Incrementally converting vacant office buildings into houses
This is my Technical Research Paper for the Architectural Engineering master track at the faculty of Architecture, TU Delft. I hope you enjoy reading it.

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1. Background

This chapter serves to sketch an image of the situation I’ll be intervening in. It will bring forward that there is a problem with the revitalization of vacant office buildings.

1.1 Vacant office buildings

As of July 2013, the Netherlands has 7,259,000 m2 of vacant office space, 14.7% of the 49,384,000 m2 total (DTZ, 2013). Most of the vacant office stock of today is defined as structurally vacant, meaning that the building has been vacant for more than three years (Hek, 2004). Forecasts show that about 70% of this office space will never again be necessary in the future (EIB, 2011). The overcapacity is simply too large; there are too many office buildings.

Fig. 1.1.1 7,259,000 m2 visualised with Amsterdam as a backdrop

The reasons for this are complicated and manifold, but I’ll try to discuss it briefly. The office market is very responsive to short-term demand. However, it takes a lot of time to complete a building. This results in many shiny new buildings after an economic bubble. When the bubble has burst, not all of those buildings will have been necessary, so an overcapacity is created. When contractual agreements end, the old offices will be left in favor of the new ones.

For the owner, a vacant office building is very unprofitable: no tenant, no profit. Furthermore, property taxes, service contracts and energy costs still need to be paid. This does not always happen properly, accelerating the deterioration process of the building. Because vacant buildings are often left unattended, there is less public surveillance, which can lead to criminal activity and further deterioration. A private problem becomes a public one. (Kooeneef, 2012).

1.2 Measures

There are 4 types of measures to deal with the structural office vacancy (NVM Business, 2010).

1. Further commercial exploitation (lowering of rents)
2. Renovation (office renewal)
3. Conversion (new function)
4. Demolishment (withdrawal from the market)

The first two options may solve the vacancy of an individual office building, by attracting tenants away from other buildings. However they do not address the fact that however cheap (1) or shiny (2), there is still an oversupply of office buildings as a whole. Demolishment may create space for something new, and the ground may be sold to another investor, but it’s still the destruction of a lot of capital. To convert the office building into a different function will not completely cover the losses (for example: office rents are nearly twice as high as houses’), but you’ll end up with a usable building that may function for a very long time (Kooeneef, 2012).

Conversion then is the preferable option: reusing the structure of the building makes it cheaper, faster to redevelop and better for the environment. So why is it happening so infrequently?
1.3 Awaiting attitude
Even though conversion may be an appropriate measure, investors are hesitant to act. There are several reasons for this. Primarily, vacancy is not an immediate problem to them, mostly because only a part of their office portfolio is vacant, the other part still generates an ‘acceptable’ yield (Koomeef, 2012). Considering the public deterioration aspect of vacancy, this behaviour is rather negligent and unethical. Ultimately, the problem is unavoidable as 70% of the currently vacant office buildings is set to become redundant (EIB, 2011).

Finally, there are always some financial risks involved with conversion: the future tenants may dislike the converted building or find it unfit to their needs, resulting in yet another vacant building. Because the housing market is a lot less generic than the office market, new housing projects need to be much more adaptable.
2. Concept

I’d like to present a solution to the problems stated in the previous chapter.

2.1 What we need
We’ve seen how a slow responding office market can cause confusion with supply and demand. We need a system that assumes no demand but can respond quickly when it arises. We’ve seen how empty buildings deteriorate the neighbourhood. We need to prevent the disappearance of public surveillance by bringing back livelihood. We’ve seen how conversion can be a capital-conserving measure. We need to convert office buildings to houses. Finally, we’ve seen how investors aren’t very motivated to do anything. We need to exclude investors from the conversion process by empowering dwellers to take measures into their own hands.

2.2 Incremental replacement to distribute costs
Fig. 2.2.1 The process of a regular office building conversion
(1) A building is selected, (2) high investments are made to update the buildings’ services to the new function (facade and installations form the highest costs by far), (3) the investments are recovered by selling dwellings in the building. This model requires the investors to take a risk: they might not sell enough units to get their investment back.

Fig. 2.2.2 The process of the proposed solution
(1) A building is selected, (2) one climatically, structurally and financially autonomous unit moves in at a time, updating the building incrementally, (3) more units may move in over time, but neither the building, the dwellings nor the finances depend on that. This model distributes the costs of conversion to the point that they can be fully paid by private clients. This circumvents the need for investors or owners to cover these costs. This way, they have nothing to lose, but much to gain.

