*De*centralized

A combination of centralized and decentralized building services for transformation of obsolete vacant office buildings into dwellings.

Research Paper

Date 06 June 2014

Name Benjamin Kwant
Student No 4101782

Department Architectural Engineering | Studio 12

First mentor Job Schroen | Acrhitecture
Second Mentor Marcel Bilow | Research

Abstract

Since the beginning of this century, there is a growing structural vacancy of office buildings in the Netherlands. A substantial part of this vacancy consists of obsolete offices at unattractive locations. Transformation of these offices into dwellings provides in a great social need. Big technical challenges for transformation are located in the different requirements of the building services, the less flexibility of the existing construction and the outdated properties of the façades. Improvement of these will have a lot of influence on the quality of the building but is also accompanied by high costs.
In this report, research has been done to a different solution regarding supply and drainage of building services. The conceptual idea is to make use of the possibilities of existing building services and shafts (centralized) and renewed load-bearing façades (decentralized) instead of making recesses in the floors. This in context of adaptability. Regarding to these concept, the research question is: “How can building services for dwellings realized adaptable and make use of the existing building services and load-bearing façades of obsolete vacant office buildings?” The answer to this question is investigated based on five sub-studies.

Chapter 2.1 discusses the requirements of building servies for dwellings. The services can be divided into three categories: comfort, energy and sanitary. Each category consists of different functions. Based on these functions different variants are rated regarding the operation.
Chapter 2.2 focuses on the adaptability requirements for the building services. The most important property for adaptability is that it must be possible to disconnect them from the other components of a dwelling. This allows maintainance or renewing and provides in flexibility for other functions, now or in the future.
Chapter 2.3 focuses on existing building services of office buildings. The setup of these services is usually central in contrast to the setup for residential functions because this is mostly per individual dwelling and decentralized. Because of that, applying decentralized building services for dwellings is often much more favorable. In addition, in general only the services for comfort can be reused because the services for energy en sanitary differ too much from the requirements for dwellings. The analysis of two case studies show that both buildings use shafts, suspended ceilings and heating in the façade zone. However, they differ very much in the number and location of the shafts.
Chapter 2.4 focuses on the load-bearing façades of office buildings. These façades can be classified into three categories: closed elements, parapets and beams. The opportunities of the first one can be found in the layout freedom whereas the placement of services and pass through of piping in the façade is usually better in the second and third category. The analysis of the two case-studies confirms to this.
Chapter 2.5 focuses on possible concepts for the building services of dwellings in vacant office buildings. This chapter is actually the conclusion of the previous chapters. It has become clear that each dwelling has areas with different requirements regarding building services. Based on these differences and the requirements regarding the operation and adaptability of the building services, several concepts which can be used for the transformation of office buildings into dwellings have been developed and judged.
Especially decentralized variants are highly valued because they offer great comfort and also provide in enough adaptability. Central variants could only be applied when the use of existing shafts is possible.
In both case studies the two most logical variants have been applied although there are several good possibilities. In case of the decentralized variants, in particular double façades score very well but the use of these much depends on the orientation of the façade.

Finally, it can be established that possibilities and limitations should be investigated per individual building. Besides that, the chosen concept is very dependent on the orientation of the façade. Ultimately, also other requirements play a significant role, for example, with regard to the aesthetics.

Table of Contents

1 Introduction

1.1 Fascination

I've always been fascinated by the integration of architecture and engineering. Firstly because this topic suits my personal interests for climate design, technical development and detailing, I like solving problems from a technical approach. Besides that also because of the technical background of my previous studies.

1.2 Background

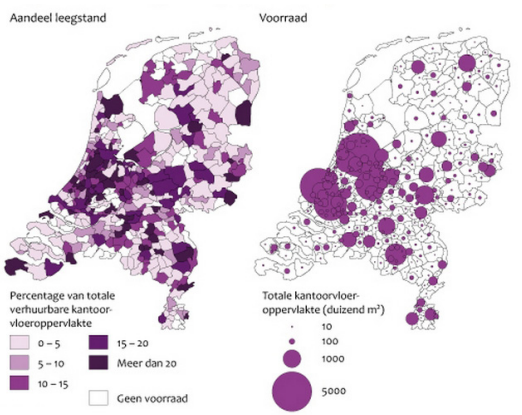
Context Since the beginning of this century, there is a growing structural vacancy of office buildings in the Netherlands, in particular in the Randstad (1). Research shows that the office market also offers a bad prospect for the next years. A substantial part of this vacancy consists of obsolete offices at unattractive locations (2). The probability that in the near future tenants will be found for this buildings is almost zero.

Program To keep the office market healthy and prevent long-term vacancy, it is necessary to remove obsolete office buildings from the market. Preservation and renovation of these buildings is, given the structural oversupply, not a real option. In contrast, transformation to dwellings provides in a great social need because the supply of new dwellings lays behind the demand, particularly in the Randstad (3). The gap which is caused concerns mainly dwellings for students, starters, young dual-earners, empty nesters and elderly people.

Environment Circa 20% of the energy consumption in the Netherlands is related to the built environment. Besides that, the building sector consumes 50% of all materials which are extracted from the earth worldwide, and produces 60% of all the waste products.
The conclusion is that in the building industry much profit can be achieved regarding sustainability, in particular to energy and material use. Transformation of obsolete vacant office buildings to dwellings can contribute to achieve this sustainability goal.

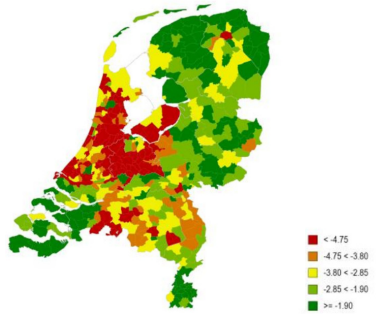
Transformation? Despite of the mentioned advantages, there are several issues which need to be taken into account when transforming office buildings into dwellings. Four factors play a crucial role in transformation projects: the market, juridical aspects, the quality of the location and characteristics of the building.

Technique Transformation of offices to dwellings can be technically complex and really depends on the flexibility of the building. The biggest technical challenges are located in the building services, the construction and the façades. Improvement of these will have a lot of influence on the quality of the building, but is also accompanied by high costs.
The differences between building services for offices and dwellings are large because the requirements in liveability and comfort differ tremendously. Sometimes the existing building services can be re-used, but usually they are largely reconstructed. This means that making recesses in the floor construction is necessary although in practice this is difficult and results in less flexibility. Finally, the façades create problems as well. In particular because of the building physics such as poor sound and thermal insulation, thermal bridges, the amount of daylight, opening of the windows and because of that the ability to ventilate. Also the appearance, the absence of balconies, the opportunities for organizing the space and the connection of interior walls to the façades play a major role during transformation.



1. Vacant office floorspace per municipality, 2013.
Source: http://www.compendiumvoordeleefomgeving.nl/content/figuren/nl/2152_005x_clo_01_nl.jpg

2. Offer of office space by age, 31 Dec 2012.
Source: Kantoren in cijfers 2012, Statistiek van de Nederlandse kantorenmarkt, NVM Business p. 45



3. Percentage of expected dwelling shortage in 2020.
Source: Ontwikkelingen in de kwantitatieve vraag (Ministerie van Binnenlandse zaken en Koninkrijksrelaties)

1.3 Problem Statement

1.3.1 Objective

The intention of this report is to do research to a different solution regarding the supply and drainage of building services when transforming obsolete vacant office buildings into dwellings. The conceptual idea is to make use of the possibilities of existing building services (centralized) and renewed façades (decentralized) instead of making recesses in the floors (4). Because both building services and façades regulate the indoor climate, a (partly) integration of these elements can provide in a logical solution.

Circa a third of the office buildings in the Netherlands exists of load-bearing façades, which has less passive flexibility than buildings with adaptable façades. Because transforming these buildings is a big challenge, they will be the context of this research.

Because of the environmental problems which are mentioned before, sustainability should be taken into account as well. To achieve sustainability regarding this research, it is important that transformation to dwellings is not again part of an existing discard cycle. Because of that adaptability is important for changing requirements and contextual conditions. This ensures that the use of energy and materials will be minimalized as well because demolishment is much less an issue and re-use will be more important.

1.3.2 Technical research question

How can building services for dwellings realized adaptable and make use of the existing building services and load-bearing façades of obsolete vacant office buildings?

1.3.3 Sub questions

1. Which functions regarding building services do dwellings need and which variants can provide in these needs the best?
2. Which properties are important to realize adaptability and which influence do these properties have on the variants of the building services functions for dwellings?
3. What are the characteristics of the existing building services and which possibilities and limitations do they offer regarding integration with the required building services for dwellings and to adaptability?
4. What are the characteristics of the load-bearing façades and which possibilities and limitations do they offer regarding integration with the required building services for dwellings and to adaptability?
5. Which variants can be made when the required building services and adaptability properties are combined with the existing building services and load-bearing façades?

1.3.4 Methodologies

Different methodologies will be used to answer the technical research question.

For the first sub question, a literature study will be done to appoint the different functions of the building services and the possible variants to fulfill these functions. By making use of a spread sheet, the variants are compared to each other on basis of different criteria.

For the second sub question, a literature study will be done to appoint the properties to realize adaptability. These properties are also used as criteria to compare the variants of the first sub question.

For the third sub question a literature study will be done to appoint the differences between building services for office buildings and dwellings and to show the possibilities of the existing services. These differences and possibilities are shown by making use of schemes.

For the fourth sub question a literature study will be done to appoint the different load-bearing façades, their characteristics and possibilities. These possibilities are also shown by making use of schemes.

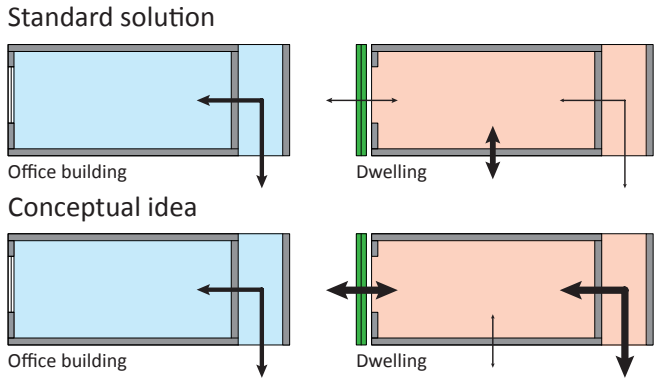
Both third and fourth sub questions will be finished with the analysis of two typical case-studies.

For the fifth sub question a subdivision will be made of the differences in building services between the typical spaces of a dwelling. Finally, on basis of a spread sheet, the schemes showing the differences and properties and by doing research by design, some concepts of building services for the two case-studies will be made.

1.3.5 Relevance

Transformation of obsolete vacant office buildings into dwellings will provide in a solution to both the owners of the offices and to the society because it offers a solution for office vacancy and housing shortage.

Different office buildings can be made suitable for dwellings when substantial investments will be done. Due to technical constraints this is not always possible. This graduation project aims to show that office buildings, which are until now difficult to transform due to the characteristics of the floor construction, can be transformed more easily by applying the proposed solution. Furthermore, this solution also provides in adaptability so changing requirements and contextual conditions will ensure the required sustainability.



4. The standard solution and the conceptual idea for a combination of centralized and decentralized building services (in section) for transformations of office buildings to dwellings. Source: own work

2 Research

2.1 Building services dwellings

2.1.1 Introduction

For each building typology different requirements are appointed for comfort, energy use and sanitary facilities. These requirements are performed by the façades and building services. The façade acts as intermediary between the indoor and outdoor space and interacts with the building services.

The goal of this study is twofold: Firstly, the requirements for comfort, energy and sanitary of dwellings in general will be researched and connected with the associated functions. Secondly, various function variants which can fulfill these requirements are compared to each other, on basis of different criteria.

In addition to the requirements for comfort, energy and sanitary, also requirements for topics like fire safety, aesthetics and space requirements are appointed, but these will not be researched in this study.

2.1.2 Functions of building services for dwellings

What are regarding to comfort, energy-use and sanitary facilities, functions which are performed by the building services of a dwelling (5)?

Comfort can be subdivided into thermal, hygienic, acoustic and visual comfort whereby thermal and hygienic comfort are related to each other strongly.

Thermal comfort is about keeping the temperature as comfortable as possible and can be divided into sun-protection, insulation, heating and cooling.

Sun protection can reduce the cooling load of a building drastically. Therefore, all sun protection principles which are generally applied are included in this study

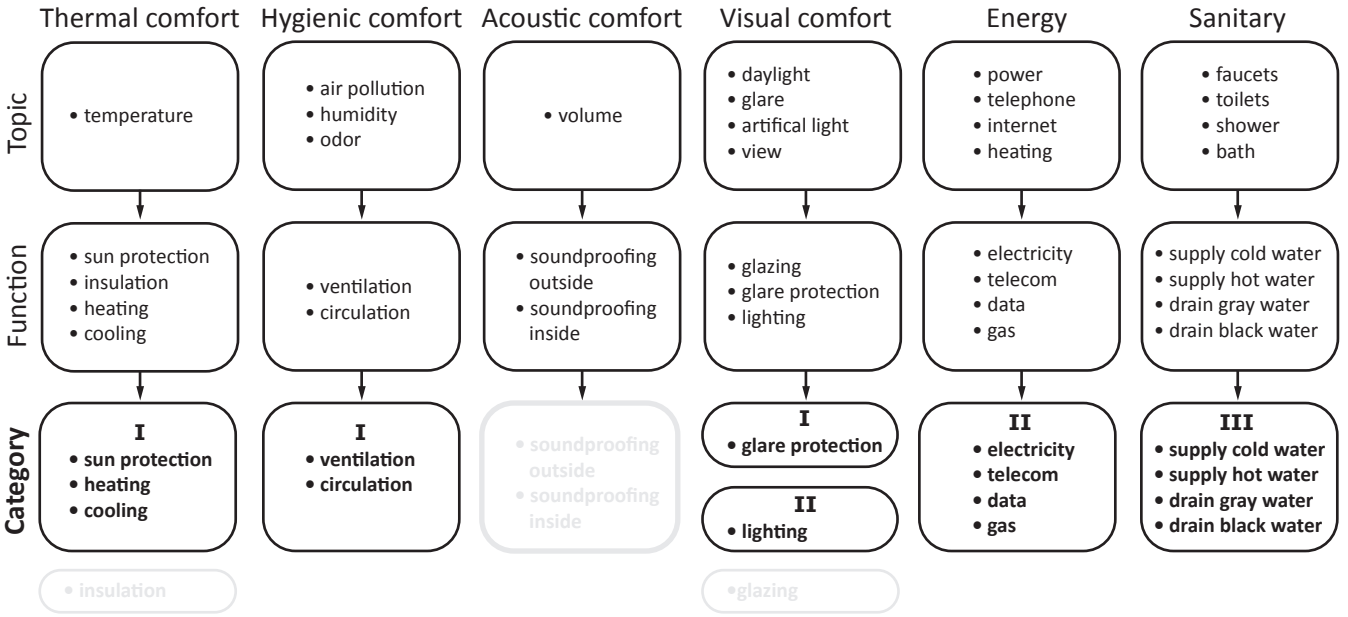
Insulation can reduce both heat and cooling load of a dwelling which reduce the required capacity of the heating and cooling services drastically. Both sun protection and insulation mostly have a passive operation. Both heating and cooling have an active operation and produce heat or coolness which is delivered to the spaces. This can be done by means of convection (transfer of energy by small particles in the air) and by radiation (radiation from surfaces). This research focuses on sun protection and functions which distribute and deliver heat and/or coolness to the space. Insulation and heat/coolness generators are, except when integrated, disregarded because they do not directly affect building services in individual dwellings.

