated model and LL_0 is the likelihood function for the model estimated with no coefficients, also known as the base model.

The value of *pseudo* R^2 from a model can not be evaluated as good or bad in singularity, but it can be judged relative to other models that have been estimated similarly. Values of 0.2 to 0.4 are considered highly satisfactory and that the model has an excellent fit, while models with values of *pseudo-R2* below 0.1 are considered weak. The models with the highest R^2 will be considered as better performing models.

As seen in Table 21. Model estimates, the model with the lowest value for *pseudo-R2* , 0.07, is the basic MNL, the one that takes all respondents into account. This low performance of the model is due to the heterogeneous structure of the respondents, all age groups and all household sizes. As the homogeneity of respondents increases, either grouped by age, household size or both, so does the value of the *pseudo-*R^2. While the block MNL by age, has on average a better performance than MNL by household size, the best performance is still given by the MNL by age and household size block, as each of the 5 estimated models have the highest heterogeneity among respondents. That is why, the MNL by age and household size block will be used for a detailed analysis.

The 1st block to be reviewed is the basic MNL. Though it has the lowest model fit, it does provide meaningful information about the general preferences. The positive sign of the B_0 coefficient suggests that generally respondents have a positive attitude towards the proposed alternatives and the significance of the coefficient comes to support this. All attributes have one or two levels that are considered significant. This high number of significant attributes can be explained by the heterogeneity of the respondents, each group having different preferences. Overall, big, half-furnished, one bedroom apartments are preferred over smaller studios, high prices have a negative impact, the availability of private outdoor as a garden is preferred, while no private outdoor whatsoever has also a negative impact. Industrial buildings are, to a small degree, preferred over office buildings. This can be explained by the association of office buildings with high-rise buildings and lack of private outdoor.

The 2nd block, MNL by age, has a better model fit due to the increased homogeneity of the respondents within the 3 models. The 18-23 MNL model has best goodness of fit, as there is increased homogeneity, by household size, also within the group (Fig.14). For this group B_0 has a very big value and it is highly significant, suggesting that this group is genuinely interested in this type of housing. As age increases, B_0 coefficient's value decreases down to the point that for the 33-64 age group it has a negative value, suggesting that this age group is not particularly interested in the small housing units. Each group has different preferences, while the youngest group shows preference for the cheapest housing units, the older groups seem to value more their privacy (showing preference for separate bedroom) and bigger surfaces. All groups have preference for the availability of private outdoor, especially for garden.

	1.Basic MNL		2. MNL by age						3. MNL by age & household size										4. MNL by household size					
	Age	HS	Age	HS	Age	HS	Age	HS	Age	HS	Age	HS	Age	HS	Age	HS	Age	HS	Age	HS	Age	HS	Age	HS
	all	all	18-23	all	24-32	all	33-64	all	18-23	single	24-32	single	24-32	couple	33-64	couple	33-64	with children	all	single	all	couple	all	with children
Variable	*Coeff.*	*Sig.*	*Coeff.*	*Sig.*	*Coeff.*	*Sig.*	*Coeff.*	*Sig.*	*Coeff.*	*Sig.*	*Coeff.*	*Sig.*	*Coeff.*	*Sig.*	*Coeff.*	*Sig.*	*Coeff.*	*Sig.*	*Coeff.*	*Sig.*	*Coeff.*	*Sig.*	*Coeff.*	*Sig.*
B_0	**0.24**	**0.00**	**1.64**	**0.00**	**0.87**	**0.00**	**-0.74**	**0.00**	**1.61**	**0.00**	**1.25**	**0.00**	**0.52**	**0.00**	**-0.73**	**0.00**	**-0.88**	**0.00**	**1.08**	**0.00**	-0.01	0.91	**-0.70**	**0.00**
H	**0.13**	**0.00**	-0.12	0.27	**0.12**	**0.02**	**0.28**	**0.00**	**-0.22**	**0.08***	0.01	0.85	**0.29**	**0.00**	**0.28**	**0.01**	**0.27**	**0.01**	0.00	0.93	**0.29**	**0.00**	**0.24**	**0.01**
S1	**0.28**	**0.00**	0.13	0.37	0.11	0.16	**0.68**	**0.00**	-0.15	0.37	-0.14	0.17	0.49	0.00	**0.79**	**0.00**	**0.69**	**0.00**	-0.06	0.48	**0.62**	**0.00**	**0.64**	**0.00**
S2	**0.09**	**0.06***	0.03	0.83	**0.12**	**0.07***	0.13	0.15	0.00	0.97	0.12	0.19	**0.20**	**0.07***	0.17	0.26	0.09	0.50	0.08	0.27	**0.21**	**0.02**	0.08	0.52
P1	**-0.24**	**0.00**	**-0.42**	**0.00**	**-0.26**	**0.00**	-0.13	0.21	**-0.57**	**0.00**	**-0.36**	**0.00**	-0.10	0.46	-0.17	0.34	-0.18	0.25	**-0.34**	**0.00**	-0.11	0.28	-0.20	0.15
P2	0.01	0.79	0.07	0.55	0.01	0.94	-0.01	0.91	0.06	0.70	-0.05	0.56	0.12	0.29	0.03	0.83	-0.03	0.85	-0.04	0.62	0.09	0.27	0.05	0.70
PO1	**0.43**	**0.00**	**0.31**	**0.03**	**0.45**	**0.00**	**0.55**	**0.00**	**0.29**	**0.07***	**0.34**	**0.00**	**0.68**	**0.00**	**0.40**	**0.02**	**0.74**	**0.00**	**0.30**	**0.00**	**0.55**	**0.00**	**0.65**	**0.00**
PO2	**0.13**	**0.01**	0.08	0.49	**0.16**	**0.02**	0.11	0.21	0.11	0.43	**0.31**	**0.00**	0.07	0.54	**0.31**	**0.04**	-0.04	0.76	**0.22**	**0.00**	**0.18**	**0.03**	-0.11	0.36
F1	0.00	0.95	0.10	0.52	0.11	0.17	**-0.20**	**0.07***	0.25	0.16	0.17	0.11	0.05	0.71	-0.22	0.22	**-0.30**	**0.08***	**0.17**	**0.04**	-0.08	0.43	-0.23	0.12
F2	**0.09**	**0.06***	**0.21**	**0.09***	0.07	0.29	0.12	0.17	0.22	0.16	0.04	0.66	0.13	0.24	0.06	0.70	0.17	0.20	0.09	0.23	0.13	0.12	0.19	0.11
BT	**0.07**	**0.05**	0.06	0.52	0.06	0.19	0.10	0.15	0.00	0.97	0.10	0.14	0.06	0.48	0.03	0.78	0.16	0.11	0.07	0.21	0.08	0.19	**0.15**	**0.07***
LL_M	-1899.01		-215.48		-848.94		-677.16		-163.28		-426.63		-340.25		-254.13		-323.06		-718.82		-663.11		-398.39	
LL_0	-2039.94		-274.95		-975.62		-771.63		-212.96		-523.29		-399.12		-292.69		-381.38		-842.58		-745.02		-452.33	
Pseudo R^2	0.07		0.22		0.13		0.12		0.23		0.18		0.15		0.13		0.15		0.15		0.11		0.12	
Resp.	230		31		110		87		24		59		45		33		43		95		84		51	
Total resp.	**230**		**228****						**204*****										**230**					

** indicates significance when assuming a 90% confidence level*

*** due to low response rate, 65+ age group was not included*

**** due to low response rate, all groups aged 65+, 33-64 singles, 24-32 with children and 18-23 couples and families with children were not included*

Table 11. Model estimates

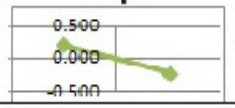
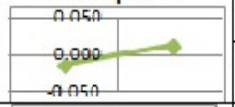
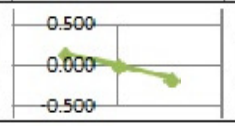
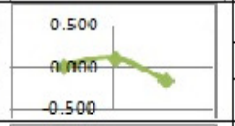
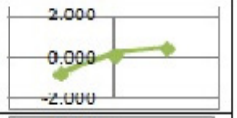
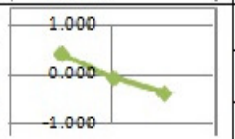
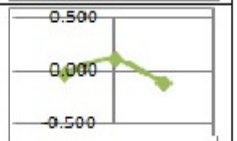
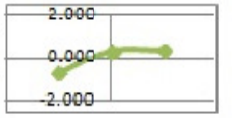
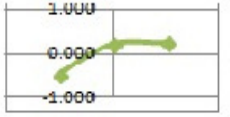
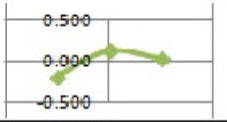
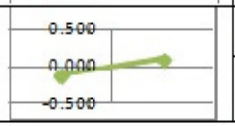
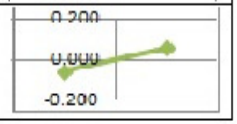
Attribute	Level	18-23 Coeff.	18-23 Sig.	Graph.	24-32 Coeff.	24-32 Sig.	Graph.	24-32 Coeff.	Couple Sig.	Graph.
Housing unit	Studio	0.216			-0.013			-0.288		
	One bedroom	-0.216	0.079		0.013	0.853		0.288	0.001	
Surface	30-49 sqm	0.147			0.024			-0.691		
	50-75 sqm	0.005	0.974		0.119	0.187		0.202	0.069	
	76-100 sqm	-0.151	0.375		-0.143	0.172		0.489	0.000	
Price	9-12 €/sqm	0.518			0.418			-0.018		
	13-16 €/sqm	0.055	0.696		-0.054	0.565		0.120	0.293	
	17-20 €/sqm	-0.574	0.002		-0.364	0.002		-0.102	0.457	
Private outdoor	None	-0.400			-0.658			-0.745		
	Balcony	0.110	0.431		0.314	0.000		0.066	0.544	
	Garden	0.290	0.073		0.344	0.001		0.679	0.000	
Furnishing	Unfurnished	-0465			-0.210			-0.181		
	Semi furnished	0.218	0.159		0.041	0.663		0.133	0.257	
	Fully furnished	0.247	0.159		0.169	0.109		0.048	0.713	
Building type	Office	0.004			-0.100			-0.058		
	Industrial	-0.004	0.975		0.100	0.136		0.058	0.482	

Table 12. Target groups preferences

The 4th block, MNL by household size, behaves similar to the second block, only that it has lower R^2 values, suggesting a better performance when respondents are grouped by age. As in the second block, the interest for small housing units decreases from singles to families with children. Singles show preference for the cheapest housing units, while couples and families value their privacy (showing preference for separate bedroom) and bigger surfaces. All groups have preference for the availability of private outdoor, especially for garden. Singles also show preference for fully furnished houses while couples and families consider it a negative aspect. Due to the association with open spaces and low rise buildings, families show preference for former industrial estates.

The best model fit, with a *pseudo-R^2* between 0.23 and 0.13, is obtained when respondents are grouped both by age and household size. That is why, the 3rd block is chosen for the in-depth analysis of the estimated parameters.

5.4.2. Market preferences by socio-demographic group

Due to its best performance, highest R^2 value, the parameters estimates from the 3rd block will be used in order to get a deeper understanding of market preferences.

The B_0 coefficient shows the attitude respondent groups have towards the small housing units presented. The negative value of the B_0 coefficient for the 33-64 couples and families with children shows that these groups do not find the presented small housing units as an attractive alternative. This result comes only to support the previously made decision in selecting the targeted market segment (2.3.3. Market trends). Out of the 5 models generated for the 4th block, only 3 are part of the target groups:

- Students (low-income singles): 18-23 single
- Starters (young, medium and low-income singles): 24-32 single
- Young two income (young couples with two incomes): 24-32 couple
- Senior citizens 65+ (low to medium income): insufficiently represented

Families with children, represented by the 33-64 age group, and adult couples, also 33-64 age group, are not part of the targeted market segment, though they have a high response rate. Also respondents from these segments have the highest percentage of 'no choice' alternative selection, as obviously expected. The most significant attributes for this target group are type of housing unit (with preference for separate bedroom), available surface (with preference for the biggest amount of sqm) and private outdoor (with preference for garden). For families with children, the negative value of the fully furnished attribute level, with high significance, suggests that when looking for housing, this group aims for unfurnished apartments.

For students, or low income singles, the B_0 coefficient is very high and the most significant attribute is price. This target group is looking for the cheapest housing possibility, with a preference for studios. The availability of a garden is also an important factor for this group, as it is for all groups within this model

For starters, 24 to 32 years-old singles, the B_0 coefficient is lower than for the previous group, but still high. Price and private outdoor are statistically significant, with similar preference for either balcony or garden.

Young couples with two incomes, have the lowest value for the B_0 coefficient, but still show a positive attitude towards these renting units. They are more interested in the division of the housing unit (with preference for separate bedroom), bigger surface and private outdoor, with an obvious preference for garden. For this group, price is not among the outmost significant attributes.

Table 12. Target groups preferences, images preferences for each attribute level by market segment. Here the non-linearity of the estimate attributes levels is highly visible, and so are the differences in preferences between groups.

In what concerns the type of housing unit, young low-income singles, show a preference for studios, while starters, singles or couples, value more their privacy, showing a preference for housing units with separate bedroom.

From the point of view of surface preferences, the youngest group opts for smaller housing units, obviously associated with the smallest rents, while single starters opt for medium to smaller sized apartments. For couples medium to large apartments are preferred, though the utility form medium to large does not show a significant improvement.

Price is the outmost significant attribute for young singles, showing high utility for the lowest price. As price was also a function of location, this group also shows willingness to pay in order to be closer to the city center, though the utility for the medium price is considerably smaller than for the lowest price. For this market segment, the highest price has a big negative influence on the final utility of the product. The price variation utility is similar for the single starters, though they seem less likely to pay in order to be closer to the city center. For two income starters, medium price, with location closer to city center, seems to be the most desirable price level, though price is not among the significant attributes.

Private outdoor seems to be significant for all market segments. While single starters get relatively the same utility either from garden or balcony, for couples, garden is the outmost preferred attribute level. The lack of private outdoor has a negative impact on all respondents groups, with coefficients decreasing stepwise from students to starters couples.

Furnishing and building type are not among the significant attributes for these market segments. Singles, either students or starters, prefer fully furnished apartments, while couples show preference for the semi-furnished ones. For this attribute the non-linear effects of its levels is highly noticeable.

Students seem to be the only group that prefers office buildings to industrial ones, though the coefficients are very small. Starters, either couples or singles, have a preference for industrial buildings, associated with lower population density and bigger possibility of private outdoors.

6. CONCLUSION

6.1. Conclusion

From the discrete choice experiment it resulted that the targeted market segments (18-23 singles, 24-32 singles and couples) are open to the idea of living in reused buildings, rejecting neither the industrial nor the office ones. The fact that none of the industrial or office buildings are considered as a negative feature of the redevelopment represents a positive outcome as it results in an increase of the number of buildings that can be considered for transformation.

As explained in (Chapter 3.) Building reuse potential in Eindhoven, the city offers a various market of vacant structures that can be transformed into housing, but obviously not all of them can deliver the same level of satisfaction to future inhabitants. There are aspects that strictly concern the architectural and business model solutions, derived from market segment, and aspects related to what the structure itself has to offer.

The first group, aspects related to architectural and business model solutions, are size, in square meters; shape/compartment of the developed housing unit and level of available furnishing. Attributes that relate to the structure are location, availability or possibility to accommodate private outdoors and the type of structure.