Using this model, the total costs might be slightly higher, however this does enable a way out of a stagnant situation

2.3 Mental ownership
Urban renewal is not only about physical or economical measures, it’s about social measures as well. Social sustainability can be achieved through the creation of mental ownership, which is the commitment of the user to something which is not physically owned, but is treated as such. Participation in the initiation, planning and realisation of place making in the private, communal and public space is of huge importance (van Etten, 2010).

This concept is about facilitating that participation. The end goal is to have an interface tool where individual dwellers can input their desires about their home and its surroundings. The interface tool should then generate a location in the building according to these desires, while keeping the desires of previous dwellers into account. This aspect of the concept will henceforth be referred to as the ‘Spatial Organisation Tool’.

Fig. 2.3.1 An example of a Spatial Organisation Tool, developed by MVRDV

2.4 Research questions
An overview of the research questions I intend to answer. Starting with the overarching question and continuing with the sub-questions. The latter have been sorted by scale: from building, to unit, to spatial organisation.
How to design a structurally and climatically autonomous living unit suitable for the evolutionary conversion of vacant office complexes and optimized for computer-controlled fabrication?

1. What role will the existing façade and facilities of the vacant building play in its conversion?
2. Which typology of building complex is best suited for conversion with autonomous units?
3. How to negotiate space to maximize the potential of both the autonomous units and the space in between?
4. What bandwidth of spatial freedom for the units is possible and preferable?
5. How to spatially organize each unit within the building complex so individual wishes are protected throughout its occupancy?
6. What bandwidth of user expression for the units is possible and preferable?
7. What kind of performative standards must the unit pass?

Fig. 2.2.1 The process of a regular office building conversion

Fig. 2.2.2 The process of the proposed solution

Fig. 2.3.1 An example of a Spatial Organisation Tool, developed by MVRDV
3. Guiding principles

This set of principles will help guide my development of the concept. Some of these will characterize the kind of problems I’ll run into, others set ambitions, and yet others explain an attitude towards the process.

3.1 Maximal cost distribution
Excluding investors from the conversion process is one of the main attractors of the concept: as much as possible, the general costs must be individualised. Decentralising some building systems and services may be challenging but not insurmountable.

3.2 Broad applicability
The concept should be applicable to a range of buildings, rather than just one. This predilects generic solutions over specific ones. This means I will try to presume as little as possible about the existing context. When applying my concept to a pilot-building, I’ll try to ignore the building-specific area’s of the design, like for example, the foyer.

3.3 Easy assembly
In line with the empowerment of the private clients, it’s important that the clients can become the producers and the builders as well. Therefore, building components must be designed with flexibility, easy assembly, transportability and cost effectiveness in mind.

3.4 Minimum Viable Product (MVP)
In product development, the Minimum Viable Product (MVP) is a strategy used for fast and quantitative market testing of a product or product feature. I choose to apply this mentality to my design process, given the product-like nature of my concept. It means I’ll design the easiest workable solution first, and elaborate (perform better, be more flexible, et cetera) later.

3.5 Evolution not optimization
I’m allowing myself the freedom of not being efficient when it comes to spatial organisation. An incremental approach is inherently not optimized, because the information is always incomplete.
This chapter is about choosing the conversion approach to the existing building, identifying what office type is best suited to this concept and choosing a pilot-building. This should adequately answer research sub-questions (1) and (2).

4.1 Conversion approach.
I’ve defined several types of to how an office building might be converted using the concept of autonomous units and distributed costs. On the left, the diagrams show the possible facade expression. On the right, the resulting climate regions, discerning outside, hallway and inside.

Fig. 4.1.1 Strip entire facade
This would leave a casco building where simple units with insulated walls could simply be shoved in. It’s a low-cost approach with an interesting architectural result. Unfortunately a concrete or steel building structure isn’t prepared for the temperature or weather changes it would face when stripped of its protective layers, the facade. The temperature changes would cause stretching and shrinking, causing cracks and eventually ‘concrete rotting’.

Fig. 4.1.2 Replace entire facade
The facade can be replaced with a simple glass skin to provide basic protection from outside and one huge hallway that could be semi-climatized behind this skin. Units can be completely freeform and be placed where ever they want. Architecturally, it will provide an interesting image and it opens a lot of possibilities for the units within. However, the high initial investment costs for the facade opposes the idea of distributed costs. Furthermore this prevents the possibility for gardens or balconies.