Hygienic comfort is about keeping the air quality in the dwellings sufficient. It is about air pollution, humidity and odor. The air quality can be maintained by adequate ventilation and circulation. To provide in hygienic comfort the supplied air quality must be sufficient and circulated enough. As well as with heating and cooling particularly building services which distribute and deliver fresh air to the space are researched.

Acoustic comfort is related to the prevention of outside noises, such as traffic and construction noise, and noises from inside, like noises of building services and people. Sound transmission can take place through the air (air noise) and through objects (contact noise). In this research, acoustic comfort is not included because it is not resolved by building services.

Visual comfort is about sufficient daylight, view, artificial light and glare prevention. Sufficient daylight and views are achieved by placing enough glazing at the right place. Artificial light is realized by artificial lighting and glare prevention is countered by sun protection. Also glazing is not included in this study because it is not part of the building services.

Energy use is about functions for distribution and deliv-



5. Functions of building services for dwellings. Source: own work

ery of electricity, gas and communication techniques.
Sanitary is about the supply of hot and cold water and drain of gray and black water, needed for faucets, toilets, showers and baths.
Finally, all functions are divided again into the categories of comfort, energy and sanitary which make a separation between the functions which hardly have any mutual relationship.

2.1.3 Rating variants

On basis of the three categories different variants have been investigated which can fulfill the established functions (6). By meaning of different criteria and weighting factors these variants are compared to each other. Both criteria and weighting factors are determined per separate function. The criteria are related to the provided comfort, the degree of individual control, maintenance and/or the usability it provides. For sun protection also view and weather resistance play a major role. The weighting factors are influenced by the importancy the criteria have for the different functions.
The differences for ventilation and circulation are slight but the double facade and decentralized unit have the highest score. Both variants offer great comfort and individual control which are the most important criteria in this category.
For heating, the radiator, underfloor heating and ceiling radiation have the highest score. For the radiator and ceiling radiation the emphasis is on individual control and for underfloor heating, comfort and maintenance have high scores.
For cooling, night cooling scores maximal despite the fact this is a passive function. The ceiling cooling elements have high scores on individual control but also for comfort and individual control they have a good rate.
For sun protection the scores are mainly divided between the fixed variants which are 'locked' into a cavity, and because of that almost free of maintenance and weather influences, and the movable variants which offer great comfort and a good view.
For the 2nd and 3rd category the position of the distribution pipes regarding to the space, and the height of the connections for delivery are important. Despite of the fact that only the criterion usability is applied here, it is clear that both the variants pre-wall, grid points and milled pipes have high scores for all functions. This is due to the fact that different heights are provided.
An exception is the discharge of gray and black water because the connections for this are always placed low.
Although the differences are not very big, it is clear that vertical drain through shafts scores higher than the horizontal drains. This also has to do with usability because raised floors are not required becaue of the direct vertical drain.

2.1.4 Conclusion

Despite the fact that for each function some variations have high scores, it does not mean that these variants are also used in the concepts which are developed finally. Firstly, because in the next chapter the variants of this research are also rated on basis of their adaptability abilities. In addition, in the fifth chapter the possibilities of the variations are investigated for use in the proposed case studies.

I — Variants

			1	2	3	4	5	6	7	8	9	10
Comfort	A	Ventilation Circulation	Windows	Windows + central shafts	Windows + decentralized shafts	Double facade	Mechanical central	Window fan	Decentralized unit			
			A comfort 3 45% 1,35	A comfort 4 45% 1,80	A comfort 4 45% 1,80	A comfort 5 45% 2,25	A comfort 5 45% 2,25	A comfort 4 45% 1,80	A comfort 5 45% 2,25			
			B individual control 5 35% 1,75	B individual control 5 35% 1,75	B individual control 5 35% 1,75	B individual control 5 35% 1,75	B individual control 4 35% 1,40	B individual control 4 35% 1,40	B individual control 4 35% 1,40			
			C maintenance 4 20% 0,80	C maintenance 4 20% 0,80	C maintenance 4 20% 0,80	C maintenance 4 20% 0,80	C maintenance 2 20% 0,40	C maintenance 3 20% 0,60	C maintenance 3 20% 0,60			
			Total 3,90	Total 4,35	Total 4,35	Total 4,80	Total 4,05	Total 3,80	Total 4,05			
	B	Heating	Radiator	Convector	Subsurface convector	Underfloor (radiant)	Concrete core	Overhead radiation ceiling	Overhead induction ceiling	Central air conditioning system	Decentralized air conditioning system	Wall
			A comfort 4 45% 1,80	A comfort 3 45% 1,35	A comfort 3 45% 1,35	A comfort 5 45% 2,25	A comfort 4 45% 1,80	A comfort 4 45% 1,80	A comfort 3 45% 1,35	A comfort 3 45% 1,35	A comfort 3 45% 1,35	A comfort 3 45% 1,35
			B individual control 5 35% 1,75	B individual control 5 35% 1,75	B individual control 5 35% 1,75	B individual control 4 35% 1,40	B individual control 3 35% 1,05	B individual control 5 35% 1,75	B individual control 5 35% 1,75	B individual control 4 35% 1,40	B individual control 5 35% 1,75	B individual control 4 35% 1,40
			C maintenance 4 20% 0,80	C maintenance 4 20% 0,80	C maintenance 3 20% 0,60	C maintenance 5 20% 1,00	C maintenance 5 20% 1,00	C maintenance 4 20% 0,80	C maintenance 4 20% 0,80	C maintenance 3 20% 0,60	C maintenance 4 20% 0,80	C maintenance 5 20% 1,00
			Total 4,35	Total 3,90	Total 3,70	Total 4,90	Total 3,85	Total 3,95	C maintenance 3,90	Total 3,35	Total 3,90	Total 3,75
	C	Cooling	Overhead radiation ceiling	Concrete core	Overhead induction ceiling	Passive chilled beam/baffles	Cooling panels/ceilings/sails	Central air conditioning system	Decentralized air conditioning system	Night flush		
			A comfort 4 45% 1,80	A comfort 4 45% 1,80	A comfort 3 45% 1,35	A comfort 4 45% 1,80	A comfort 4 45% 1,80	A comfort 3 45% 1,35	A comfort 3 45% 1,35	A comfort 5 100% 5,00		
			B individual control 5 35% 1,75	B individual control 3 35% 1,05	B individual control 5 35% 1,75	B individual control 5 35% 1,75	B individual control 5 35% 1,75	B individual control 4 35% 1,40	B individual control 5 35% 1,75	0,00		
			C maintenance 4 20% 0,80	C maintenance 5 20% 1,00	C maintenance 4 20% 0,80	C maintenance 4 20% 0,80	C maintenance 4 20% 0,80	C maintenance 3 20% 0,60	C maintenance 4 20% 0,80	0,00		
			Total 4,35	Total 3,85	C maintenance 3,90	Total 4,45	Total 4,35	Total 3,35	Total 3,90	Total 5,00		
	D	Sun & glare protection	Internal	Silkscreened patterns	In glazing	In cavity	Brise-soleil	External lamellae	Plants	Moveable: roller blinds	Moveable: venetian blinds	Moveable: sliding panels
			A comfort: sun protection 2 25% 0,50	A comfort: sun protection 3 25% 0,75	A comfort: sun protection 4 25% 1,00	A comfort: sun protection 4 25% 1,00	A comfort: sun protection 4 25% 1,00	A comfort: sun protection 5 25% 1,25	A comfort: sun protection 3 25% 0,75	A sun protection 5 25% 1,25	A comfort: sun protection 5 25% 1,25	A comfort: sun protection 5 25% 1,25
			B comfort: glare protection 5 10% 0,50	B comfort: glare protection 4 10% 0,40	B comfort: glare protection 5 10% 0,50	B comfort: glare protection 5 10% 0,50	B comfort: glare protection 2 10% 0,20	B comfort: glare protection 5 10% 0,50	B comfort: glare protection 3 10% 0,30	B glare protection 5 10% 0,50	B comfort: glare protection 5 10% 0,50	B comfort: glare protection 5 10% 0,50
			c individual control 5 15% 0,75	c individual control 2 15% 0,30	c individual control 5 15% 0,75	c individual control 5 15% 0,75	c individual control 2 15% 0,30	c individual control 3 15% 0,45	c individual control 2 15% 0,30	c individual control 5 15% 0,75	c individual control 5 15% 0,75	c individual control 5 15% 0,75
			D maintenance 3 10% 0,30	D maintenance 5 10% 0,50	D maintenance 3 10% 0,30	D maintenance 4 10% 0,40	D maintenance 5 10% 0,50	D maintenance 3 10% 0,30	D maintenance 2 10% 0,20	D maintenance 3 10% 0,30	D maintenance 3 10% 0,30	D maintenance 4 10% 0,40
			E view 3 25% 0,75	E view 3 25% 0,75	E view 3 25% 0,75	E view 5 25% 0,75	E view 5 25% 1,25	E view 3 25% 0,75	E view 4 25% 1,00	E view 4 25% 1,00	E view 4 25% 1,00	E view 5 25% 1,25
			F weather proof 5 15% 0,75	F weather proof 5 15% 0,75	F weather proof 5 15% 0,75	F weather proof 5 15% 0,75	F weather proof 5 15% 0,75	F weather proof 4 15% 0,60	F weather proof 3 15% 0,45	F weather proof 2 15% 0,30	F weather proof 2 15% 0,30	F weather proof 3 15% 0,45
			Total 3,55	Total 3,45	Total 4,05	Total 4,20	Total 4,05	Total 3,85	Total 3,00	Total 4,00	Total 4,20	Total 4,45

II — Variants

			1	2	3	4	5	6	7	8	9	10
Energy	A	Electricity, Lighting, Telecom, Data	Raised floor	c	Pre-wall	Grid points (tube)	Baseboard	Milled in walls & floors				
			A usability 3 100% 3,00	A usability 2 100% 2,00	A usability 5 100% 5,00	A usability 5 100% 5,00	A usability 4 100% 4,00	A usability 5 100% 5,00				
			Total 3,00	Total 2,00	Total 5,00	Total 5,00	Total 4,00	Total 5,00				
	B	Gas	Raised floor	Suspended ceiling	Pre-wall	Grid points (tube)						
			A usability 4 100% 4,00	A usability 3 100% 3,00	A usability 5 100% 5,00	A usability 5 100% 5,00						
			Total 4,00	Total 3,00	Total 5,00	Total 5,00						

III — Variants

			1	2	3	4	5	6	7	8	9	10
Sanitary	A	Supply cold & hot water	Raised floor	Suspended ceiling	Pre-wall	Grid points (tube)	Baseboard	Milled in walls & floors				
			A usability 4 100% 4,00	A usability 3 100% 3,00	A usability 5 100% 5,00	A usability 5 100% 5,00	A usability 4 100% 4,00	A usability 5 100% 5,00				
			Total 4,00	Total 3,00	Total 5,00	Total 5,00	Total 4,00	Total 5,00				
	B	Drain gray & black water	Raised floor	Floor	Grinding device	Seperate shafts						
			A usability 3 50% 1,50	A usability 4 50% 2,00	A usability 3 50% 1,50	A usability 5 50% 2,50						
			B comfort 4 50% 2,00	B comfort 3 50% 1,50	B comfort 4 50% 2,00	B comfort 3 50% 1,50						
			Total 3,50	Total 3,50	Total 3,50	Total 4,00						

6. Rating of function variants based on 3 categories. Source: own work

2.2 Adaptability

2.2.1 Introduction

A good building can change continuously without affecting the character. This is related to both changing environmental circumstances and to the requirements of the users. However, in practice many buildings are difficult to change regarding to functional requirements so when a building is transformed, these problems should be prevented by making them adaptable. Besides that, this also increases the durability because energy and material use is minimized.

The goal of this chapter is divided into two parts: Firstly, research has been done to properties which are important to realize adaptability. Secondly the influences these properties have on the variants of the building services for dwellings are investigated.

Ofcourse, adaptability covers more subjects than building services, but these will not be included in this study.

2.2.2 Concepts & properties

To figure out the needed properties for adaptability, firstly research has been done to concepts and theories which have been developed regarding this topic.

Already in 1914, Le Corbusier identified the idea of adaptability with his Dom-Ino concept. By using load-bearing columns, façades and spaces could be divided freely. In the sixties, John Habraken developed the theory of 'Open Bouwen' for serial housing. The essence of this idea is about how to build for an unforeseen future and in advance takes in consideration changing lifespans and changeability. In practice this means that a dwelling is divided into a support (collectively and long lifespan) and infill (individually and short lifespan) which made customized serial housing possible and can extend the lifetime of the dwellings. Nevertheless, it should be taken into account that support and infill also influence each other and cannot be designed independently.

