The ERA of sustainable housing transformation

a research on the sustainable renovation possibilities for ERA gallery flats
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Every generation has their “zeitgeist” dilemma. For example, my grandfather had to deal with the rebuilding process after two world wars, my father’s generation struggled with globalization and creation of weapons of mass destruction and I believe that my generation’s dilemma is to reduce our impact on our earth. Most residents of industrialist western countries have an ecological footprint of 6 (Global Footprint Network, 2010) meaning that if the remaining 80% of the world population would acquire the same standards, in the same destructive and singular way as we do it, we would need 6 earths to sustain the world population.

As Voyager 1, after 36 years of traveling through our solar system just entered interstellar space, the endless space between star systems, and is 40,000 years traveling from the nearest star system it becomes clear how unique our planet is and that needing 6 planets for our lifestyle is no option.
Before you lies the product of my research which I conducted for my graduation at the faculty of Architecture at the TU Delft. This research was used as the starting point of my thesis design, and together they constitute my graduation. Since the start of my study in architecture, gallery flats have always had a strange appealing effect on me. These massive buildings which are home to a small village are the victim of a national stigmatization fueled by bad examples. The problems with bad examples is that the easily outweigh their preponderant counterparts. I’m guilty as well, my initial appeal originated from mix of aversion and curiosity, curiosity for the reason of mine, and that of the rest of the Netherlands, aversion for this typology. My own reference point in this stigmatization has always been the Bijlmer, a city extension in Amsterdam south east which mainly consists of gallery flats, which is notorious for its poor living conditions. However this is just one bad example, and although I’m definitely not going to state that gallery flats are perfect, they do not deserve their public scorn. During my graduation research, my aversions gradually started to transform into affection. Affection for the cleverness with which these buildings were designed and built. Affection
for the answer that they gave to the urgency of their time. It therefore became my personal mission to contribute to the redemption of the gallery flats unfortunate faith and give them a second live with the appreciation that they deserve.

I would like to give my sincere thanks to my mentors for their guidance and my girlfriend Mariët for her editorial work and mental support.

Erik Dral
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Why
The impact of our energy use

As pointed out in the introduction we need to change the way we use the earth, from a singular to a circular system. For an architect, the intervention area is defined by the built environment. In the Netherlands the built environment is responsible for 45% of the energy consumption and 35% of the waste production (Bouwend Nederland 2013). This consumption of energy and material can be divided in three phases of a buildings life-cycle: construction; use and demolition. Depending on the way a building is built, the energy consumption in the “use” phase by far exceeds the other phases. At this moment the residential building stock in the Netherlands is responsible for 25% of the national energy consumption. This stock consists for the larger part, 33%, of dwellings constructed between 1960 and 1980 (VROM 2009). Commonly referred to as post-war mass housing these buildings were constructed as a solution for the housing famine with which the Dutch had been struggling since the Second World War. During that time the awareness for energy consumption was not present as it is today. As a result, a large percentage of the Dutch building stock is highly energy inefficient and is rated with a energy label D or E (CBS, 2013).

However this problem extends considerably further than massive amount of energy being wasted. As this type of energy inefficient dwellings are commonly designated as social housing, they are meanly resident by the part of the population with the smallest wallet. The last 10 year energy prices are soaring up and they have already doubled since 2000 (CBS 2012). Although there are different predictions of and opinions on the future energy price, the fact is that the world is facing an ever growing energy demand, which by simple economics would mean a correlated increase of the energy price. One of the consequences of this development is the struggle of low income families to pay their energy bill. Fuel poverty, a term introduced in the UK, defines a situation in which a household has to spend $10 \geq \%$ of this net-income on energy. In 2009 almost 2 million households met that requirement in the Netherlands (Rijkswaterstaat, 2009). This is an undeniable urgent problem that needs a proper solution in the very near future.

Why not demolish and replace

One solution to this problem would be to demolish and replace these energy inefficient dwellings by energy neutral dwellings. Besides the fact that demolition leads to the destruction of emotional and economic value (Hal 2008) and increases the ever growing waste production, it also simply does not happen. In building economics the demolition and replacement of buildings can be seen as “natural” process, e.g. dwellings are written off economically over a period of 50 years after which they could be demolished without profit loss. And as we are approaching the moment that a substantial amount of the Dutch dwelling stock have been standing for 50 year, we would expect them to be replaced as part of this “natural” process. But with the present annual demolition and replacement rate of 0,25% (Thomsen 2006) one can see that a dwelling needs to outlive his economical lifespan. This lifespan refers to the economical aspects as much as it refers to the functional and technical aspects of a dwelling. As discussed before, the energetic requirements for dwellings have changed drastically the last decades.
(technical). The same goes for the comfort and space requirements (functional). Thus we are facing the problem that our dwelling stock is becoming outdated but still has to function for at least half if not a whole century. High level sustainable renovation concepts/products are needed to resolve this situation.

**Occupied state**

In the last decade, many high level renovations have been conducted on ‘60 and ‘70 mass housing projects. These projects rarely had an energy reducing target and were mostly preformed in an unoccupied state (Werf 2011). From a building process point of view, an unoccupied state is the preferred condition for a high level renovation. As a result, high level renovation was frequently preluded by a long maintenance-free period, causing vacancy and deterioration of the building. This process effects not only the building but also its direct context, resulting in decreasing real estate values and deterioration of the neighborhood (Werf 2011). If the building is still occupied at the commencement of the renovation, a housing association is (economically) responsible for the move of the residents, provide (temporary) alternate housing and/or buy them out of their contract. This is an expensive operation that a housing association rather avoids. On top of the financial implications, there is the possible destruction of social structures. All these problems are avoided when renovating in occupied state. The Smart and Speedy program, a collaboration project between different institutes and companies, focuses on the creation and implementation of sustainable renovation concepts for ‘60 and ‘70 mass housing. The requirements set by the program are a minimum reduction of 45% in energy consumption, renovated in occupied state with a maximum of 5 days in which the resident are not able to access their house and a lifespan extension of 50 years which would classify it as “newly build” (Platform 31 2010). Although preliminary results caused the drop of the 5 day restriction they also showed a significantly higher energy reduction then anticipated. With these results it can be inferred that high level sustainable renovation in occupied state are possible.
Characteristics of the post-war mass housing
Sustainable solutions in built environment are commonly referred to as tailor made solutions, because every building is different and needs to be treated accordingly. When we look at the post-war mass housing, as the name already reveals, these dwellings are constructed in series. Identical dwellings copied in horizontal direction; row houses, or in both horizontal and vertical direction; flats. For this reason there is an opportunity to conduct sustainable renovations on a more generic level. Because these dwellings were constructed in a time that energetic regulation did not exist; pressure was high, the goal was to create a maximum amount of dwellings of a high standard using a minimum of materials and man hours. These restraints resulted in the creation of multiple highly standardized systems for constructing dwellings. One of these systems is the van Eesteren Rationele Aanpak (ERA). This system was used to construct more than 9,000, almost identical, gallery flat dwellings in the Netherlands (Graaf, 2009). Characteristic for the ERA system is the use of a single span dwelling, whereas many other systems used double span meaning that instead of two narrow spaces the ERA system offered one single large space which (theoretically) can be used to make any kind of interior arrangement. This flexibility gives the ERA system the potential to function for many decades to come. The potential of scaling a solution; the flexible floor plan of the ERA system and my personal fascination for ‘60 and ‘70 gallery flat resulted in following typological focus for this thesis: ERA gallery flats. It has to be pointed out that from a process point of view its assumed that the dwellings dealt with in this thesis are social rent.

Eesteren Rationele Aanpak (ERA)
Although many architects in Europe were experimenting with standardized multi-family housing before the Second World War, this rationalization of the construction process took its flight after the Second World War. The destruction of war in combination with the so called “baby boom”, a rapid growth of population, created a major housing shortage (woningnood). In order to solve this problem the government exerted great pressure onto the building industry to come up with a solution. This solution was found in the standardization of the construction process. Repetition and prefabrication were the magical words. Due to the discovery of the largest gas-bubble in Europe near the town of Slochteren, the central heating system became more and more common in Dutch dwellings. This development made it possible to create higher multi family flats (up to 19 floors). By 1980 thirty-one different standardized building systems (Priemus, 1971) were used to constructed numerous dwellings, accounting for substantial part of the total building production between 1960 and 1980. ERA is one of these systems and was responsible for the construction of more than 9,000 ERA-dwellings. The ERA system was created by J.P. van Eesteren a Dutch contractor that was founded in 1932 by Jacob Pieter van Eesteren. Characteristic for the ERA system was the use of tunnel construction creating single span dwellings of 7,65 m wide and 10,5 m in depth. This resulted in a flexible 75-85 m2 floor plan, only limited by location of the pipe shaft. The ERA system followed the philosophy of the Dutch architect and theorist John Habraken. In the philosophy of Habraken the separation of the so called bearer (drager) from the
interior (inbouw) creates a flexible dwelling (Habran 1961). As the design of the bearer gave almost total freedom to the interior and it resident, the ERA system had a standard 4 room dwelling design, but also 40 variations of this standard dwelling. Despite the large variation potential of the system, most of the early projects were only equipped with the standard dwelling. In later projects potential residents had more influences and could choose one of the variations that suited their preferences.

