Adaptive reuse of office buildings into housing
Opportunities and risks

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Adaptive reuse of office buildings: opportunities and risks of conversion into housing

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Abstract

Conversion into housing is a way of adapting and reusing vacant office buildings. Former research has shown possibilities for this type of conversion, and has delivered instruments for determining the conversion potential of vacant offices. While adaptation and renovation of outdated offices can prove to be a successful real estate strategy, conversions into housing still take place only on a small scale. There are several reasons for this, like uncertainty about financial feasibility, and little knowledge about the opportunities and risks of building conversions. This paper reveals drivers for office-to-housing conversions and conversion opportunities and risks, based on a review of international literature and a cross-case study of 15 buildings in the Netherlands which were converted from offices to housing. The findings show that various legal, financial, technical, functional and architectonic issues define the opportunities and risks of building conversions. These insights can be used to support decision making on how to deal with vacant office buildings.

Introduction

Over the last decade vacancy levels in office markets worldwide are unprecedented. In the Netherlands, about 7 million square metres (15%) was vacant in 2013, whereas 3-8% is regarded 'normal vacancy', necessary to provide for mutations in the market. Half of the vacant office space is structurally vacant, i.e. vacant for 3 or more years (Remøy 2010). The Dutch situation is comparable to other European office markets like Frankfurt and Paris, where large investments outbid the demand. A high vacancy is also recognised in markets that were hit hard by the 2009 financial and real estate crisis, like Dublin and Madrid.

Property owners have four possible strategies for dealing with vacant office buildings: consolidation, renovation or upgrading, demolition and new-build, and conversion to new functions. Most owners choose consolidation: i.e. keep the building status quo, search for new tenants and wait for better times. Selling is often not an option. The value of office buildings is based on the potential rental yield and hence the sale of a vacant building yields less than its book value, which means financial loss for the seller. Likewise, new investments are difficult to explain to investors who already lost money on a property. A second strategy is renovation or adaptation for other office market segments. Though smaller renovations are performed every 5 years (Vijverberg 2001; Douglas 2006) at some point the building requires major adaptations (Wilkinson and Remøy 2011). However, in markets with high vacancy levels, there is a risk that the benefits of adaptation will be less than the intervention costs. Demolition and new-build on the other hand creates possibilities for a good fit with current and future users' needs. However, redevelopment takes time and causes income delay. If the building is technically in a good state, redevelopment is a waste of resources and conflicts with global aims for sustainable development. Conversion to new use is the fourth strategy.. Conversion sustains a beneficial and durable use of the location and building, implies less income disruption than redevelopment and can have high social and financial benefits.

Although there are good reasons to convert vacant office buildings into housing, conversions are still scarce. One reason is the sectorial separation of real estate markets; investors do not develop, and developers do not invest in real estate for a longer period. Also, real estate markets tend to be functionally separated, and hence office investors do not invest in housing, and vice versa. Another reason is that the possibilities of conversion are not clear to office owners. The aim of this paper is to reveal the potential of conversion as a strategy for dealing with vacant offices. In addition to a literature review, fifteen completed conversions were studied, answering the following research questions: What are the drivers for office-to-housing conversions? Can conversion opportunities and risks be revealed and controlled, to increase the feasibility of the project?

Literature review

Drivers for adaptive reuse

Conversion as a means to facilitate adaptive reuse of buildings usually requires major changes of the building. Conversion is not a new phenomenon, but has taken place everywhere, at all times and on different scales, as such contributing to today's beloved historical cities and buildings. An example is the canal-houses in

Amsterdam from the 17th century. The functions of the buildings have changed a number of times, from warehouse to housing to offices and back to housing and shops, inflicting changes to the interior floors and the rear facade of the buildings (Leupen 2006; Remøy 2010). Several authors (Barlow and Gann 1993; Tiesdell, Oc and Heath 1996; Coupland and Marsh 1998; Heath 2001; Beauregard 2005; Langston *et al.* 2008; Wilkinson, James and Reed 2009; Bullen and Love 2010), describe conversions in London, New York, Toronto, Melbourne, Perth and Tokyo. These studies describe conversions of redundant office buildings in central urban areas or downtown locations.