Location is an important feature of the building as it is the only aspect that cannot be changed, no matter the amount of money invested in the redevelopment. Depending on the target group different locations are preferred. This is a very important building characteristic as it has a powerful influence on the price, both on the acquisition price of the building as on the future rent prices. The city was divided in 3 main areas: the inner city, located in the heart of the city and corresponding to the highest prices, outer city center, between the heart of the city and the city's ring, and outside the city's ring (fig. 12). For the current study, the most expensive inner central locations are not among the targeted market preferences. There seems to be a higher demand from singles, students or starters, for areas located outside the city center. The area outside the city ring, where the prices are lowest, is the most preferred for these two market segments. For starter couples with two incomes, the preferred area is outer city center.

The availability of private outdoor proved to be a very important feature of the housing unit and buildings that cannot offer any possibility whatsoever of providing it, will offer low utility to possible future residents, no matter the market segment. Though gardens are preferred, balconies or any similar solutions, like terrace, French balconies or winter gardens, should be adopted.

Neither office nor industrial buildings prove to have a significant influence on the future users' preferences, though industrial is preferred overall. This is due to its association with low-rise buildings and possibility of private outdoors as gardens, though within the selected

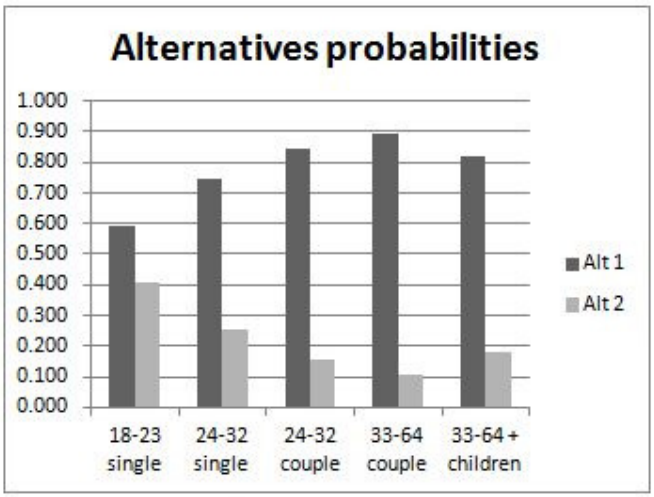
case studies there is an office building with only two levels and a vast courtyard that could also fulfill these demands.

This leads to the conclusion that from the initial list of selected vacant buildings (Appendix B.1. and Table 4. Selected case studies) even more structures can be rejected. The case might be for some of the three office buildings located in the inner city center if their redevelopment cannot accommodate private outdoors, as their reuse might lead to high prices, which the targeted market segments are not willing to pay, and low utilities (fig. 16). When buildings such as these are found unsuitable for redevelopment as housing, a different use can be found.

The MNL models developed from potential users choice studies can be easily incorporated into a decision support system (DSS) so that the impact of changes in the levels of attributes on choice shares can be predicted. Also tradeoffs in different attributes levels can be tested in order to find the most attractive solution, or to test market competition. By introducing data of different alternatives, probabilities or utilities generated by them can be predicted (fig. 16).

Alternative 1	
Attributes	Levels
Housing type	One bedroom
Surface	50-75 sqm
Price	13-16 €/sqm
Private Outdoors	Balcony
Furnishing	Semi furnished
Building Type	Office

Alternative 2	
Attributes	Levels
Housing type	One bedroom
Surface	30-49 sqm
Price	13-16 €/sqm
Private Outdoors	None
Furnishing	Semi furnished
Building Type	Office



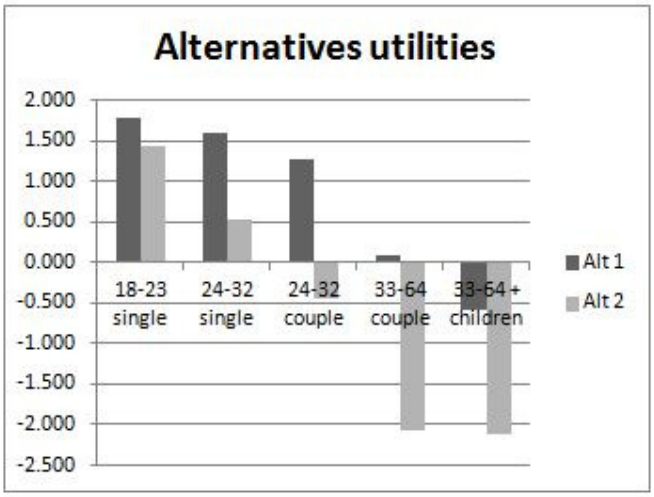


Figure 16. DSS comparing two alternatives

6.2. Discussions and recommendations

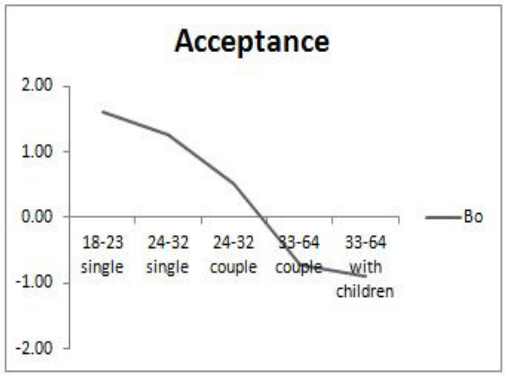


Figure 17. Acceptance of the proposed solution

The general acceptance of small housing units developed in reused buildings varies according to age and household size, decreasing from the high positive reaction of young singles to a negative value for adult families with children. While it is not established how much of this weight is due to the size of the household and how much is due to the building reuse, it is assumed that the rejection is due to the unfitted small housing unit and not due to the rejection of the building reuse. By increasing the size of the housing unit other market segments can be reached.

Another implication of the findings of this research can be the development of a integrated support tool that assists developers in choosing the best structure for reuse, by acknowledging not only the best solution from the investor's point of view (selection criteria from Appendix E. Gradual criteria for building transformation potential), but the future users' preferences as well (Table 12. Target groups preferences).

While vacant buildings decrease the value of the area and attract negative features, the redevelopment of such structures result only in benefits, both for the society and the municipality, from increasing revenues.

Even when the municipality has a passive role it should encourage redevelopments, as it is in its best interest to increase the value of the land and properties under its administration. The municipality can support transformation possibilities by facilitating legal processes, by allowing changes or exceptions from the zoning plan or exceptions from building codes.

Municipalities should increase its awareness of their structurally vacant problems and take an active role by developing policies on transformations and granting subsidies. It could initiate measures to decrease the structural vacancy by encouraging transformation of redundant and obsolete buildings and convincing several investors and housing associations to play a more active role in the initiation of transformation processes.

Typically, these types of projects are initiated by the developers, but sometimes by the local municipalities or the owners of the vacant building. By being actively involved in such projects, the risks perceived by investors are decreased and the attractiveness of such projects is increased.

From policy point of view, municipalities can use the land lease system as an instrument to encourage transformation, by lowering the lease level for transformed buildings, by lowering the land value of redevelopments, or by raising the land value for new developments in greenfields. By offering new land leases and approving of new developments, instead of focusing on the existing supply and by maintaining a low purchasing price of undeveloped land compared to the high purchasing price of inner city

locations, municipalities help this problem persist. Other legal or fiscal measures could include tax on vacant buildings and tax benefits for transformation (REMØY, 2010).

Together with real estate investors, the municipality should play a key role in limiting structural vacancy by being more critical towards which developments are accepted, focusing more on urban management than development and focusing as well on the durability of new developments (REMØY, 2010). Also focusing on large scale redevelopments of monofunctional areas with high vacancy rate would be a long term sustainable urban project that could not take place without the commitment of the municipality.

Also, in light of this research, designers should consider that "a sustainable building is not one that must last forever, but one that can easily adapt to change" (Graham, 2006). The ever changing society requires for a more dynamic built environment, ready to adapt to new demands with minimum consumption of resources. And this aspect should be considered from the first stage of the new development.

In order to achieve the common goal of sustainable city developments, the business community, civil society and various levels of government should be brought together to tackle current urban issues. All spheres of society should aim on the long term urban sustainability that focuses on creating stronger more resilient cities through the integration of environmental, social and economic wellbeing.

REFERENCES

Amponsah, N., Lacarrière, B., Jamali-Zghal, N., & Le Corre, O. (2012). Impact of building material recycle or reuse on selected energy ratios. *Resources, Conservation and Recycling* , 9-17.

Ball, R. (2010). Developers, regeneration and sustainability issues in the reuse of vacant industrial buildings. *Building Research & Information* , 140-148.

Ball, R. (2002). Re-use potential and vacant industrial premises: revisiting the regeneration issue in Stoke-on-Trent. *Journal of Property Research* , 93–110.

Bitter, C., Mulligan, G. F., & Dall'erba, S. (2007). Incorporating spatial variation in housing attribute prices: a comparison of geographically weighted regression and the spatial expansion method. *Journal of Geographical Systems, no 9* , 7-27.

Bouman, O. (2010). *Vacant NL- Where architecture meets ideas.* Venice: Rietveld Landscape.

Bryson, J. R. (1997). Obsolescence and the process of creative reconstruction. *Urban Studies, vol.34* , 1439-1458.

Bullen, P. A. (2007). Adaptive reuse and sustainability of commercial buildings. *Facilities 25* , 20-31.

Candura, A., Dal Sasso, P., & Marinell, G. (2008). *Recovery and Reuse of Rural buildings: the Spread Out Building case* . Bari, Italy: Dipartimento di Progettazione e Gestione dei Sistemi Agricoli e Forestali.

Conejos, S., Langston, C., & Smith, J. (2013). AdaptSTAR model: A climate-friendly strategy to promote built environment sustainability. *Habitat International 37* , 95-103.

Crowther, P. (2000). *Building deconstruction in Australia.* Brisbane, Australia: Queensland University of Technology.

DEH. (2004). *Preserving our past, building our future.* Melbourne: Commonwealth of Australia-Department of the Environment and Heritage.

der Weerdt, D. v. (2011). *Renovate or new estate?: The challenge towards a sustainable future* . Eindhoven: Eindhoven University of Technology.

Douglas, J. (2006). Building adaptation. Oxford, UK: Elsevier Ltd.

Drucker, P. (1974). *Management: Tasks, Responsibilities, Practices.* New York: Harper Business.

DTZ. (2013). *The Netherlands, a national picture.* Amsterdam, the Netherlands: DTZ Zadelhoff, Research.

Fik, T. J., Ling, D. C., & Mulligan, G. F. (2003). Modeling Spatial Variation in Housing Prices: A Variable Interaction Approach. *Real Estate Economics, vol. 31* , 623-646.

Funda-in-Business. (2013). *Funda-in-Business.* Retrieved March 06, 2013, from Funda-in-Business: http://www.fundainbusiness.nl/

Garstka, B. J. (2012). *Holy renovations: Adaptive re-use and dependent stakeholder opinion of converted church buildings.* Utrecht: Faculty of Geosciences, Utrecht University.

Gemeente Eindhoven. (2011). *Introducing Eindhoven: Facts & Figures*. Retrieved March 22, 2013, from Eindhoven.eu: http://www.eindhoven.eu/en/Introduction/Introducing_Eindhoven/Facts_&_Figures

Geraedts, R. P., & der Voort, T. v. (2003). Offices for living in: An instrument for measuring the potential for transforming offices into homes. *Proceedings CIB Conference W104, Open Building Implementation*, (pp. 207-229). Mexico City.

Geraedts, R., & der Voordt, T. v. (2007). *The New Transformation Meter; A new evaluation instrument for matching the market supply of vacant office buildings and the market demand for new homes.* Delft, Netherlands: Delft University of Technology.

Greenagel, F. L. (2009, January). *Demolition derby or adaptive reuse?* Retrieved January 18, 2013, from New Jersey Churchscape: http://www.njchurchscape.com

Haaijer, R., Kamakura, W., & Wedel, M. (2001). The 'no-choice' alternative in conjoint choice experiments. *International Jurnal of Market Research, vol 43* , 93-106.

Harmsen, H. (2008). De Oude Kaart van Nederland. Den Haag: Atelier Rijksbouwmeester.

Haynes, R. (2010). *Embodied Energy Calculations within Life Cycle Analysis of Residential Buildings .* Australia.

Hensher, D. A., Rose, J. M., & Greene, W. H. (2005). *Applied choice analysis: a primer.* Cambridge, UK: Cambridge University Press.

Ilesanmi, A. O. (2010). Post-occupancy evaluation and residents' satisfaction with public housing in Lagos, Nigeria. *Journal of Building Appraisal, vol. 6* , 153-169.

Kauko, T. (2007). An analysis of housing location attributes in the inner city of Budapest, Hungary, using expert judgements. *International Journal of Strategic Property Management, vol 11* , 209-225.

Kemperman, A. D. (2000). *Temporal aspects of theme park choice behavior.* Eindhoven: Technische Universiteit Eindhoven.

Korthals Altes, W., & Tambach, M. (2008). Municipal strategies for introducing housing on industrial estates as part of compact-city policies in the Netherlands. *Cities 25* , 218-229.

Kraaij, M. (2010, September 2). MSc. thesis. *Greening of gray buildings - Opportunities for the conservation of vacant offices in Eindhoven* . Eindhoven: Eindhoven University of Technology.

Kryvobokov, M., & Wilhelmsson, M. (2007). Analysisng location attributes with a hedonic model for apartment prices in Donetsk, Ukraine. *International Journal of Strategic Property Management, vol. 11* , 157-178.

Langston, C. (2012). Validation of the adaptive reuse potential (ARP) model using iconCUR. *Facilities, vol. 30* , 105-123.

Langston, C., & Shen, L.-Y. (2007). Application of the adaptive reuse potential model in Hong Kong: A case study of Lui Seng Chun. *International Journal of Strategic Property Management* , 193-207.

Massiani, J., & Rosato, P. (2008). *The Preferences of Trieste Inhabitants for the Re-use of the Old Port: A Conjoint Choice Experiment.* Milano: Fondazione Eni Enrico Mattei.

Numbeo. (2013, April). *Cost of living in Eindhoven, Netherlands*. Retrieved April 8, 2013, from Numbeo: http://www.numbeo.com

Opoku, R. A., & Abdul-Muhmin, A. G. (2010). Housing preferences and attribute importance among low-income consumers in Saudi Arabia. *Habitat International 34* , 219-227.

Orme, B. (2010). Chapter 7: Sample Size Issues. In B. Orme, *Getting started with Conjoint Analysis: Strategies for product design and product research (2nd Edition)* (pp. 57-66). Madison: Research Publishers LLC.

Perera Roderes, A., & Brand, G. v. (2006). *Re-use as a strategy for sustainable building rehabilitation.* Eindhoven: Eindhoven University of Technology.

PreservationGreenLab. (2011). *The greenest building: Quantifying the environmental value of building reuse.* USA: National Trust for Historic Preservation.

RealNext. (2013). *RealNext*. Retrieved March 06, 2013, from RealNext: http://www.realnext.nl/

REMØY, H. T. (2010). *Out of Office.* Deft: Delft Technical University.

Remøy, H. T., & Voordt, v. d. (2007). A new life: conversion of vacant office buildings into housing. *Facilities 25* , 88-103.

Rose, J. M., & Bliemer, M. C. (2013). Sample size requirements for stated choice experiments. *Transportation* , 19-45.

Setterfield, M. (1997). *Abandoned Buildings: Models for Legislative & Enforcement Reform.* Hartford, CT: Trinity Center for Neighborhoods.

Shen, L., & Langston, C. (2010). Adaptive reuse potential: An examination of differences between urban and non-urban projects. *Facilities, vol. 28* , 6-16.

Verma, R., & al., e. (2009). Predicting customer choice in services using discrete choice analysis. *IBM Systems Jurnal, vol 47* , 179-191.

Wilkinson, S. J., James, K., & Reed, R. (2009). Using building adaptation to deliver sustainability in Australia. *Structural Survey, vol. 27* , 46-61.