Nowadays, building Lean and IFD emerge increasingly. Building Lean mainly concerns the building process but IFD is focused on industrialization (I), flexibility (F) and build demountable (D). The results of building IFD are more quality, freedom of choice and supervision for the users, a better managed construction process, less impact on the environment and a shorter construction time. Practically this means that products are produced more quickly and under optimal conditions, without disturbance and with a high quality. Also that dwellings can be modified during their lifespans and disassembled for reuse or recycling after their lifespan.

Building services for dwellings has to meet a lot of requirements regarding to adaptability. Firstly, maintenance should be possible. In addition, building services

I

			Variants 1																			
			Windows			Windows + central shafts			Windows + decentralized shafts			Double facade			Mechanical central			Window fan			Decentralized unit		
Comfort	A	Ventilation Circulation	A accessibility	5	30% 1,50	A accessibility	5	30% 1,50	A accessibility	4	30% 1,20	A accessibility	5	30% 1,50	A accessibility	3	30% 0,90	A accessibility	3	30% 0,90	A accessibility	3	30% 0,90
			B detachability	4	20% 0,80	B detachability	4	20% 0,80	B detachability	3	20% 0,60	B detachability	2	20% 0,40	B detachability	3	20% 0,60	B detachability	4	20% 0,80	B detachability	4	20% 0,80
			C flexibility	2	30% 0,60	C flexibility	3	30% 0,90	C flexibility	2	30% 0,60	C flexibility	2	30% 0,60	C flexibility	5	30% 1,50	C flexibility	2	30% 0,60	C flexibility	2	30% 0,60
			D layout freedom	5	20% 1,00	D layout freedom	4	20% 0,80	D layout freedom	5	20% 1,00	D layout freedom	5	20% 1,00	D layout freedom	4	20% 0,80	D layout freedom	5	20% 1,00	D layout freedom	5	20% 1,00
			Total		4,00	Total		4,20	Total		3,40	Total		3,50	Total		3,50	Total		3,30	Total		3,30
	B	Heating	Radiator			Convector			Subsurface convector			Underfloor (radiant)			Concrete core			Overhead radiation ceiling			Overhead induction ceiling		
			A accessibility	5	15% 0,75	A accessibility	5	15% 0,75	A accessibility	4	15% 0,60	A accessibility	2	15% 0,30	A accessibility	1	15% 0,15	A accessibility	4	15% 0,60	A accessibility	4	15% 0,60
			B detachability	3	15% 0,45	B detachability	3	15% 0,45	B detachability	3	15% 0,45	B detachability	1	15% 0,15	B detachability	1	15% 0,15	B detachability	4	15% 0,60	B detachability	3	15% 0,45
			C flexibility	2	35% 0,70	C flexibility	2	35% 0,70	C flexibility	1	35% 0,35	C flexibility	2	35% 0,70	C flexibility	1	35% 0,35	C flexibility	4	35% 1,40	C flexibility	3	35% 1,05
			D layout freedom	2	35% 0,70	D layout freedom	2	35% 0,70	D layout freedom	1	35% 0,35	D layout freedom	5	35% 1,75	D layout freedom	5	35% 1,75	D layout freedom	4	35% 1,40	D layout freedom	4	35% 1,40
			Total		2,60	Total		2,60	Total		1,75	Total		2,90	Total		2,40	Total		3,70	Total		3,50
	C	Cooling	Overhead radiation ceiling			Concrete core			Overhead induction ceiling			Passive chilled beam/baffles			Cooling panels/ceilings/sails			Central air conditioning system			Decentralized air conditioning system		
			A accessibility	4	15% 0,60	A accessibility	1	15% 0,15	A accessibility	4	15% 0,60	A accessibility	4	15% 0,60	A accessibility	4	15% 0,60	A accessibility	3	15% 0,45	A accessibility	4	15% 0,60
			B detachability	4	15% 0,60	B detachability	1	15% 0,15	B detachability	3	15% 0,45	B detachability	3	15% 0,45	B detachability	3	15% 0,45	B detachability	3	15% 0,45	B detachability	4	15% 0,60
			C flexibility	4	35% 1,40	C flexibility	1	35% 0,35	C flexibility	3	35% 1,05	C flexibility	3	35% 1,05	C flexibility	3	35% 1,05	C flexibility	4	35% 1,40	C flexibility	4	35% 1,40
			D layout freedom	4	35% 1,40	D layout freedom	5	35% 1,75	D layout freedom	4	35% 1,40	D layout freedom	4	35% 1,40	D layout freedom	4	35% 1,40	D layout freedom	4	35% 1,40	D layout freedom	5	35% 1,75
			Total		4,20	Total		2,40	Total		3,50	Total		3,50	Total		3,50	Total		3,70	Total		4,20
	D	Sun & glare protection	Internal			Silkscreened patterns			In glazing			In cavity			Brise-soleil			External lamellae			Plants		
			A accessibility	5	60% 3,00	A accessibility	5	60% 3,00	A accessibility	1	60% 0,60	A accessibility	4	60% 2,40	A accessibility	5	60% 3,00	A accessibility	3	60% 1,80	A accessibility	3	60% 1,80
			B detachability	5	40% 2,00	B detachability	2	40% 0,80	B detachability	2	40% 0,80	B detachability	3	40% 1,20	B detachability	1	40% 0,40	B detachability	3	40% 1,20	B detachability	3	40% 1,20
			Total		5,00	Total		3,80	Total		1,40	Total		3,60	Total		3,40	Total		3,00	Total		3,00

			Variants 1																			
			Windows			Windows + central shafts			Windows + decentralized shafts			Double facade			Mechanical central			Window fan			Decentralized unit		
Comfort	A	Ventilation Circulation	A accessibility	5	30% 1,50	A accessibility	5	30% 1,50	A accessibility	4	30% 1,20	A accessibility	5	30% 1,50	A accessibility	3	30% 0,90	A accessibility	3	30% 0,90	A accessibility	3	30% 0,90
			B detachability	4	20% 0,80	B detachability	4	20% 0,80	B detachability	3	20% 0,60	B detachability	2	20% 0,40	B detachability	3	20% 0,60	B detachability	4	20% 0,80	B detachability	4	20% 0,80
			C flexibility	2	30% 0,60	C flexibility	3	30% 0,90	C flexibility	2	30% 0,60	C flexibility	2	30% 0,60	C flexibility	5	30% 1,50	C flexibility	2	30% 0,60	C flexibility	2	30% 0,60
			D layout freedom	5	20% 1,00	D layout freedom	4	20% 0,80	D layout freedom	5	20% 1,00	D layout freedom	5	20% 1,00	D layout freedom	4	20% 0,80	D layout freedom	5	20% 1,00	D layout freedom	5	20% 1,00
			Total		4,00	Total		4,20	Total		3,40	Total		3,50	Total		3,50	Total		3,30	Total		3,30
	B	Heating	Radiator			Convector			Subsurface convector			Underfloor (radiant)			Concrete core			Overhead radiation ceiling			Overhead induction ceiling		
			A accessibility	5	15% 0,75	A accessibility	5	15% 0,75	A accessibility	4	15% 0,60	A accessibility	2	15% 0,30	A accessibility	1	15% 0,15	A accessibility	4	15% 0,60	A accessibility	4	15% 0,60
			B detachability	3	15% 0,45	B detachability	3	15% 0,45	B detachability	3	15% 0,45	B detachability	1	15% 0,15	B detachability	1	15% 0,15	B detachability	4	15% 0,60	B detachability	3	15% 0,45
			C flexibility	2	35% 0,70	C flexibility	2	35% 0,70	C flexibility	1	35% 0,35	C flexibility	2	35% 0,70	C flexibility	1	35% 0,35	C flexibility	4	35% 1,40	C flexibility	3	35% 1,05
			D layout freedom	2	35% 0,70	D layout freedom	2	35% 0,70	D layout freedom	1	35% 0,35	D layout freedom	5	35% 1,75	D layout freedom	5	35% 1,75	D layout freedom	4	35% 1,40	D layout freedom	4	35% 1,40
			Total		2,60	Total		2,60	Total		1,75	Total		2,90	Total		2,40	Total		3,70	Total		3,50
	C	Cooling	Overhead radiation ceiling			Concrete core			Overhead induction ceiling			Passive chilled beam/baffles			Cooling panels/ceilings/sails			Central air conditioning system			Decentralized air conditioning system		
			A accessibility	4	15% 0,60	A accessibility	1	15% 0,15	A accessibility	4	15% 0,60	A accessibility	4	15% 0,60	A accessibility	4	15% 0,60	A accessibility	3	15% 0,45	A accessibility	4	15% 0,60
			B detachability	4	15% 0,60	B detachability	1	15% 0,15	B detachability	3	15% 0,45	B detachability	3	15% 0,45	B detachability	3	15% 0,45	B detachability	3	15% 0,45	B detachability	4	15% 0,60
			C flexibility	4	35% 1,40	C flexibility	1	35% 0,35	C flexibility	3	35% 1,05	C flexibility	3	35% 1,05	C flexibility	3	35% 1,05	C flexibility	4	35% 1,40	C flexibility	4	35% 1,40
			D layout freedom	4	35% 1,40	D layout freedom	5	35% 1,75	D layout freedom	4	35% 1,40	D layout freedom	4	35% 1,40	D layout freedom	4	35% 1,40	D layout freedom	4	35% 1,40	D layout freedom	5	35% 1,75
			Total		4,20	Total		2,40	Total		3,50	Total		3,50	Total		3,50	Total		3,70	Total		4,20
	D	Sun & glare protection	Internal			Silkscreened patterns			In glazing			In cavity			Brise-soleil			External lamellae			Plants		
			A accessibility	5	60% 3,00	A accessibility	5	60% 3,00	A accessibility	1	60% 0,60	A accessibility	4	60% 2,40	A accessibility	5	60% 3,00	A accessibility	3	60% 1,80	A accessibility	3	60% 1,80
			B detachability	5	40% 2,00	B detachability	2	40% 0,80	B detachability	2	40% 0,80	B detachability	3	40% 1,20	B detachability	1	40% 0,40	B detachability	3	40% 1,20	B detachability	3	40% 1,20
			Total		5,00	Total		3,80	Total		1,40	Total		3,60	Total		3,40	Total		3,00	Total		3,00

II

			Variants 1																			
			Raised floor			Suspended ceiling			Pre-wall			Grid points (tube)			Baseboard			Milled in walls & floors					
Energy	A	Electricity Lighting Telecom Data	A accessibility	3	25% 0,75	A accessibility	3	25% 0,75	A accessibility	5	25% 1,25	A accessibility	5	25% 1,25	A accessibility	4	25% 1,00	A accessibility	2	25% 0,50			
			B detachability	5	15% 0,75	B detachability	5	15% 0,75	B detachability	5	15% 0,75	B detachability	5	15% 0,75	B detachability	4	15% 0,60	B detachability	2	15% 0,30			
			C flexibility	5	30% 1,50	C flexibility	5	30% 1,50	C flexibility	4	30% 1,20	C flexibility	3	30% 0,90	C flexibility	4	30% 1,20	C flexibility	2	30% 0,60			
			D layout freedom	5	30% 1,50	D layout freedom	5	30% 1,50	D layout freedom	4	30% 1,20	D layout freedom	4	30% 1,20	D layout freedom	2	30% 0,60	D layout freedom	2	30% 0,60			
			Total		4,50	Total		4,50	Total		4,40	Total		4,10	Total		3,40	Total		2,00			
	B	Gas	Raised floor			Suspended ceiling			Pre-wall			Grid points (tube)											
			A accessibility	3	15% 0,45	A accessibility	3	15% 0,45	A accessibility	5	15% 0,75	A accessibility	5	15% 0,75									
			B detachability	5	15% 0,75	B detachability	5	15% 0,75	B detachability	5	15% 0,75	B detachability	5	15% 0,75									
			C flexibility	5	35% 1,75	C flexibility	5	35% 1,75	C flexibility	4	35% 1,40	C flexibility	3	35% 1,05									
			D layout freedom	5	35% 1,75	D layout freedom	5	35% 1,75	D layout freedom	4	35% 1,40	D layout freedom	4	35% 1,40									
			Total		4,70	Total		4,70	Total		4,30	Total		3,95									

III

			Variants 1																			
			Raised floor			Suspended ceiling			Pre-wall			Grid points (tube)			Baseboard			Milled in walls & floors					
Sanitary	A	Supply cold & hot water	A accessibility	3	20% 0,60	A accessibility	3	20% 0,60	A accessibility	5	20% 1,00	A accessibility	5	20% 1,00	A accessibility	4	20% 0,80	A accessibility	2	25% 0,50			
			B detachability	5	20% 1,00	B detachability	5	20% 1,00	B detachability	5	20% 1,00	B detachability	5	20% 1,00	B detachability	4	20% 0,80	B detachability	2	15% 0,30			
			C flexibility	5	30% 1,50	C flexibility	5	30% 1,50	C flexibility	4	30% 1,20	C flexibility	3	30% 0,90	C flexibility	4	30% 1,20	C flexibility	2	30% 0,60			
			D layout freedom	5	30% 1,50	D layout freedom	5	30% 1,50	D layout freedom	4	30% 1,20	D layout freedom	4	30% 1,20	D layout freedom	2	30% 0,60	D layout freedom	2	30% 0,60			
			Total		4,60	Total		4,70	Total		4,40	Total		4,10	Total		3,40	Total		2,00			
	B	Drain gray & black water	Raised floor			floor			Grinding device			Seperate shafts											
			A accessibility	4	35% 1,40	A accessibility	4	35% 1,40	A accessibility	4	35% 1,40	A accessibility	5	35% 1,75									
			B detachability	5	25% 1,25	B detachability	2	25% 0,50	B detachability	5	25% 1,25	B detachability	5	25% 1,25									
			C flexibility	4	20% 0,80	C flexibility	2	20% 0,40	C flexibility	5	20% 1,00	C flexibility	3	20% 0,60									
			D layout freedom	5	20% 1,00	D layout freedom	5	20% 1,00	D layout freedom	5	20% 1,00	D layout freedom	3	20% 0,60									
			Total		4,45	Total		3,30	Total		4,65	Total		4,20									

7. Rating of function variants for adaptability based on 3 categories. Source: own work

should be able to expand or shrink and applied at different places easily. Thirdly, it should be possible that building services contribute also to function changes of spaces or a whole building, both during the construction of the building and in the future. In essence this means it should be possible to disconnect the building services from the other components of a dwelling, which makes them adaptable to changing requirements.