**System variations**

In the ERA system the single dwelling can be seen as the generic module with which various arrangements could be made. The standard and most used arrangement is that of a single block, 12 dwellings in row multiplied 10 to 13 times in vertical direction with a vertical access point in the middle. With the exception of the so-called "star" flats, which as the name suggest are arranged in a star formation, all the other variations can be seen as an extension of the basic model.

**Dwelling variations**

As explained before the load-bearing structure scarcely dictates the interior arrangement of the dwellings, with the exception of the pipe shaft and the balcony / gallery orientation, virtually any arrangement is possible. This means that, although most of the ERA dwellings have a similar interior arrangement, an intervention needs to be of the same scarcely dictating nature as the load bearing structure. The ERA dwellings are generic, however there are a few exceptions. The most significant exception concerning this thesis is the ERA-1 (the first ERA complex, and also the target project of this thesis) which instead of the 85 m², has a floor plan of 75 m². Because this variation is only the result of slight increase in depth and width of the dwelling, an intervention can easily be adjusted to fit every ERA dwelling.
The goal of this research is to get more insight in the possibilities of sustainable transformation of the existing building. Although this research focuses on one particular example inside a large cluster of ‘60 and ‘70 gallery flat systems, it touches on certain aspects that could be extrapolated to a generic interpretation. This has mostly to do with the main features which all ‘60 and ‘70 gallery flat systems have in common, their repetition.

This thesis could be the starting point for a sustainable renovation of an ERA gallery flat, as it produces certain design rules based on technical evaluation, reference project, and user evaluation. But as said before, certain aspects are not solely limited to the ERA system, but could be extrapolated to other ‘60 and ‘70 gallery flat systems.

The scientific relevance of the thesis lies in the scientifically sound manner of constructing a program of requirements and design rules which can be used for the sustainable renovation of an ERA gallery.

As pointed out before the social relevance of this research is directly intertwined with its goal. The deterioration and energy inefficiency of the existing building stock is a urgent social problem which mainly effects the lower economic class of society. This thesis will try to assist in solving this problem.
How
Occupied state
As pointed out in the previous chapter renovating in occupied state has multiple advantages over renovation in unoccupied state however it does also implies some limitations concerning the intervention area. This limitation is a consequence of the amount of nuisance which a resident could experience during the renovation, and till what point this nuisance is acceptable. Van der Werf (2011) argues that extend of nuisance and whether this could have financial implication for the housing association, in the form of inconvenience fees, depends on various factors like activity type, duration, type of resident. In general she states that all activity’s inside of the dwelling, including alteration or replacement of the facade are deemed as nuisance eligible for an inconvenience fee. The degree of nuisance is also determined by the amount of influence which residents feel they have on the decisions made concerning the renovation. So whether residents have control over the amount of activities that will be preformed on their dwelling. In practice, increasing the level of influence is sometimes done by defining an obligated and a optional intervention package. When a resident does not agree to the optional package this intervention is then deferred to the moment of natural mutation. Following the research question a rough division can be made between interventions concerning the energy performance (obligated) and interventions concerning the lifespan extension and target group demands (optional). For this research, taking in account the results of the Smart and Speedy project and the statement of Mark Spee founder of the company Think Building Concept a company specialized in high speed building process, that a proper prefabricated facade (element) can be placed in 1 day (Spee, 2013), the amount of nuisance as a result of the renovation should no longer than 7 days for the obligated interventions with a maximum leave of 2 days (in which facades could be replaced) and no longer than 14 days for the optional interventions.

Modern standards
The term modern standards can be in interpreted from many different perspectives, however in this thesis modern standards refer to the state of the dwelling related to the living quality (woontech-nische kwaliteit). Straub (2001) defines living quality as “the characteristics of a dwelling relate to the use of the dwelling and the corresponding floor-plan characteristics and amenities.” Straub defines the following characteristics for measuring the living quality.
Floor-plan characteristics
1. volume of the dwelling (in m²)
2. the different rooms and their arrangement (the number and size of the habitable and other rooms, their arrangement and their relation)
3. outdoor area(s) of the dwelling (balcony / logia, roof terrace, garden), including outside storage area (s) and on-site parking.

Amenities
1. the equipment and finishing of kitchen, bathroom and toilet, heat and sound insulation, burglary resistant facilities, etc.
2. installations: heating and water heating, air conditioning, electrical installation, lighting, Communications and security, elevators (in multi-family), etc.

(Straub 2001)

An important feature which is not explicitly mentioned in measure tools is the aesthetic quality of the building and the routing. Due to the significant influence on the experience and therefore the evaluation of the building these features were included in the measurement tools.

Energy neutral building
In both the Dutch literature and practices multiple terms are used for defining the energy performance of a building. For this research the following definition, defined by Platform energietransitie Gebouwde Omgeving (PeGO), for an energy neutral building will be used:

“A project is energy neutral if on an annual basis no net import of fossil or nuclear fuel form outside the project boundaries is required to constructed, to use and to demolish a project. This means that the energy usage within the project boundaries is equal to the amount of renewable energy that is produced within that same project boundary, or to a external production that is allocated to the project. The energy consumption that derives from the construction and demolition of the project is added to the annual energy consumption depending on the assumed lifespan of the project”

(W/E adviseurs, 2009)

However, because this research deals with a renovation, the influence on the construction and demolition related energy usage is only limited to possible additional construction. On top of that there is the extension of the initial lifespan. For these reasons this research will only take into account the energy usage for the operation of the building.

Possible demands of (future) target groups
Dwellings are created to last for at least 50 year, a large quantity of the dwellings easily outlives this 50 year span. This means that we are not only building for our generation but also for generations to come. By doing so it touches on a much broader perspective of sustainability, as described by the Brundtland-commission; “development that meets the needs of the present without compromising
the ability of future generations to meet their own needs” (World Commission on Environment and Development 1987). In architecture theory we can find a theory which does not directly derive from an environmental sustainability perspective, however it does hold a possible Brundtland inspired solution for sustainable development in the built environment. John Habraken prepossess a building system in which the so called bearer (structure, load-bearing structure) is disconnected from the interior or user space. Theoretically, when the bearer is perfect, a dwellings could function for many generations, every generation could use the structure since it supports any kind of dwelling (Habraken 1961). Thus it is not about designing a building that fulfills the residents demand, but to create the possibility for the resident to meet their demands.

This research was conducted using multiple static (literature, archives) and dynamic (resident survey, expert interviews) sources. The research process can be best described as a iterative process in which constantly was switched between theory and practice.

**Literature study**
At the start of the research a literature study was performed on the subject of ‘60 and ‘70 gallery flats. The results of this study served as the starting point for the constructing of the residents survey. Secondly an literature study was performed on the subject of sustainable renovation possibilities of gallery flats and the concepts and components which could be used for this.

**Archive consulting**
Two municipality archives where consulted (Delft, Rotterdam) for retrieving technical information about existing ERA complexes. Construction calculation, floor plans, details and other information was collected in this way.

**Resident Survey**
For the collection of user related information a resident survey was set up at the target location. Residents received a questionnaire containing open and closed questions about personal information (age, education level, income, household composition etc.), they
were asked to react on statements concerning the evaluation of their dwelling using a five point scale (strongly disagree, disagree, neutral, agree, strongly agree) and they could choose or suggest a number of adaptations for their dwelling. The statements and adaptations were based on the expected problems which derived from the preliminary literature research. Of the 624 residents who received a questionnaire 43 responded (6%). The survey was validated by comparing the composition of the respondents to the actual resident composition of the ERA-1. The inherent problem with a survey is that a certain group of people, depending on the form of the questionnaire, will structurally fail to respond, excluding them from the results. Multiple biases were present in the conducted survey, some of which were recognized in the design of the survey, some of which manifested themselves after the survey was conducted.

The choice to distribute the survey by mail had a couple of reasons, first of all when using a digital way of distribution all the people without a computer or internet access are automatically excluded from the survey, secondly acquiring all the email addresses of the residents turn out to be difficult and thirdly an email in an inbox is easier forgotten than a physical letter which lays on a table.

The survey was only published in Dutch, although more than half of the residents are allochthonous. This was a deliberate choice, primarily based on the limited time that was reserved for this research and the fact that there was no predominant allochthonous group. However it does make the questionnaire less accessible for certain residents.

The differences between the response results and the actual resident statistics can be partially explained through the above mentioned biases. In the age distribution there is clearly a over representation of elderly or 55+ residents. An other explanation for this difference could be caused by the fact that elderly people, of whom the majority will be retired, simply have more time on their hands to focus on things like a resident survey. Probably the most distinct difference is the ethnic composition of the response results, not a single allochthonous resident responded to the questionnaire.

The survey has 2 main purposes, firstly it will be used to determine the most feasible target groups, secondly the information which was collected through the survey will serve as the starting point of the renovation concepts. This approach is chosen to create solutions which are an synergy of functional, technical and economical improvements.

