SPLIT TO FIT

COMPACT LIVING IN POST-WAR WALK-UP FLATS

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ABSTRACT

The current post-war walk-up dwellings are in terms of layout, installations and facilities in a very outdated condition. However, the strength of the walk-up flats is that they are easy to split into multiple smaller residential units. This way, suitable dwellings are created for the fastest growing group of households, namely one-person households. Four subjects at building level have been chosen to analyze: accessibility, vertical installation, outdoor space and infill. The broad ideas of the different possibilities will be compared in a consistent way by means of a criteria. The results from the literature study on compact living will be used to provide a design criteria to aid in decision-making process of design. The score determines the level of an alternative that fits the specific ambition. This research paper can be used as an aid for social housing corporations to split walk-up flats and thereby offer more housing units.

KEYWORDS: *compact living, post-war walk-up, accessibility, installation, outdoor, infill, research by design*

I. INTRODUCTION

The major cities in the Netherlands have grown rapidly over the past years. Young singles, young couples and highly educated have a much stronger preference for living in a busy city than before. Planbureau voor de Leefomgeving and the Centraal Bureau voor de Statistiek indicates that the four big cities, Amsterdam, Rotterdam, The Hague and Utrecht, will have to handle with a growth of more than 300,000 people till 2030 (PBL, 2016; CBS, 2016). An increase of no less than 15% in less than 15 years. This relatively high population growth leads to a high demand for housing, especially in the one person households. For 2060 the CBS (2016), 'Centraal Bureau voor de Statistiek', has predicted that 43 percent of Dutch households will consist of one person. Many existing homes are built in a social context of the past. Up to 2030, 230,000 owner-occupied and rented houses will have to be built in the Randstad (Bekkers, 2016).An important aspect is that cities are not willing to expand in size but are trying to create a so-called "compact city". Building within the boundaries of the city on the scarce unused property gives a new meaning to the building task of the coming years. In other words, more efficient and effective use of space in the existing city. This includes the splitting of dwellings into smaller units, transforming empty commercial buildings into dwellings, topping up existing dwellings with a new dwellings, installing them if a house turns out to be too small or a new building addition to the existing urban fabric.

Many existing homes have been built in a social context from the past. They relate to outdated forms of living. For instance, the average number of persons per household was 3.6 in that time (Priemus, 1994). While this decreased to 2.16 persons per household in 2018 and is expected to decrease even further (CBS, 2016).Trends are changing and therefore these outdated forms of living should also change. This also offers an opportunity to address the existing building environment in terms of contemporary forms of living and the energy performance.

Many post-war dwellings have an energy label G and have a negative environmental impact. These dwellings are often worn out, poorly insulated, too noisy, old-fashioned and impractical.

However, these post-war dwellings also have many elements of great value. They are well embedded in the existing city with a lot of public space and, most importantly, the structure frame of these houses can last for many years in a constructive way (Kerssies, 2007). Why demolish a well-functioning building block that is energy-inefficient or lacks comfort? With a new infill, the structure frame is given a second life, matching the living requirements of today and tomorrow. With post-war flats, this way of working saves approximately one hundred tons of demolition waste per home (Kerssies, 2007).

The developments described above are aimed to research whether the current post-war walk-up flats can be densified in such a way that they are suitable for habitation by single-person households. Splitting is one of the aforementioned strategies of densification in which no mass is added, but which is literally compacted, within the building envelope. The dwellings which are currently on the housing market are often prohibitively expensive for many singles. By living in a more compact way, with shared facilities and functions, living in the city can remain an option for everyone.

This research aims, through research by design, to transform the stereotypical classical typology of these walk-up flats to find alternative proposals, suitable to the contemporary way of living in the city, resulting in the following research question:

What are the splitting potentials of a walk-up flat and how can these be applied through renovation?

Sub questions;
- What are the structural features of the post-war walk-up flat?
- What meanings and values are associated with compact living?
- What are the requirements for compact living?
- What obstacles are there in dividing post-war walk-up dwellings?
- What defined criteria can be used to determine the suitability?
- What are the strategies for designing compact dwellings?

II. METHODOLOGY

In the first phase of the study, the characteristics of the post-war walk-up flat are charted on the basis of literature study to gain a better understanding of the existing limitation on layout, construction and energy performance. Based on archival research (appendix 1) of thirty walk-up flats in the Randstad a generic model is developed. This generic walk-up flat forms the basis for several alternative scenarios that can be applied to provide more accommodation units, from the smallest size to residential units of 40m^2. The scenarios are used as a tool to provide insight into the possibilities and limitations for splitting a walk-up flat. Four subjects at building level have been chosen to analyze: accessibility, vertical installation, outdoor space and infill. The broad ideas of the different possibilities will be compared in a consistent way by means of a criteria (appendix 2). The results from literature study on compact living will be used to provide a design criteria to aid in decision-making process of design. The score determines the level of an alternative that fits the specific ambition. See appendix 3 for the methodology scheme. This research paper can be used as an aid for social housing corporations to split walk-up flats and thereby offer more housing units.

III. POST-WAR WALK-UP ANALYSIS

The origin; after the war, the housing shortage was high in and around the Randstad. This necessitated a rapid production of dwellings which, in this period, had more to do with quantity than on quality. Because of the crisis and the Second World War, there was a high shortage of traditional building materials such as brick and wood. And in order to build as efficiently and quickly as possible, Jo van de Broek and other members of the Stuurgroep Efficiënte Woningbouw (SEW) have done research into the dimensions of the use of space in a dwelling. It was determined what the minimum dimensions of the various rooms should be in order to be able

to accommodate the associated functions. Subsequently, using this data, standard floor plans were developed and therefore a new type of dwelling; the walk-up flat. This was the most common housing typology until 1965 and currently has a market share of approximately 12.5% of the total building stock in the Netherlands, which corresponds to 847,000 porches. Most of these homes are owned by housing corporations (Agentschap NL, 2011).

Layout; the average housing occupancy was, as mentioned earlier, 3.6 person per household in the 1950s (Priemus, 1994). The majority of these walk-up flats are realized as three or four-room apartments of 55 to 85 square meters where the ground floor is often used as storage space. These dwellings are constructed in a wider grid and one (or more) narrower grid sizes. The stairwell is located in the middle grid area. There are two options for this variant. In the situation where two identical dwellings are situated in a mirror image around the stairwell, the space behind the staircase is divided equally between both adjacent dwellings. In this case there is a Y- connection. In the other option, the space behind the stairwell is allocated as an extra bedroom to one house. This is called a '*wisselkamer*' accessibility. In practice, this variant appears to be the most common (Thijssen, 1988).

The master bedroom and the living room are often located in the widest grid. In the narrow grid are the entrance door, the central hall with the children's rooms at the front and the bathroom and the kitchen at the back. The bathroom also served as a laundry room at the same time. Because of this double function, the bathroom is situated between the kitchen and master bedroom. The bathroom cannot be reached directly from the hallway. The grid sizes vary between a maximum of 5 meters and a minimum of 1.7 meters. The most common grid sizes are between 3.5 and 3.7 meters for the wide grid and 2.4 and 2.7 meters for the narrower grid.

Construction; the vast majority of walk-up flats are traditionally built. The building blocks are built on a pile foundation with concrete foundation beams. In the cellars, floors and walls are also of poured concrete. From the ground floor, first and second floor are built with load-bearing brick walls and wooden beam floors. Because of the wooden floor constructions it is easier and cheaper to change services compared to a concrete floor. The floors of the staircase, the area around the wet rooms and the balconies are made of reinforced concrete slabs. The brick facades are self-supporting with some supporting concrete above the windows. Instead of a cavity, the front and back facade were provided with a layer of insulating stone on the inside. There are many building-physical problems in these dwellings such as moisture penetration, mold, rotten window frames and beams, noise and poor thermal insulation.

Installation; the walk-up flats are often equipped with local heating systems such as gas fireplaces and geysers. In many cases these have already been replaced by a combination boiler. This is usually installed in the kitchen. The energy source for cooking is gas and a ventilation shaft in the corner of the kitchen sucks the air out. Water and electricity pipes are centrally located in the porch and connected from there by means of a shaft with the houses. Ventilation of the other spaces in the home is through the opening of a window.

Heating of the dwelling was done through a gas fireplace in the living room with, if necessary, facade stoves placed by the inhabitants themselves. In many cases these have been replaced by a combination boiler. This is usually installed in the kitchen. The energy source for cooking is gas and a shaft nearby the kitchen provides for ventilation. This centrally located shaft also provides water and electricity pipes and connected from there connected with upper and/or under located dwellings. Ventilation of the other rooms is through the opening of a window.