2.2.3 Rating variants

The variants of the previous chapter, which can fulfill the functions of the building services, have also been compared on basis of criteria and weighting factors for adaptability (7). The criteria are based on the three mentioned requirements and contain the topics accesability, detachability, flexibility and layout freedom. For sun protection, flexibility and layout freedom are not taken into account because they are not relevant. The weighting factors are influenced by the importancy the criteria have for the different functions.

The differences for ventilation and circulation are slight but the window variants and central mechanical system have the highest scores. The window variants offer great properties for accesibility, detachability and layout freedom. Only for flexibility they have a low score because they can only serve spaces at the façade. In contrast to this, the central mechanical system has a high score for flexibility and layout freedom and a low score for accesability and detachability because it can serve almost all spaces but it is more difficult to maintain, adapt and renew.

For heating, the radiation ceiling and both air conditioning systems have a high score. The radiation ceiling meets all criteria. The central air conditioning system is flexible and offers a good layout freedom because it can serve in almost all spaces without major changes. In contrast, the decentral air conditioning system meets the accesibility and detachability criteria very well.

Also for cooling the radiation ceiling and both air conditioning systems have high scores because of the reasons mentioned before. Night flush meets all the requirements for adaptability because it is essentially not part of the building services but part of the 'support'.

For sun protection, the internal variants have very high scores on both criteria. The remaining high-scoring variants are close to each other but the moveable variants have a fairly constant score for both criteria.

For the 2nd and 3rd category, mainly the criteria flexibility and freedom of layout are interesting. For all the functions, the raised floor and suspended ceiling have the highest score although the pre-wall scores very well too. Also here, the score is relatively constant for both criteria.

For the drain of gray and black water the raised floor, grinding device and seperate shafts have a high score, again for all criteria, although the latter is focust mainly on accessibility and detachability.

2.2.4 Conclusion

The most important property for adaptability is in essence that it must be possible to disconnect the building services from the other components of a dwelling.

This allows them to be maintained or renewed easily and provide in flexibility for other functions, now or in the future.

Despite the fact that for each function some variations have high scores, also now it does not mean that these variants are used in the concepts which are developed finally. Firstly, because then the rating of the variants of the first chapter are also included. In addition, in the fifth chapter the possibilities of all variants are also investigated for use in the proposed case studies.

2.3 Building services vacant office buildings

2.3.1 Introduction

Most of the existing building services in vacant office buildings are too old to fullfill the present standards for dwellings. On the other hand, because building services have a major impact on the budget of a transformation project it is also an opportunity to make use of the existing facilities.

The goal of this study is threefold: Firstly, the characteristics of the existing building services of office buildings will be researched. Secondly, research will be done to the possibilities and limitations they offer regarding integration with the required building services for dwellings and to adaptability. Thirdly, this research will also be done for two case studies which ensure that the characteristics, possibilities and limitations of existing building services from practice may be researched as well.

The building services will be rated based on the criteria used in the previous chapters. Some of the discussed variants of these chapters are also taken into account here if they are characteristic for vacant office buildings. Because of that, some overlap will be found in this research but that will make more clear what the opportunities of existing building services are.

This research includes only the analysis of building services for comfort, energy and sanitary and does not cover sound insulation, fire protection and the services for elevators.

2.3.2 Characteristics existing building services

To some extent, building services of office buildings already have been designed in view of transformation. There are areas for pipes, ducts and cables so they can be provided of new divisions easily. The problem is that, when transformed into dwellings, totally different requirements must be achieved regarding to the setup of the building services. Because of that, in this chapter

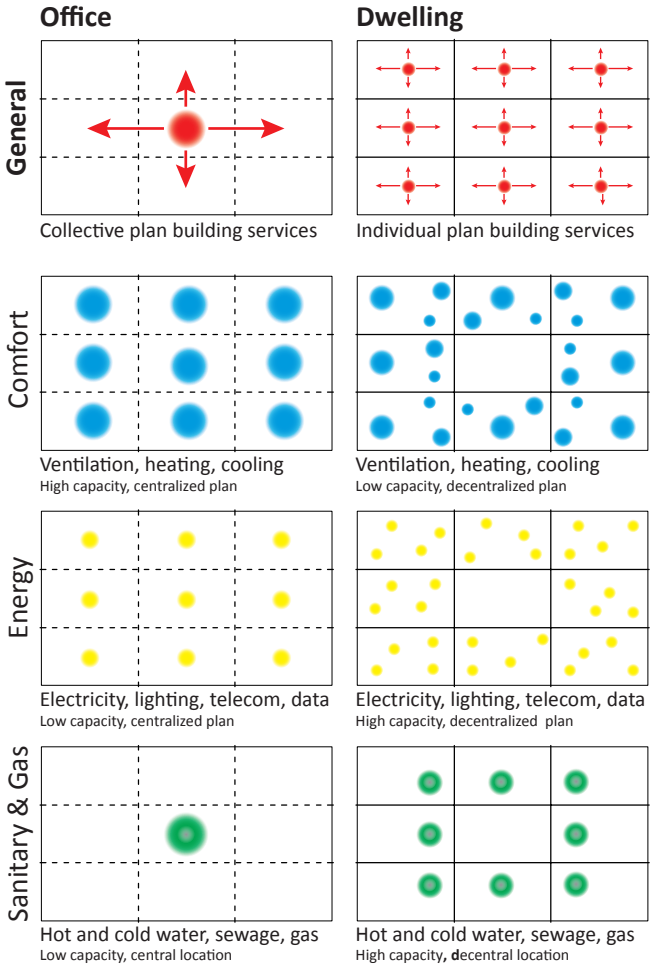
not only the characteristics of the building services set-up of office buildings is investigated, but they are also compared to the setup of services for dwellings. The services are divided according to the categories comfort, energy and sanitary, as in the previous chapters. Exceptions are the services for gas. Because these are in character very similar to sanitary facilities, they are included in that category. The main differences are all visualized in a diagram (8).

A general difference between building services for dwellings and office buildings is that offices usually have a collective and centralized setup for ventilation, heating, cooling and sanitary while for a residential function, these facilities have been set up for each dwelling individual, so decentralized. Facilities for ventilation, heating and cooling generally have plenty of capacity for residential purposes although there are big ventilation differences between the different spaces of a dwelling. Energy services in office buildings are set up differently than in dwellings and also have a much smaller capacity. This also applies to the lighting plan.

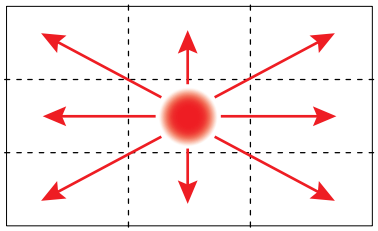
The sanitary density of office buildings is generally very low, both in relation to the supply of hot and cold water and to the drain of toilets and sinks. Facilities for showers and baths are hardly present. Usually, sanitary facilities are only positioned in the center of the office building whereas dwellings have their own sanitary facilities.

Gas installations in offices usually are limited to what is necessary for climate control systems and water heating, and usually are only positioned in the center of the building.

Based on these results it can be established that the setup of building services of offices is usually central while the setup for a residential function is mostly per individual dwelling. In addition, of the existing facilities, only services for comfort offer opportunities for reuse. The differences regarding energy and sanitary are so large that they need to be renewed largely or entirely. The second part of this study therefore, focuses on the possibilities and limitations of a centralized setup, by making use of existing shafts, versus a decentralized setup, by making use of the façades. In addition the opportunities related to reuse of building services for comfort are researched as well.

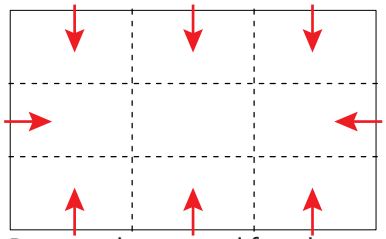


8. Comparison building services offices vs.dwellings. Source: own work



√ efficiency
X individual control
X maintenance
X accessibility
X detachability
√ flexibility
X layout freedom

Central: existing shafts



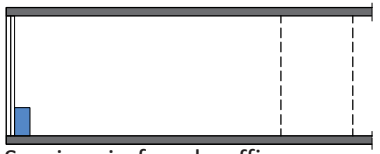
X efficiency
√ individual control
√ maintenance
√ accessibility
√ detachability
X flexibility
√ layout freedom

Decentral: renewed façades

9. Rating central vs. decentral building services. Source: own work

X individual control
X maintenance
X accessibility
X detachability
X flexibility
√ layout freedom

Services in ceiling corridor



X individual control
√ maintenance
√ accessibility
√ detachability
X flexibility
√ layout freedom

Services in facade office space

X individual control
X maintenance
X accessibility
X detachability
√ flexibility
X layout freedom

Services in ceiling office space

X individual control
X maintenance
√ accessibility
X detachability
√ flexibility
X layout freedom

Services in floor office space

10. Rating position of the comfort building services of existing office buildings (sections). Source: own work

2.3.3 Possibilities & limitations

The topics discussed in this chapter are again rated based on the criteria of the previous chapters.
As mentioned before, when applying a central setup of the building services, the existing shafts are reused. In a decentralized setup, the services move to the façade. When this possibility is chosen, for the functions of the categories energy and sanitary this means that the required services arrive at a central connection by the route of the façade. For the facilities for comfort, it is more logical to 'generate' clean air, heat or coolness also decentralized, and thus in the façade. For sun protection, this research is not relevant.
Based on the comparison it's clear that a decentralized installation setup scores the best on nearly all criteria (9). The only advantages of a centralized setup are that they are more efficient because they are shared by many users, which especially applies for the category of comfort facilities. Also flexibility is mainly related to these services because they are usually provided of canals which can reach all spaces while decentralized facilities normally cannot. The decentralized setup scores well because it can meet the requirements for comfort, individual control and maintenance, and in addition also provides in most opportunities regarding adaptability. Because the lifespan of façades and building services is roughly equal, they can also be combined very well.
Regarding to the services for comfort, there are four general concepts (10). This mainly concerns the position of the services regarding the space. In particular services under a suspended ceiling and in the façade are common. Again, the decentralized solution is by far the best for the same reasons as mentioned in the previous research. An advantage that is not mentioned in the scheme and is important in particular for the suspended ceiling and the raised floor, is that the piping of other functions, such as for energy and sanitary, can make use of this facilities as well.

2.3.4 Case-studies general

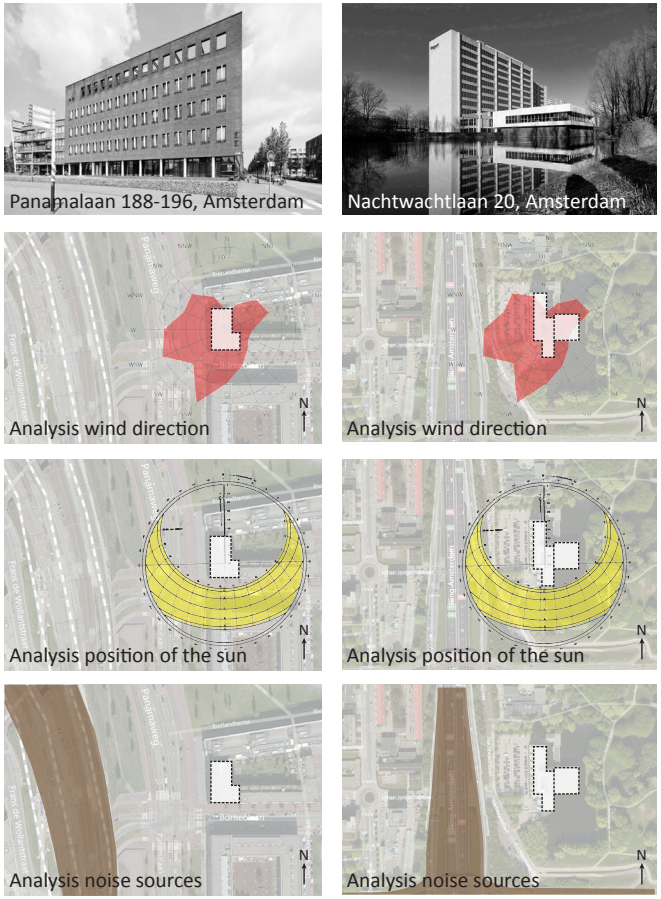
Because practice is usually different from theory, this and the next chapter are completed by two case studies. By means of various criteria, two buildings are chosen for further investigation, based on a database with 200 vacant office buildings in Amsterdam. The criteria are in particular related to suitability of the location and the age and façade construction of the building. Subsequently, the context and the office buildings are analysed which identifies the possibilities and risks (11).
The first building is located at the Panamalaan in the eastern docklands on the edge of a residential area. It is an office building from the late 90s, with a height of five stories. The structure consists of closed load-bearing façade elements with hollow core slabs in between. The second office building is located at the Nachtwachtlaan between Oud Zuid and Slotervaart, next to a park with residential flats and in between of two residential areas. It is built in the early 60s and has twelve levels. The structure consists of load-bearing façade parapets and an in-situ concrete floors. Both offices are oriented east-west and the west façade oriented to a highway or railway. This requires measures relating to both sound and sun protection. Finally, also the wind usually comes from the west. This is especially important for the office building at the Nachtwachtlaan. Because of the height spaces at the top can be influenced by the wind.

2.3.5 Building services case-studies

This research consists of an investigation to the shafts and a part which is related to the comfort facilities. What is noticed firstly towards the office building at the Panamalaan is that it is provided of a few shafts which are applied at the edge of the building (12). This is in contrast to the office building at the Nachtwachtlaan, which has a lot of centrally arranged shafts. Reuse of the shafts of the former building is difficult which means that decentralized installations seems to be the best solution. In contrast, the building at the Nachtwachtlaan offers many opportunities for reuse of the shafts.
Both buildings are provided of a suspended ceiling and heating in the façade zone (13). The ability to reuse these facilities really depends on the choice for building services in the façade or under a suspended ceiling. Hence, they are assessed both good as bad.

