Sustainability by adaptable and functionally neutral buildings

Remøy, HT; van der Voordt, DJM

Publication date
2009

Document Version
Accepted author manuscript

Published in
Conference proceedings SASBE 2009, 3d CIB international conference on smart and sustainable built environments

Citation (APA)
Remøy, HT., & van der Voordt, DJM. (2009). Sustainability by adaptable and functionally neutral buildings. In AAJF. van Dobbelsteen (Ed.), *Conference proceedings SASBE 2009, 3d CIB international conference on smart and sustainable built environments* (pp. 1-8). Delft University of Technology.

Proceedings of SASBE 2009, 3rd CIB International Conference on *Smart and Sustainable Built Environments.*
June 15-19, Delft.

SUSTAINABILITY BY ADAPTABLE AND FUNCTIONALLY NEUTRAL BUILDINGS

Hilde REMØY MSc[1]
Theo VAN DER VOORDT MSc PhD[2]


[1] Department of Real Estate and Housing, Faculty of Architecture, Delft University of Technology, The Netherlands, h.t.remoy@tudelft.nl
[2] Department of Real Estate and Housing, Faculty of Architecture, Delft University of Technology, The Netherlands, d.j.m.vandervoordt@tudelft.nl

Keywords: Transformation, conversion, adaptability, willingness to pay

Abstract

The continuing high levels of office building vacancy in the Netherlands cause a loss of income for building owners and - since the physical life span of the buildings is not getting shorter – an increase of obsolete office buildings. These buildings are deteriorated or even prospectless, with no perspective on future lease or reuse for office purposes. The situation is augmented by new buildings being added to the supply, creating a replacement market and leaving older buildings redundant; new buildings drive out bad buildings. However, the demolishment of relatively young buildings is neither economic nor socially desirable and is not corresponding with the demand for durability and sustainability. Transformation into other functions is a possible way of coping with these buildings, albeit previous research shows that there are many obstacles to be thrived. Most of the obstacles consider technical, functional and legal aspects that finally influence the financial feasibility negatively. Although in the Netherlands several successful transformations of offices into housing were completed, transformations do not take place on a large scale. Next to location characteristics, the main stated reason for this is estimated financial non-feasibility, caused by high purchase and transformation costs. Hence, when developing new office buildings it seems logical to anticipate future programmatic change. Designing and developing adaptability has been opted for during the last 40 years, but is still not very popular in the development of neither offices nor housing. Is it possible to proactively cope with future programmatic change? To which extent can the development of adaptable buildings help to prevent future building obsolescence? In addition to a reflection on earlier literature on this issue, we conducted 30 interviews with housing corporations and real estate developers to reveal in which conditions transformation of obsolete office buildings is interesting, and if anticipating programmatic change may influence the feasibility of future transformations.

1. Introduction

1.1. Background

The structural vacancy of office buildings is a hot topic in the Netherlands, for real estate investors, developers, municipalities, environmental groups, architects and urban planners, and with a reason: 13% or 6 million of the 45 million square metres of office space in the Netherlands are vacant.

Studying the Amsterdam office market we found 2/3 of the office space vacancy to be structural vacancy[1], something that might also apply to other areas in the Netherlands. Structural vacancy is a problem on many levels; a financial problem for the owners of structurally vacant buildings, but also a public problem by the negative image imposed on the surrounding area and buildings. This can lead to deterioration of the area, with rising vandalism, technical decay and further devaluation of the buildings.

Demolition and new construction is a possibility for coping with structurally vacant office buildings. However, it is socially undesirable and considered economic loss, in particular when the building has a special meaning for the users of the area, for example by being a landmark or because of memory value, or because demolishment eradicates the identity of the neighbourhood. Buildings with cultural-historic value are a reason for preservation, and finally, from a sustainability point of view reuse of redundant office space for other functions is more desirable.

In this context the energy consumption of the building industry and its use of materials are of interest. Estimates say that about 7% of the total energy consumption in the Netherlands is allocated to the production and transport of building materials; 25% of all transport has to do with building construction, whereas about 35% of all waste comes from construction and demolishment of buildings (Lichtenberg, 2005). These are good reasons to consider building transformation as a way of coping with structurally vacant office buildings. In the last decade we have seen several examples of transformation, although there are both obstacles and risks, such as high purchasing building costs (Remøy and Van der Voordt 2007). An important question is whether transformation costs can be reduced by pro-actively taking into account future adaptations and conversion. Which measures are needed to facilitate future adaptations? What are the costs and benefits of functionally neutral buildings?