Fig. 4.1.3 Incremental interior upgrade
The old facade could remain intact and only where new units are added, the interior of the facade would be updated to answer to changed requirements, regarding daylight and insulation. It’s a low-cost, incremental approach with a wide applicability. However it doesn’t solve the fact that many office building windows are too small for housing regulations. Also many people consider office facades ugly and wouldn’t want to live in them.

Fig. 4.1.4 Incremental facade replacement
A part of the old facade is dismantled when a unit moves in behind it. The unit would have to be designed with generic connections to the old facade in order to prevent leaking and thermal bridges. The costs are incremental, the facade expression will be interesting and gardens or balconies will be possible. The only downside is a higher cost per unit, because of incremental facade dismantling. This may be avoided if it becomes possible to dismantle from the inside.

4.2 Considerations
Besides the facade, several other elements will need to be considered to accommodate the existing building to the introduction of autonomous units: air channels, heating, cooling, water pipes, drainage, power and cable. Solutions will be more thoroughly discussed in §6.2 and §6.3.

4.3 Conditions for building choice
It’s important that the conditions are clear for choosing a building my concept can be applied to. However, these conditions mustn’t be too strict, otherwise the applicability
becomes too limited. It’s a two-way street between concept adaptation and building requirements.

4.3.1 Urban
Location is important. Many vacant office buildings are situated in office parks which often lack the amenities and liveliness to function as a residential neighbourhood. While they shouldn’t be written off completely, I’d the pilot-building to be situated in or adjacent to a residential neighbourhood. Furthermore I’d prefer a disadvantaged neighbourhood as it would have the most to gain from low-cost revitalization efforts. Finally, the building should be completely and structurally vacant, preferably with a single owner.

4.3.2 Architectural
In this stage of the concept development a rectangular, 5,4 or 7,2m column grid building with a straightforward layout is most preferable, because I don’t want to make the spatial organisation too complicated. I’m working towards a tool that can generate space and place, so I’m applying the idea of ‘Minimum Viable Product’ here. Following that same argument, I prefer vertical access points in the center or on the sides so the hallways won’t have to be complicated.

Architecturally speaking, I’d like the building to be quite ugly and have small windows. Houses in the Netherlands have regulations against small window sizes. These aspects would make the replacement of the facade more neccessary, which lends legitimacy to my concept.

4.3.3 Technical
In order to have as much freedom as possible with the spatial organisation of the units, a skeletal structure is preferred with no structural parapets in the facade. Depending on the type of floor it’s either possible or very dangerous to make perforations it. Floor perforations would’ve been useful for adding vertical transportation or centralised solutions for water, power and cable. However, in keeping with broad applicability, I’ll find a different solution.

The most important technical conditions to be met for the building choice are ease of dismantlement of the old facade and the possibility for climate-proof connection to the new facade.

Fig. 4.3.3.1 Façade construction principles and ratios (T. Ebbert, 2010).
Ebbert’s diagram shows several office facade types and how often they’re applied in the Netherlands.
I can immediately reject several types:
- Planar forms (parapet blocks new facade)
- Double layers (hard to dismantle)
- Rare types (not widely applicable)

The rest I’ve highlighted and will analyse for fitness to my concept. To discover ease of dismantlement, I’ve made diagrams that show how elements of the facade are related to one another in terms of fixation. The situation after dismantling is also shown.
Fig. 4.3.3.2 Facade in line with skeletal structure
The facade is basically divided into pockets in between the columns and the floors. Without impacting the integrity of the facade elements, a clean fragment can be removed. The main drawback is the minimum width of this fragment, which is as wide as the column grid (at least 3.6m). This impacts the freedom and flexibility of the spatial organisation. Also, attention will have to be given to the structure-covering elements that ensure proper water proofing and insulation.

Fig. 4.3.3.3 Parapet + window
First the parapets are attached to the columns, then window frames are mounted. This method makes it impossible to dismantle the facade one storey at a time, which is vital to my concept. A workaround would be to slice the elements that make up the parapet. However, the climate proofing properties would be compromised and unpredictable. So would the necessary connections to the new unit.