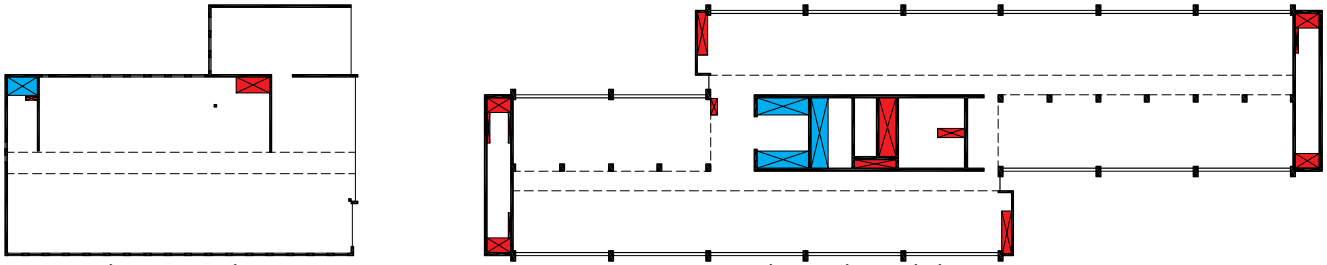
2.3.6 Conclusion

The setup of building services of office buildings is usually central whereas the setup for a residential function is mostly per individual dwelling so decentralized. This while applying decentralized building services for

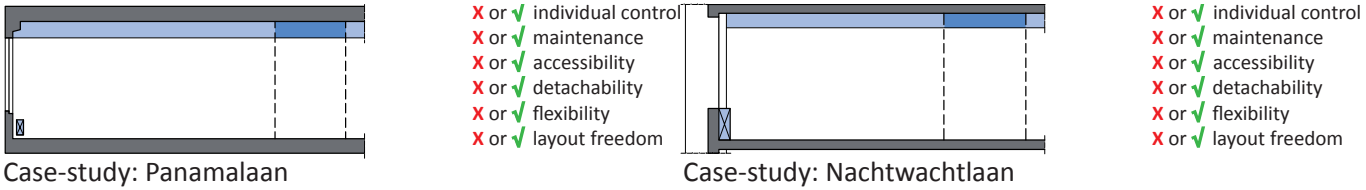


11. Analysis context case-studies. Source: own work

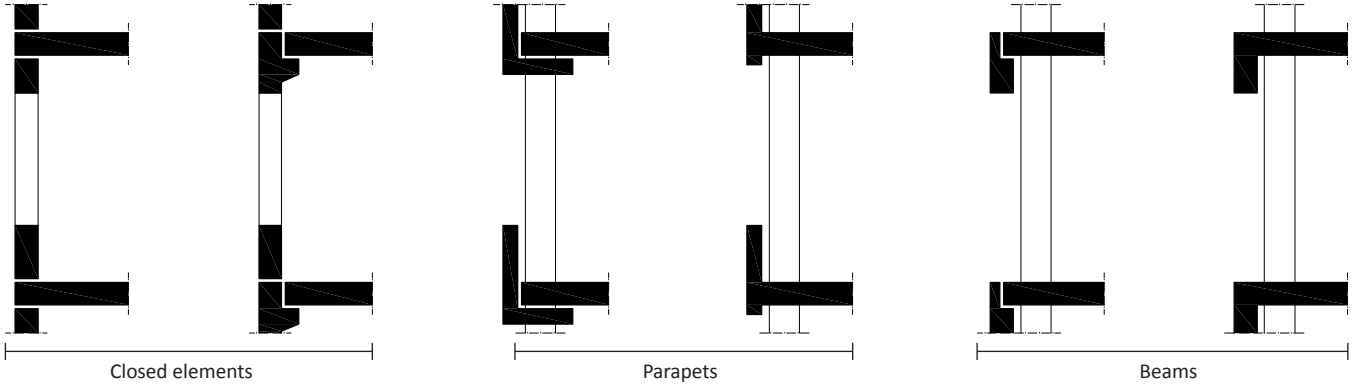
dwellings are often much more favorable. In addition, generally only the services for comfort can be reused because the other services differ too much from the requirements for dwellings.
The analysis of the case studies shows that both buildings use shafts, suspended ceilings and heating in the façade zone. However, they differ in the number and location of the shafts.
In the next chapter the façades, which should support decentralized solutions, are investigated. The results of this chapter are included in the last chapter. Based on the required functions, adaptability and the possibilities the case studies offer, some concepts for (de)centralized building services are introduced.



12. Analysis shafts case-studies (scaled to fit). Blue = elevator, red = building services. Source: own work



13. Rating position of the comfort building services case-studies (sections). Source: own work



14. Typologies load-bearing façades. Source: own work

2.4 Façades vacant office buildings

2.4.1 Introduction

Research shows that roughly one third of the vacant office buildings in the Netherlands have load-bearing façades (Ebbert, 2012). Transformation of these buildings is a big challenge because it is hardly impossible to replace these façades structurally. Because of this challenge, they will be the context of this research.
The goal of this chapter is divided into three parts: Firstly the characteristics of the load-bearing façades are researched. Secondly research has been done to the possibilities and limitations these façades offer regarding integration with the required building services for dwellings and to adaptability. The third part of this research consists of an investigation of the load-bearing façades of both case-studies.
Although the physics and esthetics of the façades are important as well, they are not part of this research because these properties are considered to be completely renewed. However, the possibilities for the connection of interior walls and placing balconies are included because both topics are very important for transformation into dwellings.

2.4.2 Characteristics load-bearing façades

Basically load-bearing façades can be subdivided into three categories: closed elements, parapets and beams (14). Strictly spoken, beams are not covered as being load-bearing façades but in these research load-bearing means that there is a structural surface in the façade zone and therefore this variant is included as well.
In many office buildings, particularly from the 90s, the façades exists of closed load-bearing elements without columns. Usually they are prefabricated and provided with insulation and non-load-bearing sheetsy. In general, for low buildings the floors can be imposed directly on the façades. When the height increases, the floors are often imposed on consoles.

Load-bearing parapets have been used much longer for office buildings. They are connected to the floors monolith at the location and transfer the floor loads to columns. This principle could be both prefab and in situ. The third category consists of façade beams on which the floors are imposed. Also this principle could be both prefab and in situ.

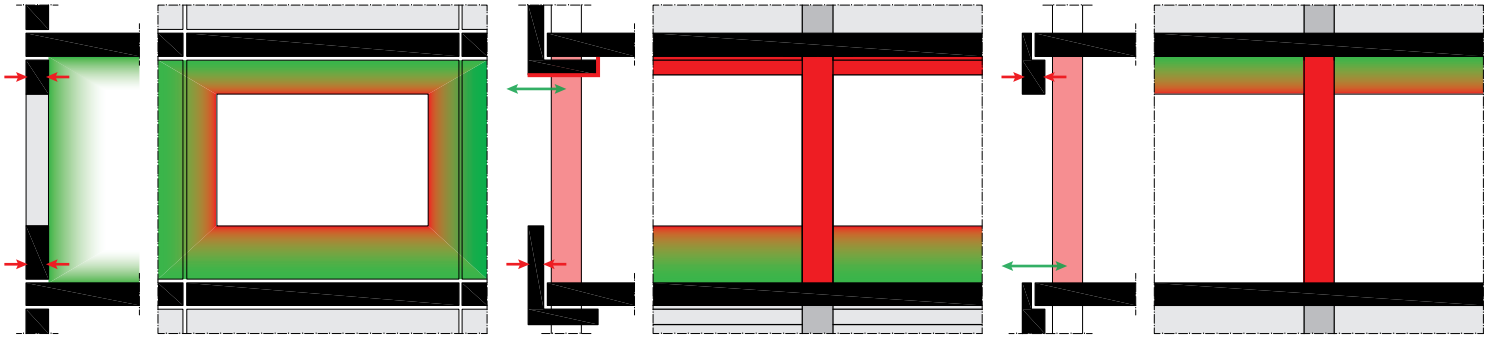
2.4.3 Possibilities & limitations

Based on these three categories the possibilities and limitations regarding to the building services and to adaptability are investigated. By making use of a diagram (15) these possibilities and limitations are indicated by using the colors red and green.

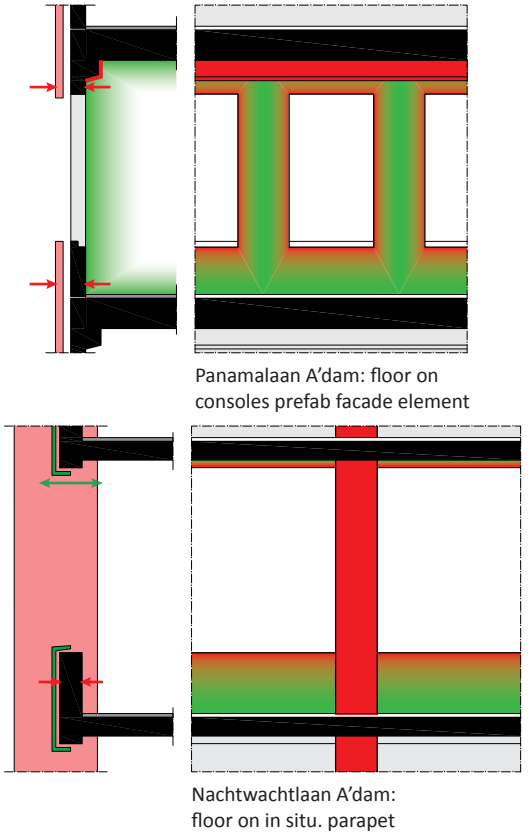
In the first category, the floors have a flexible layout (walls can be placed free) and the inside of the façades are completely flat because no columns have been used. This means that connecting the interior walls to the façade is very easy. The only limitations are the positions of the window openings. A disadvantage of applying building services or piping in the façades is that holes have to be drilled. Sometimes this also applies to the cladding, which is often difficult to remove. This limits the flexibility of the chosen building services because they are difficult to replace. Moreover, these holes cannot be drilled anywhere so research is needed to discover which parts of the façades allows drilling in terms of load-bearing capacity. When consoles are used, there are less opportunities for the implementation of building services and piping because the upper part of each element cannot be adapted.

Load-bearing parapets are regarding to layout freedom less flexible than the closed elements because interior walls mostly can only be connected to the column. Also here the elements can only be drilled at some places through which the flexibility of the chosen building services decreases. The façades cannot be used at ceiling height when prefabricated elements are used. Because of that, the building services should be placed below.

Beams offer regarding to placement of building services and piping more freedom because they don't have a load-bearing façade construction at floor level. How-



15. Possibilities & limitations load-bearing façade typologies. Source: own work



16. Possibilities & limitations case-studies. Source: own work

ever, at ceiling height these structures have less flexibility because the beams are placed there. The layout freedom is the same as for the load-bearing parapets.
In the first two cases (French) balconies are difficult to apply unless some load-bearing façade elements are replaced by a new structure or when loggias are applied.

2.4.4 Façades case-studies

Regarding to the case-studies, buildings with common load-bearing façades are chosen.
The façades of the office building at the Panamalaan consists of closed load-bearing elements with floors imposed on consoles (16). The opportunity here is the freedom of layout. The limitations are the placement or pass through of the building services and piping in or through the façades and possibly the cladding.
The office building at the Nachtwachtlaan consists of in situ. load-bearing parapets. The possibility of this parapets are the implementation of services and piping at the ceiling height. The limitations are found in the layout freedom, the connection of the interior walls to the façades and the placement or pass through of building services and piping in or through the load-bearing parapets.

2.4.5 Conclusion

Load-bearing façades can be classified into three categories: closed elements, parapets and beams. The opportunities of the former particularly can be found in the layout freedom whereas the placement of services and pass through of piping through the façade is usually better in the other two categories. Both variants are discussed in the case-studies.
In the next study these results will be used for the possibilities and limitations for concepts of the building services, both in general and for the case-studies. This in combination with the requirements needed for dwellings and to adaptability.

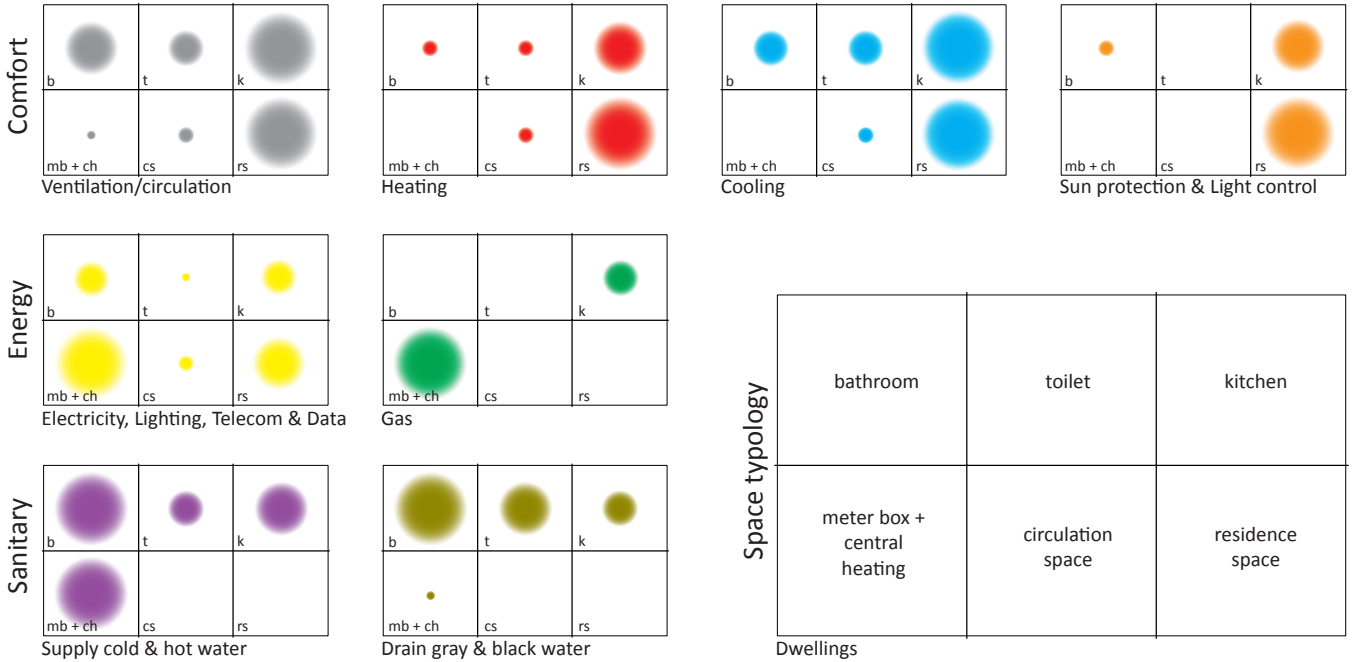
2.5 Concepts

2.5.1 Introduction

The four previous studies are combined into this chapter, resulting in a number of concepts which can be used for the transformation of vacant office buildings, especially with load-bearing façades, into dwellings.
The goal of this chapter is divided into four parts. In the first section the different spaces of a dwelling regarding to building services are investigated. In the second part the focus is on which general variants can be made when the required building services, adaptability and space properties are combined. The characteristics of office buildings are only generally discussed because specific differences lead to too many variations. In the third section the variants suitable for the case studies are investigated. This part covers the existing building services and shafts, the load-bearing façades and the context of the office buildings. In the fourth part research has been done to how these situations have been resolved up to now, based on different references. The actual designs for transformation of vacant office buildings into dwellings, based on this study, are not part of this report.