In this paper we focus on functionally neutral buildings, considering the future prospective of transformation from offices into housing, using ex-post studies of transformations and interviews that we conducted among 30 property developers and housing associations.

Figure 1 The Granida, one of the building transformations we studied ex-post. Left the office building before conversion, to the right the apartment building after conversion.

1.2. Method

Studying realised transformations, we found that the building costs add up to 50-70% of the total investment costs, including purchase of the existing building (Van der Voordt et al. 2007). Since uncertainty about the transformation costs are considered important reasons for not initiating transformation projects, the building costs of transformations were studied (Geraedts and De Vrij 2004; Mackay et al. 2008). The findings in these studies and in a cross-case study of completed transformations (Remøy and Van der Voordt 2007), suggest that designing an office building within the perspective of future change of use could possibly trigger transformation all the more. The studies confirmed the results of three earlier studies; an MSc thesis (Witte 2001), studying which building aspects influence the transformation potential of office buildings positively, and 2 studies by Geraedts and Van der Voordt. They developed tools focusing on the vacancy risk of office buildings by examining which technical and functional aspects of an office building would lead to an end of its functional life span (2003) and studying the potential of transforming office buildings into housing using a checklist of opportunities and risks, including a quick scan, a feasibility scan for further appraisal, a financial feasibility scan and a risk assessment checklist (2007).

[1] Structural vacancy is defined as vacancy of the same office space for three or more consecutive years and with no perspective on future tenancy.

Based on the suppositions from these studies, a set of interviews was conducted among 30 property developers and housing associations, asking in which market-conditions they find transformation interesting, and to which extent location and building characteristics influence the choice of starting up a transformation project. Henceforth, we questioned the interviewees' attitude towards prospective solutions comprising functional neutrality and the willingness-to-pay for investments without assurance of future revenues. Several criteria applied to the selection of the interviewees. Of the 30 respondents, 10 worked for developers without experience with transformation, 10 worked for developers with experience with transformation, and another 10 worked for a housing association or for a developer working solely for housing associations. The interviewed housing associations all had experience with transformation. The profiles of the interviewed developers differed; 3 were focusing solely on development, while the others combined development with management or contracting. The 3 largest Dutch developers were among the interviewed organisations, 2 of these had experience with transformation, and 1 had not. Within the organisations, the interviewees were selected based on their experience with transformation, or in case of the interviewees without experience they were executives within their organisation. The developers and housing corporations that we consider transformation experts all agreed to collaborate on the study.

2. Anticipating future vacancy by function neutrality

Based on our experience from the above mentioned studies, we made a new list of design criteria in order to anticipate future transformations of office buildings into housing (Table 1).

Table 1 Criteria that enhance transformation

1. Location	
	Mix of functions Zoning plan permitting future modification e.g. with mixed use including housing No serious health risk (pollution, noise, stench) Noise load on facade < 50 dB, according to Dutch building regulations No serious crime risk (vandalism, burglary, attacks) Facilities nearby, in particular public transport, shops and greenery < 0.5 – 1.0 km View and sunlight not limited by other buildings Sufficient parking space (> one per dwelling) at a distance of preferably < 250 m
2. Building	
Appearance	No "office building look", attractive identity and entrances A high spatial/visual quality issued by the design concept or the materials and colours used
Facade	Replaceable, not load-bearing Daylight admittance at least according to building regulations for housing Opportunity to add balconies Operable windows Acoustic and thermal insulation according to building regulations for housing
Flexibility / adaptability of the structure	Possibility to enlarge the building, horizontally or vertically Acoustic and thermal insulation according to building regulations for housing A structure (grid of columns) that can accommodate floor plans for different target groups (e.g. building depth > 10 m) Preferably no load-bearing walls Access and escape routes (entrances, staircases, elevators) according to building regulations for housing (e.g. including an emergency staircase and at least one elevator if the building counts 4 storeys or more) Free ceiling height > 2.60 m Floor load capacity > 3,5 kN/m2
Installations	No installations integrated in the load-bearing structure Possibility to add service ducts, including the possibility of cutting holes in floors and walls for shafts High energy performance (re-use of heated air)

Most of the criteria listed above are generic; however the fit of the existing structure depends of future target groups. Also, the building regulations for housing determine some of the criteria. These regulations are set on a national level and will therefore be different in different countries. The more of the above design criteria that are applied, the more future adaptations will be eased.