Yung, E. H., & Chan, E. H. (2012). Implementation challenges to the adaptive reuse of heritage buildings: Towards the goals of sustainable, low carbon cities. *Habitat International* , 352-361.

Zandbergen, G. (2012). *Leegstandscijfers-Vacacy figures*. Retrieved January 18, 2013, from Locatus database about the changing retail landscape : http://www.locatus.com

Zukin, S. (1982). *Loft Living: Culture and Capital in Urban Change.* Baltimore, USA: John Hopkins University Press.

APPENDICES

A. Transformation of office and industrial buildings into housing units

A.1. Transformation of office buildings

Office buildings normally have a size, shape and structure that is suitable for transformation into apartments. These structures are strong enough to support the new repartitioning walls and other necessary loads as they are normally constructed to carry more weight than in housing (standard load in offices is 300kg/m2, while in housing is 175kg/m2) and the spans and bays are easily fitted within the grids commonly used for housing. Office buildings are designed for more people per square meter and more traffic than apartment buildings, thus the number of elevators available for the new function is another positive aspect for transformation. Problematic aspects that might be found within some office buildings relate to floor height or building depth. For housing, higher requirements are demanded when considering thermal and acoustic insulation of floors or façade, leading to supplementary costs.

Most vacant office buildings are left behind by organizations that move to newer buildings as they no longer fit present performance requirements. Part of the vacancy is derived from market and economic changes. But conjuncture-related vacancy can easily become structural vacancy.

A large number of structural vacant office buildings were built between 1960 and 1980 and their transformations into housing were initially encountered in London, New York, Toronto and Tokyo. In some cases transformations occurred in central urban areas or downtown locations, like in London and Toronto or downtown Manhattan, where it was used as a very successful mean of redeveloping inner cities during the nineteen nineties, as offices were ageing and becoming obsolete.

Many office buildings are functionally or technically outdated and not flexible enough to be refitted, or have a bad spatial-visual quality. Also, the urban context of the buildings can be experienced as poor, from poor accessibility, too little parking provision, the building being situated in a housing area or being affected by other agglomeration factors. However, studies show that the performance of existing office buildings can be adapted to the level of the Dutch building legislation law as well as to the level of comfort expected by the relevant user group. There are many examples to follow in Netherlands and in Eindhoven as well, where office buildings were transformed into students or starters housing. The challenge was to deliver private outdoor space as not all structures give the possibility of adding balconies. In some cases, French balconies or winter gardens are possible solutions, adding private outdoor space inside the building's envelope.

Figure 1. Office buildings transformed into dwellings

The location of the office buildings is an important factor to consider, either in city centre or in housing areas or on the edges of such areas. These buildings are not renowned for interesting architecture or beauty; rather the quality of their external appearance is assessed as poor, but this should not be highly problematic considering our target group. The structural grid of office buildings is easily adaptable for small housing units like studios or one room apartments.

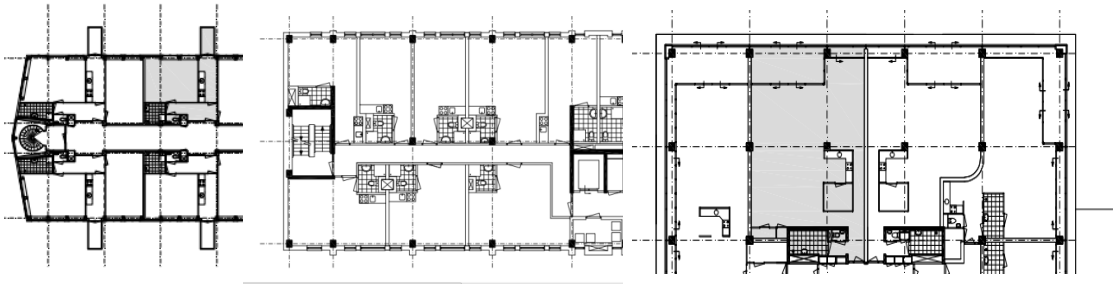


Figure 2. Floor plans of office buildings reused as dwellings.

A.2. Transformation of industrial buildings

In what concerns adaptive reuse projects for industrial buildings, they mostly consider buildings that are part of historical heritage and are transformed in new functions that require big opened spaces like retail, libraries, universities, exhibitions and so on. There are also successful examples of projects approaching housing functions. These are either international like Gasometer City, Vienna- complex of apartments, shops and offices now occupying the brick shells that once encased Simmering's massive gas supply tanks- or on national level like Meelfabriek in Leiden, 1904 reinforced concrete silos and mill are being redeveloped as hotel, homes, catering and exhibition and retail spaces. Many stakeholders, including municipal or governmental parties, are involved in large scale industrial redevelopment projects, but for private reuse projects from industrial to housing, smaller, light industrial buildings are better suited, as land contamination and other sensitive aspects can be avoided. An example of such a project could be an old water pumping station in Berlin, vacant since 1990's, now located in the middle of a residential area that after redevelopment accommodates two separate private housing areas and some living and working spaces. These properties have the advantage of being acquired at a very low price, they have a very sound structure and big opened spaces that can be repartitioned. They represent a challenge for the architect but provide the opportunity for great innovative

developments. They can be considered for housing as long as they respect the minimum location criteria and are not situated on contaminated soil or in areas with nuisance, toxic fumes, heavy vehicles, fine particles, vibrations or other hazards. As long as nowadays the buildings are surrounded by housing facilities or neighbor them closely, such hypotheses are excluded.

The Dutch government, in order to enhance urban quality, developed policies that promote mixed use developments, thus trying to introduce housing on single use industrial estates developed after the World War II. (Korthals Altes & Tambach, 2008) Mixed-use development of industry and housing is feasible nowadays, because industry has changed, new technology has reduced risk from pollution and has given birth to entirely new economic activities. Production units are smaller and more flexible and big polluting industries have moved outside cities. Hence, much industry is compatible with residential use today. Examples of such developments can be found in Binckhorst and Plaspoelpolder sites in and around The Hague and the Buiksloterham site in Amsterdam.

The concentration of development in inner-city areas is one of the cornerstones of Dutch spatial planning known as “compact-city policy”, using strict boundaries around urban areas to contain urban growth. Constructing new homes on previously developed land in built-up areas of cities and towns is part of this policy. In order to avoid building on the scarce green space inside the city, most of the new additions to the housing stock are being constructed in ‘change-of-function’ areas, like former industrial estates, railway yards, army barracks, hospitals, schools and so on.

More recently, interest has arisen in the gradual introduction of housing on functioning industrial estates where some plants may represent a significant load on the environment. This is part of a process of gradual shift in the function of these areas away from industry and towards service-based activities that can more effectively be combined with housing. (Korthals Altes & Tambach, 2008) In this context, housing is seen as an instrument for changing the local urban environment and possibly of removal of all industry from the city.

Transforming industrial buildings into lofts has been a common practice for struggling artists in the 1950’s and 1960’s. Originally popular with artists, they were later on, starting with the 1970’s, highly sought by other bohemians. This increasing attention that this style of living received and the shift from the industrial era of large cities, lead to the creation of a familiar pattern in the conversion of no longer economically viable industrial buildings to residential lofts. (Zukin, 1982)This movement started in some of the older industrial cities in the United Stated and Western Europe, like New York, London and Amsterdam and soon spread to other cities where nineteen century industrial and warehouse buildings were left vacant.

Originally used as both work and live-in studios, they were sought for the relatively low rents in the industrial areas that compensated for the inconveniences related to location. As these industrial buildings gradually moved from the edge of city towards the inner city locations, due to urban expansion, and a bohemian chic nature that was inspired by these ‘artist’s quarters’, a increasing demand emerged for lofts. Nowadays some of these lofts are created by developers during the renovation of old buildings, but also a number of them are included in the floor plans of brand new developments. They offer proximity to urban amenities without perceived safety risks of living in economically depressed formerly industrial areas. In the real estate industry "hard lofts" represent former industrial buildings

converted to residential or live/work use and "soft lofts" refer to loft-style residential buildings built entirely anew. (Zukin, 1982) Key features of former industrial space that makes for attractive use as a loft include high, unfinished ceilings, large windows, exposed brick or cinder block walls and exposed duct work. Many industrial lofts have only partial height walls separating rooms or areas within the space and only the front room has windows.

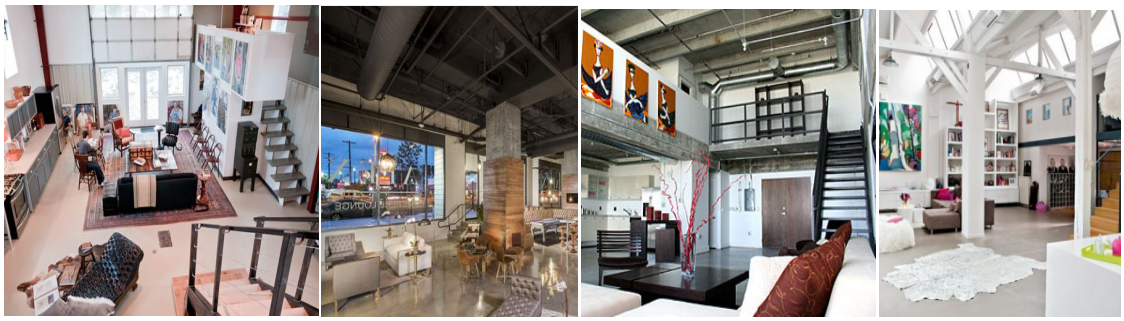


Figure3. Examples of industrial buildings transformed into studios.

Some lofts, due to the height of the room, allow for mezzanine area for where a bed or a bedroom can be installed, thus allowing unused space to be utilized within the vertical cube and adding to the living floor area. Skylight can also be kept in order to increase the level of daylight that the residence can benefit from.

The lofts appeal particularly to young professionals, singles, couples with no children, or business people looking for a second (business) home. (Dobberstein, 2005). Their location, outside areas with top rent prices per sqm and the lower investment in upgrading the appearance of the building and in finishes, makes them more affordable for lower income groups, or allow users to aim for bigger living areas within their budget.

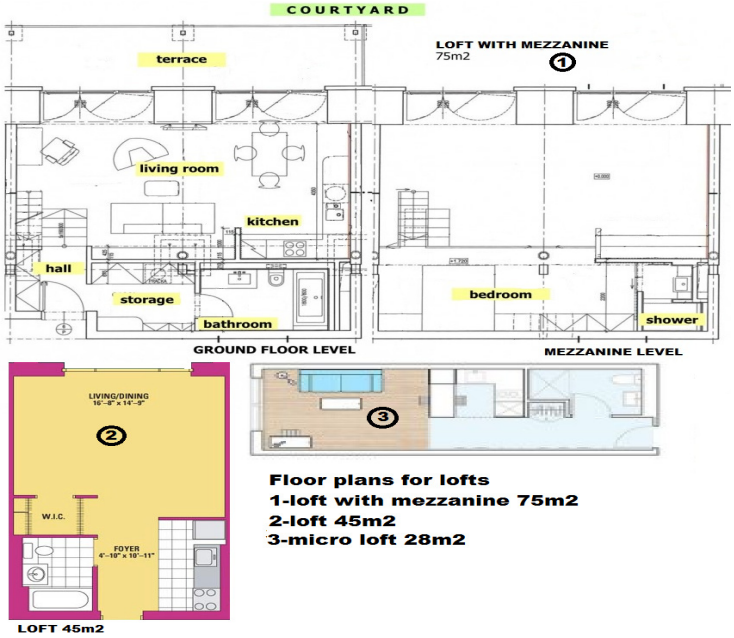


Figure 4. Floor plans of studios.

B. Case-study selection

B.1. Draft list

No	Type	Address		Surface		Advertised by	Location	Vacancy	To	Parking	Building year
		Street	No	Total	Vacant						
1	Office	Boschdijktunnel	10	3420	1710	Jones Lang LaSalle	Centrum	50%	Rent	Av**	
2	Office	Vonderweg	11	10972	10972	DTZ	Stadion	100%	Rent	170	
3	Office	Vestdijk	9	10100	3746	C I	Centrum	37%	Rent	Av**	1975
4	Office	Vestdijk	55-61	6944	5644	DTZ	Centrum	81%	Rent	100	
5	Office	Oude Stadsgracht	1	12100	3756	DTZ	Centrum	31%	Rent		
6	Office	Begijnenhof	35	1345	1345	Jones Lang LaSalle	Centrum	100%	Rent	34	
7	Office	Wal	15	5454	5454	Jones Lang LaSalle	Centrum	100%	Sale	30	1950, 1975
8	Office	Pastoor Petersstraat	170	7387	7037	CI	Centrum	95%	Rent	144	
9	Office	Bogert	1-11	2924	2924	Jones Lang LaSalle	Centrum	100%	Rent	50	
10	Office	Ruysdaelbaan	33A	1145	1145	MVGM	Lakerlopen	100%	Rent	8	
11	Office	Frederiklaan	1B	820	820	DTZ, Bossers & Fitters	PSV stadium	100%	Rent	10	
12	Office	Mathildelaan	83-85	3534	1119	CI	Centrum	32%	Rent	8	
13	Office	Frederick of Eedenplein	1	8000	8000	Municipality	Centrum	100%			
14	Office	Beukenlaan	77	4826	4826	DTZ	Rondweg	100%	Rent	93	1990
15	Office	Byrdstraat	21	842	842	V&S B*	Woensel	100%	Sale	29	
16	Office	Baltesakker	19-21	1358	1358	Bossers & Fitters , CI	De Tempel/ Vlokhoven	100%	Rent	4	
17	Office	Zwaanstraat	1	1450	1450	DTZ	Strijp T	100%	Rent	Av**	1950-60
18	Office	Limburglaan	36	3177	3177	DTZ	De Hurk	100%	Rent	100	
19	Office	Dr. Holtroplaan	3	5510	3045	Bossers & Fitters	Poort van Metz	55%	Rent	44	
20	Office	De Blecourtstraat	1	4172	4172	DTZ	Het Ven	100%	Rent	120	1994
21	Office	Beemdstraat	5	1206	1206	DTZ	De Hurk	100%	Rent	22	1999
22	Office	Limburglaan	36	3177	3177	DTZ	De Hurk	100%	Rent	100	
1	Industrial	Fuutlaan	21	2500	2500	MVGM	Central station	100%	Rent		
2	Industrial	Thorvaldsenlaan	2c	961	961	VSRM	Woensel	100%	Rent	12	
3	Industrial	Industrieweg	1	7308	7308	Industrieweg	Achtse Molen	100%	Sale		
4	Industrial	Hondsruglaan	87A/B/C	1187	1187	DTZ	Woenselse Heide	100%	Rent	16	
5	Industrial	Doornakkersweg	18-20	1550	1550	Q Bedrijfslocaties	Tongelre	100%	Rent	Av**	
6	Industrial	Zwaanstraat	1	1587	1587	DTZ	Strijp T	100%	Rent	Av**	1950-60
7	Industrial	Zwaanstraat	1	1450	1945	DTZ	Strijp T	134%	Rent	Av**	1950-60
8	Industrial	Dillenburgstraat	32	1395	1395	DTZ	De Hurk	100%	Sale	10	
9	Industrial	Hastelweg	260b	1757	1757	V&S B*	Het Ven	100%	Rent	8	

*V&S B - Verschuuren & Schreppers Bedrijfsmakelaars
*CI - Colliers International
*VSRM - Van Stekelenburg Rooijakkers Makelaars
Av**- parking available on street (no further information)

Table 1. Draft list of potential buildings for redevelopment in Eindhoven

B.2. Preliminary selection

Second draft list resulted from exclusion of buildings located in monofunctional areas or that were not 100% vacant.