2.5.2 Functions and spaces

Dwellings are composed of different spaces which all have different requirements regarding building services. In general, they can be classified into six categories: residence spaces, kitchen toilet, bathroom, meter box & central heating (if present) and circulation space (17).
The diagram clearly shows that the functions for comfort are mainly related to the residence spaces, bathroom, toilet and kitchen. Especially the required ventilation capacity is important here. For example, residential spaces require 0,7 dm³/s/m², but the required capac-



17. Building services and quantitative requirements per space typology dwelling

ity for a kitchen (21 dm³/s/m²), bathroom (14 dm³/s/m²) and toilet (7 dm³/s/m²) are much larger. Regarding electricity the requirements are more spread. The reason that the meter box has a large electricity demand is because of the meter that is present there. This also applies for the gas connection for heating, which is also required in the kitchen. (when cooking on gas). The emphasis for sanitary piping is mainly on the bathroom, toilet and kitchen. Also in this case a meter is present in the space for central heating, which measures the used water. Furthermore, also a small outlet of the boiler is present here (if present). Based on these data in the following section research will be done to which building services variants may be used in which space.

2.5.3 Concepts general

Based on the results of the research to the operation (2.1), adaptability (2.2) and very general, the results of the existing building services and load-bearing façades, a total score has been made for all functions (18). Based on this scheme and the study of the various spaces in a dwelling, the best rated functions are combined. As a result, concepts regarding the different categories arised. The first category is a stand-alone. The second and third categories have so much in common that they are combined (19). Also the concepts are compared based on the previously used criteria.

In general it can be determined that the variations of category 1 can be divided into central and decentralized concepts. This resulted in six different possibilities which are all based on the table of figure 18. However, it must be mentioned that it is assumed that windows can always be opened and thus can provide in additional ventilation. Therefore, the concepts described are the main ventilation which normally operate independent of the windows. Also important to mention is that every dwelling should be equipped with a mechanical ventilation to ventilate the bathroom, toilet and kitchen. The requirements for these spaces are so high that natural ventilation is mostly inadequate. This can either by meaning of centralized and decentralized ventilation, depending on the position of the space with respect to the façade. In figure 19, all versions are initially provided with central ventilation for these spaces.

The first variant is based on natural ventilation by meaning of a window with a ventilation strip. This can be both manually or controlled. In the second variant, the whole dwelling is mechanical ventilated by central ventilation. In practice there are also variations in which, for example, the air is supplied naturally and removed mechanically. On the contrary, the third variant is ventilated by meaning of decentralized mechanical ventilation. The fourth to sixth variant are all variants of the double façade. The first is based on the double window principle. The second model is a second skin façade. Both models are naturally ventilated. The last model is a climate façade. Here, the air is supplied mechanically into the room and removed mechanically via the shaft.

For heating and cooling three variants are proposed which are applied to all ventilation concepts, excluding the central ventilation. The simplest model is heated by radiators. In addition there are variants with floor and ceiling heating. The latter is not divided because many variants exist which in essence do not differ very much. The latter two can be used as a low temperature heating which is more comfortable and sustainable. Both floor and ceiling heating can also be used for cooling. The question is whether this is relevant, especially when ef-

I

			Variants 1	2	3	4	5	6	7	8	9	10
Comfort	A	Ventilation Circulation	Windows	Windows + central shafts	Windows + decentralized shafts	Double facade	Mechanical central	Window fan	Decentralized unit			
			A operation 3,90 50% 1,95 B adaptability 3,90 50% 1,95 Total 3,90	A operation 4,35 50% 2,18 B adaptability 4,00 50% 2,00 Total 4,18	A operation 4,35 50% 2,18 B adaptability 3,40 50% 1,70 Total 3,88	A operation 4,80 50% 2,40 B adaptability 3,50 50% 1,75 Total 4,13	A operation 4,05 50% 2,03 B adaptability 3,80 50% 1,90 Total 3,93	A operation 3,80 50% 1,90 B adaptability 3,30 50% 1,65 Total 3,55	A operation 4,25 50% 2,13 B adaptability 3,30 50% 1,65 Total 3,78			
	B	Heating	Radiator	Convector	Subsurface convector	Underfloor (radiant)	Concrete core	Overhead radiation ceiling	Overhead induction ceiling	Central air conditioning system	Decentralized air conditioning system	Wall
			A operation 4,35 50% 2,18 B adaptability 2,60 50% 1,30 Total 3,48	A operation 3,90 50% 1,95 B adaptability 2,60 50% 1,30 Total 3,25	A operation 3,70 50% 1,85 B adaptability 1,75 50% 0,88 Total 2,73	A operation 4,65 50% 2,33 B adaptability 2,90 50% 1,45 Total 3,78	A operation 3,85 50% 1,93 B adaptability 2,40 50% 1,20 Total 3,13	A operation 4,35 50% 2,18 B adaptability 4,00 50% 2,00 Total 4,18	A operation 3,90 50% 1,95 B adaptability 3,50 50% 1,75 Total 3,70	A operation 3,35 50% 1,68 B adaptability 3,70 50% 1,85 Total 3,53	A operation 3,90 50% 1,95 B adaptability 4,00 50% 2,00 Total 3,95	A operation 3,75 50% 1,88 B adaptability 2,20 50% 1,10 Total 2,98
	C	Cooling	Overhead radiation ceiling	Concrete core	Overhead induction ceiling	Passive chilled beam/baffles	Cooling panels/ceilings/sails	Central air conditioning system	Decentralized air conditioning system	Night flush		
			A operation 4,35 50% 2,18 B adaptability 4,00 50% 2,00 Total 4,18	A operation 3,85 50% 1,93 B adaptability 2,40 50% 1,20 Total 3,13	A operation 3,90 50% 1,95 B adaptability 3,50 50% 1,75 Total 3,70	A operation 4,35 50% 2,18 B adaptability 3,50 50% 1,75 Total 3,93	A operation 4,35 50% 2,18 B adaptability 3,50 50% 1,75 Total 3,93	A operation 3,35 50% 1,68 B adaptability 3,70 50% 1,85 Total 3,53	A operation 3,90 50% 1,95 B adaptability 4,00 50% 2,00 Total 3,95	A operation 5,00 50% 2,50 B adaptability 5,00 50% 2,50 Total 5,00		
	D	Sun & glare protection	Internal	Silkscreened patterns	In glazing	In cavity	Brise-soleil	External lamellae	Plants	Moveable: roller blinds	Moveable: venetian blinds	Moveable: sliding panels
			A operation 3,55 50% 1,78 B adaptability 5,00 50% 2,50 Total 4,28	A operation 3,45 50% 1,73 B adaptability 3,80 50% 1,90 Total 3,63	A operation 4,05 50% 2,03 B adaptability 1,40 50% 0,70 Total 2,73	A operation 4,15 50% 2,08 B adaptability 3,60 50% 1,80 Total 3,88	A operation 4,00 50% 2,00 B adaptability 3,40 50% 1,70 Total 3,70	A operation 3,85 50% 1,93 B adaptability 3,00 50% 1,50 Total 3,43	A operation 3,00 50% 1,50 B adaptability 3,00 50% 1,50 Total 3,00	A operation 4,10 50% 2,05 B adaptability 3,40 50% 1,70 Total 3,75	A operation 4,10 50% 2,05 B adaptability 3,40 50% 1,70 Total 3,75	A operation 4,60 50% 2,30 B adaptability 3,00 50% 1,50 Total 3,80

II

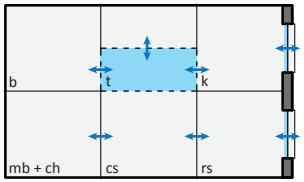
			Variants 1	2	3	4	5	6	7	8	9	10
Energy	A	Electricity Lighting Telecom Data	Raised floor	Suspended ceiling	Pre-wall	Grid points (tube)	Baseboard	Milled in walls & floors				
			A operation 3,00 50% 1,50 B adaptability 4,50 50% 2,25 Total 3,75	A operation 2,00 50% 1,00 B adaptability 4,50 50% 2,25 Total 3,25	A operation 5,00 50% 2,50 B adaptability 4,40 50% 2,20 Total 4,70	A operation 5,00 50% 2,50 B adaptability 4,10 50% 2,05 Total 4,55	A operation 4,00 50% 2,00 B adaptability 3,40 50% 1,70 Total 3,70	A operation 5,00 50% 2,50 B adaptability 2,00 50% 1,00 Total 3,50				
	B	Gas	Raised floor	Suspended ceiling	Pre-wall	Grid points (tube)						
			A operation 4,00 50% 2,00 B adaptability 4,70 50% 2,35 Total 4,35	A operation 3,00 50% 1,50 B adaptability 4,70 50% 2,35 Total 3,85	A operation 5,00 50% 2,50 B adaptability 4,30 50% 2,15 Total 4,65	A operation 5,00 50% 2,50 B adaptability 3,95 50% 1,98 Total 4,48						

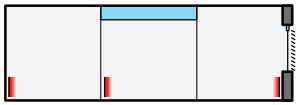
III

			Variants 1	2	3	4	5	6	7	8	9	10
Sanitary	A	Supply cold & hot water	Raised floor	Suspended ceiling	Pre-wall	Grid points (tube)	Baseboard	Milled in walls & floors				
			A operation 4,00 50% 2,00 B adaptability 4,60 50% 2,30 Total 4,30	A operation 3,00 50% 1,50 B adaptability 4,60 50% 2,30 Total 3,80	A operation 5,00 50% 2,50 B adaptability 4,40 50% 2,20 Total 4,70	A operation 5,00 50% 2,50 B adaptability 4,10 50% 2,05 Total 4,55	A operation 4,00 50% 2,00 B adaptability 3,40 50% 1,70 Total 3,70	A operation 5,00 50% 2,50 B adaptability 2,00 50% 1,00 Total 3,50				
	B	Drain gray & black water	Raised floor	floor	Grinding device	Seperate shafts						
			A operation 3,50 50% 1,75 B adaptability 4,45 50% 2,23 Total 3,98	A operation 3,50 50% 1,75 B adaptability 3,30 50% 1,65 Total 3,40	A operation 3,50 50% 1,75 B adaptability 4,65 50% 2,33 Total 4,08	A operation 4,00 50% 2,00 B adaptability 4,20 50% 2,10 Total 4,10						

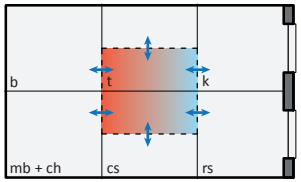
18. Total rating of function variants for the operation and adaptability of building services, based on 3 categories. Source: own work

Comfort

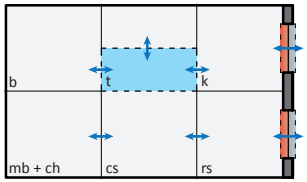


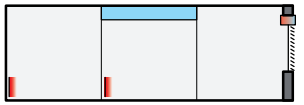


Windows + radiators			
A comfort	2,50	35%	0,88
B individual control	4,50	15%	0,68
C maintenance	3,50	5%	0,18
D accessibility	4,00	5%	0,20
E detachability	3,00	10%	0,30
F flexibility	2,50	15%	0,38
G layout freedom	2,00	15%	0,30
Total			2,90

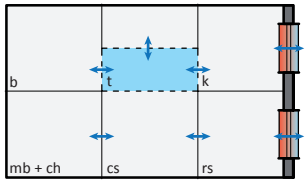


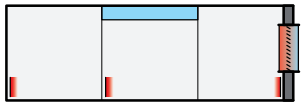
Centralized HVAC			
A comfort	3,00	35%	1,05
B individual control	3,00	15%	0,45
C maintenance	3,00	5%	0,15
D accessibility	3,00	5%	0,15
E detachability	4,00	10%	0,40
F flexibility	4,00	15%	0,60
G layout freedom	4,00	15%	0,60
Total			3,40



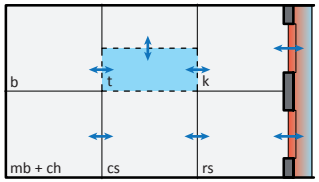


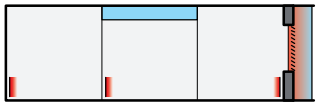
Decentralized HVAC + radiators			
A comfort	3,50	35%	1,23
B individual control	4,50	15%	0,68
C maintenance	3,00	5%	0,15
D accessibility	3,50	5%	0,18
E detachability	3,00	10%	0,30
F flexibility	2,50	15%	0,38
G layout freedom	2,00	15%	0,30
Total			3,20



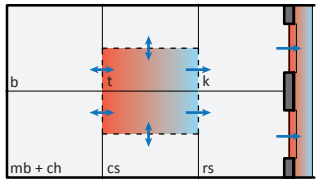


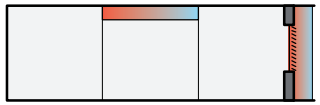
Double window + radiators			
A comfort	3,50	35%	1,23
B individual control	4,50	15%	0,68
C maintenance	3,00	5%	0,15
D accessibility	4,00	5%	0,20
E detachability	3,00	10%	0,30
F flexibility	2,50	15%	0,38
G layout freedom	2,00	15%	0,30
Total			3,23