The interviews confirmed the findings of table 1. The response to our request to mention the main reasons for coping with vacancy by transformation of the building into other functions showed that a good location with facilities nearby, an attractive building appearance that evokes positive feelings ("a beloved building is a sustainable building") and the opportunity of enlarging the building are important characteristics that stimulate transformation. On the other hand, a location in a mono-functional office park or business district reduces the willingness to start a transformation process. In the interviews, we used photos of two vacant office buildings and their location to inquire the respondents about which physical building- and location-characteristics influence their decision making when taking on a transformation project. One of the buildings was located in the centre of Amsterdam while the other was located in a monofunctional office park on the Amsterdam ring road. The location in the centre with facilities nearby was preferred by 25 out of 30 respondents. When asking the respondents to focus only on the building, most interviewees would first study the possibility of adding one or more floors at the top or to extend the building horizontally before making a final decision about transforming the building, in order to maximize the revenues of the transformation. Other stimulating characteristics mentioned were the size of the building (a building larger than 7000-8000 m2 was favoured), the local municipality's willingness to change the zoning plan, and sufficient parking space. Some respondents perceived older buildings (built before 1970) as having a higher transformation potential because of the constructions extra load-bearing capacity and large dimensions, while most office buildings from the seventies onwards have been optimised for only one function: offices. The respondents argued for investing in particular in the flexibility of the plinth (extra ceiling height, floor plans that easily adapt to new spatial-functional configurations) as the use of the ground floor will change more often than on the other floors. When the cultural or historical value is high, the building may get listed as a monument. Its potential strength can then turn into a weakness, because of restrictions in adapting the building to modern needs. Another transformation obstacle that was mentioned is the risk of not being able to foresee all kinds of technical problems and not being able to forecast future user preferences, in particular in the long run. For that reason in case of converting an existing building the cost factor "unforeseen" is usually higher than in case of a new construction (up to 10% instead of 2-3%). The respondents disagreed whether transforming a building is more or less expensive than demolishment and new construction. Two out of three respondents think that more flexible building regulations will stimulate building conversions, while 90% of our respondents agreed that a more flexible zoning plan would be a stimulating factor, too.

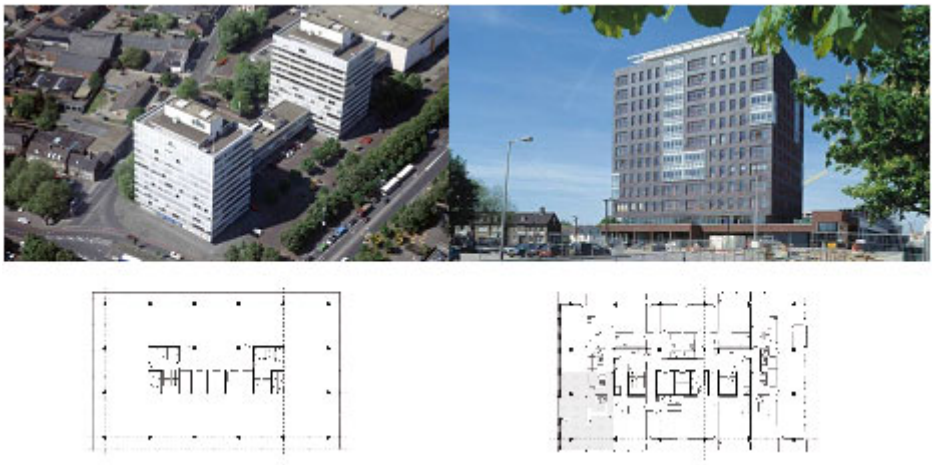

Figure 2 The Twentec building, another of the building transformations we studied ex-post. Left the building before conversion, to the right the building after conversion. The project was part of a larger restructuring of the city centre of Enschede, and one tower was demolished to allow for a large underground parking garage to be built. The other tower was transformed into housing.

3. Building costs

Even if the benefits of transformation are evident from a sustainability point of view and with regard to socio-cultural issues, the financial-economic benefits are much discussed and not convincing. According to the interviews, half of the respondents argue that building costs and the characteristics of the structure are the main obstacles for transformation. Mackay (2008) and Geraedts and de Vrij (2004) revealed a relation between transformation costs and specific building elements. Geraedts and De Vrij studied 11 conversions

from offices into student housing and revealed that changes in the structure, facade, installations, inner walls, ceilings and fixed interior influence the building costs the most, together with the total contractor costs and the purchasing costs. However, interior walls, ceilings, electrical installations and fixed interior costs were considered costs that are always made, whereas changes in the structure, facade and mechanical installations depend on the state of the original building. Geraedts and De Vrij described these differences as having a low or high influence on the variation in building costs (Table 2).