The cases of London and Toronto (Heath 2001) describe office to residential conversions as a successful strategy for inner city redevelopment. During the 1990s, the City of London and the Toronto city core were characterised as office districts with little housing, and abandoned after 6.00 PM. Office construction booms in the late-1980s and an economic recession in the early 1990s resulted in high vacancy rates and dramatic rent reductions, causing replacement markets where tenants moved to newer accommodations at comparable rents (Barlow and Gann 1995). The authorities of the two cities reacted quite differently. While in Toronto, the government played a key role in redevelopments, the London planning authority was supportive though not proactive. In Toronto, 9000 dwellings were added to the downtown area in the 1990s. By 2000 the office vacancy had fallen back to normal rates and the most suitable buildings had been converted. While in Toronto conversions were concentrated to the downtown area, in London conversions were taking place more dispersed. Drivers for conversions in Toronto and London included demographics and household compositions with changing attitudes and housing demand, causing city centre living to gain popularity. In addition, the vacant office space was not attractive as office space. A third and most important factor was the rent-gap between offices and housing; as in some situations the return on housing was estimated to be 90% higher than for commercial property (Barlow and Gann 1993).. The five major triggers and obstacles of conversions were found to be physical/design aspects, location, financial/economic and legal aspects, and the changing real estate market with a growing gap between demand and supply.

In the late 1980s offices relocated out of Manhattan as a reaction to the economic slump. Due to the recession, between 1992 and 1995 the Downtown vacancy rate was 20%, to a great extent structural vacancy (Barlow and Gann 1995). Office tenants who still preferred Manhattan moved to Midtown, as the buildings there were newer, bigger and of a better quality. A large part of the Downtown office buildings were obsolete. As a reaction, in 1995 the New York City government initiated the Lower Manhattan Revitalisation Plan to enable and

subsidise the conversion of obsolete Lower Manhattan office buildings into apartments (Beauregard 2005). Subsidies were given for conversion of office buildings constructed before 1975. The government focused on conversions into studios and small apartments for first-time renters. Because of low rents, the converted offices also became popular with other groups, although the area lacked basic services and facilities for families or elderly people. The drivers for the successful conversions in Downtown Manhattan were the tight housing market and a high supply of obsolete office buildings, as well as an active and stimulating government. From 1995 to 2005 more than 60 office buildings were converted, and the number of inhabitants in the area grew. Still, the worker population in Lower Manhattan is 3-4 times larger than the resident population and there are few services and facilities for residents.

Tokyo showed developments equal to New York. As the office market climbed up from the nineties recession, new office buildings were added to the market. However, the office take-up lagged behind and had not yet recovered as the dot-com bubble burst in 2002-2003 (The dot-com bubble describes a speculative bubble in the stock markets, led by growth in the internet sector, also leading to high estimates for office space demand in this sector. As the bubble burst, the office space demand collapsed, and the vacancy rates increased). Older and smaller office buildings, located in secondary streets became obsolete and were converted (Ogawa *et al.* 2007). Unlike New York, the tenancy perspectives for new and large office buildings were still good while the expectations for the existing buildings were low. Therefore, demolition with new construction was in general a more interesting option than conversion, resulting in an increase in scale of the urban fabric. The local government has had little influence on the urban developments. Recent focus on conservation of the urban fabric and urban sustainability might enhance the opportunities for building adaptation and conversion for the future (Minami 2007).

In Australia on the other hand, sustainability is the main driver for building adaptation and conversion. Upgrading the existing building stock to improve sustainability and reduce CO_2 emissions before 2020 is a target for the city of Melbourne (Wilkinson and Remøy 2011). The aim is shared by Perth and the Municipality of Western Australia. In Perth, high office vacancy and increased residential construction activity further increased the interest for building conversion in the last decade (Bullen 2007).

The same issues are at stake in Hong Kong. Its dense structure offers little space for new developments, and changes in the urban fabric occur as adaptive reuse or demolition and new construction. With new construction contributing only 2% per year to the building stock, it would take Hong Kong up to 100 years for energy efficient

strategies of new building construction to contribute to reduce energy use and greenhouse gas emissions according to the targets of the Hong Kong government. Hence, adaptive reuse is needed to reach the goals (Langston *et al.* 2008).

In the above discussed markets, sustainability aims, obsolete office buildings and a tight housing market were the most important conversion drivers. These drivers are also present in Dutch real estate markets. Conversion of structurally vacant offices into housing could contribute to increase and broaden the housing supply and at the same time create possible new use for obsolete office buildings (Remøy and Van der Voordt 2007; Van der Voordt *et al.* 2007). This research therefore aims to reveal the potential of conversion as strategy for dealing with vacant offices.