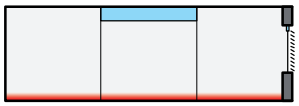


Second skin facade + radiators			
A comfort	3,50	35%	1,23
B individual control	4,50	15%	0,68
C maintenance	3,00	5%	0,15
D accessibility	3,50	5%	0,18
E detachability	2,50	10%	0,25
F flexibility	2,50	15%	0,38
G layout freedom	2,00	15%	0,30
Total			3,15

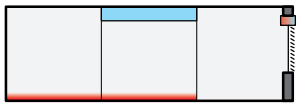




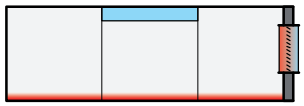
Climate facade			
A comfort	3,50	35%	1,23
B individual control	3,00	15%	0,45
C maintenance	3,00	5%	0,15
D accessibility	3,00	5%	0,15
E detachability	4,00	10%	0,40
F flexibility	3,50	15%	0,53
G layout freedom	3,50	15%	0,53
Total			3,43



Windows + floor heating			
A comfort	3,50	35%	1,23
B individual control	3,50	15%	0,53
C maintenance	4,50	5%	0,23
D accessibility	2,00	5%	0,10
E detachability	1,50	10%	0,15
F flexibility	1,50	15%	0,23
G layout freedom	5,00	15%	0,75
Total			3,20



Decentralized HVAC + floor heating			
A comfort	4,50	35%	1,58
B individual control	3,50	15%	0,53
C maintenance	4,00	5%	0,20
D accessibility	1,50	5%	0,08
E detachability	1,50	10%	0,15
F flexibility	1,50	15%	0,23
G layout freedom	5,00	15%	0,75
Total			3,50



Double window + floor heating			
A comfort	4,50	35%	1,58
B individual control	3,50	15%	0,53
C maintenance	4,00	5%	0,20
D accessibility	2,00	5%	0,10
E detachability	1,50	10%	0,15
F flexibility	1,50	15%	0,23
G layout freedom	5,00	15%	0,75
Total			3,53

Second skin facade + floor heating			
A comfort	4,50	35%	1,58
B individual control	3,50	15%	0,53
C maintenance	4,00	5%	0,20
D accessibility	1,50	5%	0,08
E detachability	1,00	10%	0,10
F flexibility	1,50	15%	0,23
G layout freedom	5,00	15%	0,75
Total			3,45

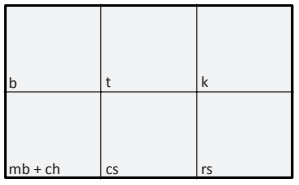
Windows + cealing heating			
A comfort	3,50	35%	1,23
B individual control	4,50	15%	0,68
C maintenance	4,00	5%	0,20
D accessibility	3,00	5%	0,15
E detachability	2,50	10%	0,25
F flexibility	2,50	15%	0,38
G layout freedom	3,00	15%	0,45
Total			3,33

Decentralized HVAC + ceiling heating			
A comfort	4,50	35%	1,58
B individual control	4,50	15%	0,68
C maintenance	3,50	5%	0,18
D accessibility	2,50	5%	0,13
E detachability	2,50	10%	0,25
F flexibility	2,50	15%	0,38
G layout freedom	3,00	15%	0,45
Total			3,53

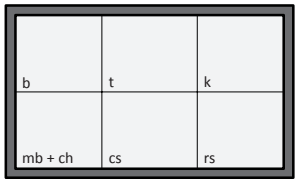
Double window + ceiling heating			
A comfort	4,50	35%	1,58
B individual control	4,50	15%	0,68
C maintenance	3,50	5%	0,18
D accessibility	3,00	5%	0,15
E detachability	2,50	10%	0,25
F flexibility	2,50	15%	0,38
G layout freedom	3,00	15%	0,45
Total			3,53

Second skin facade + ceiling heating			
A comfort	4,50	35%	1,58
B individual control	4,50	15%	0,68
C maintenance	3,50	5%	0,18
D accessibility	2,50	5%	0,13
E detachability	2,00	10%	0,20
F flexibility	2,50	15%	0,38
G layout freedom	3,00	15%	0,45
Total			3,58

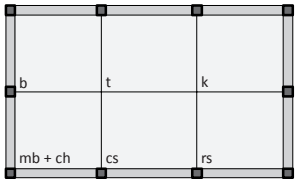
Sanitary & Energy



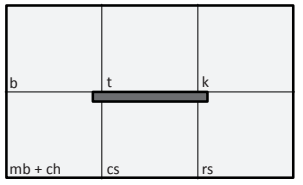
Raised floor			
A usability	3,00	50%	1,50
B accessibility	3,00	10%	0,30
C flexibility	4,00	25%	1,00
D layout freedom	5,00	15%	0,75
Total			3,55



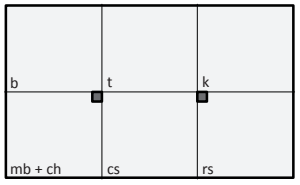
(Pre)walls			
A usability	5,00	50%	2,50
B accessibility	5,00	10%	0,50
C flexibility	4,00	25%	1,00
D layout freedom	4,00	15%	0,60
Total			4,60



Grid points			
A usability	5,00	50%	2,50
B accessibility	5,00	10%	0,50
C flexibility	3,00	25%	0,75
D layout freedom	4,50	15%	0,68
Total			4,43



Raised floor + Wall			
A usability	4,00	50%	2,00
B accessibility	4,00	10%	0,40
C flexibility	5,00	25%	1,25
D layout freedom	4,00	15%	0,60
Total			4,25



Raised floor + Grid points			
A usability	4,00	50%	2,00
B accessibility	4,00	10%	0,40
C flexibility	4,50	25%	1,13
D layout freedom	4,50	15%	0,68
Total			4,20

19. Rating of composed variants for the operation and adaptability of building services, based on 3 categories. Source: own work

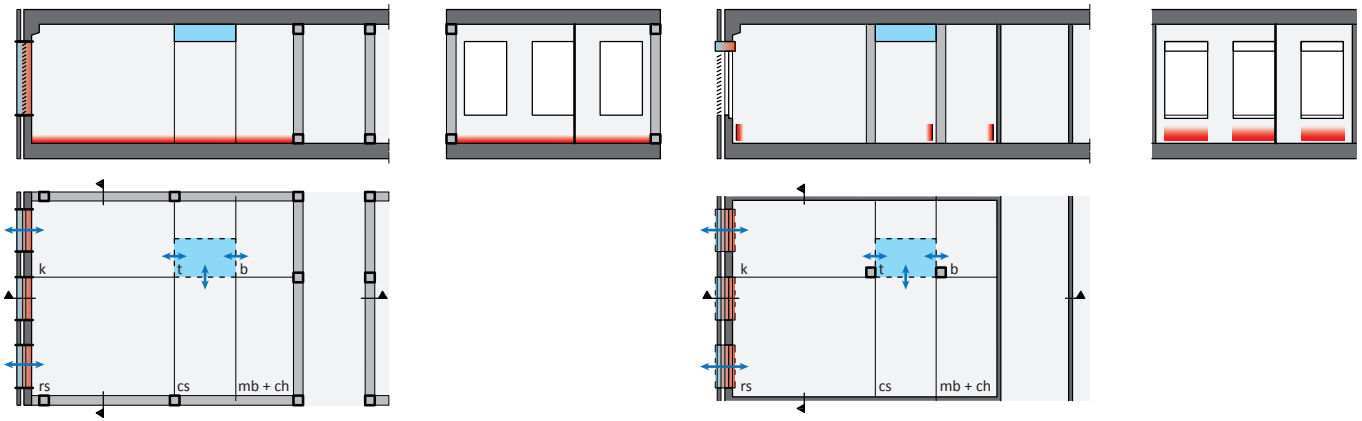
ficient blinds are applied. A fourth variant is based on heating or cooling by meaning of a centralized system and has only also been applied to this ventilation concept. Finally, night flush ventilation can always be applied if the construction is not covered. An advantage of night flush ventilation is that cooling of the dwelling is of less importance.
Regarding sun protection, outdoor blinds are by definition better than inside blinds. Only glare can be blocked well inside. For outdoor blinds, moving blinds are by definition better than fixed ones because these can be adjusted individually, based on the position of the sun and the weather. A comment is that this is dependent on the wind, thus moving blinds can be applied only on higher elevations when placed in a cavity. In case of this research the most ideal situation is assumed so all variants are fitted with moveable blinds.
Concluding it can be determined that decentralized variants have the highest scores. This has to do with the comfort which can be achieved and the possibility of individual control. Nevertheless, it should be mentioned that double façades and blinds are only interesting for sun-facing façades. The differences between floor and ceiling heating are very small so the choice for this should be determined for each project separately. The resulting differences mainly relate to the slow warming-up of the floor heating and the opportunities related to adaptability. The central services score reasonably as well. What is striking is that they have a fairly stable but average score on all criteria. They are particularly useful when a lot of existing shafts can be used.
Regarding the second category, in figure 18 it can be noticed that especially (pre-) walls and grid points score well for all functions. Also the raised floor scores for almost all functions reasonably high. Because the discharge of gray and black water will always take place at a low point, again a raised floor will function the best. When combining the various possibilities it should be mentioned that always horizontal elements are necessary for the supply and discharge of the various functions. This is because the starting point of this study is that no holes are drilled into the floor. Therefore, horizontal elements are required in all cases except when functions are located directly next to a shaft or façade. Finally, five variants has been made: a raised floor, walls or grids on the edges of the dwellings and combinations of both.
Based on the analysis, it can be concluded that in particular (pre-)walls and grids on the edges of the dwellings have highly valued. This is because raised floors are not required and the flexibility and freedom of the layout are also not affected. Both possibilities can also be provided with walls or grids at three, two or only one side, although this will drastically reduce the flexibility. The combined variants do also have a quite high score, mainly because they offer a lot of flexibility in the middle of the dwelling. The choice for one of these solutions will have much impact on the floor plans.

2.5.4 Concepts case-studies

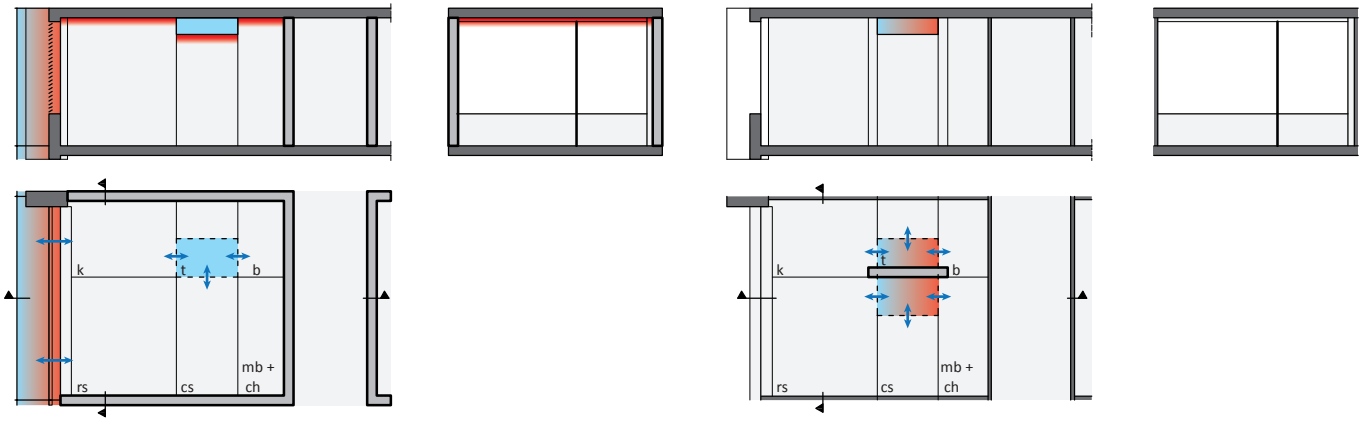
Ultimately, there are no concepts that clearly have the highest value. This means that it must be determined per building which concept suits the best. For both case studies several good concepts are possible, but only the two most logical concepts are elaborated. In addition, in both cases the concept is only applied to the most difficult façade. The other façades suffice with a simpler concept and are therefore less interesting to be researched.
The office building at the Panamalaan is characterized by a façade oriented to the west and also to a busy railway. This means that sun and sound insulation must be taken into account. The building has a load-bearing façade of closed elements and only has two shafts, both at a decentralized location. Based on these properties it is determined that a double façade is the most logical choice. This variant has decentralized ventilation and has a good soundproofing as well, even when the windows are opened. Because of the closed load-bearing façade the best variant which can be applied is the double window because then the construction hardly needs to be adjusted. Both the floor and ceiling heating could be used, in particular as an additional heating or cooling when the façade cannot provided in the needs. In this variant floor heating is chosen. For the piping of the second and third category the grid point's model is chosen. This variant scores very well and has a lot of potential regarding the layout freedom. This is already a strong point of this building and thus more emphasized by applying this variant.
In the second variant, the decentralized HVAC has been applied although additional measures should be taken into account regarding sound insulation. When the windows are opened, soundproofing is not possible. In this case, the existing radiators are used. Although this variant does not have the best comfort and most possibilities regarding adaptability, the piping is already present. For the piping of the second and third category also the grid system is chosen but in this case placed in the middle of the dwelling in combination with a raised floor (20).
The office building at the Nachtwachtlaan is characterized by a façade oriented to the west and to a busy highway. In addition, the height plays (12 floors) a major role as well. This means that in addition to sun-protection and sound proofing also nuisance regarding the wind should be avoided. The building consists of load-bearing parapets which give more freedom in the plane of the façade compared to closed elements. It is also provided of many central shafts. Based on these properties also here a double façade has been chosen, although in this case it is the façade filling variant. Eventually, this could also be a climate façade. Also here, heating and cooling can be performed by a floor or ceiling heating. Here has been chosen for ceiling heating. Information about the existing installation space behind the parapet is not present and because of that not

used. For the piping of the second and third category the pre-wall system is chosen. Because the layout of the building provides slightly less freedom, a variation which just provides in additional flexibility regarding piping has been chosen.
Because of the present shafts, the second solution is a central ventilation system. This variant also provides in heating and cooling by meaning of this ventilation. Eventually, also a part of the existing suspended ceiling could be used, when in a good condition. For the piping of the second and third category the raised floor and wall variant is chosen (21).