**Expert interviews/consulting**

Multiple experts were interviewed/consulted on different aspects of this research. Unfortunately not all of these conversations were properly documented. A summary of these interviews is included in the appendix B.
The main research question can be divided into two main research areas. For both these two research area's subquestions were created in order to answer the main question. All answer to the subquestions will be subject to the criteria of “the possibility of renovating in occupied state”.

**Building Technology - Energy efficiency**

“What are design principles for renovating an occupied ERA gallery flat to an energy neutral building of modern standards and adjust the dwellings to the demands of (future) target groups?”

**Architecture - Living quality**

**Building and surrounding**

*What are the architectural characteristics of an ERA flat?*

*What are the problems, imperfections of the existing building?*

**The Resident**

*Who are the existing residents?*

*Which aspects/elements are valued and devalued in the existing building?*

*What are the wishes of the residents concerning their building/dwelling?*

*What are the possible (future) target groups?*

**Building technology - Energy efficiency**

**Structure**

*What are the existing structure of an ERA flat?*

*What are possible structural interventions?*

**Energy**

*Which approach can be used to created an energy neutral building?*

*What are the existing systems and consumption of an ERA flat?*

*What building technology related problems are present?*

*What kind of systems/components can be used to create an energy neutral ERA flat?*
Because the starting point of a renovation is always the existing, this thesis will start with a mapping of the architectural characteristics of an (ERA) gallery flat in the Theme Architecture. This will be done through literature, archive and expert consulting and a resident survey which was conducted on the target project. The mapping will include the architectural strength and weaknesses; the residents demographics; residents dwelling evaluation and preference. This mapping will function as the starting point of the second part of this thesis, the theme Building technology in which the technical status and possibilities, both structural and energetically, of the ERA system will be examined. Combining this technical examination with the findings of chapter 1 and 2 this theme will conclude with a possible system which could be used to renovate an ERA flat to an energy neutral building of modern standards. Every subquestion and the main research question will be concluded with a set program of requirement rules followed by design recommendations which can be used as a toolset when designing a sustainable renovation of an ERA flat. The program of requirements recommendations which are the result of a certain subquestion shall be displayed in a cyan textbox at the end of it’s relevant chapter and in the theme conclusions.
fig. 0.9  
bird eye view of the ERA-1 (Google, 2014)

fig. 0.10  gallery ERA-1
fig. 0.11  gallery facade ERA-1
fig. 0.12  entrance ERA-1
Although the ERA system is a generic system, there will always be differences between projects as e.g. location; orientation; amount of dwellings and status of the complex can differ. For this reason this thesis will have a target location on which to test proposed systems. This location will also be the location of the thesis design connected to this research. Multiple ERA gallery flat projects in Delft and Rotterdam matched the requirement that they had never been substantially renovated since their creation. Out of these projects the ERA-1 was chosen because the whole project was owned by a single housing association and there was already contact established with both the housing association and the residents. On top of that choosing the first ERA gallery flat project has a symbolic value.

ERA-1 (Prinsenland Rotterdam)

Building date: 1967
Architect: Rein Fledderus
Developer: J.P. van Eesteren (ERA-bouw)
Number of dwellings: 624 dwellings
Dwelling dimensions: 75 m² area (+10 m² balcony)
Owner: Woonstad Rotterdam
Occupation form: Rent

The ERA-1 was the first ensemble to be realized using the ERA building system. It is also the smallest variant of the ERA system, the dwellings are 75 m² instead of the later used 85 m². The 624 dwellings are arranged in 4 buildings that are positioned in a so-called mill sail position. The ERA-1 is located at the north east corner of the Rotterdam neighborhood Prinsenland and next to the periphery of Rotterdam, the A16 highway. The project never had a substantial renovation since its completion and the owning house association already did a preliminary investigation in the renovation possibilities.

In this thesis the ERA-1 will be used as a reference to simulate proposed energy and renovation concepts. Its also the location at which the resident survey was held. This is done to create a maximum coherence between the thesis design and this research.
Building and it’s surrounding

What are the architectural characteristics of an ERA flat?

What are the problems, imperfections of the existing building?

The resident

Who are the existing residents?

Which aspects/elements are being valued in the existing building?

What are the wishes of the residents concerning their building/dwelling?

What are the best (future) target groups?
Architecture
Building and it’s surrounding

The following chapter is the first analysis which was done for this research. Firstly a literature research was preform to map and understand the origin and the architectural and technical characteristics of the ERA gallery flat. The information displayed in this chapter partially derive from literature and archive sources and partially form conversation with residents, experts and partially from personal experience which was acquired during one of the many field trips to ERA projects. The results of this research were used to constructed the resident survey of which the results will be discussed in the second chapter of this theme.

The Gallery flat

“What are the architectural characteristics of an ERA

Born out of necessity

Gallery flats are the children of rationalization, they are the result of a necessity which triggered the largest production of buildings in the Dutch history. In 1945 the Netherlands housing stock counted just over 2 million dwellings, today it consist of more than 7 million dwellings (CBS, 2012). This dramatic increase met its height in 1973 when an astonishing amount of 156 329 dwellings were completed that year. To put this in perspective, in 1973 103.397 infants were born in the Netherlands. In that year, 1.5 times more dwellings were produced than infants were born. This building rage was fueled by the suffocating shortage of dwellings with which the Netherlands had been coping since the end of Second World War. The politicians of that time supercharged the construction companies and housing associations to find a solution. The task was clear, create as many high standard dwellings as possible in the shortest possible time, with a minimum of material and man hours. The solution was found in the industrialization and rationalization of the building process. Multiple building systems were created with which hundreds of thousands of dwellings were created at a breath taking speed. Spacious, clean and neat dwellings where suddenly affordable for the common man. The ERA system which is the focus of this thesis could produce a 152 dwelling containing flat in less then 10 months, where traditional methods would have taken 18. Although this was a unprecedented breakthrough in the construction history, only 10 years after their creation the high rise systems were already deemed as a mistake.

ERA

As explained before the ERA systems was created by the Rotterdam construction company J P van Eesteren. Typical for this system is the use of “tunnels” to create the casted concrete main structure. This method allowed to create single span dwellings of 7,60 m wide and 11 m in depth. One side of the building is dominated by dwelling wide balcony (1,45 m in depth), while the other houses the galleries. The ERA system is a textbook example of rationalized construction system as most element (facades, balcony- and gallery slabs, interior elements) were constructed in the ERA factory in Bergambacht, after which they were transported to the building site and mounted onto the main concrete structure (Gunst & Heeswijk, 2013). Although the single span gave the opportunity for various interior arrangements, ERA dwellings are mostly equipped with the standard a slight variation on the standard arrangement.
fig. 1.3  balcony facade ERA flat (half of the facade)

fig 1.4  cross section (dwellings)

1 living room  (21.5 m²)
2 bedrooms  
   - (13 m²)
   - (11.5 m²)
   - (5 m²)
3 kitchen  
(5.5 m²)
4 bathroom  
(2.8 m²)
5 toilet  
(1 m²)
6 hall  
(8 m²)
7 storage  
(3 m²)
8 balcony  
(10 m²)
9 gallery

fig 1.5  ERA standard interior arrangement
although these flats are referred to as high rise, they are actually more like high slabs, which is articulated by the horizontal lines of the balconies and galleries.

The decay of a ideal
Before most of the gallery flats celebrated their first decade of existents they were already out of grace with society. Bad examples like the Bijlmermeer, a large city extension in the south east of Amsterdam, strongly influenced the public opinion about gallery flats. They would even be responsible for the creation of a, never actually medically proven, physiological disease called “flat neurosis” (flat-neurose). Due to this bad image, and the conviction of the superiority of low rise after 1975, the construction of high rise dwellings systems became history.

Unfinished business
Although gallery flats suffer a low public opinion there are many examples in which people are happily living in an gallery flat. A proper example is Ommoord in Rotterdam, comparable to the Bijlmermeer this is a neighborhood that completely consists of flats, however this neighborhood is not considered a ghetto, a term sometimes used for the Bijlmermeer. For some reason this neighborhood, and with it many more flat neighborhoods, function much better as their Amsterdam sister. De Gunst (2013) argues that this is the result of the less compulsive urban plan of Ommoord. Aside from the bad stigma gallery flats have a lot of positive features which make them valued dwellings. Low rent compared to the amount of square meters; beautiful view; a “no stair” floor plan (great for seniors); large open facades and large balconies. And although 50 years ago these buildings were built on the outskirts of the city, today they are completely incorporated in the urban fabric and have become part of the city. But the fact that people are happily living in these gallery flats does not mean that these building do not have weaknesses. Because of the enormous time pressure under which these buildings were designed and build, little attention was given to the more subtle architectural aspects like urban embedding; routing and finishing. As de Gunst (2013) puts it, gallery flats are unfinished business.
Problems & imperfections

“What are the problems and imperfections of ERA gallery flat?”

This paragraph will discuss architectural problems which are typical for ’60 and ’70 gallery flats. One of these problems is experience of entering the building which can be best illustrated in a narrative, based on personal experience, making an imaginary visit to a gallery flat. After this narrative a summation, organized by scale, will follow of the different architectural problems concern the connection between building and surround, access route, social and dwellings specific problems will be addressed. These problems were defined using conversations with the current residents, an interview with Dick de Gunst (Hans van Heeswijk Architects), analysis of the existing plans, drawings and the actual building.