Location potential: opportunities and risks

Worldwide, properties in city centres, housing areas or edges of such areas are converted into housing, while conversion of office buildings in business parks and peripheral areas rarely happen. Office building conversions in the city centres can offer valuable additions to the existing housing stock. Considering the functionally realisable apartment types as well as the location of office buildings, interesting target groups (buyers or renters) can be found. The price that a target group is willing to pay for an apartment defines the possible building costs and the purchasing costs of the existing building.

Office buildings in mono-functional business parks are not regarded fit for conversion into housing. When structurally vacant office buildings are situated in such locations, location transformations are necessary. Industrial and harbour areas, the so-called Brown-fields, were once developed on the fringes of cities but are now pocketed in central urban areas. The same goes for some of the first business parks, planned in the 1930's and developed shortly after the Second World War. The transformation of such locations is triggered by the renewed interest for inner-city living (Hall 1999; Florida 2004; Hamnett and Whitelegg 2007), leading to gentrification of areas that used to accommodate harbour and industrial areas and housing for the working class.

In Dutch cities this development is best seen in the Amsterdam harbour area, where artists and squatters moved in as the harbour activities came to an end, followed by the development of housing for higher market segments (Avidar, Havik and Wigger 2007; Smit 2007). The business parks developed from the 1970s onwards are located further away from the city centres. Cities were expanded in this period. The locations

were typically well accessible by car and public transportation. Some of these locations are now becoming redundant and obsolete with downwards spiralling developments of financial yields while the public space is neglected and the maintenance of the buildings is minimised. New initiatives are essential to prevent further downgrading of the locations and depreciation of the properties (Koppels, Remøy and El Messlaki 2011). As the locations are typically well accessible and do not accommodate hazardous activities, conversion into housing is possible (Muller, Remøy and Soeter 2009). Redevelopments should however be part of transformations towards multi-functional urban areas.

Building characteristics: opportunities and risks

Usually, building characteristics do not make conversion impossible, but can influence the financial feasibility substantially (Mackay, De Jong and Remøy 2009). Successful building conversions are often buildings with a cultural-historical- or symbolic- value, or listed monuments (Benraad and Remøy 2007). Most office buildings are not listed though, as the need for office buildings world-wide grew with the service economy from the 1950s onwards; most office buildings are relatively new. In the Netherlands, most structurally vacant office buildings were built between 1980 and 1995 and are not known for interesting architecture; rather the external appearance is assessed as poor (Remøy, Koppels and De Jonge 2009). In these cases, the main driver for conversion is the future value of the location.

The functional adaptability of office buildings is of critical importance to conversion feasibility, including the measurements of the buildings structural grid (Douglas 2006; Geraedts and Van der Voordt 2007). Post-war office buildings were designed as “cockpits” to fit closely around the function they were meant to accommodate (Brand 1994). This tight fitting threatens the functional feasibility of conversion into housing.

Legal aspects can also reduce the financial feasibility of conversions. As the requirements for residential buildings and other buildings that accommodate overnight-stay are stricter than for day-use functions like offices, adaptations of the buildings structure, stairways and facade are often needed. In these cases, the conversion costs might become too high compared to the expected benefits, and conversion may be financially unfeasible. Mackay *et.al*. (2009) found an evident relationship between building costs and the alterations of specific building elements. The major cost generator for most office-to-housing conversions is facade-alteration (27% of the total building costs), followed by interior walls (17% of total building costs) and contractor costs, a group of costs in Dutch estimates combining site costs, general costs of the contractor and his profit (15% of

total building costs). Whereas the costs for interior walls depend on the new function and can easily be predicted, the costs related to the facade depend on the building shape, technical state and quality of the existing building, and on the demand for external appearance, comfort and quality of the converted building. The necessity for facade alterations should therefore be thoroughly assessed when studying office-to-housing conversion potential.

The appraised market value of office buildings is normally based on the income approach, described by the potential rental income. Although structurally vacant office buildings generate no income and have no perspective of future tenancy, appraisal of structurally vacant office buildings is in most literature based on potential tenancy of the property using either the cap rate or discounted cash flow methods (Ten Have 1992, 2002; Hendershott 1996; Hordijk and van de Ridder 2005). The accounted value is too high for re-developers, who calculate land and existing building value residually. As long as these two ways of calculating the value of structurally vacant office buildings are not compatible, the price will be experienced as too high by re-developers and too low by owners.

Ex-post evaluation of 15 completed conversions in the Netherlands

Research methods

To further explore the effect that location- and building- characteristics have on office building conversion potential, a multiple case study has been conducted. The cases in this research are examples of conversions from offices into housing (see Table 1). They are of significant size (the smallest counted 18 apartments) and were carried out between 1999 and 2011, as the legal framework for conversions was unchanged during this period. The cases represent a variety of conversions regarding geographic location, building type and user group. Figure 1-3 show three of the cases before and after conversion.