If outdoor areas are important, bigger adjustments are necessary. This can be done by the exchange of a load-bearing wall into an open element. A second option is applying a loggia although some requirements related to thermal insulation are important then.
The next step in the process is the making of design but that does not belong to the contents of this report. Also in that case, several variants are developed and/or combined which means that the final façade can also be performed as a 'hybrid' of 'integrated' façade (Knaack et. all. 2011). This combines the advantages of different concepts.



20. Concepts office building Panamalaan 188-196. Left: double window, right: decentralized HVAC. Source: own work



21. Concepts office building Nachtwachtlaan 20. Left: second skin façade, right: centralized HVAC. Source: own work

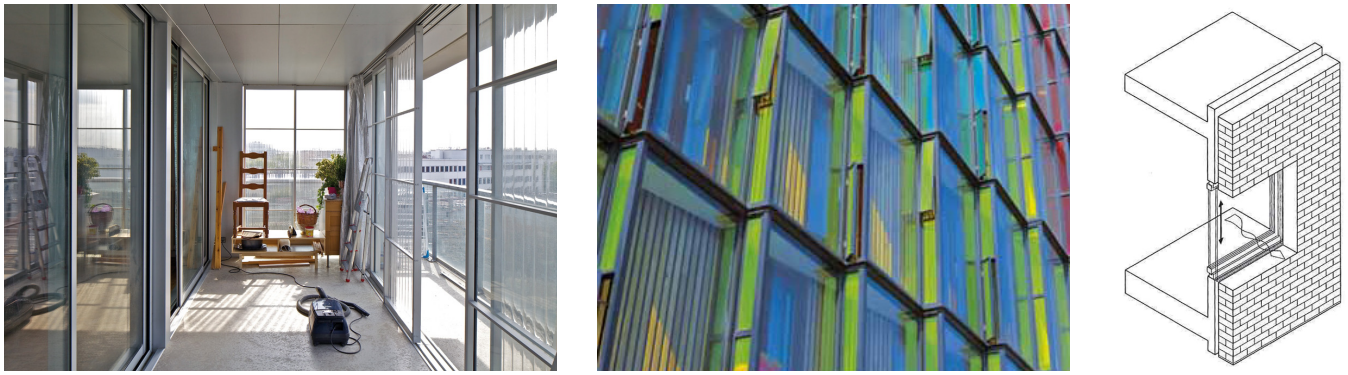
2.5.5 References

In order to show how situations like this have been solved in practice, this paragraph is focused on references. In particular, references of solutions are shown which do not occur frequently in dwellings.
Both first two references show examples of double skin façades. Although these are not combinations with load-bearing façades, both solutions indicate the potential of double façades for dwellings. In the first case, the dwellings are equipped with extra surface by placing a winter garden and balcony in front of the existing structure. Expected is that the energy needs will decrease to 50% (22a). In the second reference the façade is provided of a double skin for soundproofing of the adjacent highway. In this picture, it is also clear where the ventilation flaps are positioned (22b). The third reference is of a double window. This is a variation of the second skin façade and is applied within the framework of one window (22c).
The fourth and fifth reference show different variants of decentralized services. The ClimaRad system is a combination of balanced ventilation and heating (23a). The breathing window is a balanced ventilation system with heat recovery (23b). The sixth reference shows a ceiling heating. By meaning of a foil, it can be heated electrically and provide in infra-red radiation in the spaces (24). The last three references are related to the supply and drainage of piping in dwellings. The first reference shows a variant of the flexible floor. The space under the floor is used for the pass through of various types of piping. This system is suited for both offices and dwellings (25a). The second reference shows also a variant of the flexible floor. By meaning of a matrix tiled foam-floor, various pipes can be applied, both on the lower and the upper face (25b). The third reference shows a flexible wall system for the connection of, in particular, sanitary pipes (26c). All these references show that the developed concepts are based on existing systems and thus work in practice.

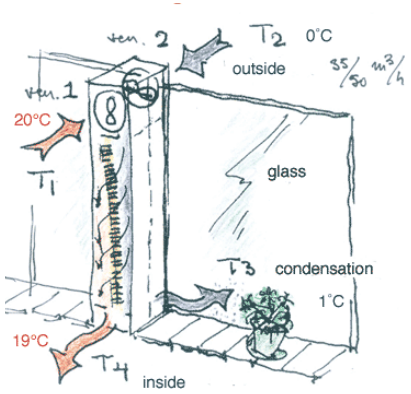
2.5.6 Conclusion

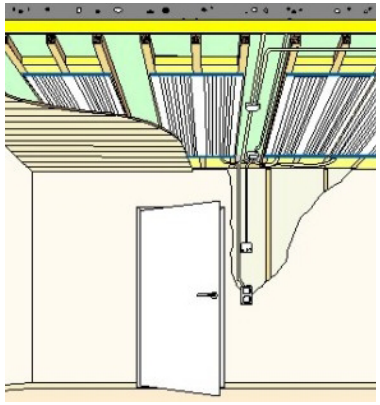
Regarding this last chapter, it has become clear that each dwelling has areas with different requirements regarding building services. Based on these differences and the requirements regarding operation and adaptability, several concepts which can be used for the transformation of office buildings into dwellings have been developed and judged. Especially decentralized variants are highly valued because they offer great comfort and also provide in enough adaptability. Central variants could be applied when the possibility to use existing central shafts is present.

In both case studies the two most logical variants have been applied although there are several good possibilities. The actual designs for the case studies, based on this study, are not part of this report. They will be designed based on more research to the different applied systems.



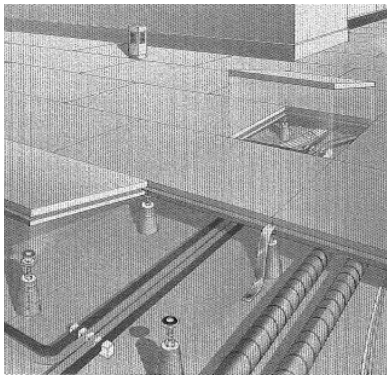
22. a: Lacaton & Vassal, Paris, b: de Architekten Cie, Amsterdam, c: Hans Kollhoff, Berlin

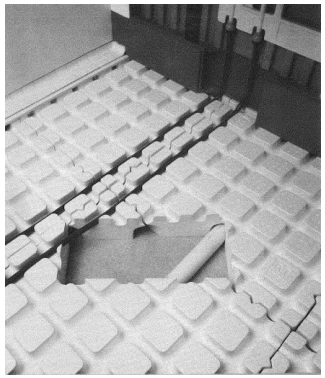


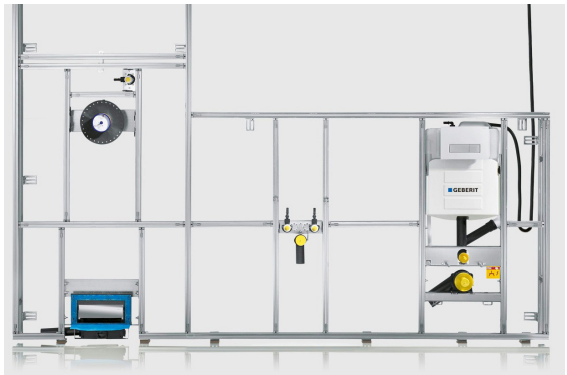


23. a: ClimaRad, b: Breathing window

24. Infraheat heatings foil







25. a: Interlevel floorsystem, b: Matura floorsystem, c: Geberit wallsystem

3 Conclusion & Recommendations

Regarding to the problem statement it is clear that new, often decentralized, systems are required for transformation of office buildings into dwellings. Affecting the floors because of the pass through of building services gives some structural problems. Because of that a concept which makes use of the possibilities of existing building services and shafts (centralized) and renewed load-bearing façades (decentralized) is conceived. This is instead of making recesses in the floors and in context of adaptability. Based on this concept an answer to the following research question has been found: “How can building services for dwellings realized adaptable and make use of the existing building services and load-bearing façades of obsolete vacant office buildings?”
Based on five sub-studies this report has led to the following conclusions:

1. Building services for dwellings are related to comfort, energy and sanitary and each category can be divided into different functions. These functions can be completed by different variants.

2. The most important property for adaptability is that it must be possible to disconnect the building services from the other components of a dwelling. This allows maintainance or renewing and provides in flexibility for other functions, now or in the future.
3. For transformation it is important to know what kind of shafts regarding the amount, the dimensions and the position, are present in an office building.
4. Generally, only building services regarding comfort are able to be reuse. Because of the large qualitative and quantitative differences in energy and sanitary, this categories are hardly possible to reuse.
5. Load-bearing walls can be divided into three categories:
A: Closed façades without columns.
These offer a lot of layout freedom, but cause more difficulties when interaction between the two sides of the load-bearing structure is necessary.
B: Parapets with columns.
These offer less layout freedom but have more options regarding integration of building services in the façade.
C: Beams with columns.
Also these offer less layout freedom and have more options regarding integration of building services in the façade.
6. Decentralized systems are usually the best option because they offer much comfort but still are adaptable.
7. An office building that provides in the ability to reuse existing shafts, sometimes can also be provided of centrally organized services.

Based on these conclusions it can be established that possibilities and limitations should be investigated per individual building. Besides that, the chosen concept is very dependent on the orientation of the façade.
Finally, also other requirements play a significant role, for example, with regard to the aesthetics.
Regarding the input of this report a design will be made for one of the case studies. In this case, more research will be done into the variants of the chosen concept.

4 Bibliography

Bak, R.L. (2012), Kantoren in cijfers 2012. Nieuwegein: NVM Business

Benraad, K. (1994), Van werkplek naar woonstek. Herbestemming van kantoorpanden. Rotterdam: Stuurgroep Experimenten Volkshuisvesting.

Bilow, M. (2012), International Façades - CROFT Climate Related Optimized Façade Technologies. Thesis TU Delft.

Bouwmeester, H. (2003), Industrieel, flexibel en demontabel bouwen 2002. Demonstratieprojecten IFD-bouwen. Ouderkerk a/d IJssel, Drukkerij Goos.

Bouwmeester, H. (2004), Industrieel, flexibel en demontabel bouwen. Demonstratieprojecten IFD-bouwen 2004. Ouderkerk a/d IJssel, Drukkerij Goos.

Dartel, H.A.J. (2005), SLIM BOUWEN©, het integraal ontwerpen van gevel en installatie, TVVL magazine 7-8.

Ebbert, T. (2010), Re-Face. Refurbishment strategies for the technical improvement of office facades. Proefschift TU Delft.

Eekhout, M. (2011), Facade intervention of post-war high-rise buildings. (afstudeerverslag), Delft: TU-D Faculteit Bouwkunde.

Hengeveld, D.J., Zanten, J.H. van, Hoedt, A. den, Deerns raadgevende ingenieurs b.v. (2004), Jellema, Bouwtechniek. Installaties. B werktuigbouwkundig en gas. Utrecht/Zutphen: Thiememeulenhoff.

Kamerling, M.W., Kamerling, J.W. (2004), Jellema 9, Bouwmethoden Utiliteitsbouw. Utrecht/Zutphen: Thiememeulenhoff.

Kendall, S. (2005), An Open Building Strategy for Converting Obsolete Office Buildings to Housing, Lean Building Conference, Virginia, USA (BSCOOBH). http://www.aia.org/aiaucmp/groups/ek_public/documents/pdf/aiap080054.pdf

Knaack, U., Klein, Tilmann., Bilow, M., Auer, T. (2011), Principes van het construeren, Gevels. Amsterdam: Uitgeverij SUN.

Kok, W., Luijn, P. van. (2012) Transformation 'office to dwelling' and 'Dweling to user'. MSc Graduation thesis TU Delft Faculty of Architecture.

Koornneef, F.P. (2012), Converting office space. Using prefab architecture to convert vacant office buildings. MSc Graduation thesis TU Delft Faculty of Architecture.

Linden, A.C. van der. (2006), Bouwfysica.Utrecht/Zutphen: Thiememeulenhoff.

Meeuwissen, C., Veelen, I. van, Hogeling, J.J.N.M. (2004), Jellema, Bouwtechniek. Installaties. A elektronisch en sanitair. Utrecht/Zutphen: Thiememeulenhoff.

NVM Business. (2014), Nederlandse kantorenmarkt nog steeds in zwaar vaarwater. Retrieved: 03-03-2014, from: http://www.nvm.nl/businessnieuws/2014/20140225kantoren.aspx

Pieters, B. (2012), Transformation Zero. From office towards an energy-neutral residential building. MSc Graduation thesis TU Delft Faculty of Architecture.

Rentier, Ch., Reymers, J., Salden, M.W.R. (2001), Jellema 4b, Omhulling. Utrecht/Zutphen: Thiememeulenhoff.

Rybak, M. (2014), T.echnical, E.conomical and S.ustainable T.ransformation (afstudeerverslag), Delft: TU Delft Faculty of Architecture.

SBR. (2010) Transformatiewijzer: van kantoor naar woonruimte. Perspectief, financiën en regelgeving. Rotterdam: SBR.

Spierings, T.G.M., Amerongen, R.Ph. van, Millekamp, H. (2004), Jellema 3. Bouwtechniek Draagstructuur. Utrecht/Zutphen: ThiemeMeulenhoff.

Twynstra Gudde Management Consultans. (2004), Van werken naar wonen. Transformatie van kantoren tot woningen. Voorburg: NVB Vereniging voor Ontwikkelaars & bouwondernemers.

Voordt, T. van der, Geraedts, R., Remøy, H., Oudijk, C. (2007), Transformatie van kantoorgebouwen. Thema's, actoren, instrumenten en projecten. Rotterdam: Uitgeverij 010.

Vreedenburgh, E., Mooij, M., Randen, A. van. (1990), Leidingsystematiek in relatie tot flexibiliteit. Verslag IOP-onderzoek 'Leidingen'. Delft: Publikatieburo Fakulteit der Bouwkunde.