Table 2 Factors affecting the variation in transformation costs

High costs, high influence	High costs, low influence
Structure	Interior walls
Facade	Ceilings
Mechanical installations	Electro-technical installations
Total contractor costs	Fixed interior
Purchasing costs	
Low costs, high influence	**Low costs, low influence**
Roof	Foundation
Floors	Elevators
Stairs, ramps, railings	Plot

Source: Geraedts and De Vrij, 2004, based on eight projects

Mackay (2008) studied the building costs of transformation into housing of 12 office buildings constructed between 1970 and 1985. The building costs were described using the elements method, a method describing the building costs at three different levels of detail, according to the stage the project is in. Using this method, the building can be seen as clusters of building elements (level one and two), built up by single elements (level three). The Dutch version (NL/SfB) like the UK-version CI/SfB, is based on the Swedish original. By determining the amount of elements to use and the elements' costs, the building costs are calculated and the cost generators may be described. In Mackay's study the building costs were assumed to relate to different typological building properties; these were properties belonging to the existing office building as well as properties belonging to the new housing function (Table 3).

Table 3 Influence on the transformation costs related to 36 building properties of the existing office building and the new housing function

Office building		Residential building	
General	gross floor area	*General*	number of units
	number of floors		number of floors
	floor-to-floor height		gross floor area
	outline/lay-out		type of dwelling
	functions		target group
	year of completion		finishing
	screen	*Extension*	gross floor area
	stability elements		type of extension
Facade	level of adaptability		number of floors
	building type		number of units
Columns	material		type of dwelling
	grid		target group
Floors	material		finishing
	load-bearing structure	*Other function*	gross floor area
			number of floors
			function
		Parking	number of parking places
			type of parking

Source: MacKay, 2007, slightly adapted by the authors

These 32 building properties were linked to 52 elements on level 3 of the elements method. The results of this analysis were far too detailed to be comprehensible, and so a second analysis was conducted, linking the 32 building properties to 14 element clusters on level 2 of the elements method. Interestingly, three cost generators appeared to be the most important in all the 12 cases: the facade, the interior walls and the contractor costs. Again, with an average of 20% of the total building costs, the costs of replacing or upgrading the facade were remarkably high. Looking more closely into the cost data, because of the high building costs of the facade, buildings with a square floor-plan were found to have lower reconstruction costs than differently shaped buildings. Also, the level of finishing of the new residential function was found to have a high impact on the variance of the total building costs, though only in two projects the finishing was found to be among the most important cost generators. The interior walls were found to be one of the three most important cost generators. However, when looking back at Geraedts and de Vrij's study, though the costs of the interior walls are described as high, these costs are of little influence on the conversion cost variance. These costs will always have to be made and are not varying much from one project to another.

To conclude, the costs generated by interventions in the facade, the structure and the mechanical installations are the most important that can be related directly to the building, while the contractor's costs are more or less generated by the project type (Table 4).

Table 4 The three most important cost generators per case

Case name	cost generator		
	highest	*second high*	*third high*
Wilhelminastaete	facade	interior walls	contractor costs
Churchill tower	facade	interior walls	contractor costs
PDV building	interior walls	contractor costs	facade
Rijswijkstraat	facade	finishing	contractor costs
AKZO building	facade	interior walls	finishing
Bodelograve	facade	contractor costs	site preparation
J.C. Van Markenlaan	facade	contractor costs	Interior walls
GAK office	facade	interior walls	structure
Putgraaf	facade	interior walls	contractor costs
Roos & Doorn	contractor costs	facade	sanitary equipment
Labdiek	contractor costs	roof	facade
Bakenmonde	facade	interior walls	contractor costs

Source: MacKay, 2008

In the interviews we asked the respondents about what they see as the main obstacles for transformation projects. The building structure (grid) and building costs were mentioned the most, though the dimensions of the structure were seen as a bigger obstacle than interventions in the facade. The dimensions of the structure are not expressed as costs in either of the two studies on building costs, probably because the dimensions influence whether or not the building may be transformed into housing for a specific user group, and not so much influence the final building costs.