IV. GENERIC MODEL

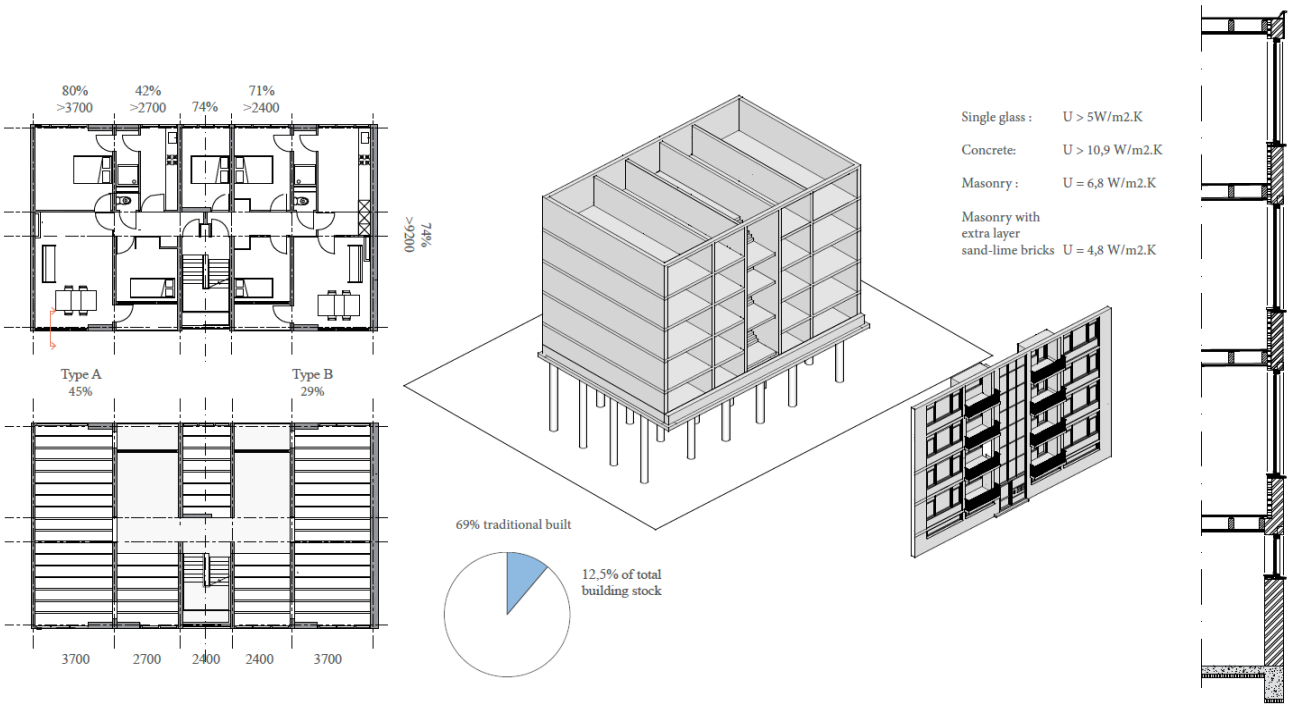

Figure 1. Generic model

V. COMPACT LIVING

Dividing dwellings into smaller housing units increases the supply for single people. There has been a lot of experimenting with compact living solutions, especially in countries with overwhelming populations, but the most of them has a relatively low standard of living. A point of attention remains that compact living should always maintain quality.

Spatial efficiency is certainly one of the strategies that will have a positive impact on the quality of life in minimal dwellings. In the book "*Small Movements: Architecture Strategies for Unit in Social Housing*," Andrea (2012) introduced a concept of hyper efficiency: '*A strategy that seeks to maximize the use and functionality of the space inside the unit. In a hyper-efficient unit, no space is unused or underused; all possible space has dual, triple or even quadruple purposes*'.

Apart from the internal efficiency, the quality of the enclosed external space is another important factor that affects the standard of living. Proposed by Goodchild (1997) in his book '*Living and the urban environment*': '*the most discussion about quality in housing design concentrate on its socio-cultural aspects. They focus on how people experience the environment around them; how they interact with that environment; and how they judge its suitability in relation to their daily routines and their expectations for the future*'.

The internal efficiency and the quality of the external space can empower each other. By sharing facilities and services in external spaces with fellow residents and / or the neighborhood, it is possible to save space in the dwellings and therefore the price of the dwelling can be reduced. In addition, the facilities and services can be of a higher level of quality than in an individual dwelling. Examples of shared facilities are a cooking studio, roof terrace, (vegetable) garden, guest room, babysitting center, shared cars, flexible workspace or laundry.

When looking at shared facilities, the underlying challenge of privacy cannot remain unspoken. The need for privacy is universal. The meaning of privacy is not limited to the possibility of being able to retreat, but also concerns the possibility for social intervention. The desired level of social

interaction depends on personal characteristics, social influences, the physical environment and culture (Gifford, 1997). This can therefore vary per person. As Lieke Knijnenburg describes, city dwellers live in spaces where they can meet, but where meeting is not absolutely necessary: reading a book in a busy park or working in a café. A home can therefore only provide the primary private activities (2015). Semipublic or semi-private facilities become the extension of the home or the extension of the city.

Not everyone wants to share everything, just as some are willing to share everything they own. The '*shared house project'* has a survey online that has been filled in by more than a hundred people. The scheme below gives a general picture of the willingness of people to share certain functions.

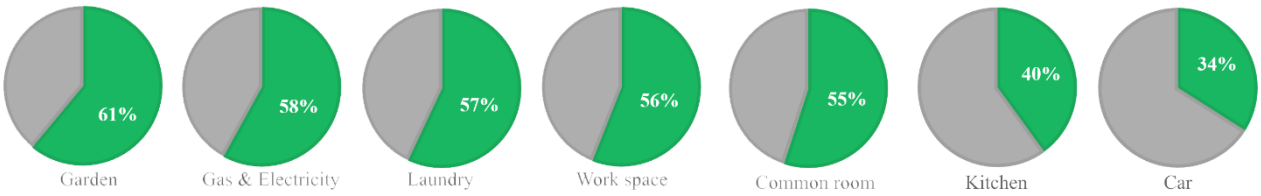

Figure 2. Results '*shared house project'*

Another reason why many people are willing to share function, has to do with the need for a community. Research show that people who live alone compensate the lonely home by becoming more socially active (Meesters, 2009). A report by the Mental Health Foundation, on co-living pointed out that among young people, the "loneliness epidemic" has become viral; nearly 60 percent of 18-34 year-olds told the foundation that they felt lonely frequently. This is an important social problem and shared housing or shared facilities is a possible solution to provide more comfortable social meeting platforms.

Architect and researcher H. van de Wal clarify in his book interview; '*The opportunity to meet is just as valuable as the location and size of a dwelling*' (2016). This is supported by Dorst; '*The social environment is more important than the spatial environment*' (2015). The spatial environment makes social activity possible, which makes the design of the spatial environment therefore even more important and in particular its use of it. The spatial environment facilitates the social environment with the effect that more social interaction can take place, as mentioned previously, if the user this desires. It is necessary to find a good balance between private, communal and public.

The border between private and public between dwelling and the city must therefore disappear. From private dwelling to public space is a big transition. This transition is diminished by the presence of an intermediate area: the hybrid zone. With a well-designed zone, people can determine the amount of interaction themselves and can match the desired amount of privacy in a certain zone (Altman, 1975). If the privacy zoning is not been respected, residents are inclined to retreat into their dwelling. The entrance of the dwelling is the border with a common and / or open space which is accessible to everyone. The other side usually has a private outdoor space that is not or only to a limited extent accessible to others. In the hybrid zone, a resident can feel safe when he or she opens or closes the front door with his back to the street. The hybrid zone can consist of a front garden, a height difference in the sidewalk, a place in front of the door, which is created by an offset in the facade or by a number of planters. The hybrid zone also has a function in engaging a social interaction. A study by Skjaeveland and Garling concludes that 80% of the informal social contacts in a neighborhood starts from the front yard or the hybrid zone (1997). The resident stays safe on his own territory and is easily approachable for everyone. Another function of the hybrid zone is that residents can show their identity by giving it a personal interpretation.

VI. SPLITTING

The dwellings which are currently on the housing market are often too expensive and too large for single-person households. By splitting existing dwellings an alternative can be offered so that living becomes affordable for many people. It is important that these dwellings also contribute to dwelling diversity, so that supply and demand connect. Dividing dwellings may not lead to a singular housing type supply (Stebo, 2010). Because the requirements and wishes of residents change over time and also differences per person, it is important to apply flexibility measures in the design. Layout flexibility is the possibility of splitting up, rearranging or combining dwellings into different spatial units in a simple way (Geraedts, 2003). By taking into account layout-flexibility, a wide range of housing types are possible. Dwellings can be fitted between the structural elements, the grids. The size varies from one to four grid sizes (Appendix 4). The study is based on the maximum partitionability. This means that a design is based on the largest possible number of (small) standalone functional units within the building. The aim of this research is to provide insight into the possibilities and limitations for splitting a walk-up flat. Four design aspects were chosen to analyze: accessibility, vertical installation transport, outdoor space, and infill.

6.1 Accessibility

When splitting the walk-up flat, several smaller housing units are created. This means that additional accesses are necessary to gain access to the new dwellings. The dwellings can be made accessible in several ways (Appendix 5). The way of accessibility has a direct influence on the appearance and dimensioning, and should therefore be chosen with care. Walk-up apartments can be accessed by a portico, gallery, corridor and/or elevator. So there are also mixed forms of access methods. An ingenious example of this is the residential complex Piraeus on the KNSM Island in Amsterdam, designed by the German architect Hans Kollhoff (Appendix 6).

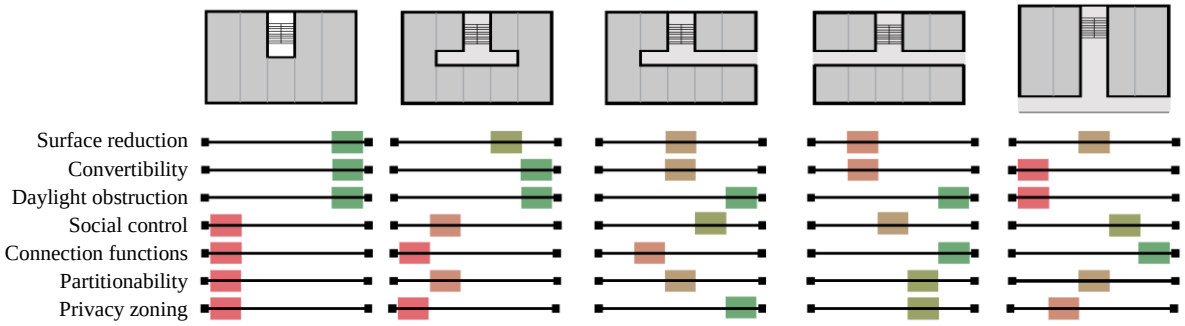

Figure 3. Comparison matrix accessibility

Portico; characteristic of a portico is that the dwellings are accessible by a communal enclosed (indoor) stairwell, where there is one escape route pass along other dwellings entrance doors. In most walk-up flats the staircase ends in a small porch where at least two dwellings per floor have been accessible. For a building block in which many people live, there is lack of social cohesion (SEV, 2007). There is little chance that neighbors can meet and have a random conversation within their community. Upon entering the building, a maximum six or eight households are accessible. So there is a big chance that you will enter an empty staircase. Even if neighbors encounter each other, the narrow staircase would prevent them to carry on further communication. The porches are also quite dark. Some porches have small windows that limit natural light. From the outside it is not easy to see what is happening inside. The same applies to the residents themselves. Despite the lockable hall there is no insight into whether there are any strange visitors inside the stairwell. Research in social control show that the user wants knows what he can expect each step of the way. If a space is understandable and recognizable to the user, it is often perceived as positive by the user (Altman 1975). Control is part of our basic needs (Dorst, 2015). When applying this access it becomes difficult to divide the dwellings into multiple units.