No	Address		Postcode		Surface	Location	Parking	Building year
	Street	No	No		Total			
1	Vonderweg	11	5611	BK	10972	Stadionkwartier	170	
3	Begijnenhof	35	5611	EK	1345	Centrum	34	
4	Wal	15	5611	GE	5454	Centrum	30	1950, 1975
5	Bogert	1-11	5612	LX	2924	Centrum	50	
6	Ruysdaelbaan	33A	5613	DX	1145	Lakerlopen	8	
7	Frederiklaan	1B	5616	BN	820	PSV stadium	10	
8	Frederick of Eedenplein	1	5616	NK	8000	Centrum		
9	Beukenlaan	77	5616	VC	4826	Rondweg	93	1990
10	Byrdstraat	21	5623	PL	842	Woensel	29	
11	Baltesakker	19-21	5625	TC	1358	De Tempel/Vlokhoven	4	
12	Zwaanstraat	1	5651	CA	1450	Strijp T	available	1950-60
13	Limburglaan	36	5652	AA	3177	De Hurk	100	
14	De Blecourtstraat	1	5652	GB	4172	Het Ven	120	1994
15	Beemdstraat	5	5653	MA	1206	De Hurk	22	1999
16	Limburglaan	36	5652	AA	3177	De Hurk	100	
1	Fuutlaan	21	5613	AB	2500	Central station		
2	Thorvaldsenlaan	2c	5623	MB	961	Woensel	12	
3	Industrieweg	1	5627	BW	7308	Achtse Molen		
4	Hondsruglaan	87A/B/C	5628	DB	1187	Woenselse Heide	16	
5	Doornakkersweg	18-20	5642	MP	1550	Tongelre	available	
6	Zwaanstraat	1	5651	CA	1587	Strijp T	available	1950-60
7	Zwaanstraat	1	5651	CA	1450	Strijp T	available	1950-60
8	Dillenburgstraat	32	5652	AP	1395	De Hurk	10	
9	Hastelweg	260b	5652	CN	1757	Het Ven	8	

Table 2. Preliminary selection list

B.3. Scoring of preselected buildings

Scoring of buildings from the preliminary selection list

	Address Street	No	Postcode		Location	Accessibility: car	Accessibility: OV	Parking	Visual image	Services-Surroundings	Adaptable for housing	Total +	Total 0	Total -
1	Vonderweg	11	5611	BK	Stadionkwartier	++	0	+	+	++	++	8	1	0
2	Begijnenhof	35	5611	EK	Centrum	+	++	++	0	+	++	8	1	0
3	Wal	15	5611	GE	Centrum	++	++	-	0	0	0	4	3	1
4	Bogert	1-11	5612	LX	Centrum	++	+	0	-	0	-	3	2	2
5	Ruysdaelbaan	33A	5613	DX	Lakerlopen	++	+	0	+	+	0	5	2	0
6	Frederick van Eedenplein	1	5616	NK	Centrum	0	0-	+	+	+	++	5	2	1
7	Beukenlaan	77	5616	VC	Rondweg	++	++	++	0	+	++	9	1	0
8	Byrdstraat	21	5623	PL	Woensel	++	+	++	+	++	++	10	0	0
9	Baltesakker	19-21	5625	TC	De Tempel/Vlokhoven	++	+	-	0	0	0	3	3	1
10	Zwaanstraat Gebouw	1	5651	CA	Strijp T	++	0	0+	0	+	++	6	3	0
11	Limburglaan	36	5652	AA	De Hurk	++	0	++	0	0	+	5	3	0
12	Beemdstraat	5	5653	MA	De Hurk	++	0	++	+	--	++	7	1	2
1	Fuutlaan	21	5613	AB	Central station	++	++	+	-	+	0-	6	1	2
2	Thorvaldsenlaan	2c	5623	MB	Woensel	++	++	++	0	+ 0	0	7	3	0
3	Hondsruglaan	87A/B/C	5628	DB	Woenselse Heide	++	+	++	+	+	0	7	1	0
4	Doornakkersweg	18-20	5642	MP	Tongelre	++	+	+	-	+	--	5	0	3
5	Zwaanstraat Pomphuis	1	5651	CA	Strijp T	++	0	0+	0	+	0	4	4	0
6	Dillenburgstraat	32	5652	AP	De Hurk	+	-	++	-	--	0	3	1	4

Table 3. Scoring of preselected buildings

C. Gradual criteria for evaluation of building transformation potential

	Aspect	Gradual Criteria
Location	Functional	
	Urban Location	Building in industrial estate or office park far from town centre Building gets little or no sun View limited by other buildings on > 75% of floor area
	Distance and quality of amenities	Shops for daily necessities > 1 km. Neighborhood meeting-place (square, park) > 500 m. Hotel/restaurant/snackbar > 500 m. Bank/Post Office > 2 km. Basic medical facilities (practice, health centre) > 5 km. Sports facilities (fitness, swimming pool, sports park) > 2 km. Education (from kindergarten to university) > 2 km.
	Public transport	Distance to railway station > 2 km. Distance to bus/underground/tram > 1 km.
	Accessibility by car and parking	Many obstacles; traffic congestion Distance to parking sites > 250 m. <1 parking space/100 m2 road surface
	Cultural	
	Tone of neighborhood	Situated on or near edge of town (e.g. near motorway) No other buildings in immediate vicinity Dull environment No green space in neighborhood Area has poor reputation/image; vandalism Dangerous, noise or odor pollution (factories, trains, cars)
	Legal	
	Urban location	Noise load on façade > 50 dB
	Ownership of ground	Leasehold
Building	Functional	
	Year of construction or renovation	Building recently built (< 3 years) Recently renovated (< 3 years)
	Vacancy	Some space still in use Building unoccupied < 3 years
	Features of new dwelling units	< 20 -person units (50 m2 each) can be made Layouts suitable for local target groups can't be implemented
	Expendability	Not horizontally extendable (neighboring buildings) No extra storey (pitched roof; insufficient load-bearing cap.) Basement cannot be built under building
	Technical	
	Maintenance	Building poorly maintained/looks in poor condition
	Dimensions of skeleton	Depth < 10 m Module of support structure < 3.60 m Distance between floors > 6.00 m
	Support structure (walls, pillars, floors)	Support structure is in poor/hazardous condition
	Facade	Can't be made to blend with surroundings or module > 5.40 m Façade (or openings in façade) not adaptable Windows cannot be reused/opened
	Installations	Impossible to install (sufficient) service ducts
	Cultural	
	Character	No character in relation to surrounding buildings Impossible to create dwellings with an identity of their own
	Access	Unsafe entrance, no clear overview of situation
	Legal	
	Environment	Presence of large amounts of hazardous materials Acoustic insulation of floors < 4 dB Very poor thermal insulation of outer walls and/or roof < 10% of floor area of new units gets incident daylight
	Requirements of Dutch building decree	No lifts in building (> 4 storeys), no lifts can be installed No (emergency) stairways Distance of new unit from stairs and/or lift " 50 m

Table 4. Gradual criteria as in the transformation meter (Geraedts & der Voordt, 2007)

D. Design matrix

The experimental design plan aims at generating an optimal orthogonal design. While the design is not optimal (16 is not a multiple of 3), the orthogonality is tested with the correlation matrix.

Symbol	Explanation
H	Housing unit
S	Surface
P	Price
PO	Private outdoor
F	Furnishing
BT	Building type

Table 5. Attributes labels

Treatment combinations	Design matrix					
	H	S	P	PO	F	BT
1	0	0	0	0	0	0
2	1	0	1	1	2	0
3	1	0	2	2	1	1
4	0	0	1	1	1	1
5	1	1	0	1	1	1
6	0	1	1	0	1	1
7	0	1	2	1	2	0
8	1	1	1	2	0	0
9	0	2	0	2	2	1
10	1	2	1	1	0	1
11	1	2	2	0	1	0
12	0	2	1	1	1	0
13	1	1	0	1	1	0
14	0	1	1	2	1	0
15	0	1	2	1	0	1
16	1	1	1	0	2	1

Table 6. Design plan

Correlation matrix						
	H	S	P	PO	F	BT
H	1					
S	0	1				
P	0	0	1			
PO	0	0	0	1		
F	0	0	0	0	1	
BT	0	0	0	0	0	1

Table 7. Design plan correlation matrix

E. Generating and randomizing choice sets

				Attributes levels for Alternative I						Attributes levels for Alternative II					
Choice set	Set	Alt I	Alt II	I_H	B_S	I_P	I_PO	I_F	I_BT	II_H	II_S	II_P	II_PO	II_F	II_BT
1	1	8	2	1	1	1	2	0	0	1	0	1	1	2	0
2	1	7	6	0	1	2	1	2	0	0	1	1	0	1	1
3	1	9	4	0	2	0	2	2	1	0	0	1	1	1	1
4	1	13	15	1	1	0	1	1	0	0	1	2	1	0	1
5	1	1	10	0	0	0	0	0	0	1	2	1	1	0	1
6	1	14	5	0	1	1	2	1	0	1	1	0	1	1	1
7	1	16	12	1	1	1	0	2	1	0	2	1	1	1	0
8	1	11	3	1	2	2	0	1	0	1	0	2	2	1	1
9	2	4	13	0	0	1	1	1	1	1	1	0	1	1	0
10	2	14	12	0	1	1	2	1	0	0	2	1	1	1	0
11	2	11	9	1	2	2	0	1	0	0	2	0	2	2	1
12	2	3	15	1	0	2	2	1	1	0	1	2	1	0	1
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…

Table 8. Choice sets coding

Alt I and Alt II are alternatives that will be presented to the decision maker at each choice set. Each alternative corresponds to a treatment combination.

Given that there are 16 treatment combinations that generate 8 choice sets, each respondent will receive a corresponding group of 8 questions. A total of 50 such groups of choice sets were generated for each of the Dutch and English survey.

				Attributes level labels for Alternative I						Attributes level labels for Alternative II					
Choice set	Set	Alt I	Alt II	I_H	B_S	I_P	I_PO	I_F	I_BT	II_H	II_S	II_P	II_PO	II_F	II_BT
1	1	8	2	One bedroom	50-75 m2	13-16 €/m2	Garden	Unfurnished	Office	One bedroom	30-49 m2	13-16 €/m2	Balcony	Fully furnished	Office
2	1	7	6	Studio	50-75 m2	17-20 €/m2	Balcony	Fully furnished	Office	Studio	50-75 m2	13-16 €/m2	None	Semi-furnished	Industrial
3	1	9	4	Studio	76-100 m2	9-12 €/m2	Garden	Fully furnished	Industria	Studio	30-49 m2	13-16 €/m2	Balcony	Semi-furnished	Industrial
4	1	13	15	One bedroom	50-75 m2	9-12 €/m2	Balcony	Semi-furnished	Office	Studio	50-75 m2	17-20 €/m2	Balcony	Unfurnished	Industrial
5	1	1	10	Studio	30-49 m2	9-12 €/m2	None	Unfurnished	Office	One bedroom	76-100 m2	13-16 €/m2	Balcony	Unfurnished	Industrial
6	1	14	5	Studio	50-75 m2	13-16 €/m2	Garden	Semi-furnished	Office	One bedroom	50-75 m2	9-12 €/m2	Balcony	Semi-furnished	Industrial
7	1	16	12	One bedroom	50-75 m2	13-16 €/m2	None	Fully furnished	Industria	Studio	76-100 m2	13-16 €/m2	Balcony	Semi-furnished	Office
8	1	11	3	One bedroom	76-100 m2	17-20 €/m2	None	Semi-furnished	Office	One bedroom	30-49 m2	17-20 €/m2	Garden	Semi-furnished	Industrial
9	2	4	13	Studio	30-49 m2	13-16 €/m2	Balcony	Semi-furnished	Industria	One bedroom	50-75 m2	9-12 €/m2	Balcony	Semi-furnished	Office
10	2	14	12	Studio	50-75 m2	13-16 €/m2	Garden	Semi-furnished	Office	Studio	76-100 m2	13-16 €/m2	Balcony	Semi-furnished	Office
11	2	11	9	One bedroom	76-100 m2	17-20 €/m2	None	Semi-furnished	Office	Studio	76-100 m2	9-12 €/m2	Garden	Fully furnished	Industrial
12	2	3	15	One bedroom	30-49 m2	17-20 €/m2	Garden	Semi-furnished	Industria	Studio	50-75 m2	17-20 €/m2	Balcony	Unfurnished	Industrial
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Table 9. Choice sets with labels

F. Questionnaire

F.1. Dutch questionnaire

Figure 5. Introduction page

Figure 6. Socio-demographic questions

Technische Universiteit Eindhoven University of Technology

Woonvoorkeuren.

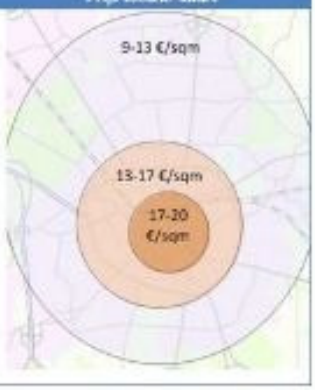
Dit gedeelte bestaat uit 8 vergelijkingen van verschillende woning alternatieven.

Zoals grootte, prijs en andere karakteristieken van de woning veranderen van de één naar het andere alternatief, kunt u overwegen dat:

- Alle woningen zijn te huur.
- Alle woningen hebben een B energie label
- Alle woningen hebben ten minste één parkeerplaats.
- Alle woningen zijn goed bereikbaar met de auto en openbaar vervoer. (Rekening gehouden met frequentie van de bus en afstand naar de bushalte)

De attributen die verschillen van het ene alternatief naar de ander zijn:

Karakteristiek	Verschillen	Uitleg
Woning	Studio	Verdeling van de vloer ruimte: Leef, eet en slap kamer gecombineerd (open vloer plan).
	Eén slaapkamer	Appartement aparte slaapkamer.
Oppervlakte (in m^2)	30-49 m^2	Totale oppervlakte van de woning.
	50-75 m^2	
	76-100 m^2	
Prijs (€/m^2)	9-12 €/m^2	Huur prijs verschil bepaald door de afstand tot de stads centrum. 9-12 €/m^2 voor 2.5-4.5 km tot stads centrum
	13-16 €/m^2	13-16 €/m^2 voor 1.1-2.4 km tot stads centrum
	17-20 €/m^2	17-20 €/m^2 voor 0-1 km tot stads centrum
Privé buiten plaats	Geen	Aanwezigheid van een privé buitenplaats/
	Balkon	
	Tuin	
Inrichting	Niet ingericht	Alleen keuken.
	Half ingericht	Keuken plus basis inrichting(bed, tafel, stoelen en klerenkast)
	Compleet ingericht	Alle voorzieningen (witgoed kleinhuishoudelijk enz. enz.)
Type gebouw	Kantoor	Oorspronkelijk gebruik van het gebouw
	Industrieel	



Een ingevuld voorbeeld vraag:

Karakteristieken	Alternatief I	Alternatief II	Geen
Woning	*Studio*	*Studio*	
Oppervlakte	*50-75 m2*	*30-49 m2*	
Prijs	*17-20 euro/m2*	*13-16 euro/m2*	
Privé buiten plaats	*Balkon*	*Balkon*	
Inrichting	*Niet ingericht*	*Half ingericht*	
Type gebouw	*Industrieel*	*Industrieel*	
Uw keuze	○	◉	○

Klik op "Volgende" om te beginnen.