While I approach the building it’s hard to recognize my own front door. As typical gallery flats contain more than 100 generic dwellings, resulting in a very repetitive facade, I have to count rows and columns to locate my home. A small protrusion in the ground plinth marks the entrance of the building. Tinier than a single dwelling this is actually the entrance for a small village. Because I mostly do not meet other residents of the building in a social way, this is a strange moment where I am forced to step into a small room and endure a socially unpleasant moment riding the elevator. When I step on to the gallery I am standing outside again. But because I am now elevated 10 stories above the ground floor, rain and wind make this a very unpleasant place to be. I start walking along the gallery to my front door, along the way passing closely to my neighbors windows. When I finally open our front door we are glad that we are inside.
Ground level
Although there is a abundance of green space and sufficient parking places, this urban plan that was once designed for a decent an communal society, fails it’s purpose. While the original intention was a collective green space, a place of social cohesion for which all the residents should feel responsible, the individualization of todays society turned this place in a green desert. Although this is partially a result of a changing zeitgeist, its also a result of an architectural error, the blind plinth. Because the storage units for the dwellings are place on the ground floor of the building, there is no direct contact with the residents of the building and the ground floor. This creates a architecturally induced indifference towards the tending of the ground level by the buildings residents. A situation that has led to the deterioration of the ground level.

Entrance Hall
As illustrated in the narrative, the entrance hall is remarkably modest taking into account the a small village lives behind that door. Its also only accessible from one side of the building making the building a barrier in the urban design, in this way the building actually functions as a wall, disconnecting the entrance area, on the gallery side, from the recreational greenery which is mostly at the balcony side of the building.

Elevator
On top of the fact that these elevators are small and claustrophobic they also only serve either the even or uneven floors. Resulting in the fact that you would practically never meet your under or above neighbors. This exacerbates problems like sound nuisance, as will be illustrated below.

Gallery
A gallery is an unpreferred way of entering your dwelling, this is mainly caused by two factors. Firstly there is the passing by of other
dwellings while walking along the gallery. This effect is enhanced by the narrow depth (1.45 m) of the gallery. Secondly there is the influence of the weather, especially at higher floor the gallery can be a windy place.

5 Sound insulation
Because these buildings were built at the lowest possible costs, a minimum amount of concrete was used to construct the load-bearing structure. Although the structure is more than strong enough to carry the load, the relatively slender walls and floors provide a poor sound insulation. Residents complain about noise nuisance from their neighbors especially from the dwelling just above their own. Noise nuisance is as much a technical problem as it is a social problem, but because social cohesion is low and residents scarcely meet their neighbors this tends to be a major annoyance.

6 Indoor climate
Due to bad insulation (Rc 2, U 5) and a high infiltration factor (2.15 dm³/s/m²) the indoor climate suffers from cold rooms and draught. Resulting, especially in the colder months of the year, in discomfort for the residents.

7 Room configuration
These dwellings were designed for 3-4 person households, however they are currently inhabited by 1-2 person households. As a consequence, there are unnecessary bedrooms and an undersized bathroom and kitchen.

8 Balcony
Considering the square meters, the balcony is quite spacious. However, due to its narrow depth it’s highly unpractical. 1.45 m minus the curb and railing leaves little room for anything less then a small chair.

9 Furnishing and Finishing
Due to deterioration by time the existing furnishing and finishing of the kitchen, bathroom and toilet are getting outdated and unappealing. Elements subject to renovation would be:

- tilling in kitchen, bathroom and toilet
- kitchen equipment
- shower equipment
To conclude this chapter it can be inferred that ERA flats are unfinished building. Although residents have been living in ERA flats with satisfaction, the flats have certain shortcomings which have to be fixed to make them suitable for another five decades. These finished and unfinished element can be categorized by scale form urban to dwelling scale and lastly the less tangible human scale.

### “What are the architectural characteristics of an ERA flat?”

<table>
<thead>
<tr>
<th>Finished</th>
<th>Unfinished</th>
</tr>
</thead>
<tbody>
<tr>
<td>- set in a green surrounding</td>
<td>- entrance area</td>
</tr>
<tr>
<td>- sufficient parking</td>
<td>- plinth</td>
</tr>
<tr>
<td>- located in urban environment</td>
<td>- ground level design</td>
</tr>
<tr>
<td>- prefabricated elements</td>
<td>- routing</td>
</tr>
<tr>
<td>- repetition</td>
<td>- appearance</td>
</tr>
<tr>
<td></td>
<td>- social cohesion</td>
</tr>
<tr>
<td></td>
<td>- energy efficiency</td>
</tr>
<tr>
<td>- large affordable dwellings (75 m2)</td>
<td>- interior arrangement</td>
</tr>
<tr>
<td>- flexible floor plan</td>
<td>- balcony</td>
</tr>
<tr>
<td>- no stair dwellings</td>
<td>- facade properties</td>
</tr>
<tr>
<td>- lots of daylight entering the dwelling</td>
<td>- size (depending on the residents)</td>
</tr>
<tr>
<td>- view</td>
<td></td>
</tr>
<tr>
<td>- dwelling wide balcony</td>
<td></td>
</tr>
<tr>
<td>- the appearance of being more</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- low social cohesion</td>
</tr>
<tr>
<td></td>
<td>- anonymity</td>
</tr>
<tr>
<td></td>
<td>- no personal expression</td>
</tr>
</tbody>
</table>

**Urban scale**: set in a green surrounding

**Building scale**: entrance area, plinth, ground level design

** Dwelling scale**: prefabricated elements, routing, appearance, social cohesion, energy efficiency

**Human scale**: large affordable dwellings (75 m2), flexible floor plan, no stair dwellings, lots of daylight entering the dwelling, view, dwelling wide balcony, the appearance of being more

**Low social cohesion**, **anonymity**, **no personal expression**
“What are the problems, imperfections of ERA flat?”

**Urban scale**
- entrance area should be less dominated by the car.
- green space should be better defined in public and semi public.
- possible addition of functions (sport and social)
- the connection between the dwellings and the ground level should be enhanced by eliminating the blind plinth.

**Building scale**
- entrance should be well marked
- the entrance hall should have more grandeur.
- their need to be a connection between front and back of the building through the entrance hall.
- the elevator should stop a every level.
- the elevator should be larger.
- the elevator hall, similar to the entrance hall, should have more grandeur en should have its own identity per floor
- the gallery route should be shorter or more comfortable
  - addition of extra vertical access point
  - protecting the gallery from weather
- every gallery/floor should have it own identity and should therfore be recognizable when entering the gallery.
- gallery plate should have more depth
- there should be room for personal expression
- it should not be discouraged to use the balcony as a storage place.

**Dwelling**
- a larger kitchen
- new finishing kitchen
- larger bathroom
- new finishing bathroom
- adding the 3th bedroom to either the other bedroom or the kitchen.
- the balcony should have an usable area (2 x 3 m)
- the sound insulation between dwelling should at least be improved in the bedrooms of the dwelling.

**Human scale**
some problem like noise nuisance, littering in public places and other irritations can be prevented by a better social cohesion. Although architecture can not force people to get along, it can create the opportunity for people to get to know each other.

- the ERA flat should have a public place suitable for community activities.
Comparison of the resident composition of the Rotterdam average, the ERA-1, and the survey.

Graph 2.1: Household types comparison:
- **ERA-1 (woonstad)**: 18-30 (21%), 30-55 (46%), 55+ (23%)
- Survey Rotterdam: 18-30 (17%), 30-55 (45%), 55+ (38%)
- Woonstad Rotterdam: 18-30 (10%), 30-55 (14%), 55+ (28%)

Ethnic composition:
- **ERA-1 (woonstad)**: Autochthonous (53%), Allochthonous (47%)
- Survey Rotterdam: Autochthonous (52%), Allochthonous (48%)
- Woonstad Rotterdam: Autochthonous (52%), Allochthonous (48%)

Other details:
- **ERA-1 (survey)**: 18-30 (63%), 30-55 (22%), 55+ (15%)
- Survey Rotterdam: 18-30 (30%), 30-55 (30%), 55+ (3%)
- Woonstad Rotterdam: 18-30 (3%), 30-55 (9%), 55+ (63%)

Legend:
- 18-30
- 30-55
- 55+
- Single person household
- Cohabitation without kids
- Married without kids
- Cohabitation with kids
- Married with kids
- Single parent households
- Autochthonous
- Allochthonous

References:
- CBS
- Woonstad Rotterdam (2013)
- COS (2009)
- Dral (2013)
The Residents

Because this research deals with an existing building, which has been in use for almost half a century, there is a lot of user related information about these dwellings. To acquire this information a survey was conducted. An anonymous questionnaire consisting of both open and closed questions about personal information, dwelling evaluation and dwelling preferences was distributed, on paper, among the residents of the ERA-1 (target project). The questionnaire, as distributed, is included in the appendix. The first and second chapter cover the first part of the survey which answers the questions “who are the existing residents?” the third and fourth chapter will cover the second and third part of the survey concerning the dwelling evaluation and preference of the existing residents. This information will be combined in the last chapter answering the question “What are the best (future) target groups”

2.1 Resident demographics

“Who are the existing residents?”