Central hall; a central hall is a form of access where the dwellings surround the accessibility area (almost) completely. This access is very similar to that of the portico but has a larger passage. This central passageway makes back-to-back dwellings possible. The back facade of the dwellings is shared by another dwelling. Only the front facade has windows. Also in this accessibility principle there is no second escape route and difficult to divide the dwellings into multiple units.

Corridor, internal linear access; the entrances of the dwellings are connected to a central corridor or an extended central hall, located within the building mass. The existing accessibility can remain intact and there are no elements which extend outside the current facade line. Because a corridor is located within the building envelope, there is a high freedom of design in the facade. By means of a complete corridor, all dwellings are connected to each other, creating a high access possibility. However, a complete corridor takes up a lot of space within the building, which makes the dwellings smaller. The corridor can also stop to close by staircase instead of through the entire building block. This means there are two escape options. Study by Stony Brook University show that students with a room in a continuous corridor have fewer social contacts and experience less social control than students with a room in a dead-end corridor (Baum, Aiello & Calesnick, 1978, Evans et al., 2000). Another distinction between dead ends and continuous hallways is the presence of passers-by. With an increase in the amount of traffic, the amount of social contacts decreases (Rogers, 1997). Another big advantage is that no entrance hall in de dwelling is needed, which protects the user against wind and weather. With this, space is gained.

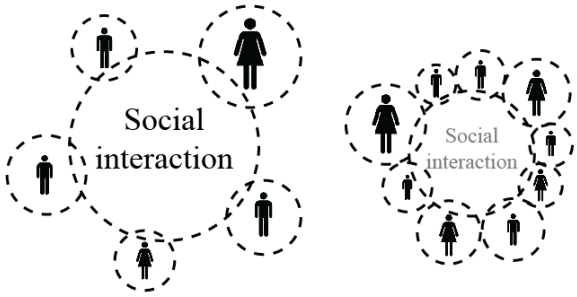

Figure 4. Schematic comparison social contacts

Gallery, external linear access; a central access consisting of galleries on the outside is added. By using an outdoor gallery, wind and weather must be taken into account. This can be solved by creating an entrance hall in the dwelling. This can be considered as loss of space. By adding a gallery, the dwellings can become wheelchair accessible without decreasing the surface area of the dwellings, which makes the building block more accessible for elderly. Accessibility of the dwellings is one of the most important consideration aspects for the growing target group. The extension can also be used as outdoor space for the dwellings. The balconies result in more space on the galleries, so that the residents can pass each other well. The gallery thus becomes a meeting place and as a result the social interaction increases. In the short gallery (two dwellings) the social interaction is appreciated as more private (quiet and pleasant) than in the long gale-row (seven dwellings) (Dorst, 2005). In a field study conducted by the DSP group, the safety of an accessibility principle was investigated. This showed that flats with a gallery have a lower intrusion risk than a corridor (de Savornin Lohman et al., 1986). This is mainly due the outside views on the entrances to the dwellings. By adding the gallery on one side, only a *doorzonwoningen* are possible. In a *doorzonwoning* the living room has the full depth of the building block. For example, the living room has a window at the front and back, so the sun can shine through the whole living room. Back to back dwellings are only possible if the gallery is added on both sides of the building block. A major disadvantage of galleries is that the daylight penetration of the lower dwellings is obstructed. The gallery also runs along the facades of the dwellings, which reduces the privacy. If the privacy zoning is not been respected, residents are inclined to retreat into their dwelling. It also reduces the possibility of designing a more spacious dwelling by means of attachments.

6.2 Vertical installation transport

The new installation structure plays an important role in dividing walk-up dwellings. The number of tapping points increases if more residents are connected to the shafts. It is important that there is the possibility to change the layout of the dwellings (Gijsbers, 2012). By keeping installations accessible, dwellings can be easily adjusted. Installation services are important for a building and has a big influence on the comfort of the dwelling. The demand for comfort changed over time, causing changes in the systems. In this section, the integration of future installations in the building is assessed. The number, the location, the need to move or create shafts and the direct connections between the bathroom and the kitchen are discussed. The more favourable the location of the piping shafts in relation to the floor plans, the higher the valuation.

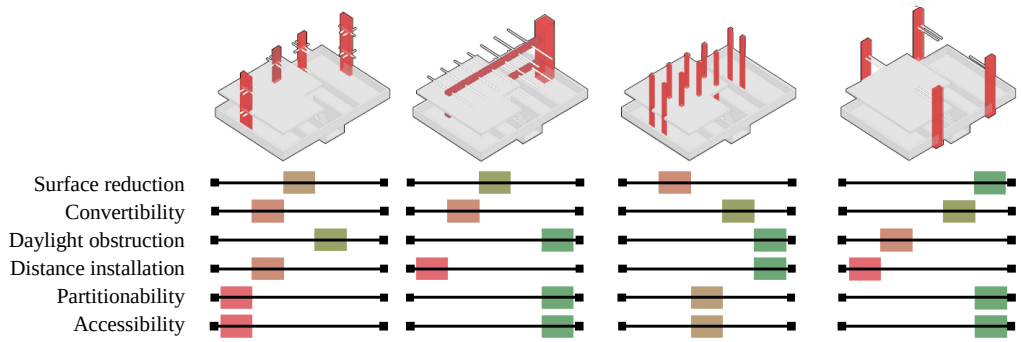

Figure 5. Comparison matrix vertical installation transport

Existing shafts; buildings are often demolished because the existing installation spaces of the buildings are often too narrow for new installations. If the position of the existing shafts is favorable, they can be reused. However, the existing shafts of the most walk-up flats are not positioned on the outside of the new and smaller dwellings. There is thus a limitation in the repartition of the dwellings. The position is often not favourable and often the shafts are too narrow for new installations. This could be solved with a sewage grinder. The waste water and the faeces are collected in a reservoir. A pump ensures that the wastewater and faeces can be pumped through a smaller pressure pipe. A major drawback is that such toilet systems can become clogged if there are wet wipes thrown in. Good instructions for the user are therefore necessary.

One installation room; from the installation room the pipes are brought to the dwellings via one central horizontal shaft. The main pipe is placed in a zone between the dwellings. In this way, this zone becomes a central backbone with the installations of the dwellings that are linked to each other. There are various options to keep the installations accessible. A raised access floor provides maximum accessibility to the installations due to the removable panels. This is a common way in the office buildings. Another approach is the lowered ceiling. It is basically the same approach as the raised access floor. The pipes and channels are installed under the floor and hidden by means of a panel suspended ceiling (Sprengers, 2015). It is recommended to use only removable panels in the main circulation areas because dwellings prefer in general a plaster ceiling instead of panels (Sprengers, 2015). This type of zoning allows the dwellings, which are accessible from the corridor, to be easily connected to the main pipe. This layout of installations has the advantage for transformations (Kamerling, M.W. & Kamerling, J.W., 2004). This gives the functional spaces, such as kitchen and bathroom, a free layout along the entire rear wall of the dwellings. Nevertheless, pipes are difficult to pass through joists, so it is possible that they must be placed under or over the beams. As a result, the free height will be reduced. However, the holes that have been created by removing the old pipes can be reused for the new situation.

Individual small shafts; each dwelling has its own shaft. Placing multiple shafts can result in fewer crossings and shorter horizontal installation transport in the floors. However, a shaft in each dwelling reduces the surface size and flexibility of the indoor layout. The wet rooms should be placed around the shafts, or at least within the construction beam field, so fewer installations need to be made in the floor and walls. If these spaces are not positioned directly to the shaft, installation channels are necessary. The position of the shafts determines the limitation of the layout flexibility of the floor plan. By placing the shafts in the dark zone, which appears to be the favourable position for functional rooms, the limitation is minimal (see appendix 7). A shaft in a separating wall between two dwellings, makes it possible to share the shaft with the neighbour.

Along/in the facade; another way to deal with vertical installation transport is to place them in or on the outside facade. In many renovation projects they refine the facade for energy reasons. This can be combined with the renewing of installations. The installations can be disconnected from all other building layers which makes accessibility and adaptability possible. Maintenance and adjustments are easily realizable without disruption of the residents. The facade layout will consist of vertical segments that partly limit the facade surface. Vertical shafts are connected to the adjacent floor. This has the same disadvantage has as with one central shaft; Pipes can hardly pass through joists, so it is possible that they must be placed under or over the construction beams. A connection of pipes through walls to the delivery-systems creates an obstruction of the surface area and room layout, because then there cannot be made any changes in the floor plan without making changes to installations. An advantage to put the installations in the floor or ceiling is that the interior is therefore open to any layout (Bernard Leupen, 2005).