Vorige | Volgende

Figure 7. Introduction to discrete choice experiment

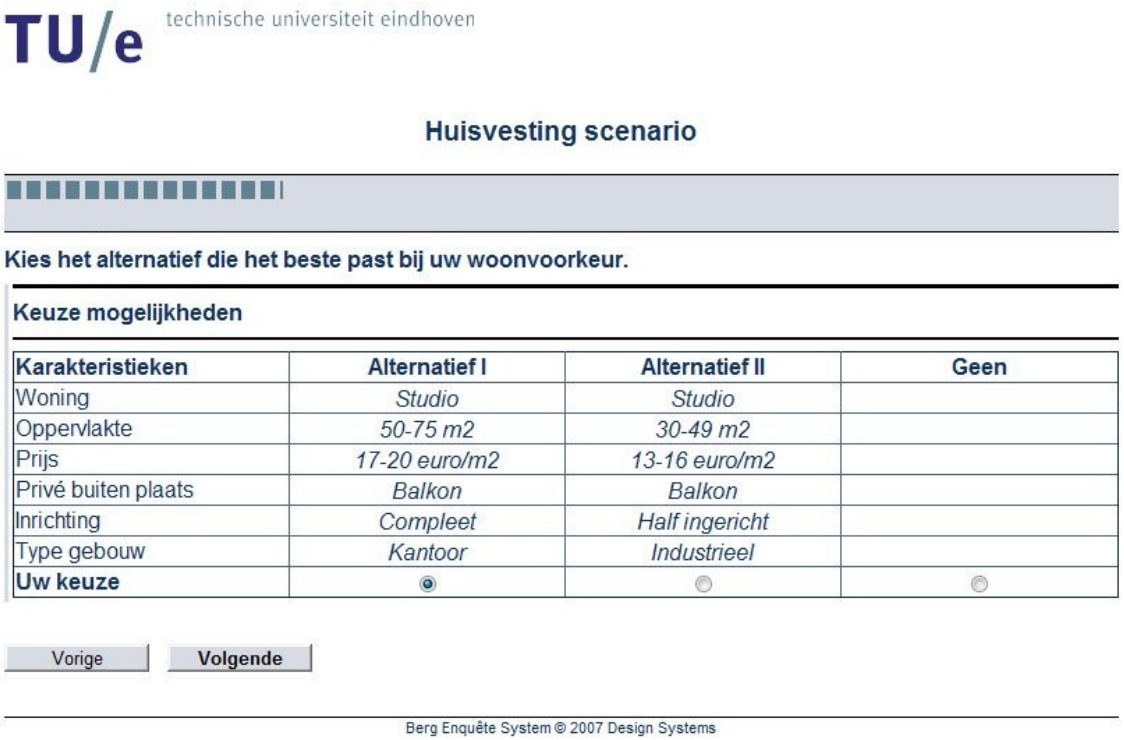


Figure 8. Example of 1 out of 8 choice tasks

Figure 9. Last page with thank you note

F.2. English questionnaire

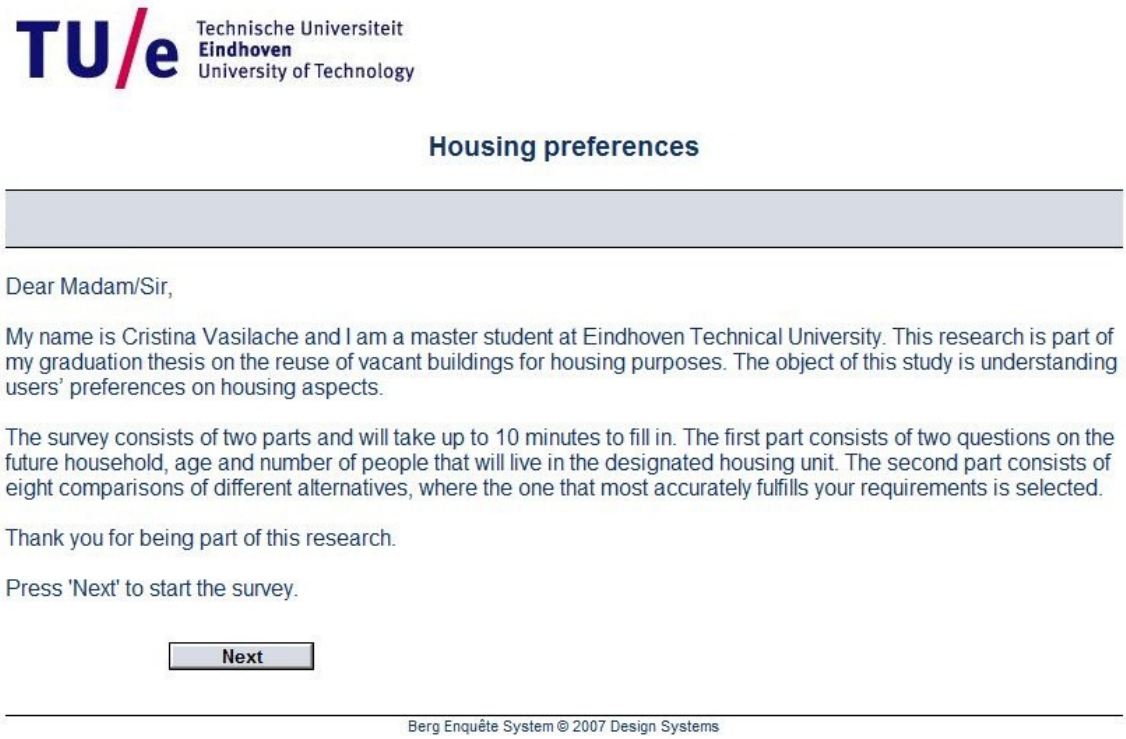


Figure 40. Introduction page

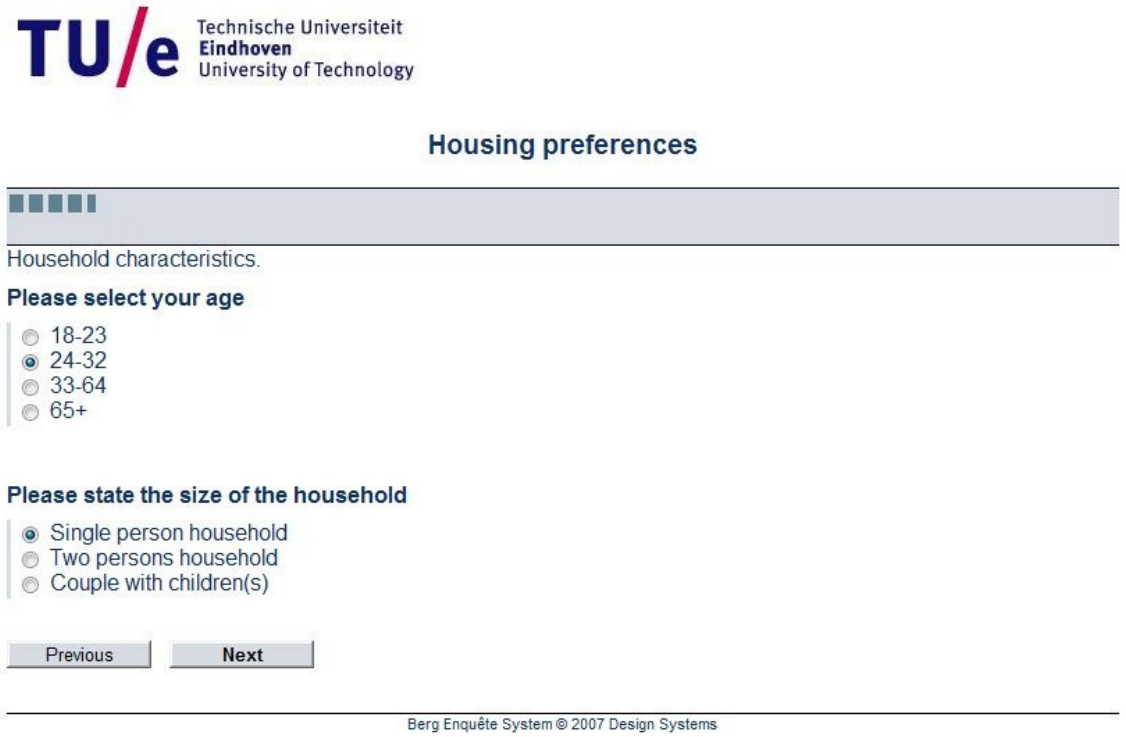


Figure 11. Socio-demographic questions

Technische Universiteit Eindhoven University of Technology

Housing preferences

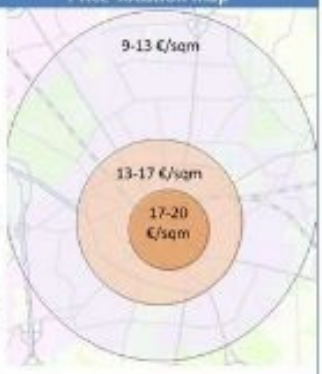
This part consists of 8 comparisons of different housing alternatives.

As dwelling size, price and other characteristics change along the survey, please consider that:
- All dwellings are for rent
- All dwellings have B energy label
- All dwellings have at least 1 parking space per 50 sqm of rentable area
- All dwellings are easily accessible by car or public transport (bus frequency and distance to bus stop)

The attributes that vary from one alternative to another are:

Attributes	Levels	Explanation
Housing unit	Studio	Partitioning of floor space: Living, dining and bedroom combined (open floor plan)
	One bedroom	Apartment with separate bedroom
Surface (in sqm)	30-49 sqm	Total surface of the housing unit
	50-75 sqm	
	76-100 sqm	
Price (€/sqm)	9-12 €/sqm	Rent price according to distance to city center: 9-12 €/sqm for 2.5-4.5 km to city center
	13-16 €/sqm	13-16 €/sqm for 1.1-2.4 km to city center
	17-20 €/sqm	17-20 €/sqm for 0-1 km to city center
Private outdoor	None	Availability of private outdoor: none, balcony or garden
	Balcony	
	Garden	
Furnishing	Unfurnished	Only kitchen furniture
	Semi-furnished	Kitchen plus basics (bed, table with chairs and wardrob
	Fully furnished	All amenities (washing machine, microwave and so on)
Building type	Office	The initial use of the building
	Industrial	

Price-location map



A filled in example question:

Features	Alternative I	Alternative II	None
Housing unit	*One bedroom*	*Studio*	
Surface	*50-75 sqm*	*50-75 sqm*	
Price	*13-16 euro/sqm*	*13-16 euro/sqm*	
Private outdoor	*None*	*Garden*	
Furnishing	*Fully furnished*	*Semi-furnished*	
Building type	*Industrial*	*Office*	
Your choice	◉	○	○