The case studies were performed ex-post by site visits, interviews with stakeholders and studying drawings and documents. By combining the information from the different media, the characteristics that have an effect on the residential conversion potential were revealed and compared to literature.

Table 1: Fifteen Dutch completed conversion cases

	Delivery	Delivery converted	Amount of units	Type of dwelling	Interviews
Westerlaantoren	1950-1960	2011	40	Luxurious, buy	1
Wilhelmina Estate	1969	2007	43*	Mixed, buy	2
De Enk	1956	2006	69	Starters, buy	2
Granida	1958	2005	30*	Luxurious, rent	3
De Stadhouder	1974	2005	70	Starters buy	1
Billiton	1938	2004	28	Luxurious, buy	2
Eendrachtkade	1980	2004	83	Students, rent	1
Schuttersveld	1915-1923	2003	104	Luxurious, buy	2
Twentec Building	1960-1965	2002	87*	Luxurious, rent	2
Lodewijk Estate	1954	1999	24	Seniors, buy/rent	1
Westplantsoen	1970-1980	1999	45	Students, rent	1
De Deel	1959	1999	18	Seniors, buy	1
The Churchill towers	1970	1999	120	Mixed, rent	2
Puntegale	1940-1946	1999	210*	Starters, rent	2
Hof ter Hage	1935-1967	1998	97*	Mixed, buy	2

*Other functional programmes were added, such as shops, health care and commercial space.

Data collection and analysis

Interviews were held with architects, developers or both, when information from one interview was not sufficient to get a clear picture of the conversion. In most projects, the developer was also the client. When the project was not commissioned by a developer, the client was interviewed. The interviews discussed project specificities throughout the construction process, from project initiative and design phase to construction phase and project delivery. Typically, the projects were initiated by the developer, but sometimes by the local municipality or the owner of the vacant building. Information about the design phase was retrieved from the architect. The executive project director was sometimes the architect, sometimes the developer. No end users

were interviewed. The focus of this research was on location and building characteristics related to opportunities and risks, and not on tenancy issues, though (mis)fits between demand and supply were included in the interviews with the initiators.

All buildings were visited. Photos of the existing situation and the architectural drawings of the building before and after conversion gave a good overview of the existing structure, stairways, elevators and exterior and structural walls. The written documents consisted of magazine- and newspaper- articles. These were especially useful in the study of older conversions where the interviewees had forgotten the details.

Project and process descriptions were written based on the interviews and documents. The drawings and photos were used to explain the situation. The drafts were sent to the interviewees for feedback and accordance. A cross-case analysis was the last step of the analyses. The data were arranged in a matrix and analysed for patterns. This cross-case analysis focused on the project opportunities and risks. The aspects were divided into legal, financial, technical, functional and cultural-historic aspects.