Because the validation of the survey (p. 25) showed that a significant part of the actual residents are not represented in the survey, the following chapter is therefore a combination of information acquired from Woonstad, COS and the survey. Firstly the current residents, based on the information acquired from woonstad, will be compared with those of Rotterdam to see if there are notable differences. Secondly supplementary information like education, income, rent and energy bill will be discussed. This chapter will be concluded with a profile of the current residents.

Age

As stated before these dwellings are especially suited for older residents, commonly referred to as the 55+ age group, this reflects in the states as the age group 55+ is 12% larger than the Rotterdam average. A certain quantity of these 55+ group are so called residents of the first hour, as they moved in within a few years after the completion of the complex. (Woonstad Rotterdam, 2013; COS, 2009)

Household types

When we compare the different CBS household types (see graph 2.1) it becomes clear that the percentage of single person households takes up 8% more than the Rotterdam average, also there is a 6% increase for single parent households and a 11% decrease for the married couples with kids (Woonstad Rotterdam, 2013; COS, 2009).

Ethnic composition

The ethnic composition of the complex is comparable with that of Rotterdam. However there are some differences among the different buildings in the complex. The Favre building (east) has as significant higher percentage of autochthonous residents compared to the other buildings. An explanation can be found in the fact that this building has the least importance for the high way, this could have had an effect on the mutation grade of the dwellings (Woonstad Rotterdam, 2013; COS, 2009). As most of the allochthonous residents started to move to this complex around 15 year ago, they were mostly allocated in the dwellings that had a high mutation.
That fact that almost half of the residents are of non-dutch origin, and are divided over almost 10 different cultures is a source of tension. This came forward in the resident survey as lot of elderly (Dutch) residents complained about the some what exuberant lifestyle of their allochthonous neighbors.

Out of these results it could be inferred that a gallery flat is most suitable, or more appreciated by elderly (55+) 1-2 person households, single parent households and non-married couples. However, these difference could also be the result of economical instead of architectural characteristics. Gallery flat apartments are, in case the parameters for a choice are a low price and a relatively high amount of m², quite unprecedented in an urban environments. This price to quantity ratio could explain the higher percentage of single parent households and non-married couples, who are likely to be starters. On top of that there is the element of location, because the research involves only a single location, thus differences between neighborhoods are left out of the equation.

**Education level**

Education levels of the respondents are, compared to the national average, on the lower side (Dral, 2013). This could be caused by the fact that only a certain part of the residents is represented in the survey.

**Income**

The income levels are actually quite high for this type of dwelling. Gallery flats are typically reserved for social housing, meaning that eligible households should have a gross yearly income no higher than 33,000 euro (Philipsen 2013). This would correspond with a net monthly income of around 1800 euro's. However, the survey shows that almost half of the respondents have a higher net income. This phenomena is called “skewed income-to-rent ratio” (scheefwonen). Although this would be a concerning fact, it can again be explained by the over representation in the survey of a specific group of people, 55+. Commonly income increases with age, probably these people where eligible for social housing when they started renting, but over the years their income increased above the eligible level.

**Rent and energy bill**

Information about the rent and energy are displayed by 3 numbers; the high value, lowest value and the average. The accuracy of these numbers can be doubted due to the high difference. Probable cause of these difference could be a wrong assumption in the questionnaire, because in the case of the ERA-1 residents pay a total amount for their heating and rent, gas for cooking and tap water, electricity and water are billed separately. The questionnaire asked for a monthly gas, water and electricity bill. This could have led to confusion. The high difference between the max and minimum value could also be the result of the fact that there are actually 9 different energetic types of dwellings inside a single flat. Some dwellings have 2 or more extra out-facing facade (roof or blind facade) which results in a higher transmission loss. Due to the low response rate (43 out of 624) a single high or low value can influence the average significantly. When comparing the results to the
national average for gallery flats, the average gas consumption of the ERA-1 is lower than that of the national average. This could be caused by the above described bias. Calculations on the expected energy consumption have shown that energy usage should be higher than the results of the survey, this will be discussed in the theme Building Technology chapter energy consumption.

existing resident groups: (categorized by age, household type and income)

Age 18 - 30
- starters 1 - 2 person households

Age 30 - 55
- low income 1 - 2 person households
- low income family
- single parents households
- middle income 1 - 2 person households
- high income 1 - 2 person household

Age 55+
- low income 1 - 2 person households
- middle income 1 - 2 person households
Dwelling evaluation

"Which aspects/elements are being valued/devalued in the existing building?"

The second part of the survey consisted of several statements concerning the valuation of their dwelling. These statements were drafted based on the result of chapter 1.1 and 1.2. Residents were asked to give their opinion on statements like “I am satisfied with my kitchen” or “the curtains on the gallery side are always closed”, using a 5 point scale ranging from "strongly disagree" to "strongly agree". Supplementary to the 5 point scale, residents could also give a written comment with each statement. It is assumed that Woonstad makes use of a, commonly used, incidental maintenance strategy which means that they only repair and replace specific elements when they do not function anymore. Such a strategy, although economically interesting, results in a fragmented quality throughout the building. Some dwellings have newly installed equipment whereas others are still have the original equipment, resulting in strong variations in dwelling evaluation. For this research it was chosen to map the difference between age groups and house hold types, this choice is based on the fact that it is expected that the differences within these groups are substantial. The results, which are shown on page 46-47, are constituted from the average choice of a subgroup expressed from the neutral state (0). The most salient results will be discussed in this paragraph.

By age group

The age group is divided in 3 sub groups, 18 - 30 (15%), 30 - 55 (22%), 55+ (53%). This was done on the assumption of resembling validation within a group and the creation of target groups, which will be discussed later in this theme. When looking at the satisfactory level (“are you satisfied with...”), it can be inferred that although on average the satisfactory level is not too bad, there is a significant difference between age groups. Middle aged residents (>30 <55) are less satisfied with their dwelling than younger (<30) and older (>55) residents. Satisfaction is particularly low concerning the bathroom (0.4) and kitchen (0.5), as was already predicted by earlier research (chapter Building and surround) in the supplementary comments the dimensions of the bathrooms and kitchen, too small, is mainly referred to as the cause of the dissatisfaction, however also the deteriorated state of the tiles and shower and the noisy ventilation systems are causing nuisance. As expected, some strong differences occur between different respondents which is explained by their supplementary comment, “recently new bathroom installed by cooperation” or “installed a new kitchen on own expense”. A salient result that does not correspond with the earlier research is the usage of the balcony. Although predicted to be very poor, especially on higher floor levels, the results show a positive attitude towards the balcony. However, it should be said that, according to the supplementary comments, it becomes clear that many respondents evaluate their balcony in a situation with nice weather. However bad weather moments are neglected as they are not seen as moments to sit on your balcony. Thus the balcony evaluational is biased. The presence of the A16, causing noise nuisance is also mentioned as a reason not to sit on the balcony. Overall, the middle age group (>30<55) is the most critical of their dwelling. They are the least satisfied with their dwelling.
By household type

The division of household types was based on the CBS household types. Single person households (52%), single parents (5%), married couples without kids (30%), non married couples without kids (10%) and non married couples with kids (5%). Because more different subgroups are present in these results, greater difference appears, however this is also caused by the fact that some sub groups consist of a very small group of respondents (single parents (2), non married couples without kids (2) and non married couples with kids (1)). When we look at the overall satisfaction it seems that there is a strong difference between households with and without kids, where households without kids are generally positive about their dwelling, their counterparts with kids are generally negative. This difference could be caused by multiple reasons. Firstly, the amount of space, 75 m², is not much for a family with one or more children and secondly, the typology of the flat restricts the amount of control that a parent has over its outside playing children. For example, if you are on the 10th floor, you have no control over what happens at ground level, so every time your kids want to play outside, you are obliged to go with them. From conversations with residents who have been living at the ERA-1 since or just after its completion, it became clear that in the earlier years of the ERA flats, these problems were solved by a social regulation system in which mothers took turns watching over the playing children. However, with the ever more increasing individualism of today’s society these kind of social structures do not exist anymore. Nevertheless, if architecture could increase the social cohesion in the flat, perhaps these structures could exist again and gallery flats could become more “child friendly” again. Both married couples without kids and cohabitation with kids households regard their dwelling as too small and the married couples without kids are also prepared to pay more for a larger and more luxurious dwelling. Except from single parents and cohabitation without kids households, everybody would like a different interior arrangement. This has to do with the earlier described arrangement with 3 bedrooms. Because single parents need another bedroom and the cohabitation without kids are in this case no relational households (students living together) they too need more than 1 bedroom. Most other households only need a single bedroom. A negative aspect which was mentioned by multiple respondents, was the arrangement feature where the entrance of the dwelling is located inside the kitchen. Except for the cohabitation without kids (starters and students) all the residents would rather live in a different neighborhood.
I am satisfied with my house
I am satisfied with my bathroom
I am satisfied with my kitchen
I am satisfied with my bedroom(s)
I often use my balcony
I have contact with my neighbors
I would like more contact with my neighbors
I like living in a flat
the curtains on the gallery side are always closed
my neighbors make a lot of noise
I actually want to live somewhere else
I suffer from noise
I would pay more for a larger house
I suffer from noise from neighbors
in winter it can be very cold in my house
I think my house is too small
I feel safe in my house
I would like to have a different interior arrangement
I can properly ventilate my house
I would pay more for a luxury home
I would like to live in a more diverse neighborhood

strongly disagree disagree neutral agree strongly agree

55+ 30-55 18-30

Graph 2.5 dwelling evaluation by age group
Groter balkon
meer licht in mijn woning
minder geluidsoverlast
veiliger woning
grotere badkamer
grotere woning
een bad
een keuken met eettafel
een extra wc
een grotere keuken
minder slaapkamers
een kleiner balkon
tweede buitenruimte
nieuwe keuken
een grotere woonkamer
energie zuinige woning
meer contact met mijn buren
meer slaapkamers