Press Next to start

Previous Next

Berg Enquête Systeem © 2007 Design Systems

Figure 12. Introduction to discrete choice experiment

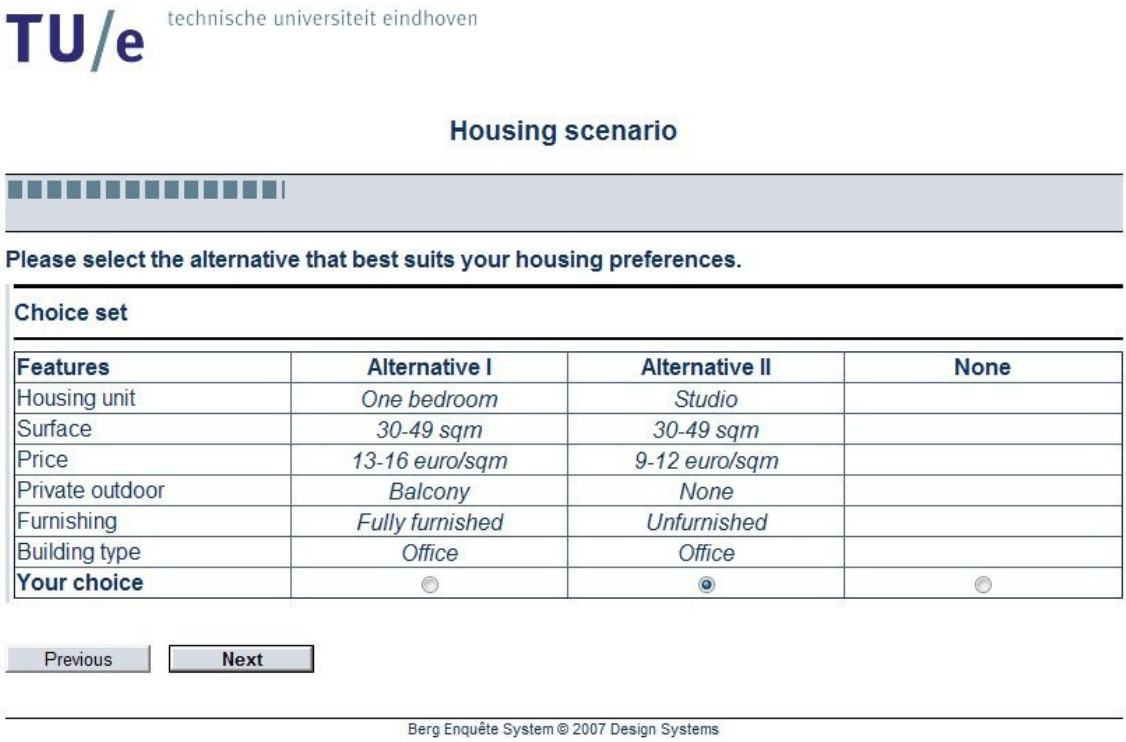


Figure 5. Example of 1 out of 8 choice tasks

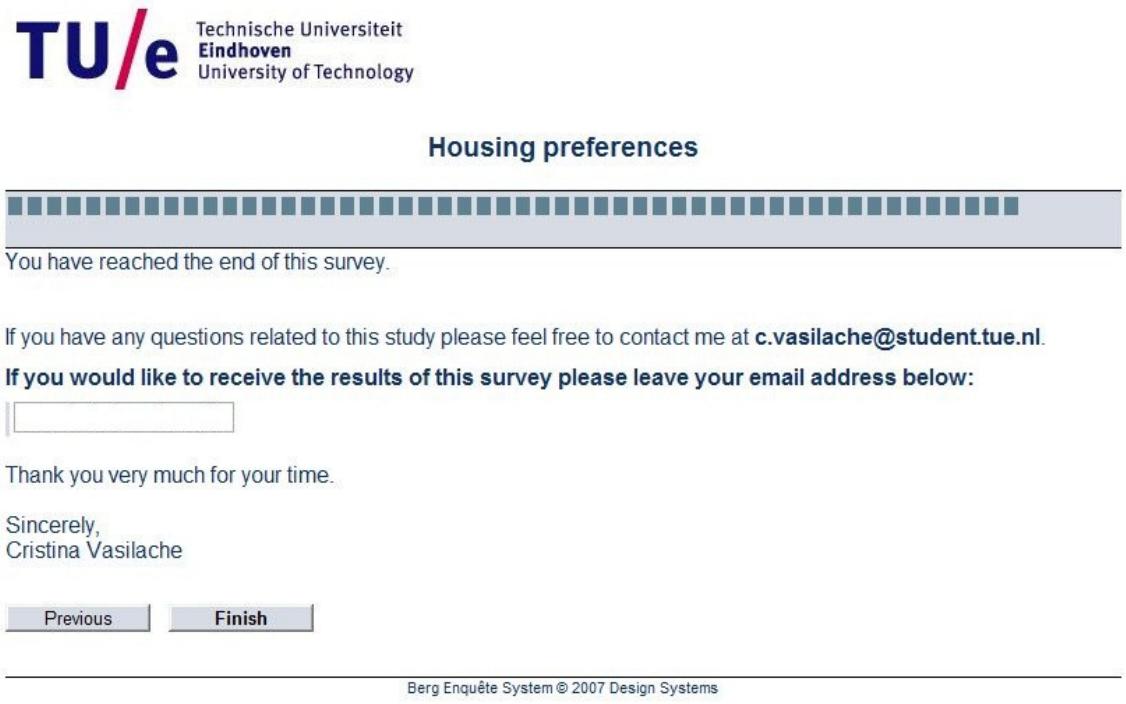


Figure 6. Last page with thank you note

G. Data analysis

G.1.Correlation matrix

	ID	ALTI	CSET	CHOICE	H	S1	S2	P1	P2	PO1	PO2	F1	F2	BT	AGE	HS
ID	**1.000**	0.000	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.025	-0.001
ALTI	0.000	**1.000**	0.000	-0.044	0.012	-0.038	-0.041	0.019	-0.001	-0.031	0.027	0.017	0.001	0.032	0.000	0.000
CSET	0.000	0.000	**1.000**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CHOICE	0.019	-0.044	0.000	**1.000**	0.065	0.122	0.073	-0.080	-0.038	0.165	0.104	0.001	0.017	0.022	-0.139	-0.127
H	0.000	0.012	0.000	0.065	**1.000**	-0.006	-0.003	0.000	0.008	0.000	0.000	0.000	0.000	-0.004	0.000	0.002
S1	0.000	-0.038	0.000	0.122	-0.006	**1.000**	0.426	-0.009	-0.004	0.000	0.000	-0.004	-0.008	0.006	0.000	0.000
S2	0.000	-0.041	0.000	0.073	-0.003	0.426	**1.000**	-0.004	-0.002	-0.006	-0.002	-0.007	-0.006	-0.001	0.000	0.000
P1	0.000	0.019	0.000	-0.080	0.000	-0.009	-0.004	**1.000**	0.426	0.000	0.000	-0.009	-0.004	0.006	0.000	0.000
P2	0.000	-0.001	0.000	-0.038	0.008	-0.004	-0.002	0.426	**1.000**	-0.006	-0.002	-0.004	-0.009	-0.001	0.000	0.000
PO1	0.000	-0.031	0.000	0.165	0.000	0.000	-0.006	0.000	-0.006	**1.000**	0.422	-0.004	-0.002	0.000	0.000	0.001
PO2	0.000	0.027	0.000	0.104	0.000	0.000	-0.002	0.000	-0.002	0.422	**1.000**	-0.008	-0.003	-0.004	0.000	0.001
F1	0.000	0.017	0.000	0.001	0.000	-0.004	-0.007	-0.009	-0.004	-0.004	-0.008	**1.000**	0.428	0.000	0.000	0.000
F2	0.000	0.001	0.000	0.017	0.000	-0.008	-0.006	-0.004	-0.009	-0.002	-0.003	0.428	**1.000**	-0.004	0.000	-0.002
BT	0.000	0.032	0.000	0.022	-0.004	0.006	-0.001	0.006	-0.001	0.000	-0.004	0.000	-0.004	**1.000**	0.000	0.001
AGE	-0.025	0.000	0.000	-0.139	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**1.000**	0.505
HS	-0.001	0.000	0.000	-0.127	0.002	0.000	0.000	0.000	0.000	0.001	0.001	0.000	-0.002	0.001	0.505	**1.000**

Table 10. Correlation matrix

KENWIB Summary – English

SUSTAINABLE BUILDING REUSE
Understanding user preferences for the housing market

Cristina Vasilache

Graduation program:
Construction Management and Urban Development 2012-2013

Graduation committee:
Prof. Dr. Ir. W.F. (Wim) Schaefer (Chairman TU/e)
Dr. Ing. B. (Brano) Glumac (Graduation Supervisor TU/e)
Dr. Q. (Qi) Han (Graduation Supervisor TU/e)

Date of graduation:
16-07-2013

ABSTRACT
Vacant buildings represent an insufficient exploited "gold mine" for future developments. By finding the future users preferences, vacant buildings can be reused and could generate a significant contribution towards a more sustainable development within the construction industry. Throughout this paper the environmental, social and urban benefits of building reuse are presented and a discrete choice experiment is used to indicate the most important attributes and the preferences of the potential future occupants.

Keywords: sustainability, building reuse, vacancy, discrete choice experiment, housing market, user preferences.

INTRODUCTION

Due to increased focus on sustainability and the current European Union targets to reduce the carbon footprint, the construction sector, as a major energy consumer, should also explore its options towards more sustainable solutions.

There are ongoing research works to investigate how to significantly reduce the consumption of energy and material flows in the building industry. In residential buildings, embodied energy in the building process represents between 30 and 100% (for passive houses) of total life cycle energy consumption. That is why, the adaptive reuse of existing building stock that has reached the end of its useful life, but not its physical life, is an important ingredient in the necessary change of the building industry in order to diminish its impact the environment and to conserve valuable resources for the future.

Vacant buildings represent an insufficient exploited "gold mine" for future developments. By finding the future users preferences, vacant buildings can be reused and can generate a significant contribution towards a more sustainable development within the construction industry.

When considering sustainability performances, the environmental benefits of building reuse are obvious from waste management and embodied energy perspective, but there are other two major factors that must be taken into account. These are the economic and social development in terms of its life cycle performance. Building vacancy is an emergent

problem of our society with repercussions not only on environmental level but on economic and social levels too. This research hopes to elucidate the specific attributes that would lead to success and increased feasibility of a building reuse project. Decreasing vacancy and encouraging developers to consider building reuse, as viable solution prior to demolition and new build, will lead to a more sustainable build environment.
Successful reuse and preventing vacancy in the building's new life must be ensured by uncovering users' preferences on specific attributes. Revealing attributes and quantifying their importance according to potential future occupants' preferences is the key to a sustainable reuse project that will prevent further future vacancy.

Problem definition and research question

According to statistics by 2030 more than 80% of the global population will live in cities. Inevitably, this puts a substantial pressure on urban land use, especially as, over time, the built environment becomes obsolete and needs replacing. By regenerating previously developed buildings to maximize the use of existing resources, the increasing pressure on urban areas can be answered. Of course this is not sufficient to solve such a great emergent problem, as urban agglomeration, but it makes the best out of the available inner city means and can diminish urban sprawl. The focus of the adaptive reuse of vacant buildings is on the ones from urban areas, justified by the high land value and the increasing losses caused by their vacancy.
"*The existence of unused buildings represents an underutilization of city resources, a missed opportunity for forms of urban development that might, with simple yet often untried technical solutions, make effective use of physical resources. These buildings represent a negative feature for the idea of the sustainable community*." (Ball, 2010) Reuse of an existing structure may be a project's major sustainable feature. But finding the right structure for reuse that also meets users' preferences in terms of location and attributes is the challenge.
Coping with vacancy by transformation into housing is the main issue of this research as the transformation of structurally vacant buildings may offer a solution to the tight Dutch housing market. This leads to the main research question:
What type of building is best suited to fulfill customer preferences in a building reuse project developed for the housing market?
During this research the focus is on building reuse for housing purposes. Both industrial and office buildings are tested against user preferences in order to asses which one proves to be best fitted for the new use.
In order to better understand vacancy coping possibilities, other sub questions are answered:
Sub question 1: What are the contributions of building reuse towards sustainability within the construction sector?
Sub question 2: What is the targeted market segment?
Sub question 3: What are the main attributes that future users look for in a reuse building project developed for the housing market?

Research design

The research comprises of 4 main blocks: a literature study, a case study, a discrete choice experiment and results analysis and conclusion.

By focusing on buildings reuse contribution to sustainability and current state of vacancy in the Netherlands and Eindhoven, the literature study tries to answer the question : Why does building reuse matter? Considering current market trends, a solution for diminishing the increasing levels of vacancy is proposed.
The case study is researching Eindhoven's potential for building reuse. Using the results of this case study and the market situation, a discrete choice experiment aims at finding future users' preferences. This is a market research using an online questionnaire, specially developed to give insight on possible future users expectations.
The last part of the thesis analyses the results of the market research, a conclusion is drown and recommendations are made.

WHY DOES BUILDING REUSE MATTER?

Adaptive reuse of buildings

'Adaptive reuse is a process that changes a disused or ineffective item into a new item that can be used for a purpose other than which it was built or designed for.' (DEH, 2004) While old buildings become unsuitable for their programmatic requirements, as progress in technology, politics and economics moves faster than the built environment, adaptive reuse comes in as a sustainable option for the reclamation of sites. In many situations, the types of buildings most likely to become subjects of adaptive reuse include industrial buildings, as cities become gentrified and the process of manufacture moves away from city; political buildings, such as palaces and buildings which cannot support current and future visitors of the site; and community buildings such as churches or schools where the use has changed over time.
Adaptive reuse is seen as an effective way of reducing urban sprawl and environmental impact of the build environment. By reusing an existing structure within a site, the energy required to create these spaces is lessened, as is the material waste that comes from destroying old sites and rebuilding using new materials. Through adaptive reuse, old, unoccupied buildings can become suitable sites for many different types of use.
There are often several criteria for deciding whether a building should be conserved and reused or just demolished, these generally concern historical and social value of the site, natural ecological condition of the site and potential for reuse of the structure, as in potential damage, and building's character and fitness for the new use.

Building reuse contribution to sustainability

Contribution of building reuse to a sustainable environment must be regarded from environmental, economical and socio-cultural points of view.
While economical benefits are still being debated, due to unforeseen expenses or costly interventions in order to update old buildings to current standards; the environmental and social ones are obvious.
An important debate currently running in the building industry concerns the relative costs and related benefits and constraints of reuse versus new build. Adaptive reuse may not be an economically viable option when the structure of a building requires extensive strengthening to be undertaken. Also the presence of contaminations by substances or other materials, such as asbestos, and nonconformance with current governmental health and safety standards can become barriers for adaptive reuse.

Environmental benefits of building reuse

One of the environmental benefits of building reuse is diminishing urban sprawl by maximizing the use of inner city resources, thus preserving greenfiels.

Another environmental benefit of building reuse, compared to demolish and new build, is the preservation of the embodied energy of the building. In residential buildings, embodied energy in the building process represents between 30 and 100% (for passive houses) of total life cycle energy consumption. The total life cycle energy consumption is made up of embodied energy and operational energy. Operational energy is the energy requirement of the building during its life from commissioning to demolition (not including maintenance or renovations). The embodied energy is the energy required to construct and maintain the premises. A brick wall for example, consists of the energy required to make the bricks, transport them to site, lay them, plaster them and (if necessary) paint and replaster over the life of the wall.

The reuse of building components is an alternative for the reduction of construction and demolition waste when renovating and demolishing buildings. By performing building deconstruction, the recovery of building parts as functional components such as bricks, windows, tiles is enabled. This is different from traditional demolitions in which parts are transformed into amorphous materials. The energy used in producing building materials corresponds to a considerable amount of the total energy consumed during the building life cycle, thus reusing and recycling buildings parts result in an energy saving that cannot be ignored.

But still, the most energy efficient solution considering the lifecycle of a building, with smallest environmental impact, is the reuse of the building, incorporating reuse of materials, components and forms of the building. The remaining parts of the building can be reused and form a new existence, together with the additions. This way, hardly energy is required to keep the materials in the built environment. With a rehabilitation design, there are always subtractions and additions. This process can be even forward improved by reducing the unnecessary subtractions and by minimizing additions. Further on, by not extracting natural resources for the additions, the designer will be preventing and preserving the natural resources.

Social benefits of building reuse

For society, vacancy presents problems of insecurity and social uncertainty and may bring about criminality ranging from vandalism and graffiti to break-ins, illegal occupancy and fires. Abandoned buildings are often unattractive, and it is not just the building itself, but their surrounding grounds too, and they affect other properties within a neighborhood by lowering property values, having a negative effect on community and neighborhood aesthetics. Other negative impact of vacancy on social level may concern purely economic aspects of well being as they trigger loss in tax revenues for the community as a whole. By adaptive reuse of these buildings, negative impacts are removed and replaced by the benefits of new developments. Also, adaptive reuse can restore and maintain the heritage significance of a building and help to ensure its survival

Current vacancy levels

Though it seems unrealistic for a densely populated country like Netherlands, to face vacancy, the numbers are increasing day by day, for example: a farm a day, two churches a week and so on. (Vacant NL, 2010)

In Netherlands, on industrial level there is 3.5% vacancy, leading to above 9 million sqm of vacant estate; for office 14.6% vacancy, which is considerably higher than 8% assumed normal on a healthy property market and resulting in almost 8 million sqm of vacant property; and for retail there is a 5.9% vacancy rate resulting in almost 2 million sqm.
The research is focusing on office and industrial buildings, as they generate the highest amount of vacant estate.
In Eindhoven, the office market has 13% vacancy rate, below the national level and still decreasing, and a 9% vacancy for industrial property, the second highest vacancy rate in Netherlands, with continuous increasing tendency.

Proposed solution

When faced with vacancy, property owners have 5 different options of coping with this problem. Preservation and waiting for better times to come, thus generating maintenance costs and susceptibility of the building to vandalism, squatting and degradation. Renovation or upgrading, resulting in disruption of building use and income of revenues, might be expensive and does not guarantee the influx of new users if vacancy is due to location characteristics. Selling, on a lower price that initially expected, because selling a vacant building results in smaller prices than for a fully occupied one. Demolishment and new build, which is an expensive solution and a waste of materials if the building is in a good state. Transformation/reuse of the building, resulting in disruption of use for a shorter period, but must also consider that location is suited for the new use.
Considering the tight Dutch housing market and the continuous migration toward urban areas, vacant buildings are proposed for reuse to support the increasing housing demand and as an adjoining solution to urban sprawl.
In Netherlands, the shortage of dwellings is approximately 2.5% of the total housing stock and with the increasing number of households (CBS, 2010) and a large part of the housing stock that needs to be replaced, will lead to an increase of demand if the production of housing is not speeded. According to CBS, Central Statistical Office , the number of persons per household is changed, from an average of 3.93 person/household in 1950 to 2.22 person/household nowadays and a predicted further decrease to 2.09 persons by the year 2040 (CBS, 2005). Following this trend, the demand for single occupancy dwellings (like e.g. apartments) will increase.
Transformation of structurally vacant buildings into housing can help balance the housing supply and at the same time create redevelopment possibilities for these buildings of which the current function no longer satisfies market demands.
In such a tight housing market, newcomers have a difficult time finding accommodation. So the target groups is composed of lower income groups like students and starters, singles or couples. Smaller housing units developed for starters, can also be suitable for elderly, so they are also included as possible market segments.

BUILDING REUSE POTENTIAL IN EINDHOVEN

In order to test Eindhoven's potential for building reuse, a list of vacant buildings was created using information from RealNext (2013) and Funda-in-Business (2013). Obviously not all vacant buildings are suitable for redevelopment into housing and through literature a wide variety of tools and instruments have been developed in order to analyze buildings' transformation potential and feasibility using a range of criteria.

Wilkinson, James and Reed (2009) made an extensive literature study about the attributes identified in previous researches considering risks which need to be acknowledged and managed in reuse projects. These building adaptation criteria are summarized as age, condition, depth of the building, envelope and cladding, structure, building services, internal layout, flexibility for a range of differing uses and functional equipment, purpose of the built buildings, location, perceived heritage value, size, accessibility, proactive policy making/legislation (planning and building codes including fire), acoustic separation, user demand and site conditions. (Wilkinson, James, & Reed, 2009)

The adaptive reuse potential (ARP) is a conceptual framework, which requires an estimate of the expected physical life of the building and the current age of the building, both reported in years. It also requires an assessment of physical, economic, functional, technological, social and legal obsolescence. Here the economic variable is tightly related to the geographic location of the building relative to a major city, central business district or other primary market or business hub. (Langston, 2012)

There is also a 10 performance criteria tool developed and used to assess the level of satisfaction that a residential building can offer to its users, developed by Ilesanmi (2010). These criteria concern: external visual quality of buildings, maintenance quality of buildings, structural quality of buildings, detailing quality of buildings (doors, windows, ceilings, roofing members), quality of building services and, quality of estate roads, quality of landscaping, quality of semi-public open spaces, quality of environmental layout, quality of the location. The first five criteria relate to the buildings, while the next five deal with their location. They cover aesthetic, functional and technical quality. (Ilesanmi, 2010)

In its book on building adaptation, James Douglas (2006) published a series of checklists developed by Building Research Establishment (BRE), BRE Good Building Guides. These checklists focus mainly on the buildings characteristics and their potential of transformation, and do not approach the location or neighborhood characteristics. (Douglas, 2006)

For this study only a quick-scan is used to select the case studies, using an adaptation of the “transformation meter” developed by Geraedts and Van der Voordt (2003) (2007) (Remøy & Voordt, 2007). This tool, initially developed for office buildings, uses physical aspects of buildings and their location in order to estimate their value and suitability for housing, also considering organizational and market aspects. While most of the aspects related to the internal building characteristics can be modified, the location criteria can be the source to a negative transformation advice. For transformation to be a feasible way of coping with structural vacancy, location criteria should be met. It must also be taken into consideration that the financial feasibility of the transformation projects varies greatly depending on the targeted market segment.