6.3 Outdoor space

A lot of research is done on residential preferences. A well-designed outdoor space is one of the most important aspects that the dwelling must meet (De Wit 2008, Dynamis 2007, and Bouwfonds 2009). For small inner-city apartments, there can be compensated by French balconies or collective outdoor space, such as a communal garden or roof terrace. However, dwellings without balconies sell less well in the rising market and rise less in price than dwellings with balconies (Dynamis, 2007; Companen, 2008; Bouwfonds, 2011)

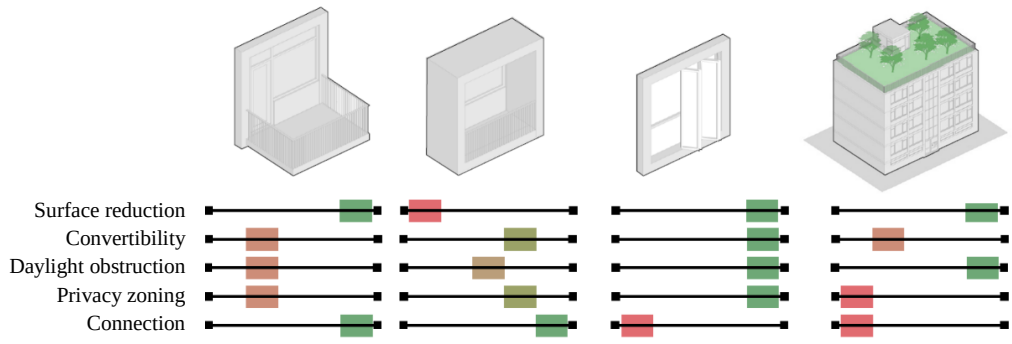

Figure 5. Comparison matrix outdoor space

External; an outdoor space that protrudes outside the facade, for example, supported by braces or *"hung"* on the facade. The construction of a balcony can be attached to the main supporting structure by means of an isokorf, without creating a thermal bridge. It is important to check during the design phase whether the main support structure is dimensioned for a larger moment load caused by the addition of balconies. If not, the outdoor spaces should be self-supporting by, for example, a column structure. External balconies have more influence on the amount of daylight of the dwellings underlying dwellings than internal outdoor spaces. Nevertheless, outdoor outside spaces provide more visibility on the street and thereby the liveability of the environment will increase (Dynamis, 2007). An external balcony, in contrast to an indoor balcony, does not cause space loss within the building.

The use of balconies creates a playful effect, creating a tension between the massive appearance of the building and the balconies attached to it. According to Huisman, most architects dislike external balconies, as it would disrupt the composition of a facade (de Wit, 2008). From modernist ideals, clean facade lines are being pursued and balconies are often forbidden by urban planning provisions (Van Hoek et al, 2010).

Internal; an outdoor space that lies within the facade line of the building. The disadvantage of an internal outdoor space is the loss of space in the building. It also takes away part of the light in adjacent rooms (Smit, 2011). A loggia is, for example, an internal outdoor space. It must be taken into account whether this outdoor area is outside the thermal layer of the building, otherwise structural adjustments are necessary to extend the thermal layer. Applying a second skin facade is a way to create an outdoor space without making structural adjustments (Sprengers, 2015).

The use of an internal balcony can be aesthetically desirable, because the original facade image can be retained more easily, in contrast to the use of external balconies. Companen (2008) also states that many designers prefer loggias and winter-gardens to extensions on the facade.

Roof; in different forms of group living, it is sufficient to have shared outdoor spaces, which gives more freedom in their placement. Green roofs provide good insulation, cooling and can absorb part of the rainwater. In addition to the positive effect on water management, green roofs also have a positive effect on the air quality. En expert can give on the basis of the construction drawings a definite answer about the structural strength of the roof and the possibilities to realize a roof garden. In addition to assessing whether the construction permits, it is important to see whether the roof terrace can be reached safely and easily. The lack of sufficient escape routes can be an obstruction to (be able to) create a roof garden.

Facade; the private outdoor space for small inner-city apartments is often replaced by French balconies (Smit, 2011). However, a French balcony is not really seen as an outdoor space. The feeling of 'outside' must be experienced. In its pure form, it has two inward-opening doors, with a balustrade in front whereby the façade intact remains (De Wit, 2008). There are many variations on French balconies, varying from a large sliding windows to harmonica doors, which can be opened almost entirely. The big advantage of a French balcony is the double use of space. The space will be used as an indoor space and when the doors are open, it becomes a semi-outdoor space.

6.4 Layout

In the past century many different ideas and designs for compact dwellings have been created where different typologies are visible. For the drafting of these typologies, the design features that are most dominant are investigated. During the research, nineteen projects were divided into the following three main typologies; Core zone, Service zone and Multiple zone (See appendix 8 for further explanation). This part of the research tries to test these typologies by applying them in the structure of the generic walk-up flat with different grid sizes (appendix 4, 5 and 7). The broad ideas of the different solutions will be compared in a consistent way on the basis of the criteria.

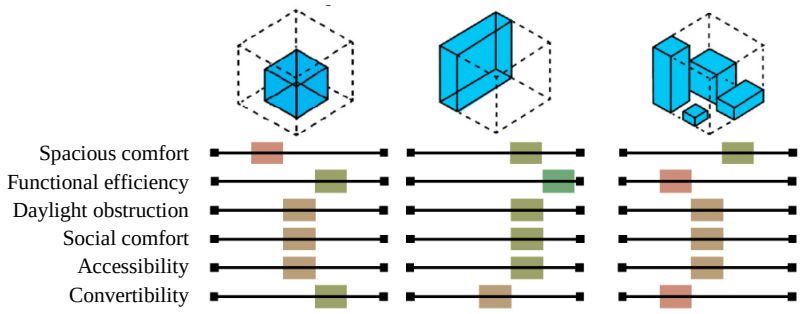

Figure 6. Comparison matrix infill typology

Core zone; the functions such as the bathroom and kitchen stands like a compact element in the middle of the room that divides the apartment into different zones, a social zone and private zone. This allows a 360 degree circulation around the core which makes the space continuous and larger than it seems (SFARO Architects, 2011). However, the core hinders the daylight and therefore creates a dark space. If the floor plan is smaller than 25m^2, there is not much room left to move if the core is positioned in the middle of the floor plan, which means that the spatial comfort scores low. Also the 360 degree circulation creates a lot of traffic space that cannot be used. Usable space in a compact floor plan is more important than a 360 degree circulation. By placing the core on the outside of the floor plan, more useable space is available. Because the core consists of one volume, the assembly process is much simpler and saves a lot of time.

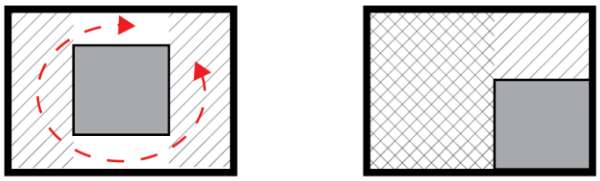

Figure 7. Schematic comparison position core

Service zone; the floor plan is divided into two different rooms, an open space and a service zone. By means of movable parts, the space can be adjusted according to the needs of the user. By applying the service strategy, more functional space can be created. The functions that are not used are *closed* and offers more space for the other functions. For example, extra space can be created to receive guests. It is important that the resident can receive any guests so that the resident can become more active in society (Meesters, 2009). The flexibility of the furniture is useful in the smaller spaces. However, this can also be seen as a disadvantage. Many actions need to be taken to use a different function.

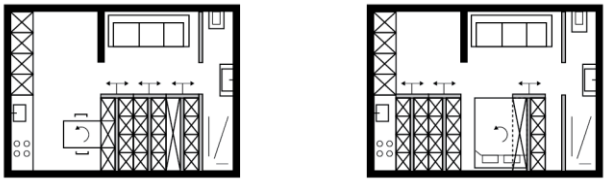

Figure 8. Schematic day-night comparison service zone

Multi zone; because everything is in a fixed location and does not consist of movable parts, no actions need to be carried out to use a function. The layout is spread out and therefore has a high layout freedom. If the zones are organized in such a way that the functions which not require a lot of daylight are placed in a dark zone, the open area can receive plenty of daylight.

VII. CONCLUSION

The current post-war walk-up dwellings are in terms of layout, installations and facilities in a very outdated condition. However, the strength of the walk-up flats is that they are easy to split into multiple apartments. Dwellings can be fitted between the structural elements, the grids. For this renovation approach, the necessary interventions have been given in this research. These interventions can be divided into the building components accessibility, vertical installation transport, outdoor space and layout. On the basis of this conclusion it can be established what the possibilities and limitations are for splitting a post-war walk-up flat. The choice of possible alternatives is very dependent on the context of the project.

Study of compact living show that efficiency in use of space and safety are important considerations when it comes to access, but a well-functioning privacy zoning is essential for the liveability of the apartment building. When a route or gallery is directly connected to a private

zone, the windows will be screened so that people no longer have any view inside of the dwelling. If the privacy zoning is not been respected, residents are inclined to retreat into their dwelling. This makes social control also impossible. With a well-designed zoning, the residents can determine the amount of interaction themselves without losing any social control. Meeting and connection must be central, but not necessary. Long hallways, such as overly present in gallery flats, are less or not suitable for social interaction. Dead ends have more space for social interaction. The quality of stay is important there.

The number of tapping points increases if more residents are connected to the shafts. In principle, the wet areas can be positioned independently of the shaft, because long distances are possible with installation pipes. To limit pipe lengths it is better to place appliances near the shaft. It is important that there is the possibility to change the layout of the dwellings (Gijsbers, 2012). The position of the shafts determines the limitation of the layout flexibility. By keeping installations accessible, dwellings can be easily adjusted. It is important to designate areas in which the presence of adaptable use of the installations is possible to enable flexible use. Examples are a raised access floor, panel suspended ceiling and vertical elements along/in the facade.