Fig. 4.3.3.4 Heavy unitized
The main drawback is the inability to remove a fragment without removing the one above it as well. If the conversion happens from the top floor down, which is likely, this problem disappears. Otherwise this is probably the cleanest way to remove a fragment. Because of the shape and its connection to the floor, dismantlement will have to happen from outside, which increases costs.

Fig. 4.3.3.5 Stick-system
This system provides a clean way to remove a narrow fragment. By using the window frame fixtures of the old facade to join with the new facade, a climate proof connection can be ensured. Because this is the easiest and most flexible facade type to work with, I will use it with my further investigations.

From this we can conclude several things for the design of the unit:
- Its facade will have to be supported by the floors of the building
- In order to avoid leaks or complicated old-new connections, the the floor, ceiling and facade of the unit should protrude slightly from those of the building

Fig. 4.3.3.6 Hole versus protrusion

4.4 Building choice
As of yet, a definitive building is not yet chosen. It’s quite difficult to locate a building that fits all the requirements. Fortunately, at this point in the research a fictive building works just as well.
Fig. 4.3.3.2 Facade in line with skeletal structure

Fig. 4.3.3.3 Parapet + window
5. Spatial organisation

In developing the concept further, efforts should be made towards a ‘Spatial Organisation Tool’. The goal of this tool is for users to have an interface to input their own requirements for their home in terms of size, arrangement and expression. This allows users to customize some design aspects to their liking, thereby increasing mental ownership and satisfaction. The tool should also feedback the financial consequences the user input generates so it can be considered as an argument when making choices. Finally the tool saves the information inputted by previous users so it can find a location in the building where every configuration can be realized without trespassing on other peoples’ inputted preferences.

This chapter is concerned with the location-finding and placemaking aspect of this tool. By considering empty space, the boundaries of spatial organisation, the rules that should apply, in what order those rules apply and how performance can be improved, it should be possible to answer research sub-questions (3), (4) and (5).

5.1 Empty space

We’ve seen how on an urban level, the lack of liveliness causes detioriation and unattraciveness. This happens on a building level as well. The fact that with my concept the conversion process is incremental means that dwellers may experience parts of their building to be completely empty and possibly uncared for. Not an attractive prospect for early adopters. How to maximize the potential of both the autonomous units and the space in between?

This is where communal space comes in. On a per-storey-basis the dwellers are free to temporarily (until a unit moves in on top of it) develop the unused space into communal functions like playgrounds, seating area’s, vendors, sport fields et cetera. Dwellers will also be able to reserve open area’s adjacent to their homes to permanently develop into communal functions.

I’m not going to go into the efficacy of this measure or it’s possible outcomes, but I’m mentioning it here because it’s an element in spatial organisation that needs to be accounted for.

5.2 Bandwith of spatial freedom

As an exercise to reveal what kind of rules should apply to spatial organisation, I’m considering what it would mean to have total spatial freedom.

Fig. 5.2.1 Considering the blob

The blob is multi-storey, has multiple heights, cantilevers, in fact ignores the building perimeter, ignores the resulting hallway shape, wastes space, has infinite arrangements, garden could be anywhere, communal space too. All these characteristics are disastreous for developing a clear spatial organisation, more so for developing a tool that can generate it.

5.3 Rules

At this point it may be neccessary to set the definitions of several terms:
- Structure: the floors and columns of the building
- Hallway: the unused space in between units, half-climatized
- Communal space: unused space that’s been developed for public use
- Lot: privately owned space that’s filled with either dwelling or garden
- Unit: the combination of the lot with the dwelling and the garden.
- Dwelling: fully climatized part of the lot in which the dweller lives
- Garden: non-climatized part of the lot to which the dwelling has access
- Perimeter: outside shape of the structure
- Hallway edge: the side of the lot connecting to the hallway
- Perimeter edge: the side of the lot connecting to the perimeter

So, in line with the philosophy of ‘Minimum Viable Product’, let’s see what kind of rules for a unit would result in a clear spatial organisation.

**Fig. 5.3.1 Unit heights**
- Single storey units (it’s undefined if floor structure allows perforations)
- One height
- Unit edges follow the facade grid

**Fig. 5.3.2 Lot shape**
- Orthogonally shaped units
- Adjustable width and depth on a grid: lots can be between 5,4 x 7,2m and 12,6 x 14,4m.