The initial list was filtered using aspects related to location and building characteristics, like floor height and building depth, which were unanimously considered most important throughout literature.

Location is the most important, as it is the only aspect about the building that can’t be modified no matter the amount of investment. If located in the city centre, in housing areas or on the edges of such areas, they have high possibility of suitability for transformation into housing, while transformation of buildings in mono-functional parks will need further consideration, as they need to be considered on a large scale urban area development. Other aspects related to location that must be considered are pollution, noise, air-quality, travel time, parking possibilities, level of facilities and services in or near the location, green area and the mix of functions are the most important.

From building characteristics point of view, structures must provide the minimum allowable floor height for housing units and their depth must allow day light inside the dwelling.
Taking these aspects into consideration, a final list with a total of 11 buildings with reuse potential was created, showing that Eindhoven has high potential for such redevelopments.

DISCRETE CHOICE EXPERIMENT

The discrete choice approach requires that a representative sample of customers make choices in simulated situations derived from realistic variations of market offerings. Performing a discrete choice model experiment typically comprises of three steps. First, using market assessment, case studies, industry data, literature reviews and other information sources, a list of drivers that are believed to influence customers' decisions is compiled. Once the list of choice drivers, attributes, is finalized, experimental design techniques are used to develop many realistic versions of alternative offerings. Next, choice experiments are constructed that ask respondents to select one out of two or more alternatives available to them in a series of choice sets. In the final phase, econometric models based on responses from a representative sample of potential future customers are used to identify empirical key patterns in the survey responses, providing a relative weighting, for each attribute and its levels. Developers and managers can then select the optimal combination of attributes to develop a profitable and sustainable value proposition that, under normal competitive constraints, will maximally leverage their available resources. (Verma & al, 2009)
For the market research, an online questionnaire was developed both in English and Dutch, and it was distributed through social media. All respondents were presented with a scenario, developed according to the targeted market segment. Because the target market consists of lower income groups, the housing units are for rent and the energy label is B, in order to keep the redevelopment costs and also the rent prices lower. All housing units have parking and are easily accessible, as required for the selection of the case studies in Eindhoven.
The attributes used were: type of housing unit, surface of the dwelling, price that was defined in relation to the distance to city center, availability of private outdoor, furnishing and type of building.

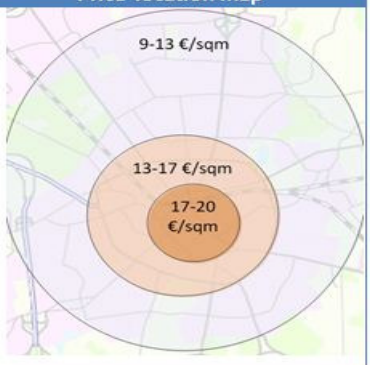
Attributes	Levels	Explanation	Price-location map
Housing unit	Studio One bedroom	Partitioning of floor space: Living, dining and bedroom combined (open floor plan) Apartment with separate bedroom	
Surface (in sqm)	30-49 sqm 50-75 sqm 76-100 sqm	Total surface of the housing unit	
Price (€/sqm)	9-12 €/sqm 13-16 €/sqm 17-20 €/sqm	Rent price according to distance to city center: 9-12 €/sqm for 2.5-4.5 km to city center 13-16 €/sqm for 1.1-2.4 km to city center 17-20 €/sqm for 0-1 km to city center	
Private outdoor	None Balcony Garden	Availability of private outdoor: none, balcony or garden	
Furnishing	Unfurnished Semi-furnished Fully furnished	Only kitchen furniture Kitchen plus basics (bed, table with chairs and wardrob All amenities (washing machine, microwave and so on)	
Building type	Office Industrial	The initial use of the building	

Figure 7. Researched attributes and their levels

Building type attribute was introduce because it was of interest to see how the initial use of the building affects the decision of the respondents, as building type can influence not only the exterior appearance of the building but also the internal layout and the character of the

housing unit. If respondents reject a certain building type, this has a great influence on the number of buildings suitable for housing transformation that Eindhoven has to offer.
Respondents were presented with 8 choice sets each consisting of two alternatives and a "no choice" alternative.

Features	Alternative I	Alternative II	None
Housing unit	*One bedroom*	*Studio*	
Surface	*50-75 sqm*	*50-75 sqm*	
Price	*13-16 euro/sqm*	*13-16 euro/sqm*	
Private outdoor	*None*	*Garden*	
Furnishing	*Fully furnished*	*Semi-furnished*	
Building type	*Industrial*	*Office*	
Your choice	◉	○	○

Figure 8. Example of choice set

Next to the discrete choice questions, respondents were asked to answer some questions regarding their socio-demographic characteristics (SDC), stating their age and size of the household, in order to generate interest groups. Though our target group consisted of singles or couples, many respondents with households with children took part in the survey.

IDENTIFYING GROUP PREFERENCES

In total there were 230 respondents, above the minimum threshold of 200. The market group of adults with children (between the ages of 33 and 64) was highly represented among respondents, but also had the highest percentage of "no choice" responses. This was expected as they are the least probable to be interested in the small housing units.
The minimum number of respondents of 30 was reached for all age cathegories except the 65+ group, where only 2 respondents addressed the questionnaire, so this market segment, elderly, can't be further modeled.
4 blocks of multinomial logit model (MNL) were generated. The first model was designed with all respondents in one group, the second grouped respondents by age, the third grouped respondents by age and household and the last one where respondents were grouped by household size. Goodness of fit increases with the increase in heterogeneity of the group, so the focus is on the third block, where respondents are grouped also by age and household size, generating 5 groups: 18-24 singles, corresponding to students; 25-32 singles and couples, corresponding to starters; and 33-64 couples and families with children, corresponding to adults.

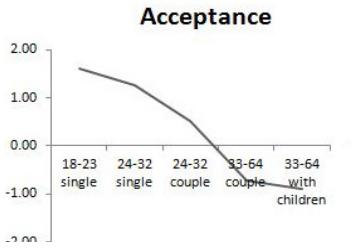


Figure 3. Acceptance variation

The general attitude towards the presented alternatives was modeled. This varies from + to -, showing that age group 33-64, couples or with children, are not interested in these type of developments, while younger age groups show a high level of acceptance. This was expected as adult families were not part of the targeted groups. A positive outcome is that the targeted groups, students, young singles and couples, have a positive attitude towards this type of redevelopment. Further on, only the targeted market segments are analyzed.

The table from Fig. 4, images the preferences for each attribute level by targeted market segments. Here the non-linearity of the estimated attributes levels is highly visible, and so are the differences in preferences between groups.

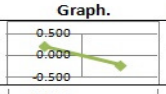
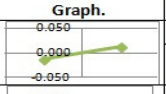
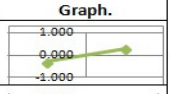
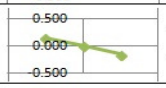
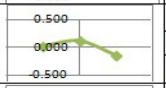
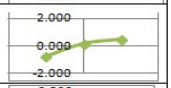
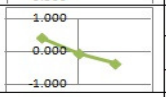
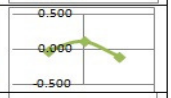
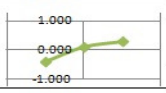
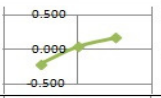
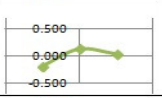
Attribute	Level	18-23 Coeff.	Single Sig.	Graph.	24-32 Coeff.	Single Sig.	Graph.	24-32 Coeff.	Couple Sig.	Graph.
Housing unit	Studio	0.216			-0.013			-0.288		
	One bedroom	-0.216	0.079		0.013	0.853		0.288	0.001	
Surface	30-49 sqm	0.147			0.024			-0.691		
	50-75 sqm	0.005	0.974		0.119	0.187		0.202	0.069	
	76-100 sqm	-0.151	0.375		-0.143	0.172		0.489	0.000	
Price	9-12 €/sqm	0.518			0.418			-0.018		
	13-16 €/sqm	0.055	0.696		-0.054	0.565		0.120	0.293	
	17-20 €/sqm	-0.574	0.002		-0.364	0.002		-0.102	0.457	
Private outdoor	None	-0.400			-0.658			-0.745		
	Balcony	0.110	0.431		0.314	0.000		0.066	0.544	
	Garden	0.290	0.073		0.344	0.001		0.679	0.000	
Furnishing	Unfurnished	-0465			-0.210			-0.181		
	Semi furnished	0.218	0.159		0.041	0.663		0.133	0.237	
	Fully furnished	0.247	0.159		0.169	0.109		0.048	0.713	
Building type	Office	0.004			-0.100			-0.058		
	Industrial	-0.004	0.975		0.100	0.136		0.058	0.482	

Figure 4. Market preferences

For students, or low income singles, the most significant attribute is price. This target group is looking for the cheapest housing possibility, with a preference for studios. The availability of a garden is also an important factor for this group, as it is for all groups within this model

For starters, 24 to 32 years-old singles, the acceptance is lower than for the previous group, but still high. Price and private outdoor are statistically significant, with similar preference for either balcony or garden.

Young couples with two incomes, have the lowest positive acceptance level, but still show a positive attitude towards these renting units. They are more interested in the division of the housing unit (with preference for separate bedroom), bigger surface and private outdoor, with an obvious preference for garden. For this group, price is not among the outmost significant attributes.

The results of the MNL model can be easily incorporated into a decision support system (DSS) so that the impact of changes in the levels of attributes on choice shares can be predicted. Also tradeoffs in different attributes levels can be tested in order to find the most attractive solution, or to test market competition. By introducing data of different alternatives, probabilities or utilities generated by them can be predicted

CONCLUSION AND DISCUSSIONS

From the discrete choice experiment it resulted that the targeted market segments (18-23 singles, 24-32 singles and couples) are open to the idea of living in reused buildings, rejecting neither industrial nor office ones. The fact that none of the industrial or office buildings are considered as a negative feature of the redevelopment represents a positive outcome as it results in an increase of the number of buildings that can be considered for transformation.

Due to the high contribution to sustainable urban development, building reuse should be encouraged by municipalities, by being cooperative and allowing exceptions from the zoning plan or facilitating legal procedures. Another way for municipalities to encourage such redevelopments is by limiting access for developers to greenfields, and forcing them to look for project opportunities within the city boundaries and by lowering land lease for vacant buildings.

Further research can be developed to establish if adult families reject the proposed housing units due to the size of the household or due to the building reuse. By increasing the size of the housing unit other market segments can be reached and their interest in such redevelopments can be tested.
Another implication of the findings of this research can be the development of a integrated support tool that assists developers in choosing the best structure for reuse, by acknowledging not only the best solution from the investor's point of view (building transformation potential), but the future users' preferences as well.
Taking into consideration that society is changing in a faster rhythm than the build environment, architects should develop buildings that are easily adaptable, thus buildings should be regarded not as a finished product, but as an ongoing process as part of a dynamic built environment.

ACKNOWLEDGEMENTS
This research would not have been possible without the contribution of the respondents for the online survey and without the good guidance of Eindhoven University staff, Dr. Brano Glumac and Prof. Wim Schaefer.

REFERENCES
Ball, R. (2010). *Developers, regeneration and sustainability issues in the reuse of vacant industrial buildings*. Building Research & Information , 140-148.
DEH. (2004). *Preserving our past, building our future.* Melbourne: Commonwealth of Australia-Department of the Environment and Heritage.
Douglas, J. (2006). *Building adaptation*. Oxford, UK: Elsevier Ltd.
Harmsen, H. (2008). *De Oude Kaart van Nederland*. Den Haag: Atelier Rijksbouwmeester.
Ilesanmi, A. O. (2010). *Post-occupancy evaluation and residents' satisfaction with public housing in Lagos, Nigeria.* Journal of Building Appraisal, vol. 6 , 153-169.
Langston, C. (2012). *Validation of the adaptive reuse potential (ARP) model using iconCUR*. Facilities, vol. 30 , 105-123.
Opoku, R. A., & Abdul-Muhmin, A. G. (2010). *Housing preferences and attribute importance among low-income consumers in Saudi Arabia.* Habitat International 34 , 219-227.
REMØY, H. T. (2010). PhD thesis: *Out of Office*. Deft, Delft Technical University.
Verma, R., & al., e. (2009). *Predicting customer choice in services using discrete choice analysis*. IBM Systems Jurnal, vol 47 , 179-191.
Wilkinson, S. J., James, K., & Reed, R. (2009). *Using building adaptation to deliver sustainability in Australia*. Structural Survey, vol. 27 , 46-61.

CRISTINA VASILACHE

Born in 1985 in a family of civil engineers, Cristina began her engineering studies in Romania in 2004, graduating as a structural engineer in 2009. Willing to further her studies, she turned to the management field of the construction industry. Combining both her interest in buildings and management, she researched the potential of building reuse as a solution for a more sustainable build environment.

2004-2009 Bachelor in Structural Engineering (Romania)
2009-2010 Master in Construction Management (Romania)
2009-2011 Assistant Quantity Surveyor at SC Stibina SRL (Romania)
2011-2013 Master in Construction Management and Engineering (TU/e)
2013-Now Proposal Engineer at Tideway Offshore Solutions (Breda, Netherlands)

KENWIB Summary – Dutch

DUURZAAM HERGEBRUIK VAN GEBOUWEN
Inzicht in de gebruikersvoorkeuren voor de woningmarkt

Cristina Vasilache

SAMENVATTING

Leegstaande gebouwen vormen een onvoldoende benutte "goudmijn" voor toekomstige gebiedsontwikkeling. Door voorkeuren te ontdekken van de toekomstige gebruikers, kunnen leegstaande gebouwen worden hergebruikt en een belangrijke bijdrage leveren aan een meer duurzame ontwikkeling binnen de bouwsector.

INTRODUCTIE

Vanwege toegenomen aandacht voor duurzaamheid en de huidige doelstellingen van de Europese Unie om de CO_2 footprint te verminderen, moet de bouwsector, als een belangrijke energieverbruiker, haar mogelijkheden naar meer duurzame oplossingen verkennen.

Aangepast hergebruik van bestaande gebouwen die niet meer courant zijn maar niet het einde van hun fysieke leven hebben bereikt kunnen een belangrijk ingrediënt zijn voor de noodzakelijke veranderingen van de bouwsector om haar afdruk op het milieu te verminderen en waardevolle grondstoffen voor de toekomst te behouden.

Leegstaande gebouwen vormen een opkomend probleem voor onze samenleving met als gevolg dat niet alleen op het milieu vlak, maar ook op economisch en sociaal niveau zich problemen voordoen. De afname van leegstaande gebouwen en het stimuleren van ontwikkelaars om deze her te gebruiken voorafgaand aan sloop of nieuwbouw, zal leiden tot een duurzamere bouwindustrie.