Anders cohabitation with kids
doors cohabitation without kids
married without kids

single parent
single person household

strongly disagree
disagree
neutral
agree
strongly agree

dwelling evaluation by household type

graph 2.6
At the end of the second part of the survey the residents were asked to answer the following two questions in writing: “what do you value most about your dwelling” and “what do you value least about your dwelling”. The results of these two questions were quantitatively analyzed using a so called “word cloud”. Such a program counts the amount which a certain word is used and then produces a figure in which words are scaled depending on their frequency. This produced graph 2.7 and 2.8 which are displayed on the right page (p.49)

“Which aspects/elements are being valued/devalued in the existing building?”

+ view
+ balcony
+ green environment
+ large living room
+ daylight
+ visual connection front and back dwelling

- bathroom
- kitchen
- noise nuisance
- outdated finishing
- balcony
- interior arrangement
- low insulation
- outdated boiler
Graph 2.7 valued dwelling aspects

Graph 2.8 devalued dwelling aspects
In the third part of the survey the residents were asked to choose from a number of suggested interventions. Multiple interventions could be chosen and it was also possible to suggest an intervention which was not mentioned. The proposed interventions derived from the conclusions of chapter 1.1 and 1.2. The results were again arranged by age group and by household type and they are displayed on page 50-51. The graph shows the percentage of a subgroup that has chosen for a certain intervention. Finally, the respondents were asked for the willingness in both money and nuisance when these interventions would be executed in a renovation. Similar to the last chapter the different groups (age and household types) will be discussed and the most salient results shall be examined in detail.

**By age group**

The elderly age group (+55) are especially interested in a large balcony, more depth, more than 40% chose this as a preferred intervention against 30% of the younger and middle aged group. In this case it is doubtful if the question was correct, because the balcony is already of significant size, however its dimensions make it somewhat impractical. So the question should not have been if they would like a larger, but rather, a more practical balcony. According to the survey, daylight entering the dwelling is no problem at all, 0% would like more daylight in their dwelling. Important in a renovation is not to create this wish, by decreasing the amount of daylight entering the dwelling. The elderly age group appears to have the most nuisance from noise. This is an interesting fact as they are also sometimes the creators of noise nuisance, due to bad hearing they tend to turn up the volume of their tv. The bathroom is, as already has been shown in the dwelling evaluation, a prior cause of dissatisfaction. More than half of all the respondents would like a larger bathroom, the younger group (50%) would also like a bathtub to be included in their bathroom. The middle age group (30-55) indicates that their kitchen, and dwelling overall, is too small and they would like a larger kitchen with a dining table and almost half of all the respondents would like a new kitchen (new equipment and furnishing). The awareness about energy usage is the most prominent with the younger group( 80%), probably because of the current zeitgeist which was mentioned in the introduction of the thesis. They are followed by the elderly group (60%), this could be caused by the fact that this group is more sensitive to an uncomfortable indoor climate in which they probably spend more time than their younger and middle aged neighbors. The placement of a washbasin in the toilet, an intervention which was not given as standard choice in the survey, was mentioned multiple times by respondents in the comment area. This is a typical example of the little things which designers probably would forget but are of significant importance to the residents in their dwelling evaluation. The willingness in terms of monthly rent increase is quite evenly spread over the different age groups(€ 60), the younger group naturally has a lower willingness in term of monthly rent increase because their economic capacity is lower than that of their older neighbors. The willingness in terms of renovation time is quite different. Here we see a sharp difference between the middle aged group (2-3 weeks), who are likely to work through most of the day and would therefore have less nuisance from renovation activities
than the other subgroups (1-2 weeks). It also shows that the middle aged group, which is the most critical of their dwelling, is also the most willing to accept the nuisance from the renovation activities.

**By household type**

These results are, like the dwelling evaluation, skewed due to the fact that some subgroups are very small. Nevertheless, some interesting results appear when the survey data is arranged by household type. On the one hand, there is the not surprisingly correlation between household size and the wish for a larger balcony. On the other hand, the wish for a larger bathroom shows a contrary trend, smaller households seem to find the size of their bathroom more important than larger households. Whereas the wish for a new kitchen (new equipment and furnishing) is again a positive function of the household size.

The willingness in terms of the monthly rent increase is again quite evenly distributed around the €50. However, married couples without kids and cohabitation households without kids could afford a little more (€25). The willingness in renovation time is almost evenly spread (1-2 weeks).

**Salient comments**

As described before, the respondents also had the opportunity to suggest interventions/adaptations to their dwelling which were not mentioned. This paragraph will examine the most salient of these comments. For one it was mentioned multiple times that the total appearance of the building was of concern to the residents. This is not an unsurprising fact, nevertheless, there were no questions in the survey concerning the public space and appearance of the building/complex and respondents felt the need to mention this. Another interesting comment was the nuisance caused by on-orthodox garbage disposal, which is sometimes thrown over the balcony. It was also mentioned that the elevators should stop at every floor, instead of every second floor, something already mentioned in the last chapter Building and surrounding. Lastly, the tap water boiler inside every dwelling is poorly appreciated because of its low capacity and bad temperature control.

Similar to the dwelling evaluation there are transcending and subgroup specific preferences, which is of course no surprise considering the fact that a negative evaluation of an element will automatically lead to preference in adapting that element. To answer the subquestion of this chapter “what are the wishes of the residents concerning their dwelling?” the interventions were considered by the average of the whole survey. The answer to the subquestion, a list of significant interventions, is ordered by frequency of choice. The more an intervention was chosen, the higher it is on the list. The threshold of the list was defined at 15% (for an intervention to be considered significant it needs to be chosen by at least 15% of the respondents).
large balcony (more depth)
more daylight
less noise pollution
safer dwelling
large bathroom
large dwelling
a bathtub
diner-table in the kitchen
extra toilet
large kitchen
less bedrooms
smaller balcony
second balcony
new kitchen
large livingroom
more energy efficient dwelling
more contact with my neighbors
more bedrooms
Groter balkon
meer licht in mijn woning
minder geluidsoverlast
veiliger woning
grotere badkamer
grotere woning
een bad
een keuken met eettafel
een extra wc
een grotere keuken
minder slaapkamers
een kleiner balkon
tweede buitenruimte
nieuwe keuken
een grotere woonkamer
energie zuinige woning
meer contact met mijn buren
meer slaapkamers

Anders cohabitation with kids cohabitation without kids married without kids single parent single person household

graph 2.12 dwelling preference by household type
**Possible (future) target groups**

“What are the best (future) target groups?”

Combining the results of chapters 2.1 - 2.4 a selection can be made to define the most feasible target groups and their preference concerning their dwelling. The list of existing target groups at the end of chapter 2.1 can be filtered using the results of the survey; the lower the dwelling evaluation of a group the lesser a group is considered suitable for an ERA flat. Other factors influencing the filtering are; household size and income.

Although only one of the existing target groups is deemed “unsuitable” for an ERA flat; the 30 - 50 aged high income 1 - 2 person household, there is a gradation in which certain target groups are suitable for an ERA flat which has to do with the level of adaption to the dwelling that is needed to meet the wishes of that target groups. In the right bottom textbox this gradation is indicated with 1,2 or 3 + signs. 3 meaning that very little adaptation is needed to meet the target group wishes. Using the information of the survey an intervention profile was established for the most feasible target groups.

**Starters 1-2 person households**

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<th></th>
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<tbody>
<tr>
<td>age</td>
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</tr>
<tr>
<td>income</td>
<td>€ 1000 – 1500</td>
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<tr>
<td>max rent</td>
<td>€ 600</td>
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</table>

**preferred improvements**

<table>
<thead>
<tr>
<th>dwelling</th>
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<tbody>
<tr>
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</tr>
<tr>
<td>bedroom</td>
<td>renewal</td>
</tr>
<tr>
<td>kitchen</td>
<td>renewal, bath</td>
</tr>
<tr>
<td>balcony</td>
<td></td>
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<table>
<thead>
<tr>
<th>building</th>
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</tr>
</thead>
<tbody>
<tr>
<td>energy performance</td>
<td>++++</td>
</tr>
<tr>
<td>social contact</td>
<td>+</td>
</tr>
<tr>
<td>willingness</td>
<td></td>
</tr>
<tr>
<td>economical</td>
<td>+</td>
</tr>
<tr>
<td>time</td>
<td>+++</td>
</tr>
</tbody>
</table>
existing resident groups: (categorized by age, household type and income)

Age 18 - 30
  starters 1 - 2 person households

Age 30 - 55
  low income 1 - 2 person households
  low income family
  single parents households
  middle income 1 - 2 person households
  high income 1 - 2 person household

Age 55+
  low income 1 - 2 person households
  middle income 1 - 2 person households

“What are the best (future) target groups?”