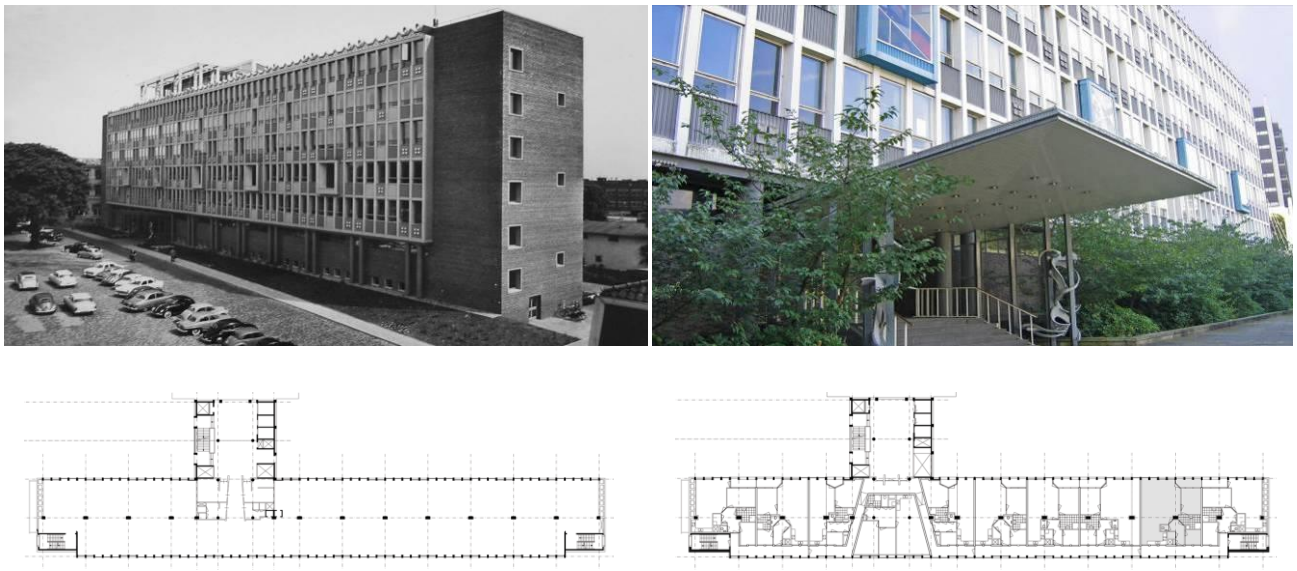

Figure 1: De Enk. Left: before conversion, right, after conversion. The conversion was successful due to the cultural-historic quality of the building, the location near the city centre, and low purchasing cost. A model apartment was furnished, showing potential buyers exactly what they would get.

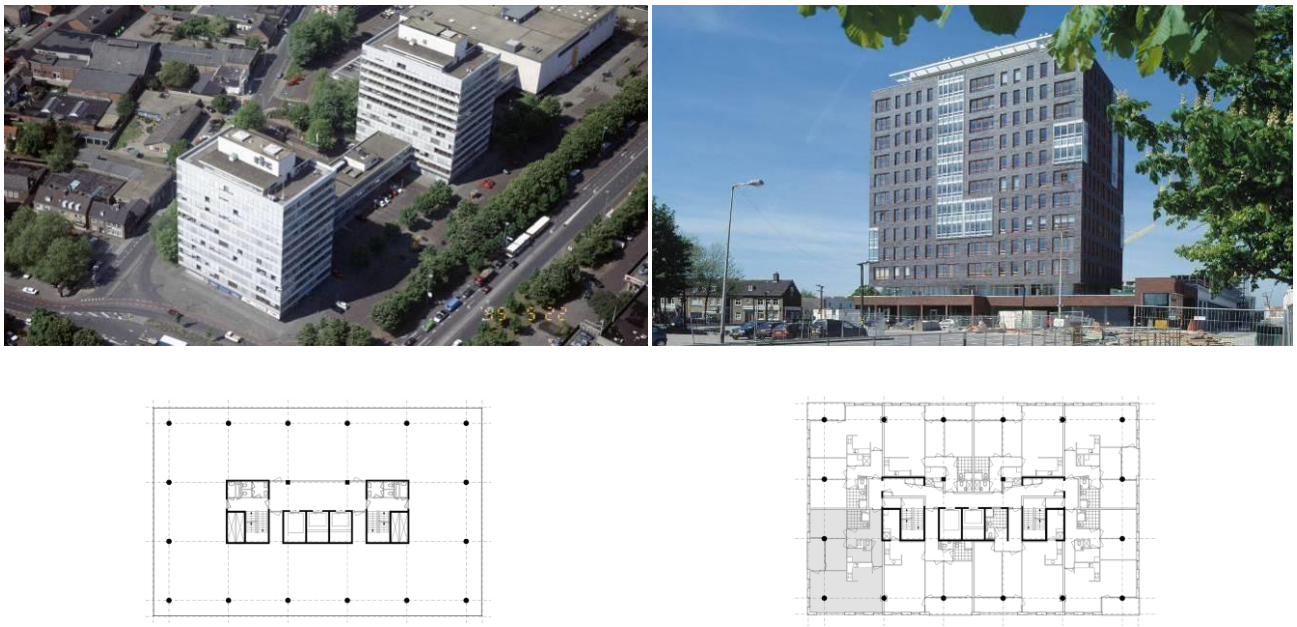

Figure 2: Twentec building. Left, before conversion, right, after conversion. The apartments were developed for the expensive rental segment. The façade was completely renewed and balconies were added, but this alteration was seen as necessary to attract the target group.

Results: Opportunities

The conversions were all completed, which implies that the legal requirements of zoning plans and building code were met. The short development time-span from the first sketch till delivery of the apartments was considered an opportunity. One project took only two years from the first sketch till delivery. While still working on the design, the building was stripped down to structure, stairs and elevator. Not only was time saved because the main structure was already there, but also because of this, less days were lost due to bad weather.