By adding an outdoor space the quality of the dwelling will increase. According to Smit (2011), private outdoor spaces for small inner-city apartments can often be replaced by French balconies or collective outdoor space, such as a communal garden or roof terrace. A variety of studies show, however, that this is not the case in the eyes of the residential consumer and that collective outdoor space is rather an addition than a replacement for private outdoor space.

External balconies capture more sunlight than internal ones, which are therefore found to be less attractive for most consumers (Bouwfonds 2011). Dynamis (2007) also notes this and adds that consumers also prefer external outdoor space because they provide more visibility on the street and thereby the liveability of the environment will increase. At the same time, the consumer wants a certain shelter for privacy on his balcony or terrace (De Wit 2008, Bouwfonds 2009). It must be prevented that residents themselves would take privacy measures.

In the past century many different ideas and designs for compact dwellings have been created where different typologies are visible. From research to various case studies, it can be concluded that there are three main typologies; Core zone, Service zone and Multiple zone. After testing these typologies, by means of research of design, the following findings can be concluded;

Core zone; the functions such as the bathroom and kitchen stand as one compact element in the middle of the room. This allows a 360 degree circulation around the core which divides the apartment into different zones. The 360 degree circulation creates a lot of traffic space that cannot be used. This is a major disadvantage for creating compact dwelling. This can be solved by positioning the core on the outside.

Service zone; by applying the service strategy, more functional space is created. The functions that are not used are closed and provide more space for the other functions. This is convenient in the smallest spaces. However, shifting with functions can also be seen as a disadvantage. Many proceedings have to be done to make use of another function.

Multiple zone; the spaces are still compact but more efficiently organized. Floor plans, above the $30m^2$, become more liveable and user-friendly, so it is recommended to split the existing apartments into apartments around $30m^2$. This still ensures that there are twice as many apartments compared to the existing context

In conclusion, all the alternatives developed during this research can either be combined, further designed or applied as they were intended to be. These alternatives provide the first attempt to an approach for splitting a walk-up flat and thereby offering more housing units. This can be used as an aid for social housing corporations.

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IX. APPENDICES

Appendix 1

Construction year	Site	*Wisselkamer*	Width grid 1	Width grid 2	Depth building block	Type
49	Den Haag	Y	3,7	1,8	10,4	D
49	Den Haag	Y	3,8	2,4	9,2	A
51	Amsterdam	N	3,7	1,8	8,7	B
51	Amsterdam	N	4,6	3	8,3	A
51	Den Haag	Y	4,2	2,4	9,2	A
51	Den Haag	Y	3,6	2,3	9,4	A
52	Den Haag	N	3,8	2,5	9,0	A
52	Amsterdam	N	3,7	1,8	9,6	A
52	Amsterdam	N	3,8	2,7	9,7	B
52	Den Haag	Y	3,7	2,3	8,9	A
53	Amsterdam	N	3,7	2,4	9,6	B
53	Rotterdam	Y	3,5	2,4	9,5	A
54	Den Haag	Y	3,7	2,4	9,2	A
55	Den Haag	Y	4,4	2,3	8,9	D
55	Den Haag	Y	3,8	2,4	9,2	B
55	Amsterdam	N	4,1	4,8	7,8	C
55	Utrecht	Y	3,5	2,7	9,8	B
56	Amsterdam	Y	3,7	2,7	9,5	B
56	Den Haag	Y	4,4	2,2	8,9	D
56	Amsterdam	Y	3,5	2,9	8,7	B
56	Rotterdam	Y	3,5	2,5	9,7	B
57	Amsterdam	Y	3,9	2,9	9,9	A
58	Rotterdam	Y	3,6	4,3	10,8	C
58	Amsterdam	Y	3,9	2,6	9,7	A
59	Rotterdam	Y	3,5	3	9,4	A
59	Den Haag	Y	3,9	2,3	9,3	A
59	Rotterdam	Y	3,7	2,7	9,9	C
60	Den Haag	Y	3,7	3,4	9,7	B
63	Amsterdam	N	3,7	2,7	10,3	C
65	Amsterdam	Y	4,5	2,7	9,6	C
-	Den Haag		3,6	2,3	9,2	A

Archival research partly adopted from Thijssen (1988)

Appendix 2

For the four design aspects, a rating is given for each criterion. The valuation ranges from 1 to 5; 5 being the best and 1 the worst rating.

Criteria Accessibility

Surface reduction; the surface reduction of the access components will be assessed. The surface area of the access areas can be at the cost of the size of the dwellings. This is calculated by means of a percentage of the entire residential block. A larger surface in reduction is therefore valued at a lower level.

A solution for reducing the loss of space, created by the access, is to combine the access areas with external functions.

Convertibility; in this section the relation of the existing construction will be assessed. This means how much the current construction must be adapted; the complexity of the interventions; the number of new construction components need to be made and the adaptability of the existing construction. For the assessment, the larger and more complex the adaptation and new constructions are, the lower the alternative is valued.

Daylight obstruction; according to P. Keedwell in the book *'The Psychology of City Living*', the amount of light entering a dwelling is of great importance. For a compact dwelling this would mean that the 'active' spaces, such as the living room, dining room and bedroom, should have a high connection with sunlight. A great design freedom in the facade is therefore valued higher.

Social control; many apartment blocks, despite a lockable entrance hall, suffer from intruders. Inhabitants have no insight into whether or not there are any strangers. If one cannot see clearly from the outside what is happening there is more trouble with vandalism and burglary in and around the dwellings. Control is part of our basic needs. People are happiest when we have control in an environment (Dorst, 2015). If a space is understandable and recognizable to the user, it is often perceived as positive by the user (Altman, 1975). This is assessed by means of the number of sight lines in and on the access.

Connection functions; by evaluating thousands of public spaces around the world, PPS - Project for Public Spaces - has recognize that successful public spaces have four important characteristic;

- they are accessible;
- people are engaged with activities there;
- the space is comfortable and has a good reputation;
- and finally it is a social place.

The space becomes useful when a strong connection is established between the area and the user. By allowing sight-lines to connect one space to another, both legibility and communication between occupants are increased (Richmond, 2012)

Partitionability; it means that the dwelling can easily be adjusted during the using-phase in terms of size and layout. The intervention can vary from movements of a party wall to the complete revision of the layout. It offers the possibility of changes in layouts in a relatively easy way (Hermans et al., 2013). From the point of view of adaptability it would be ideal that all apartments could be connected, both vertically and horizontally. This way dwellings can become larger without the accessibility being adjusted.

Privacy zoning; the spatial environment makes social activity possible, which makes the design of this spatial environment more important and in particular its use of it. The spatial environment facilitates the social environment with the effect that more social interaction can take place if the user wishes to do so. The term privacy also plays a part in this. The entrance of the dwelling is the border with a common and / or open space which is accessible to everyone. The other side has usually a private outdoor space that is not accessible to others. If these sides are the same, there is a hard line between private and public. In this way, in many cases are the windows of a living room or kitchen that are directly connected to a route (or a gallery) closed. This makes social control also impossible. The assessment applies if the user has more control over entering into and avoiding social interaction, the higher the design is valued.

Criteria vertical installation transport

Surface reduction; an important criterion is the space that an application or technique occupies. The surface area of an installation space can be at the cost of the size of the dwellings. This is calculated by means of a percentage of the entire residential block. A larger surface in reduction is therefore valued at a lower level.

Convertibility; in this section the relation of the existing construction will be assessed. This means how much the current construction must be adapted; the complexity of the interventions; the number of new construction components need to be made and the adaptability of the existing construction. For the assessment, the larger and more complex the adaptation and new constructions are, the lower the alternative is valued.

Daylight obstruction; according to P. Keedwell in the book *'The Psychology of City Living*', the amount of light entering a dwelling is of great importance. For a compact dwelling this would mean that the 'active' spaces, such as the living room, dining room and bedroom, should have a high connection with sunlight. A great design freedom in the facade is therefore valued higher.

Distance installation; it is essential where the application or technique is located. The more favourable the location of the piping shafts in relation to the floor plans, the higher the valuation. To limit pipe lengths it is better to place appliances near the shaft. If the bathroom and the kitchen have a direct connection or within one beam grid, this is valued higher than a connection where the kitchen and the bathroom are in a different beam pattern.

Partitionability; it means that the dwelling can easily be adjusted during the using-phase in terms of size and layout. The intervention can vary from movements of a party wall to the complete revision of the layout. It offers the possibility of changes in layouts in a relatively easy way (Herman et al., 2013). From the point of view of adaptability it would be ideal that all apartments could be connected, both vertically and horizontally. This way dwellings can become larger without the accessibility being adjusted.

Accessibility; many buildings are demolished early if their outdated systems are too deeply embedded for easy replacement. It is therefore important that the shafts remain accessible for maintenance and have the possibility to expand. Pipes are preferably fitted in such a way that repair and / or replacement is possible without demolishing some structures (Geraerds, 2000).

Criteria outdoor space

Surface reduction; the surface reduction of the access components will be assessed. The surface area of t proposed alternative can be at the cost of the size of the dwellings. This is calculated by means of a percentage of the entire residential block. A larger surface in reduction is therefore valued at a lower level.

Convertibility; in this section the relation of the existing construction will be assessed. This means how much the current construction must be adapted; the complexity of the interventions; the number of new construction components need to be made and the adaptability of the existing construction. For the assessment, the larger and more complex the adaptation and new constructions are, the lower the alternative is valued.

Daylight obstruction; according to P. Keedwell in the book *'The Psychology of City Living'*, the amount of light entering a dwelling is of great importance. For a compact dwelling this would mean that the 'active' spaces, such as the living room, dining room and bedroom, should have a high connection with sunlight. A great design freedom in the facade is therefore valued higher.