Costs related to changes in the construction, facade and mechanical installations could be influenced by considering future re-use in the original building design. Real estate developers consider the construction and the facade to have the most influence on the transformation potential of office buildings. However, they suggest that the facade should not be considered an aspect for making future transformation possible. The facade is seen as an aspect that is often changed not only because of the style of existing office buildings, but also because of the changing requirements on daylight, ventilation and acoustic- and thermal insulation. Also it is argued that if transforming an office building into housing, balconies are often added to the facade, while these are neither wanted nor needed for office buildings. According to developers, a future reuse of the construction should be considered when designing and developing an office building. The dimensions of the spaces and rhythm of the construction should be considered, and eventually also its ability to support extra layers in future redevelopments.

4. Investing in functional neutrality

4.1. Willingness to invest

The benefits from investing in a building with a high transformation potential are earned in a later phase of the buildings lifespan, while the investments are made up front, when developing the building. Transformation may not even be necessary, or maybe it will be required after 20-30 years. At this time, the building might not be owned by the initial investor or developer and therefore, since the revenues of such an investment are too uncertain, these actors are quite hesitant to invest in functional neutrality and adaptability. Although most interviewees supported the idea of pro-actively developing buildings with a high transformation potential (by paying more attention to the main measurements, the installations and the services), only nine respondents are prepared to pay for it, 10 respondents are not, and the others "don't know". A stimulating factor for willingness to invest is a low rent level and the expectation that building costs will rise fast in the future. Furthermore the willingness to invest may increase in case of a long period of ownership by the first owner of the building. Some developers considered a lower return on investment than usual acceptable provided that the higher transformation potential reduces the risk of structural vacancy or not being able to sell the building. A lower purchasing price may have contradictory effects. On the one hand it stimulates transformation of vacant buildings to a new function, but at the same time the attractiveness of demolishment and new construction increases as well.

4.2. Proposals for functionally neutral buildings

The idea of linking function neutrality to durability and sustainability has been studied methodically by architects, of which three are of influence on the train of thoughts in this paper. Already in 1961, Habraken presented his book "support, an alternative to mass housing", where he discussed housing as an act that is not completed by a property developer, but instead offers a system of structure and finishing elements, where the users may influence the finishing elements. In 1964 Habraken initiated the Foundation for Architectural Research (Stichting Architecten Research, SAR), that focused on industrial manufacturing methods and the industrial production of the support structure. While in later studies, adaptability has foremost been seen as an instrument for expanding a buildings life-span, to Habraken adaptability gave inhabitants the possibility to influence their own dwelling. Duffy (1997), considering mainly the office building, defined buildings as systems with several layers and recognised shell, services and scenery, where scenery is what may be altered without influencing the functioning of the services or the shell. The services comprise electricity, sewerage and ventilation and elements like elevators, while the shell includes both the buildings facade and its construction. His definition of adaptability is based on refurbishments of office buildings and which elements or layers may be altered to renew the working environment without influencing the technical functioning of the office building itself. Finally, Leupen (2002) refers to Duffy and Habraken and builds forth on their research, recognising five *frames*; structure, skin, scenery, services and access. A frame is described as independent from and with the ability to free what it frames. A high independency of the frames makes adaptations possible. Case studies are central in Leupens research and illustrate his theory. Accordingly, buildings that consist of several frames are sustainable and are more likely to be adapted than buildings where the frames are dependent of each other.

The above studies are opting for sustainable architecture in the form of durable architecture, all being academic approaches or based on experiences from the architectural practice. And although these methods of approach have had impact on academic and architectural theory, the impact of these studies on construction and development practice is not evident.

The idea of linking function neutrality to durability and sustainability is also being studied in practice, as functional neutrality is seen as a means of expanding the buildings lifespan. Frank Bijdendijk, ceo of the housing association "Stadgenoot", introduces the "solid"; an urban building that is designed and developed to accommodate different functions. The only functions not allowed are functions that may hinder the use of the other parts of the building. The solids are still developed on an experimental level and the exchangeability of functions is prescribed in the zoning plan of the area where the first solids are being built. The most important function of the design of the solids is the initial quality of the building. By using durable materials and applying floor-plans that may accommodate different functions, the building's ability to become cherished increases, and beloved buildings are always adapted and reused and therefore also more durable and sustainable. This quality is difficult to prescribe but is evident for instance in the old Venetian "palazzi" or the Amsterdam warehouses, and is experienced as value of use or experience value. The frames of the solids are developed for a technical life span of 100 years, considering that several functional alterations, namely in the buildings interior, will be performed during the buildings lifespan. The investment perspective is that of a normal development; for a housing association approximately 30 years, so that after 30 years the buildings may be technically upgraded.