Age 18 - 30
  starters 1 - 2 person households  +++

Age 30 - 55
  low income 1 - 2 person households  +++
  low income family  +
  single parents households  ++
  middle income 1 - 2 person households  +

Age 55+
  low income 1 - 2 person households  +++
  middle income 1 - 2 person households  ++

+++ no adaptations required
++ few adaptations required
+  many adaptations required
### low income 1-2 person households

<table>
<thead>
<tr>
<th>Age</th>
<th>30 - 55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>€ 1000 - 1500</td>
</tr>
<tr>
<td>Max rent</td>
<td>€ 500</td>
</tr>
</tbody>
</table>

#### preferred improvements
- **dwelling**
  - Living room: 1
  - Bedroom: 1
  - Kitchen: renewal, larger
  - Bathroom: renewal, larger
  - Balcony: more depth
- **building**
  - Energy performance: +++
  - Social contact: +++
- **willingness**
  - Economical: +
  - Time: ++

### single parent households

<table>
<thead>
<tr>
<th>Age</th>
<th>30 - 55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>€ 1000- 1500</td>
</tr>
<tr>
<td>Max rent</td>
<td>€ 500</td>
</tr>
</tbody>
</table>

#### preferred improvements
- **dwelling**
  - Living room: 2
  - Bedroom: 2
  - Kitchen: renewal
  - Bathroom: renewal
  - Balcony: more depth
- **building**
  - Energy performance: +++
  - Social contact: ++
- **willingness**
  - Economical: +
  - Time: ++
### Low Income Family's

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>age</strong></td>
<td>30 - 55</td>
</tr>
<tr>
<td><strong>income</strong></td>
<td>€2000 - 2500</td>
</tr>
<tr>
<td><strong>max rent</strong></td>
<td>€600</td>
</tr>
</tbody>
</table>

**Preferred Improvements**

**Dwelling**
- Living room: larger
- Bedroom: 2-3
- Kitchen: larger, dinetable
- Bathroom: renewal, larger
- Balcony: more depth

**Building**
- Energy performance: ++++
- Social contact: ++

**Willingness**
- Economical: ++
- Time: ++++

**Specific Requirements**
- Garden or more control on the ground floor, e.g. by ground floor access to the dwelling

### 55+ 1-2 Person Households

<table>
<thead>
<tr>
<th></th>
<th>55+</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>age</strong></td>
<td>55+</td>
</tr>
<tr>
<td><strong>income</strong></td>
<td>€1500 - 2000</td>
</tr>
<tr>
<td><strong>max rent</strong></td>
<td>€600</td>
</tr>
</tbody>
</table>

**Preferred Improvements**

**Dwelling**
- Live course resisted
- Living room: 1
- Kitchen: renewal
- Bathroom: renewal, larger
- Balcony: more depth

**Building**
- Energy performance: +++
- Social contact: ++

**Willingness**
- Economical: ++
- Time: +++
“What are the architectural characteristics of an ERA flat?”

- repetition
- prefab elements
- flexible floor plan
- horizontal articulated facade
- rationality and industrialization

“What are the problems, imperfections of ERA flat?”

Embedding in the urban plan
- ground level design
- plinth
- entrance area

Building
- entrance hall
- elevators
- gallery
- anonymity of the facade
- low social cohesion

Dwelling
- insulating properties facade
- interior arrangement and finishing
- balcony dimensions

Social cohesion

some problem like noise nuisance, littering in public places and other irritations can be prevented by a better social cohesion.

architecture can not force people to get along, but it can create the opportunity to get to know each other.

- the ERA flat should have a public place suitable for community activities.
“Who are the existing residents?”

Existing resident groups:
(categorized by age, household type and income)

Age 18 - 30
- starters 1 - 2 person households

Age 30 - 55
- low income 1 - 2 person households
- low income family
- single parents households
- middle income 1 - 2 person households
- high income 1 - 2 person household

Age 55+
- low income 1 - 2 person households
- middle income 1 - 2 person households

“Which aspects/elements are being valued/devalued in the existing building?”

+ view
+ balcony
+ green environment
+ large living room
+ daylight
+ visual connection front and back dwelling
+ no stairs in dwelling

- bathroom
- kitchen
- noise nuisance
- outdated finishing
- balcony
- interior arrangement
- low insulation
- outdated boiler
- dwelling size
ERA flats were born out of necessity, treated with indecency but are now ready to be reborn. The buildings do have some (architectural) flaws, with which needs to be dealt to ensure another 50 years of living pleasure. These flaws or design errors can be divided in scale related categories.

**Urban scale**
- The buildings are poorly embedded in their surrounding, proper organization and design of the ground floor, creation of extra functions like public BBQ equipment, a small community center could enhance both the activation of the ground floor and the social cohesion in the neighborhood.
- The access areas can be marked and made less unsafe by upgrading it with light and objects.

### “What are the wishes of the residents concerning their building/dwelling?”

- more energy efficient dwelling 55%
- large bathroom 48%
- large balcony (more depth) 42%
- new kitchen (equipment and finishing) 39%
- less sound nuisance 32%
- larger kitchen 23%

### “What are the best (future) target groups?”

**Age 18 - 30**
- starters 1 - 2 person households +++

**Age 30 - 55**
- low income 1 - 2 person households +++
- low income family +
- single parents households ++
- middle income 1 - 2 person households +

**Age 55+**
- low income 1 - 2 person households +++
- middle income 1 - 2 person households ++

+++ no adaptations required
++ few adaptations required
+ many adaptations required
The blind plinth, the storage units that take up the ground floor, creates an architectural induced indifference between the residents and the ground floor. Opening the blind plinth and/or creating access points for the first floor dwellings will enhance the resident's feeling of responsibility for the ground floor and increase the embedding in its surrounding, instead of being a fortress.

**Building scale**
- The access route from parking, entrance hall, elevator, gallery to the front door is a topic of concern. The parking lot should be less domination in the ground floor level.
- The entrance hall should be of considerable dignity as a small villages passes through it every day.
- Extra vertical access points could be created to unburden the elevators so they could stop at every floor.
- The gallery is windy and unpleasant, especially at the higher floor. Protection from wind and rain could enhance the experience of getting from the elevator to the front door.
- The architectural appearance of gallery flats is referred to as monotonous and anonymous. Creating possibilities for personalization and differentiation could create more identity. The blind facades at the ends of the building could be upgraded with e.g. a green wall which enhances both the aesthetic appreciation and the energy efficiency of the building (Riccardo, 2013).

**Dwelling scale**
- The arrangement of the dwelling was initially designed for a 3-4 person household. These dwellings are currently mainly occupied by a 1-2 person household. Small and unnecessary rooms are the result. It must be noted that in some cases a small household is very happy with the abundance of room which they use e.g. as hobby room.
- Especially the bathroom is too small for today's standard. The furnishing and equipment is outdated and is in need of replacement.
- The kitchen has the similar problem, too small and in most cases outdated. The merge of e.g. the kitchen and the small bedroom could be a possibility to create larger room and get rid of the unnecessary ones.
- The balcony is very impractical, more depth should be created to enhance the usability.
- The facade has a very low insulating value, single glazing, cold bridges and high infiltration rate cause discomfort especially in the colder months.
- Ventilation is done by natural suction, this systems fails especially if a neighbor installed mechanical ventilation.
- Noise pollution from outside (in the case of the target location the A16 highway) can causes nuisance. Better sound proof facades or a second facade could improve this situation.
- Due to the minimum concrete structure (180 mm) the sound insulation is sometimes dramatic. And as a result of (current) building regulations it is not possible to put in a floating floor because the minimum floor to floor height (2.6) is not met (the dwelling currently have a floor to floor height of 2.6) So technique is proba-
bly not going to solve this problem, however, sound nuisance is as much a technical problem as it is a social problem, coaching and a better social cohesion could lead to less nuisance. Installation of noise reducing carpet could also help.

- Due to the differences between preferences of target groups and the freedom that the ERA structure provides, it is advised to create multiple components which can be use separately or combined to create customized variation. The demountability of the components should be carefully designed to create a greater flexibility in interior design which could be altered with each new resident.

pict. 2.1 Second facade
(de noordwachter, Hans van Heeswijk architecten)
Structure

What is the existing structure of an ERA flat?

What are the possible structural interventions for an ERA flat?

Energy

How do you create an energy neutral building?

What are the existing energy related systems and how do they perform?

What is the current energy consumption of an ERA flat?

What kind of systems/components can be used to renovate an ERA flat to an energy neutral building?