Privacy zoning; the occupant wants shelter on his balcony or terrace (De Wit 2008, Bouwfonds 2009). This means that there is the possibility that the user can determine the amount of interaction (Altman, 1975). It must be prevented that residents themselves would take privacy measures.

Connection; Most people prefer to see their outdoor space directly adjacent to the living room (De Wit 2008, Bouwfonds 2009, Dynamis 2007). An easy connection between inside and outside increases the user satisfaction.

Criteria infill

Spacious comfort; the dimensional and architectural characteristics that are relevant to specific household needs, the suitability of the dwelling with regard to freedom of movement and the ergonomics of the components (Rubenach, 2017). This is calculated by the size of the open area

Functional efficiency; the functionality of the room is maximized. In studies by Amorim (1997, 2001), the spatial sectors are subdivided into four functional sectors: social, private, service and the mediator (transitional) sectors. All possible spaces are efficiently laid out and have multiple purposes. Floor plans with spaces that are underused are valued low.

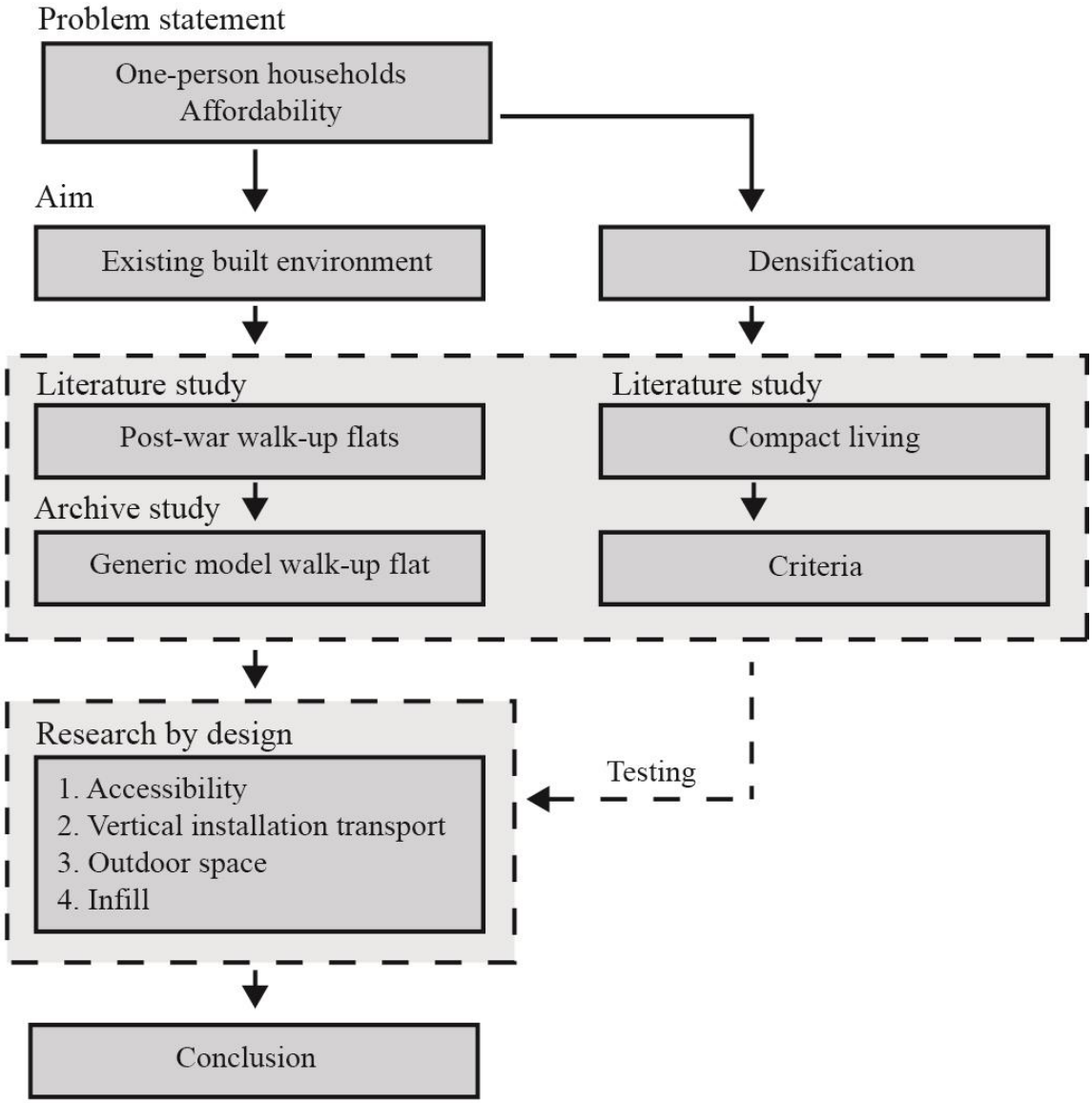
Daylight obstruction; according to P. Keedwell in the book *'The Psychology of City Living'*, the amount of light entering a dwelling is of great importance. For a compact dwelling this would mean that the 'active' spaces, such as the living room, dining room and bedroom, should have a high connection with sunlight. A great design freedom in the facade is therefore valued higher.

Social Comfort; the ability of the dwelling to support visitors (Rubenach, 2017).

Accessibility; accessibility in design promotes equal access to apartments for all members of the community, including people with reduced mobility and the elderly.

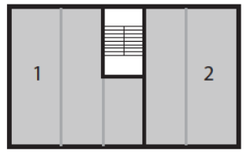
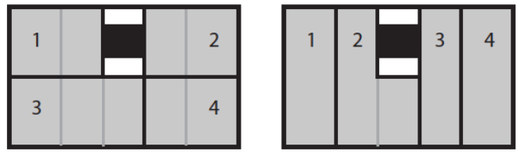
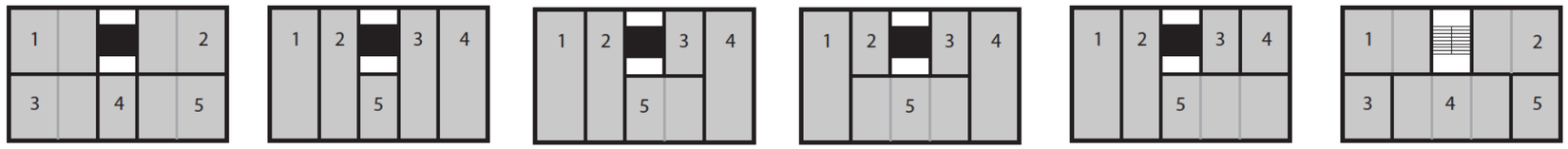
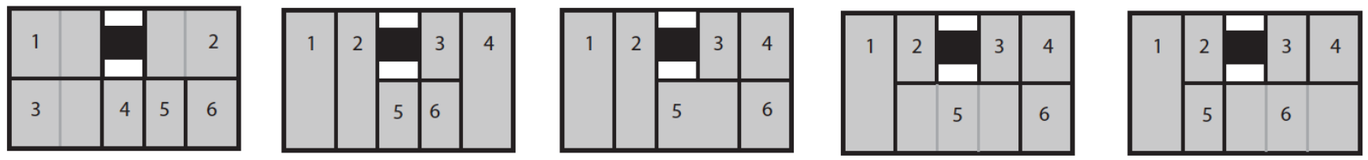
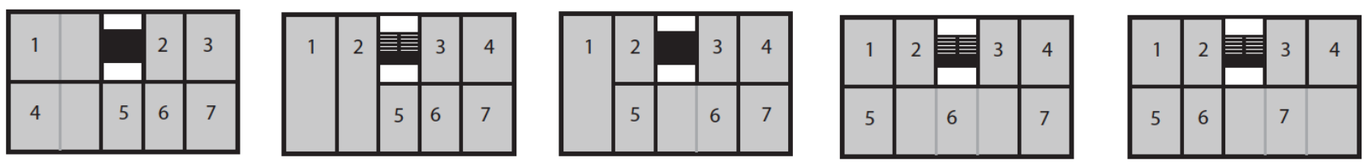
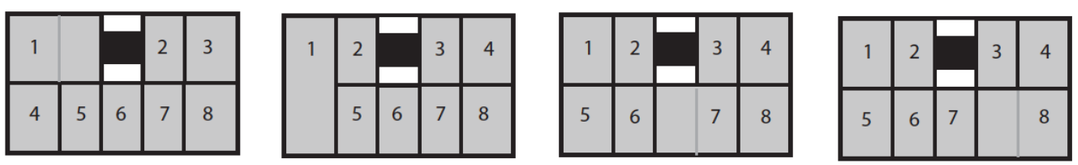
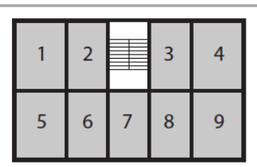
Convertibility; in this section the relation of the existing construction will be assessed. This means how much the current construction must be adapted; the complexity of the interventions; the number of new construction components need to be made and the adaptability of the existing construction. For the assessment, the larger and more complex the adaptation and new constructions are, the lower the alternative is valued.