**Fig. 5.3.3 Lot location**
- Front edge of lot must always touch building perimeter; no cantilevers
- Unused space must always leave a path of at least 1,8m wide that touches every lot
- New lots cannot overlap with old lots and reserved unused space

**Fig. 5.3.4 Hallway location**
- Because of the alignment of the lots to the building perimeter and the three different lot depths, the hallway can only be at one of four different depths
- Space in between lots counts as unused space that can be developed into communal space
- New lots cannot be placed so that no hallway path is possible anymore

**Fig. 5.3.5 Garden & communal space**
- Garden is placed within lot
- Minimal dwelling dimensions are 7,2m x 4,8m
- Users may reserve unused space adjacent to their lot
- Reserved unused space is always the same depth as the lot and a multiple of 1,8m wide
- Reserved unused space can only be developed into a hallway or communal space, not into a dwelling

The reasoning for some of these rules may only become apparent on a unit-level which will be discussed in the next chapter.

**Fig. 5.3.5 Potential sequence progression**
The above diagram shows how the conversion of the building might progress. On the right a random lot as a user might configure it is depicted. On the left it’s placement in the building. A standard office building plan from before 1990 is used as a basis (Remey, 2007).
Extra specific rules may be added to steer the end result in a certain way. Such as:
- A fixed percentage of communal space per floor
- A high minimum or low maximum lot size
- A fixed lot depth or width
- An incentive to locate lots close to each other so a more compact configuration might be achieved
- Space is not allowed to be wasted

5.4 Choice sequence
When users are presented with the 'Spatial Organisation Tool', the end result may be affected by the order in which choices are made and information is presented. The user might prefer a cost centric, a location centric or a public activity centric approach, depending on their priority.
Fig. 5.3.5 Potential sequence progression
This chapter is about working towards a design of the unit. First the bandwidth of individual expression for the unit is set. Then climate solutions are considered as well as the connections to centralised facilities. Finally all the elements of this and the previous two chapters can come together in the unit design. This should adequately answer research sub-questions (6) and (7).

6.1 Bandwidth of individual expression

Individual expression for the users is important, because it increases mental ownership and satisfaction with the dwelling. Many rules have been made on the level of spatial organisation that impose on the unit as well.

Fig. 6.1.1 Spatial organisation rules for the unit
- The dwelling has to fill the lot and leave room on the perimeter for garden space
- The lot is orthogonally shaped
- It’s single storey, single height
- The sides follow the facade grid

There is, however, still room for individual expression with the unit width and depth, inner wall and room division, garden placement and front facade position. Furthermore, facade cladding, layout and shape might be customized, opening the possibility for high diversity.

6.2 Climate solution

Climate in office buildings is usually handled using airducts and water pipes, coming from a single location, the installation room. Because my generic approach doesn’t allow me to assume the location or the adequacy of the existing solution, I’m choosing to strip the existing climate facilities and I’m opting for a decentralised solution so the costs can be distributed.

The PassivHaus standard offers a useful approach with an integrated solution for ventilation, heating, cooling and hot water.

Fig. 6.2.1 Basic principles for Passive Houses (PassivHaus Institut)
A PassivHaus building is extremely well protected by outside temperature influences.

Fig. 6.2.2 Compact heat pump unit (Passipedia.org)
Thanks to this unit, air can act as the transporting medium for the heating and at the same time serves as the source of heat (on the exhaust air side) for the heat pump.

Because the heating power requirement in a PassivHaus is so low, the supply air from the heat exchanger is enough to heat it the building. Case studies indicate that indoor temperature exceeds 25°C less than 1% of the time if windows can be tilted. This is well under the acceptable limit (Passipedia.org). My goal is not to receive the PassivHaus certificate, but I will apply the principles necessary to facilitate this climate solution.

6.3 Necessary central connections

Unfortunately, it’s impossible to decentralise water pipes, drainage, power and cable as they’re all using a very specific source. It won’t be possible to randomly make perforations in the floor as one might perforate a unit below it as well! A type of plug-and-play solution is necessary that connects to the pre-existing vertical access points. It seems a small investment is unavoidable.
Fig 6.1.1 Spatial organisation rules for the unit

Fig 6.2.1 Basic principles for Passive Houses (PassivHaus Institut)

Fig 6.2.2 Compact heat pump unit (Passipedia.org)

Fig 6.3.1 Section of pipes, adapted from Koorneef (2012)
To determine the best location for a plug-and-play type solution, I’m using Koorneefs’ overlay method (2012). The red circles indicate cold water, power and cable. The green circles indicate drainage (lower) and drainage relief pipe (upper).