The “WYSIWYG-factor” contributed to this advantage: What You See Is What You Get. In many cases, model apartments were furnished before the reconstruction started. Whereas most people cannot interpret architectural drawings, the model apartments were thought to better inform potential buyers and boost the apartment sales. The financial feasibility was improved by selling the apartments before construction start, leading to lower financing costs and risks.

Moreover, the conversion costs were found to be lower than for demolish and new-build. However, the conversion costs varied from € 550,- to € 1300,- per square metre gross (measured in the year of conversion). High conversion costs were caused by high-quality demands for the external and internal finishing and high

demands for comfort by the target group (acoustic and thermal insulation). Low conversion costs were accomplished when few changes were made to the facades (i.e. student housing) and when the floor-plan was well adaptable.

The conversions studied received few objections from neighbours or neighbouring users. Redevelopment was thought positive in the cases of a building in an area with high vacancy and dilapidation. This added to the developers and investors opportunity to increase the financial feasibility of a project.

Finally, conversion of vacant offices was considered a sustainable alternative to demolition and new build, saving building materials and transportation, and producing less waste than demolition and new construction. A frequently heard argument for demolition is that older buildings are not sustainable. However, the performance of the studied buildings was adapted to the level of the Dutch building code as well as to the level of comfort expected by the relevant user group. Table 2 summarises the most striking opportunities found in the Dutch cases.

Table 2: Opportunities defined by the cross-case analysis of the 15 cases

	Aspect
1. Legal	1. New function fits zoning plan 2. Conversion preferred by neighbours 3. Measures fit with building code requirements
2. Financial	1. Low purchasing price 2. Preselling implies lower financing costs 3. Commercial activities in plinth
3. Technical	1. Reuse of large parts of existing building, e.g. facade and construction 2. Strong floors, possible to add extra weight 3. Strong foundation, vertical extension possible
4. Functional	1. Sufficient parking places 2. Existing floor plan easily adapted 3. Extra “left-over space”, not available in new developments
5. Cultural-historic	1. Historical value, strong architectural appearance 2. Positive impact on surrounding area

Results: Risks

Asbestos was found in seven of the fifteen projects. Asbestos removal follows strict rules and therefore incurs high expenses. In all the projects asbestos removal was accounted for in the building assessment.

In a few cases, apartment sales were challenging; in one case, luxury apartments without private outdoor space and with incidentally low ceilings (not according to the building rules) were sold only after lowering the prices significantly. In another case, apartments with daylight from the north only, were not sold for the initial asking price. The characteristics of these apartments clearly did not correspond to the preferences of the target group. Even in a tight housing market, quality and willingness to pay was found to correspond, especially in the top segment of the housing market.

3 of the 5 buildings constructed before 1950 and 3 of the 5 buildings constructed between 1950 and 1965 were not built according to drawings and the construction materials and measurements were different per floor. This was explained as in the first years after the Second World War housing was prioritised over commercial buildings in the Netherlands. It was difficult to get building materials, and in many cases contractors used the material they could find without altering the drawings. The buildings constructed after 1965 showed no such differences.

The main structure was in an unsatisfactory state only in one of the 15 projects (Granida). The concrete in the external columns was deteriorating; hence it was repaired and reinforced. The repair itself added extra costs to the project, but additionally, as a result of the repairs the columns became wider, and the design needed modification. In other projects light concrete deterioration and steel corrosion was found but required only minor reparations. In most cases, this kind of technical problems was assessed in the preliminary phase. Office buildings are constructed to carry more weight than housing, and in most cases, additional floors could be carried by the existing structure.

Apartments require more vertical shafts for electricity, water and plumbing than offices. In the buildings constructed before 1965, floors were penetrated and shafts were placed without problems. After 1965, prestressed concrete was commonly used, making larger spans possible. The problem of prestressed concrete though, is that it loses strength when the steel is cut. In three of the five buildings constructed after 1965, prestressed concrete was used.

The measurements of the structural grid in the buildings constructed before 1965 were small and came with thin, light floors. Though these floors are strong, the acoustic insulation was poor and needed improvement to meet modern building standards. This was achieved by adding floating floors and suspended ceilings. The Dutch building code requires better thermal and acoustic insulation of the facade for housing than for offices. Buildings from the 1980s onwards have double glazing. The thermal insulation of the facade is sufficient for housing; but the acoustic insulation is often not. The facades were replaced in 8 of the buildings. In 7 projects, the thermal and acoustic insulation of the facades was improved; in 5 of these it was not possible to change the facade because the buildings were listed monuments.