Volgens statistieken zal in 2030 meer dan 80% van de wereldbevolking in steden wonen. Door nieuw leven in te blazen in eerder ontwikkelde gebouwen met als doel het gebruik van bestaande middelen te optimaliseren, kan de toenemende druk op stedelijke gebieden worden gereduceerd. Vanzelfsprekend is dit niet voldoende om grote probleem als stedelijke agglomeratie op te lossen, maar herontwikkeling maakt het optimale gebruik van de beschikbare middelen in de binnenstad mogelijk en kan stadsuitbreiding verminderen. De focus op het adaptief hergebruik van leegstaande gebouwen is met name nuttig in stedelijke gebieden. Dit wordt veroorzaakt door de hoge waarde van de grond en de toenemende verliezen als gevolg van de leegstand.

Hergebruik van een bestaande gebouwstructuur kan een belangrijke duurzame doelstelling van een project zijn. De uitdaging echter is het vinden van de juiste aanpak voor herontwikkeling die tevens voldoet aan voorkeuren van gebruikers in termen van locatie en gebouwkenmerken (attributen). Het omgaan met leegstand door transformatie naar woningen is de belangrijkste kwestie van dit onderzoek. De transformatie van structureel leegstaande gebouwen een oplossing kan bieden voor de krappe Nederlandse woningmarkt. Dit leidt tot de onderzoeksvraag:

Welk type gebouw is het meest geschikt om de wensen van de klant te vervullen in een project waarin gebouwen herontwikkeld worden voor de woningmarkt?

Zowel industriële als kantoorgebouwen worden in het onderzoek getoetst aan gebruikersvoorkeuren om er achter te komen welk type het meest geschikt is voor de nieuwe bestemming.

Het onderzoek bestaat uit 4 blokken: een literatuurstudie, een case study, een discrete choice-experiment en analyse van de resultaten met de conclusies. De literatuurstudie helpt de vraag te beantwoorden: In hoeverre levert een focus op op de hergebruik van gebouwen een bijdrage aan duurzaamheid en het huidig niveau van leegstand in Nederland en Eindhoven. Gelet op de huidige trends in de markt worden oplossingen voorgesteld met als doel de toenemende leegstand te beperken. Daarnaast worden specifieke marktsegmenten gedefinieerd.
Het case study onderzoek richt zich op de mogelijkheden om gebouwen her te gebruiken in Eindhoven. De resultaten van dit case study onderzoek en de marktsituatie vormen de basis voor een discrete choice-experiment met als doel voorkeuren van de toekomstige gebruikers te vinden.. Het experiment wordt uitgevoerd met behulp van een online enquête. De enquête is speciaal ontwikkeld om inzicht te krijgen in de verwachtingen van de potentiële toekomstige gebruikers. In het laatste deel van de thesis worden de resultaten van de enquête geanalyseerd, een conclusie getrokken en aanbevelingen geformuleerd.

INHOUD

Bijdrage hergebruik van gebouwen aan duurzaamheid

De bijdrage van hergebruik aan een duurzaam milieu moet worden beschouwd vanuit milieu-, economisch en sociaal-cultureel oogpunt. Ondanks dat over de economische voordelen ten gevolge van onvoorziene uitgaven of dure ingrepen om de oude gebouwen te updaten naar de huidige standaar nog wordt gediscussierd, zijn de milieu-aspecten en sociale voordelen duidelijk.
Adaptief hergebruik wordt gezien als een effectieve manier om het stedelijke wildgroei en milieu-impact van de gebouwde omgeving tegen te gaan. De gebruikte energie tijdens het bouwproces vertegenwoordigt tussen 30 en 100% (voor passieve huizen) van het energieverbruik in de totale levenscyclus. Hergebruik van een bestaande structuur op een bouwplaats vermindert de energie die nodig is om nieuwe ruimtes te creëren. Reduceert het materiaalafval wat afkomstig is van sloop en maakt herbouwen met gebruikte materialen mogelijk. Met adaptief hergebruik kunnen oude, leegstaande gebouwen geschikte locaties worden voor veel verschillende gebruikseinddoelen.
Leegstand resulteert voor de maatschappij vaak in onveiligheid, sociale onzekerheid en kan leiden tot criminaliteit variërend van vandalisme tot graffiti, inbraak, illegale bezetting of branden. Verlaten gebouwen zijn vaak onaantrekkelijk, verlagen de waarde van omringend ontroerend goed, hebben een negatieve impact op de gemeenschap en leiden op economisch vlak tot verlies van belastinginkomsten. Middels adaptief hergebruik van deze gebouwen, kunnen negatieve effecten verdwijnen of omgekeerd worden door de voordelen van nieuwe ontwikkelingen. Daarnaast kan adaptief hergebruik de erfgoedbetekenis van een gebouw herstellen, onderhouden en helpen het voortbestaan te verzekeren.

Huidige leegstand

Hoewel het voor een dichtbevolkt land als Nederland opmerkelijk is om met leegstand geconfronteerd te worden, stijgen de aantallen met de dag. Bijvoorbeeld: een boerderij per dag, twee kerken per week en zo voort. In Nederland, is er op industrieel niveau 3,5% leegstand, wat tot meer dan 9 miljoen vierkante meter aan leegstaande gebieden leidt. Kantoor leegstand is goed voor 14,6% (8 miljoen vierkante meter), hetgeen aanzienlijk hoger is dan 8%, wat normaal is in een gezonde vastgoedmarkt en voor de functie detailhandel is er 5,9% leegstand wat resulteert in bijna 2 miljoen vierkante meter.

Het onderzoek zal zich richten op kantoor-en industriële gebouwen omdat deze de hoogste leegstand van vastgoed veroorzaken. In Eindhoven is de kantorenmarkt onderhevig aan 13% leegstand en betreft de leegstand van industriële eigendom 9%, wat leidt tot de tweede plaats op gebied vanleegstand in Nederland.

Voorgestelde oplossing

Gezien de krappe Nederlandse huizenmarkt en de voortdurende migratie naar stedelijke gebieden, komen leegstaande gebouwen in aanmerking voor hergebruik om de toenemende vraag naar woningen te ondersteunen en als medeoplossing te dienen voor stadsuitbreiding. In Nederland is het tekort aan woningen ongeveer 2,5% van de totale woningvoorraad. De transformatie van structureel leegstaande gebouwen in woningen kan de balans in het woningaanbod ondersteunen. In 'een dergelijke krappe woningmarkt hebben nieuwkomers hebben het moeilijk met het vinden van huisvesting. De doelgroepen komen voort uit de lagere inkomensgroepen zoals studenten en starters, alleenstaanden of stellen. Kleinere woningen, die voor starters ontwikkeld zijn, kunnen ook geschikt zijn voor senioren. De laatste groepdie als marktsegment in het onderzoek opgenomen wordt.

Gebouwhergebruik potentieel in Eindhoven

Om de mogelijkheden met betrekking tot hergebruik van gebouwen in Eindhoven te onderzoeken, is een lijst van leegstaande gebouwen gemaakt met behulp van informatie uit RealNext (2013) en funda-in-Business (2013). Uiteraard zijn niet alle leegstaande gebouwen geschikt voor herontwikkeling tot woningen. Door middel van literatuurstudie, is een breed scala aan gereedschappen en instrumenten die worden gebruikt om de transformatiepotentie van gebouwen te analyseren vastgesteld.

De initiële lijst is gefilterd op aspecten die verband houden met locatie en gebouw kenmerken zoals ruimtehoogte en bouwdiepte die unaniem als belangrijkste werden beschouwd in literatuur. Locatie wordt gezien als het belangrijkste omdat dit het enige aspect is van het gebouw wat niet kan worden gewijzigd ongeacht een investering. Uit het oogpunt van gebouwkenmerken, moet de gebouwstructuur de minimaal toegestane kamerhoogte voor woningen bieden en diepte om daglicht in de woning toe te laten.

Rekening houdend met deze aspecten, is een definitieve lijst is gemaakt met een totaal van 11 gebouwen met potentieel voor hergebruik. Uit de studie blijkt dat Eindhoven een groot potentieel voor dergelijke herontwikkelingen heeft.

Discrete choice-experiment

De discrete choice benadering vereist dat een representatief aantal respondenten keuzes maken in gesimuleerde situaties die afgeleid zijn van realistische varianten van de aanbodmarkt. Door gebruik te maken van de antwoorden zijn de belangrijkste patronen in de antwoorden op de enquête geïdentificeerd en er wordt per eigenschap en niceau een relatief gewicht gegeven.

De enquête is uitgevoerd met behulp van een online vragenlijst. Alle respondenten zijn geconfronteerd met een scenario ontwikkeld volgens het beoogde marktsegment. De attributen die werden gebruikt waren: type wooneenheid (studio of appartement met een slaapkamer), oppervlakte van de woning (30-49m^2, 50-75m^2, 76-100m^2), prijs die werd vastgesteld in relatie tot de afstand tot het centrum (9-12 euro/m^2, 13-16 euro/m^2, 17-20 euro/m^2), beschikbaarheid van eigen buitenruimte (geen, balkon, tuin), meubels (ongemeubileerd, gestoffeerd, gemeubileerd) en type gebouw (kantoor of industriël).

Respondenten kregen 8 keuzesets voorgelegd, elk bestaande uit twee alternatieven en een "geen keuze" alternatief.
Naast de discrete choice taken, is de respondenten gevraagd om een aantal vragen over hun socio-demografische kenmerken (SDC) te beantwoordenom belangengroepen te genereren zoals leeftijd en grootte van het huishouden.

Resultaten

In totaal hebben 230 respondenten de enquête beantwoord, ruim boven het minimum aantal van 200. Vijf groepen respondenten zijn gedifferentieerd met behulp van leeftijd en grootte van het huishouden: 18-24 singles (studenten), 25-32 (starters) singles en stellen en 33-64 (volwassenen) stellen en gezinnen met kinderen.
De leeftijdsgroep 33-64 (stellen of gezinnen met kinderen) zijn niet geïnteresseerd in dit soort ontwikkelingen, terwijl de jongere leeftijdsgroepen in het marktsegment, een positieve houding tonen. De onderstaande tabel, presenteert de voorkeuren van de marktsegmenten voor elk attribuut level. Hier is de niet-lineariteit van de geschatte attributenniveaus en de verschillen in voorkeuren tussen groepen goed zichtbaar.

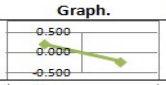
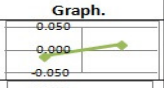
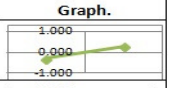
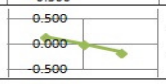
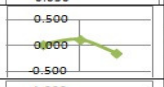
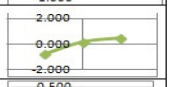
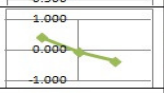
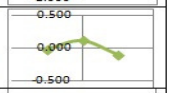
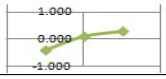
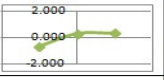
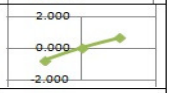
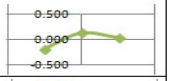
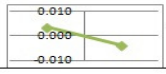
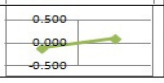
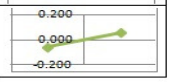
		18-23	Single		24-32	Single		24-32	Couple	
Attribute	Level	Coeff.	Sig.	Graph.	Coeff.	Sig.	Graph.	Coeff.	Sig.	Graph.
Housing unit	Studio	0.216			-0.013			-0.288		
	One bedroom	-0.216	0.079		0.013	0.853		0.288	0.001	
Surface	30-49 sqm	0.147			0.024			-0.691		
	50-75 sqm	0.005	0.974		0.119	0.187		0.202	0.069	
	76-100 sqm	-0.151	0.375		-0.143	0.172		0.489	0.000	
Price	9-12 €/sqm	0.518			0.418			-0.018		
	13-16 €/sqm	0.055	0.696		-0.054	0.565		0.120	0.293	
	17-20 €/sqm	-0.574	0.002		-0.364	0.002		-0.102	0.457	
Private outdoor	None	-0.400			-0.658			-0.745		
	Balcony	0.110	0.431		0.314	0.000		0.066	0.544	
	Garden	0.290	0.073		0.344	0.001		0.679	0.000	
Furnishing	Unfurnished	-0465			-0.210			-0.181		
	Semi furnished	0.218	0.159		0.041	0.663		0.133	0.237	
	Fully furnished	0.247	0.159		0.169	0.109		0.048	0.713	
Building type	Office	0.004			-0.100			-0.058		
	Industrial	-0.004	0.975		0.100	0.136		0.058	0.482	

Table 3. Voorkeuren van de marktsegmenten

Voor studenten of singles met lage inkomens is prijsde belangrijkste eigenschap. Dit doelgroep is op zoek naar de goedkoopste woningmogelijkhedenen heeft een voorkeur voor de studio's. Ook de beschikbaarheid van een tuin is een belangrijke factor voor deze groep. Dit gegeven geldt voor alle groepen in dit model.
Voor starters, 24 tot 32 jaar oud en single, is de acceptatie lager dan voor de vorige groep, maar nog steeds van belang. Prijs en eigen buitenruimte zijn statistisch gezien significant, met gelijkwaardige voorkeur voor balkon of tuin.
Jonge stellen met twee inkomens zijn meer geïnteresseerd in de verdeling van de wooneenheid (met voorkeur voor aparte slaapkamer), groter oppervlak en een eigen buitenruimte gekenmerkt door een duidelijke voorkeur voor de tuin. Voor deze groep behoort prijs niet tot de belangrijkste attributen.
De resultaten van de enquête kunnen worden opgenomen in een beslissingsondersteunend systeem (DSS) zodat met het vastellen van de niveaus per attribuut de keuze voor alternatieven kan worden voorspeld. Met het systeem kunnen ook afwegingen van verschillende attributenwaarden worden gemeten om de meest aantrekkelijke oplossing te

vinden of om de concurrentie in de markt te testen. Door het invoeren van gegevens voor de verschillende alternatieven kunnen kansen worden voorspeld.

CONCLUSIE EN DISCUSSIES

Uit de discrete choice experiment volgt dat de respondenten uit degeselecteerde marktsegmenten zowel industriële als kantoorgebouwen voor herontwikkeling in woningen accepteren. Dit resulteert in een toename van het aantal gebouwen wat als geschikt kan worden beschouwd voor transformatie.

Vanwege een potentieel hoge bijdrage aan duurzame stedelijke ontwikkeling, dient hergebruik van gebouwen te worden gestimuleerd door gemeenten. Dit is mogelijk door zich meewerkend te stellen bij afwijkingen van het bestemmingsplan, door het vergemakkelijken van juridische procedures en het toegang tot onontwikkelde grond voor ontwikkelaars te beperken of door verlaging van belasting toe te passen in geval van leegstaande gebouwen.

Verder onderzoek kan worden uitgevoerd om vast te stellen of volwassen gezinnen voorgestelde woningen afwijzen vanwege de grootte van het huishouden of door het hergebruik concept. Een andere ontwikkeling als gevolg van de bevindingen uit dit onderzoek kan de ontwikkeling van een geïntegreerd beslissingsgereedschap zijn. Dit hulpmiddel kan ontwikkelaars helpenbij het kiezen van de beste strategie voor hergebruik waarbij niet alleen de beste oplossing vanuit het oogpunt van de investeerder (gebouw transformatiepotentie), maar ook die de voorkeuren van de toekomstige gebruikers worden meegewogen..

Rekening houdend met het feit dat de maatschappij in een sneller tempo verandert dan de gebouwde omgeving, moeten architecten gebouwen ontwerpen die gemakkelijk aanpasbaar zijn.. Een gebouw hoeft niet als een eindproduct te worden beschouwd. De ontwikkeling is een continu proces ten gevolge van een dynamisch gebouwde omgeving.