Appendix 3



Research framework diagram

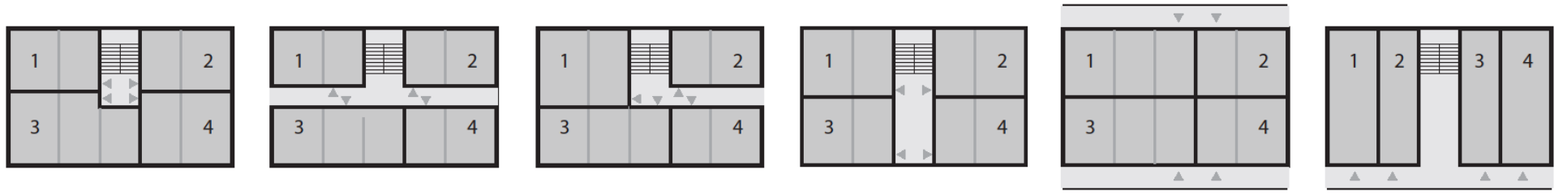
Appendix 4

Standard floor plan	
Divided into **four** dwellings	
Divided into **five** dwellings	
Divided into **six** dwellings	
Divided into **seven** dwellings	
Divided into **eight** dwellings	
Divided into **nine** dwellings	

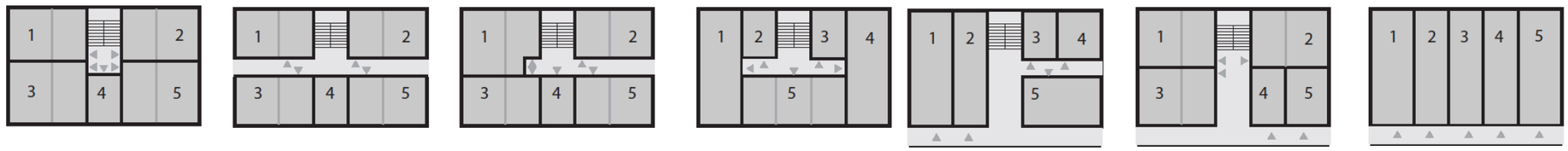
Dividing possibilities of generic walk-up flat

Appendix 5

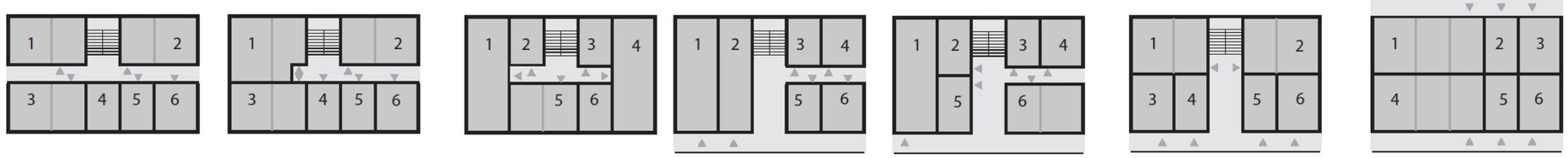
Divided into **four** dwellings



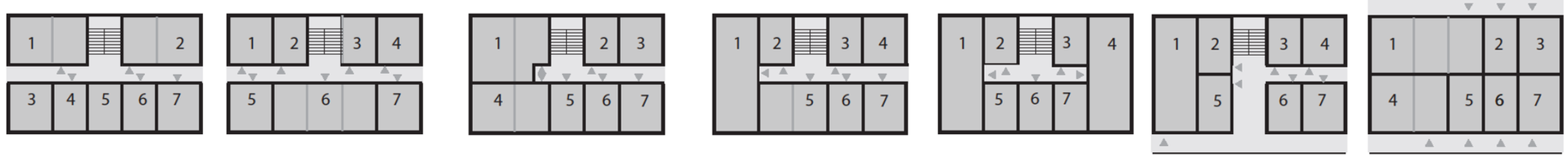
Divided into **five** dwellings



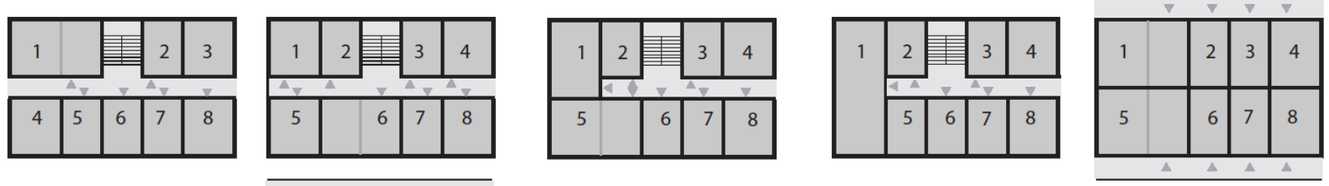
Divided into **six** dwellings



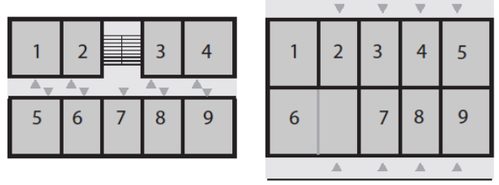
Divided into **seven** dwellings



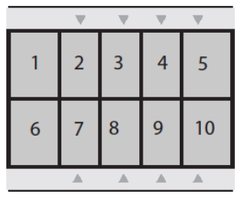
Divided into **eight** dwellings



Divided into **nine** dwellings

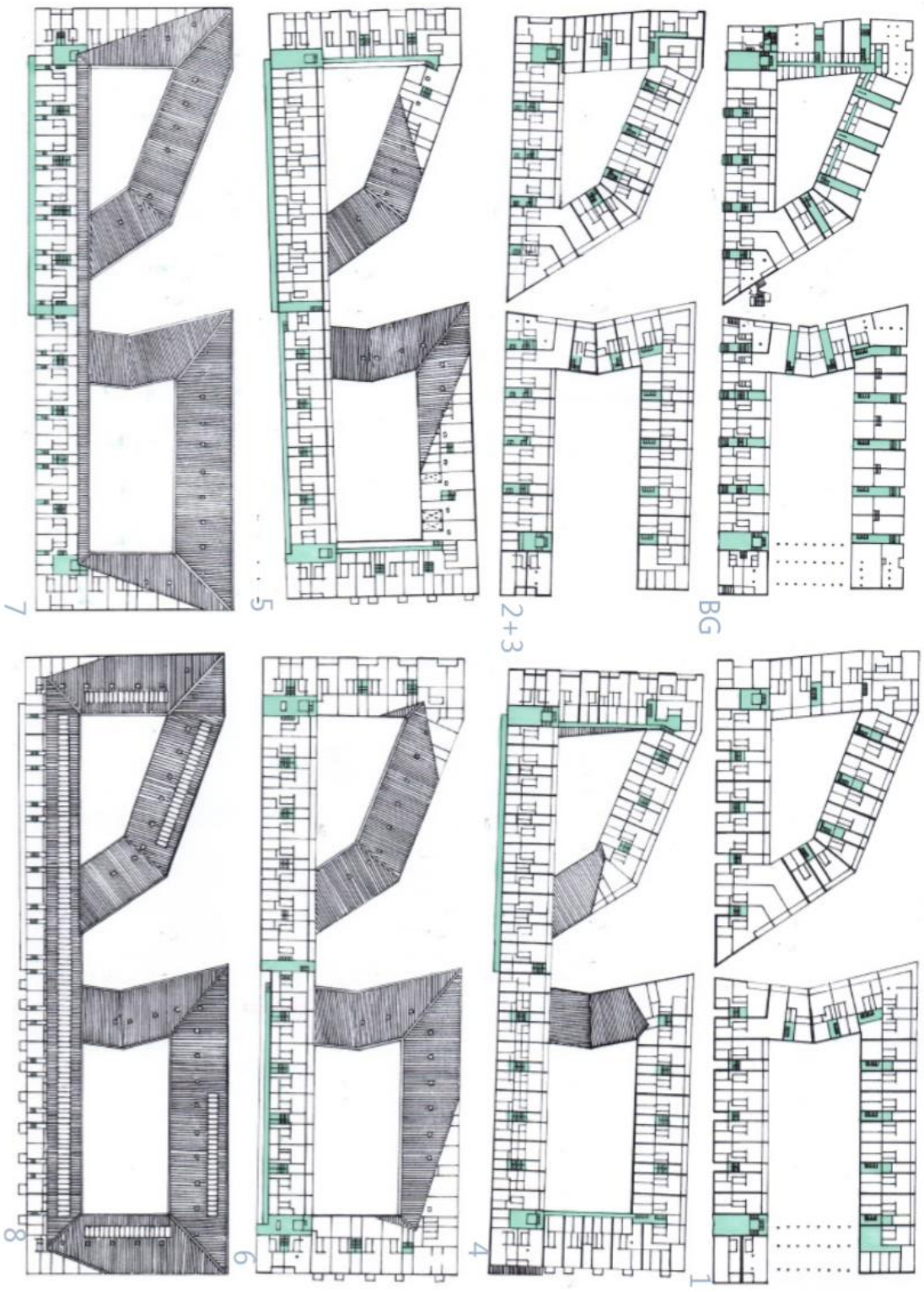


Divided into **ten** dwellings



Dividing possibilities of generic walk-up flat with accessibility

Appendix 6



Source: Piraeus Hans Kollhoff,
Jeroen Boogaard, Benjamin Catsburg, Joris van der Hoff, Stefan Klaseboer