In several cases the zoning plan and the municipality not allowing for exceptions was considered a problem. Long lasting procedures slow the process and delay income, threatening the financial feasibility. In most

projects however, the municipality was quite co-operative because conversion into a well-functioning building was found to improve the image of the environment and reduce risks of vandalism and feelings of unsafety.

Most of the revealed risks were technical. Several influence the financial feasibility. A lowered ceiling and floating floor were placed; constructions were repaired, shafts cut through reinforced concrete floors and legal procedures were fought, before permits were obtained. But the conversion costs rose as a result. Developers who were interviewed complained about overrun budgets and too many hours spent to develop specific solutions to problems that occurred during the construction. Still, the projects were financially feasible. Table 3 summarises the most striking risks found in the Dutch cases.

Figure 3: Granida. Left: the building before conversion; right: the building after conversion. The location near the city centre and the image of the building were important success-factors for this conversion. Alterations of the façade and a bad technical state of the structure led to high construction costs.

Table 3: Risks defined by the cross-case study of the 15 cases

	Aspect
1. Legal	1. Zoning law: Impossible to meet municipal requirements, zoning law, city policy 2. Building code: Impossible to meet requirements e.g. regarding noise-level and fire-precautions, the municipality is unwilling to cooperate 3. Monumental act. The monumental status does not allow adaptations that are required to match future user needs.
2. Financial	1. Development costs: slow handling of procedures (loss of income, high interests) 2. Vacancy: failing incomes from exploitation or sale of the apartments 3. Owner not willing to sell for a reasonable price due to high book value
3. Technical	1. Incorrect or incomplete building structure assessment 2. Poor state of the main structure/foundation (rotten concrete or wood, corroded steel) 3. Insufficient shafts available; construction allows no extra shafts being made 4. Insufficient thermal and acoustic insulation in the floors and facades 5. Insufficient daylight for housing
4. Functional	1. Present grid does not fit with measurements required for new purposes, resulting in waste of space or costly adaptations of the technical structure 2. Private outdoor space impossible
5. Cultural-historic	1. The appearance of the building does not fit with the required appearance of the new function

Lessons learned

Location

The only location characteristics that could be said to be a veto-criterion for residential conversion are: too high levels of noise at the facade and bad air quality.

Other location characteristics were found less critical, depending on the target group and the combination of characteristics. However, other houses nearby was considered an important “soft factor”. Most of the realised conversion projects are located in established housing locations or mixed-use locations. Housing associations and developers, the primary actors in conversions, hesitate redeveloping in industrial locations as to most target groups living in industrial locations is unattractive. Still, residential conversions for specific target groups were found possible in business parks, i.e. if the location is near the central business district and social and commercial facilities, and if a large scale project can be initiated to pull area re-development.

Building

The lessons learnt from the cross-case analysis show that conversion opportunities and risks are closely related to the architectural characteristics of existing buildings. To be able to use the information from these ex-post cases to study the conversion potential of other buildings ex-ante, the building characteristics that were found to influence the conversion potential were elaborated upon and structured as typological characteristics, as this is how the conversion potential is assessed in practice.

a. Structure and floors

The main structure of standard office buildings most commonly has a span or bay width of 7.2 metres, though a structural grid of 5.4 metres is sometimes used as well. In Dutch housing 5.4 metres is a standard measurement for the width of apartments, while in newer apartments 7.2 metres is frequently used. The large number of columns in older offices may cause a partition problem for conversions. The linear structures from the 1980s can be more easily adapted to new use. Beams under the floors may cause problems, because the free height of the floors is incidentally lowered, and challenge the fitting-in of new installations. Office buildings floors are normally constructed to carry more weight than in housing (In offices, 300kg/m^2, in housing 175kg/m^2). However, office buildings are normally constructed using prestressed concrete floors. The limited possibility of penetrating these floors makes it difficult to add vertical shafts. The steel cables in the floors may

be located, but are not always located on the same place in all floors. Solutions could be found by smart reuse of central existing shafts. The storey height of office buildings is normally sufficient for conversion into housing; the Dutch building code requires 2.6 metres free ceiling height. The acoustic insulation of typical office floors is not sufficient for housing. In most conversions adherence to the building code requires additional acoustic insulation, with a suspended ceiling and a floating floor.