Fig 6.3.2 Water, power and cable concept
Placed along the perimeter to ensure each home is reached.

Fig 6.3.3 Drainage concept
Since it’s impossible to perforate the floor, the drainage pipe will have to be placed above it. In order to interfere with the hallway path as little as possible, the pipes are placed along the perimeter. They can be integrated with the floor as soon as units move in on top of it. Considerable floor height has to be preserved as the collector pipe needs a slope of 5 - 20mm/m (Jellem A, 2004).

Placing the pipes just below floor-level would be a prettier solution, so if the floor type allows it, that would be my preference.

6.4 Unit design
All things considered, I want to design a unit that follows the borders of the lot, protrudes from the building facade, encases the garden and frees the position of its front facade.

Fig. 6.4.1 Shell
The concept of the shell provides uniform tangent surfaces, which simplifies the connections to be made between old and new (1). The thick walls function to attain the high insulation values required for the climate concept to work and to encapsulate the connections to the old context (2). The adherence to the grid and its modularity simplifies connections between new and new (3). The garden and front facade are contained by the shell, freeing them from fixed positions (4).

Fig. 6.4.2 Facilities & climate
Connections to the facilities are easily made by the raised floor and the free space above the ceiling. A desired climate division is reached: the hallway climate remains the same, a highly climatized area is created within the dwelling, the dwelling is adjacent to outdoor space, but the climate from the outdoor space cannot transfer into the hallway.

Fig. 6.4.3 Shell connections the old facade
Using PassivHaus details for inspiration, the connections were designed. The aim was to create generic details that could be applied to many office facades. However some detailing parts such as the structure cladding may be facade type specific. While designing these details I’ve noticed the huge amount of space the walls take in. About 0.4m² per meter wall. I do not yet know the land prices, but it may be justifiable to use ‘Vacuum Insulation Panels’. They may be more expensive, but are only 20 – 50mm thick, saving a lot of space. It’ll be worth investigating once I get more into pricing at a later moment.
Fig 6.3.1 Section of pipes, adapted from Koorneef (2012)

Fig 6.3.2 Water, power and cable concept

Fig. 6.3.3 Drainage concept

Fig. 6.4.1 Shell

Fig. 6.4.2 Facilities & climate
Fig. 6.4.3 Shell connections the old facade

Fig. 6.4.3 Shell connections the old facade (cont.)
7. Conclusion

This chapter serves to reflect on the past and make recommendations for the future.

7.1 Reflection

I think the concept has stood remarkably strong despite continued scrutiny. Even after spending almost half a year with it, I still think it’s a very realistic and promising idea.

There have been many setbacks and mistakes during the development process, but I think I’ve been lucky to keep my basic premise intact. This has ensured that throughout the process, I’ve always known what to do. The setbacks were largely due to insufficient or inadequate sources or from running against the same wall over and over while a different approach was possible.

The end result is a very useful frame for developing this concept further. Each fork along the path has been ventured, always keeping the same basic merits in mind: distribution of costs, high applicability, minimum viable product. This has resulted in a basis that is quite far along, but still very moldable.

Another thing. So far the concept has focused on private clients (particulier opdrachtgeverschap). The money saving argument would be much, much stronger if it would be applied to collective private clients (collectief particulier opdrachtgeverschap). One could imagine an entire office floor being converted at once, for a number of dwellings. The cost for dismantling the facade would go down dramatically. The necessity for ease of dismantlement for the horizontal connections would disappear, allowing greater applicability. The great drawback is the dependence on other people. Nonetheless it’s worth it to investigate it at another moment.

7.2 Follow-up studies

The study is about halfway done and there is much more to do. The product isn’t finished. I haven’t been able to get to the actual fabrication of the unit, nor has any programming been done towards an actual tool. Also the collective version needs a lot more thinking.

Subjects for further study are the spatial organisation tool, a pricing calculator, finetuning the architectural value, further optimization for flexibility, easy assembly, transportability and cost effectiveness, expansion of individual participation and improving applicability to extra office typologies.

Lots to do!
8. Bibliography

This chapter provides a list of sources used for this paper. In order of appearance.


Etten, R. van (2010) Msc thesis: Empower people to make the city; how mental ownership can lead to a sustainable renewal, TU Delft.


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