Appendix 7

Mutli zone

1:200

10 m²

16 m²

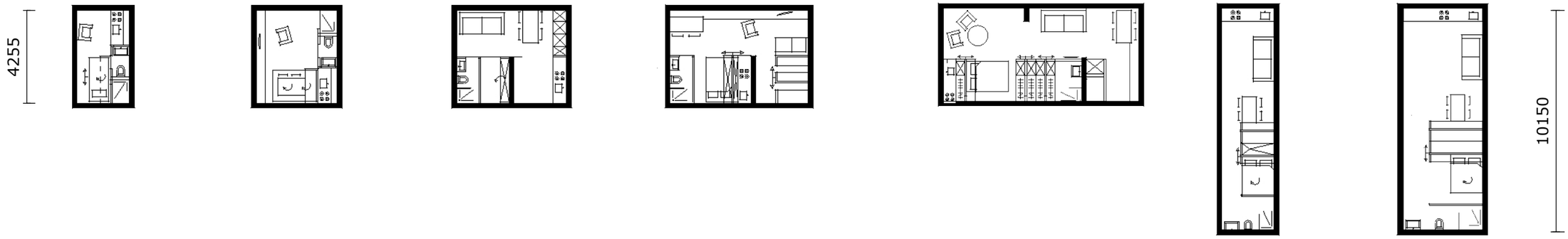
21 m²

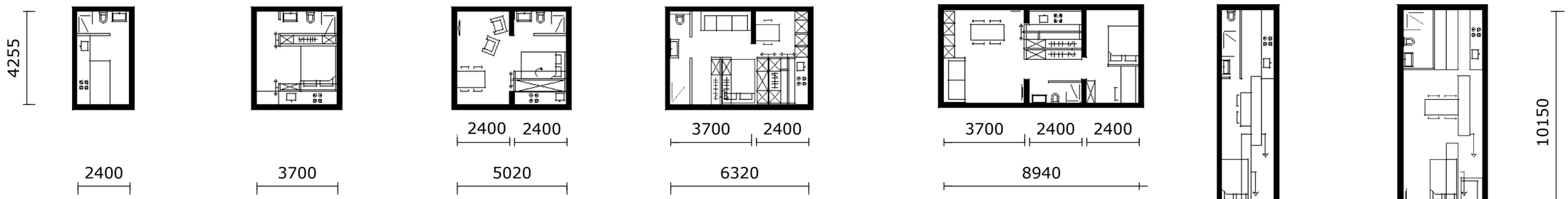
27 m²

38 m²

24 m²

38 m²





Service zone 1:200

Core zone

1:200

Appendix 8

Short Case Study Analysis

By means of the book by Leupen and Mooij it was possible to understand how a dwelling could be divided into different typologies. During the research, three projects were divided into the following three typologies: Core zone, service zone and multiple zone. For the drafting of these categories, the design features are examined which are predominant in the design.

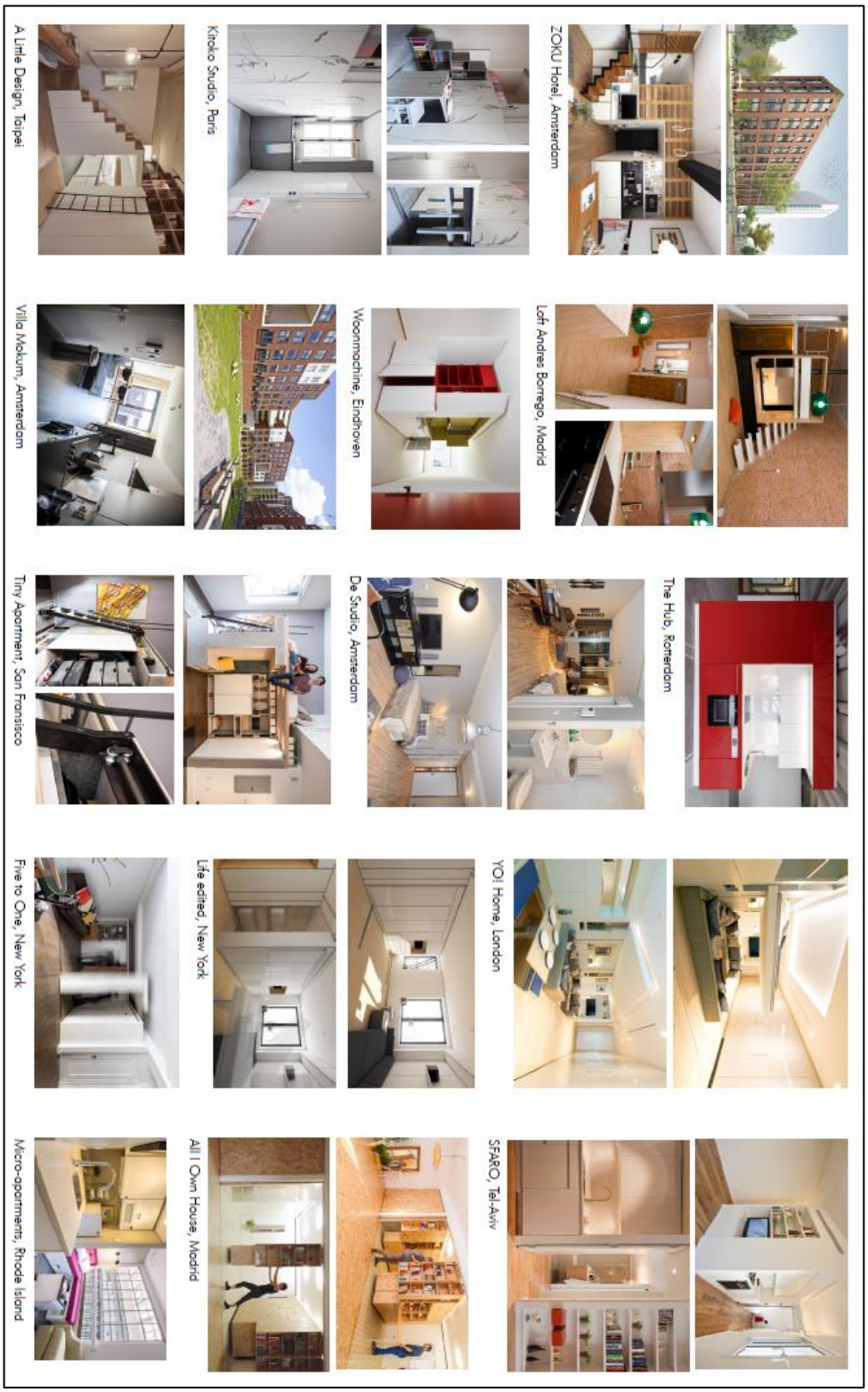


Figure X. Nineteen case studies projects compact dwellings

Core zone; In response to the rising house prices in Tel-Aviv between 2008 and 2011, many people were forced to renovate their existing apartments instead of selling them. The owner of this design wanted to renovate her apartment and have a residence with 1 bedroom where a full-size bed fits in, including wardrobes and a large separate kitchen. As a design solution, it was chosen to condense all programmatic functions and storage units into a cube, centred in the floor plan, dividing the apartments into 4 zones and allowing a 360 degree circulation. This makes the space continuous and bigger than it actually does. By adding sliding doors that disappear into the cube, the spaces can be suitable to the needs of the user. This application of centring offers more contributions to the feeling of a multifunctional spaces (Archdaily, 2011).

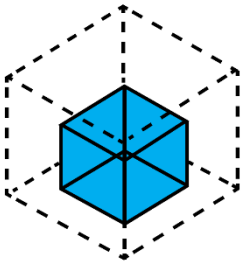


Figure X. Core zone diagram

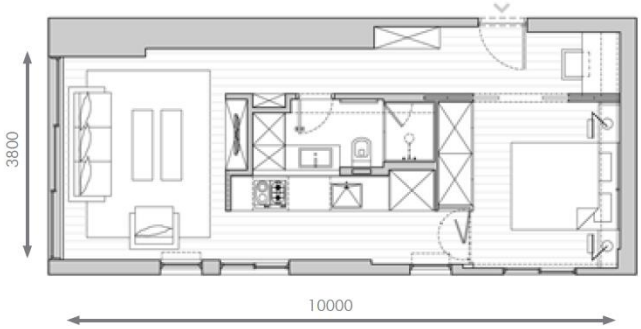


Figure X. 40 sqm Refurbishment / SFARO Architects

Services zone; In an already small apartment, architects PKMN has divided the floorplan into different spaces. An open living room facing a service zone. The service zone of 15m2 with on the outside the fixed facilities, the bathroom and kitchen. In between those, different rooms can be created by sliding modular units with a dressing, storage cabinet and folding bed. When all units are pushed to the left, the kitchen appears. Everything to the right, the bathroom emerges. The size of each can be easily adjusted, depending on the desire of the user. This transformable system that allows people to live in small spaces that have the functionality of spaces approximately three times larger (Archdaily, 2014).

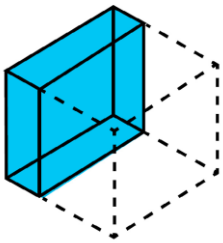


Figure X. Service zone diagram

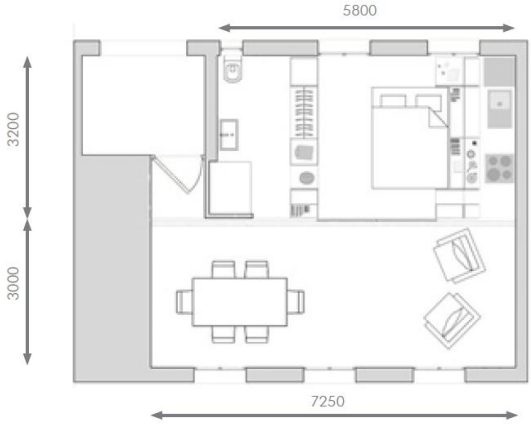


Figure X. Micro-apartments / Northeast Collaborative

Multiple zones; In America's oldest indoor shopping mall, which was built in 1828, are 38 micro apartments built. The property manager at the Arcade explained that the micro units are minimally furnished—many of them are 20 or 27,5m2, and none of them have stoves or ovens. Instead, the apartments have maximized space utility with built-in furniture and efficient storage. The community has laundry room, common room, game room, and porches as well as bike access with an outside ramp that brings riders directly to a bike-storage room. The interior in these units are simple, feature a living room at the entrance, kitchen in the middle and a built-in beds facing storage space. Due the position of the kitchen, there is little daylight at the entrance(Garfield, 2016).

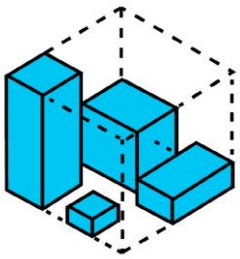


Figure X. Service zone diagram

Figure X. Loft Andrés Borrego / Beriot, Bernardini Arquitectos