Another study was issued by the Dutch developer and contractor Ballast Nedam. To Karel Sant, ceo of Ballast Nedam, the anticipated similarity of the office building type and the apartment building type was the

reason to initiate a study on the possibilities for developing buildings that are fit for both uses. The possibility of different uses will increase the value in use of the building and thereby also increase the buildings commercial value. He also noticed the probability of poly-functional buildings having a longer lifespan and thereby influencing positively the durability and sustainability of the built environment. In this study, buildings are described by their structure, facade, interior fitting, installations and access points. The separation of these 5 physical characteristics is seen as a sixth meta-characteristic that can add to the durability of the 5 basic characteristics. Special attention is given to the installations, since the implementation of installations in offices is very different from the way installations are applied in housing, and therefore, as concluded by Mackay (2008) and Geraedts and De Vrij (2004), adapting the installations is one of the most important cost-generators of transformations.

5. Reflection and conclusions

This paper shows a number of reasons why transformation of structurally vacant office buildings may be superior to demolishment and new construction. Some buildings have a particular emotional, architectural, historical or cultural value and/or contribute to the identity of the neighbourhood. Prescribing these intrinsic qualities in new facilities is difficult, though based on our studies of transformations ex-post and comparing the qualities of these buildings to the increased value in use as opted for by Bijdendijk and Sant, we can describe design aspects for the development of flexible and adaptable office buildings, as shown in table 1.

From a sustainability point of view, transformation means less economic loss, less waste of materials and a reduction of building materials transport. However, some of these advantages are reduced if a building is “stripped” completely and only the structure is reused (approximately 8% of the building costs). In theory it is possible to anticipate future transformations by creating a mixed-use zoning plan or functionally neutral zoning plan, including all kinds of facilities, a construction that allows a fill in with different housing types without the need for complex and expensive technical interventions, a facade that can easily be replaced, and installations that can easily be replaced by installations that fit with the needs of new tenants. Other issues such as a location without public health risk, crime or vandalism, an attractive architectural appearance, daylight and sunlight, spacious floor plans, and a high energy performance not only support future conversions to other functions but contribute to the present quality of the building as well, making the building more attractive to office organisations during the whole life cycle of the building. However, the costs of improving future transformation potential have to be paid by the first owner, whereas the return on investment is uncertain and probably just benefits future owners. For this reason design and construction with future transformations in mind is most attractive to actors that own the building for a long time, for example the governmental building agency, a housing association or a pension fund. At this moment we are continuing our research by studying investor’s willingness to invest in the flexibility and adaptability of office buildings, linking flexibility and adaptability to a prolonged building lifespan and a durable and sustainable built environment.

6. References

Geraedts, G. and N. De Vrij 2004, *Transformation meter revisited*. CIB w104 Open Building Implementation, Ball State University, Ball State University.

Geraedts, R. P. and D. J. M. Van der Voordt 2003, *Good buildings drive out bad buildings*. International Conference on Open Building, Hong Kong, The University of Hong Kong.

Geraedts, R. P. and D. J. M. Van der Voordt 2007, *A Tool to measure opportunities and risks of converting empty offices into dwellings*. ENHR ; Sustainable Urban Areas, Rotterdam.

Lichtenberg, J. 2005. *Slimbouwen*. Eindhoven.

Mackay, R., P. De Jong, H. Remøy (2008), Transformation building costs; understanding building costs by modelling. Delft, Delft University of Technology.

Remøy, H., P. W. Koppels, H. de Jonge, *Structural vacancy of office buildings and how it relates to location characteristics*. ARES Annual Meeting, Monterey, California, Cal State Fullerton, College of Business and Economics.

Remøy, H. and T. Van der Voordt 2007. *Conversion of office buildings; a cross-case analysis.* BSA 2007, Tokyo, Tokyo Metropolitan University.

Remøy, H. and T. Van der Voordt 2007, "A new life - conversion of vacant office buildings into housing." *Facilities* 25 (3/4): 88-103.

Van der Voordt, D. J. M., R. P. Geraedts, et al., Eds. 2007. *Transformatie van kantoorgebouwen thema's, actoren, instrumenten en projecten*. Rotterdam, Uitgeverij 010.

Witte, A. R. (2001). Het woonkantoor; ontwikkeling van transformatiegeschikte kantoren. Real Estate & Housing. Delft, Delft University of Technology. MSc: 170.