b. Floor lay-out, building length and depth

An efficient housing lay-out of an office floor may be thwarted by the design of the existing office floor plan. The location of the central elevator and staircases may be inconvenient for housing. Moving the elevator core and staircase is usually impossible, because the core also contributes to the stability of the structure. Placing a new elevator or staircases in many cases would only be possible outside the existing building, so that no extra shafts have to be made in the existing floor. However, applying radical changes to the buildings' staircases or elevator cores critically increases the conversion building costs. The building depth may be an obstacle for the conversion of older office buildings; buildings from the 1960s were generally deep and with little day-light access.

c. Stairs and elevators

Office buildings are designed for more people per square metre and more traffic than apartment buildings. Therefore, the number of elevators is a positive aspect for conversion. Elevator shafts that are not needed may be reused as shafts for HVAC, electricity, water supplies and sewer. Since the shafts are often used to provide for structure stability, the possibility for making holes in the shaft walls may be restricted. The requirements for escape routes however, are stricter for housing than for offices. Adding extra stairs may be necessary though most new office buildings will suffice.

d. Facade

Interventions in the facade represent a critical factor for the financial feasibility of conversions. Frequently, office buildings have an appearance strongly related to office work. In these cases, the facade is often replaced, even if it is technically well maintained and meets the requirements for housing. However, completely replacing the existing facade implies high conversion costs and is not feasible for housing in the lower market segments. When offices are adapted into housing in higher market segments, extensive alterations or replacements can be made, and are sometimes also necessary and include adding balconies. Most people

demand an apartment with a balcony or other private outdoor space, especially in more expensive high-end apartments. Until the seventies, modernism had a great effect on the design of floor plans. Le Corbusier Domino principle was incorporated in its pure form with columns and floors, with cantilevering floors and a curtain wall facade. Such a structure makes addition of balconies difficult. Adding a loggia is an alternative, and also French balconies or winter gardens is possible.

Conclusions and discussion

Structural vacancy is an important driver for office conversion, in the Netherlands and worldwide. Conversion is one of the possible strategies for dealing with vacant offices. However, the real estate market is segregated and office investors are not keen on investing in the housing market. Developers, investors and housing associations have the choice of converting for sale or for the rental market. The high asking price for vacant office buildings is an obstacle for conversions. In locations with high housing demand and low office space demand, residential conversion is especially interesting. Housing- and inner city locations have positive influence on the conversion potential. However, 70% of the office buildings in the Netherlands are located in mono-functional office locations. Conversions in such locations are only possible if the location is transformed.

The measurements and technical state of the building structure are critical building characteristics for conversion. Subsequently, facade characteristics and necessary changes to the facade have the highest impact on the conversion costs. The most striking risks of conversions are legal or technical aspects, though these eventually translate into financial aspects. If taken into account, most risks can be dealt with, increasing the feasibility of a project. The 15 cases that were studied in this research showed some striking success factors like: low purchasing price, providing an adaptable floor plan, subsidy granted by the government, or purchase and conversion by housing associations that in general work with long-term investment scenarios and do not require profit-maximisation. The cross-case findings showed that it is possible to generalise the opportunities and risks of conversion i.e. the critical success- and failure factors. Assessing these factors in the initial phase of a conversion project can contribute to an increased feasibility of conversions.

Nowadays, prestressed concrete is the most commonly used material in office buildings. When converting newer buildings, this should be taken into account. By designing apartments with a minimum of shafts the problem can be solved. The accurate place of the steel cables can be located with metal detectors. Municipalities may make exceptions from the building code depending on the target group. If the relevant user groups are seniors, acoustic insulation is important while students care less about noise. When a first scan is

made of the building to be converted, the storey heights need attention. In most cases, office buildings have higher storeys than requested for apartments, but when a floating floor and a suspended ceiling are added, excess height is required. To be sure to obtain a free ceiling height of 2.60 meters (required by the building code), the inter-floor spacing should be 3 meters, allowing for mechanical ventilation above a suspended ceiling and a minimum height of 10 centimetres for a floating floor.

Comparing the sustainability of conversion to demolish and new-build, the expected life-span of the new or to be reused building has a large influence on which option is the most sustainable; if new-build is expected to have a significantly longer life span than conversion it is likely to be more sustainable. Equally, in uncertain market situations, where the lifespan of new constructions is expected to be shorter, conversion will be more sustainable (Jansz 2012).

In order to facilitate future conversions, developers and architects should incorporate change-of-use adaptability as an important issue in briefing and design of office buildings. An ex-ante assessment of future conversion potential by designing an alternative floor plan that fits future adaptive reuse might help to explore these opportunities and risks (Remøy, De Jong and Schenk 2011).

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