What are possible systems to create an energy neutral ERA flat?
Building Technology
The load bearing structure of an ERA flat, depending on the configuration, consists of a number of in-situ casted concrete frameworks joint together by the prefab floors and a casted elevator shaft of the access route(s). Although the ERA-1 has smaller dimensions than later ERA flats, due to the fact that the ERA-1 is the target project of this thesis its dimensions and structural aspects shall be considered. However, when applicable, the differences between the ERA-1 and the later ERA projects will be noted.

Casted Framework
The framework of the ERA-1 is built on a grid of 7.45 m center-to-center distance for the walls, 2.8 m floor-to-floor with a depth of 10.5 m. Later versions were built with a 7.8 m center-to-center distance for the walls and a 11.10 m depth. As the walls and floors consist of 180 mm of casted concrete (floors include another 20 mm of finishing layer) the net dimensions of a cell are 7.27 x 10.5 x 2.6 m with a floor space of 76.3 m². One framework holds 14 x 6 = 84 cells of which 78 are reserved for dwellings. The remaining 6 make up the ground floor and houses the storage and installation rooms (ERA 1964).

Gallery and balcony
The gallery and balcony slabs are identical and were created in the ERA factory in Bergambacht. They consist of prefabricated reinforced concrete 1.43 m in depth and a length corresponding with the centre distance of the framework.

The gallery and balcony plates are supported by prefabricated reinforced concrete cantilevers (1350x180x450 mm) which were connected to the framework during the casting. The cantilevers are calculated to support a balcony/gallery plate of 2407 kg with a variable load of 3836 kg (ERA, 1964). In a renovation of an ERA flat in Zaandam it was proven that an additional 800 kg per dwelling could be added to the existing cantilevers.

Vertical access point
The vertical access point has, other than the dwellings, a width of 5.8 m and a depth of 10.50 m. The vertical access point forms the connection between the 2 casted frameworks of dwellings. The floor of the vertical access point are prefabricated rib-floor which rests on an edge which was casted in the dwelling frameworks. The in-situ casted concrete elevator shaft (3.5 m x 3.6 m) houses 2 elevators which either serve half of the floors.
Facade

The prefabricated wooden framework facade is connected to the main concrete structure using a wooden plank which is mounted to the outside of the floors. The facade placed on the top of the wooden plank put in position in a way that can be compared with the closing of an awning window. (see detail). This detail made it possible to quickly install the facade elements when they arrived at the building side, contributing to the high building speed. A new intervention should have the same cleverness which can be used to conduct the renovation in occupied state. The facade is calculated to weigh 56 kg/m². The surfaces of the facade is 18,9 m² (excluding the part above the cantilever) resulting in a total weight of 56*18,9 + 83 kg (for the part above the cantilever) = 1141,5 kg.

“What is the existing structure of an ERA flat?”

- 1 floor (main structure)
- 2 balcony/gallery slab
- 3 lower part facade
- 4 upper part facade
- 5 wooden “connection”
- 6 cantilever

fig 3.3 connection detail facade
Possible structural interventions

“What are possible structural interventions for an ERA flat?”

The concrete structure of the ERA flat offers several possibilities. For this research a mapping was done of the most feasible structural interventions, in the framework of the research question, which would contribute the overall value of the flat. The interventions are divided in 3 categories. Firstly, we will discuss the possibility of adding something to the balcony and/or gallery side of the building. These interventions concern the addition and/or upgrading of space without altering the main structure. Secondly, the joining of dwellings will be discussed and lastly, the interventions that alter the way how the building is accessed will be discussed. The interventions are based on existing renovations performed on ERA or comparable flats. As stated before, this summarization does not state all possibilities but rather the ones that have been proven possible by actual renovations. Every intervention is evaluated by its influence on the three criteria defined in the main research question; energy efficiency, living comfort, executability in occupied state. This evaluation was done based on information available from the reference projects and by means of reasoning using the criteria definitions (p.22-23)

Addition

1. As mentioned before the balcony and gallery are large but impractical in usage due to its small depth (1,35 m net). A lighter slab with more depth or with a varying depth, which is possible with today’s techniques, could replace the original slab. The slabs are dry connected to the cantilever, so removing them is no problem. A calculation using high performance concrete shows that a slab of 1,9 meters depth could replace the old slab without extra support.

<table>
<thead>
<tr>
<th>slab type</th>
<th>dimension (depth)</th>
<th>slab weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>existing slab</td>
<td>1,35 m</td>
<td>2407 kg</td>
</tr>
<tr>
<td>high performance slab</td>
<td>1,90 m</td>
<td>2378 kg</td>
</tr>
</tbody>
</table>

(Hi-con, 2013)

Energy efficiency: no influence
Living comfort: enlarging the balcony slab will increase the usability of the balcony (private outdoor space) or gallery and can have a profound effect on the aesthetic appearance of the whole building.
Executability in occupied state: this intervention happens outside the climate facade, does not require demolishing any element and is therefore highly executable in occupied state.

2. Another possibility is to add a second facade to the outside of the balcony. This was done in the renovation of the Noordwachter, an ERA flat which was renovated by Hans van Heeswijk architects. A glass facade was placed on the outside of the balconies shielding them of from the noise produced by the nearby highway (initial reason) but it also created an addition to the living space and extra insulation. Out of conversations with the residents it became clear that they are truly satisfied with the renovation,
enlarging balconies

adding a second facade
reference project: De Noordwachter
by Hans van Heeswijk Architects

adding an additional structure
reference project: Tour Bois le Prêtre
by Lacaton & Vassal
although the conservatory tents to overheat in the summer. The glass facade burdens the balcony cantilevers with another 800 kg per cantilevers, but calculations (and reality) have shown that this is no problem. Because the the design of the new facade was made in the same repetition philosophy as the original ERA flat it was economically possible to manufacture a specific aluminum detail specially created for this renovation but it also made it possible that the total facade could be placed in a single day (excluding preparation time) (Heeswijk, 2001).

**Energy efficiency**: the addition of a second facade will increase the insulating capacity of the balcony facade. However if it is not properly ventilated it can overheat in the summer, which can cause extra energy for cooling.

**Living comfort**: as shown in the reference project the Noordwachter this intervention creates additional living space in the form of a winter garden and increases the usability of the balcony.

**Executability in occupied state**: this intervention happens outside the climate facade, does not require demolishing and was done in occupied state in the reference project.

3 Then there is the possibility of adding actual dwelling space to the building. This can be achieved by removing the balcony and placing a “box” in front of the dwelling. This box could be supported by either the existing cantilevers with extra attachment to the main structure or it could be placed on a new structure. A good example of such an intervention is the renovation of an apartment block in Paris by Lacaton & Vassal. They removed the old facade and balconies and replaced them by a self supporting structure which added extra dwelling space and generous balconies to the building.

**Energy efficiency**: replacing the facade gives an opportunity to add a better insulating facade.

**Living comfort**: the intervention results in additional living space and more usable space. Caution is needed not to obstruct too much sunlight form entering the dwelling.

**Executability in occupied state**: the intervention requires the removal of the existing facade. The reference project shows that when the additional element is prefabricated the renovation is possible in occupied state.

**Joining dwellings**
Another way of creating larger and/or more luxurious dwellings is by joining them together. By connecting dwellings in either horizontal or vertical direction graceful voids and large facade fronts can be realized. The downside of this approach is that it is practically impossible to perform such an intervention in occupied stated.

4 Connecting dwellings in a vertical direction by means of a void results in maisonnettes (+/-140 m²) with a beautiful double high balcony facade. Important for the structure is that it is not possible to create a wall to wall void as this will affect the stability of the structure due to the increasing buckling length of the load bearing wall. This intervention will also result in the removal of half of the
vertically connection dwellings
reference project: De Noordwachter
by Hans van Heeswijk Architects

horizontally connecting dwellings
reference project: De Noordwachter
by Hans van Heeswijk Architects
gallery and balcony slabs. On top of the fact that this intervention is most likely impossible to perform in occupied state, there is also the problem that every typology has a so called maximum real estate value and corresponding maximum rent (Zuijderwijk, 2013). So upgrading to 140 m² will create a dwelling which due to its typology (gallery) does not reach the expected real estate value. This transformation will also force the current residents to move as they (probably) can not afford the new dwelling.

Energy efficiency: no influence
Living comfort: creation of a larger dwelling, with a vide. However the addition of stairs in the dwelling limits the target group (no 55+)

Executability in occupied state: construction requires cutting and sawing the concrete floor which is due to noise and dust unlikely to be executed in occupied state.

Connecting dwellings horizontally is much easier than vertically because only a relative small hole has to be made in the load bearing wall. A feasible way for doing this is to make 2 out of 3 dwellings. This would limit the dwelling space to around 110 m² which should keep it affordable for its original residents. This intervention could possibly be executed in occupied state, nevertheless, it will cause much nuisance to the residents of the whole building due to the contact sound that is created by the concrete saw or cutter. Structurally it is important to not weaken the stability of the structural walls, as shown in the most left drawing, not all doors could be placed on the same line as this would disrupt the stability line of the wall.

If this intervention is combined with smart placement of additional vertical access point it would put an end to the so called “by pass” effect which would upgrade the gallery facade to a fully fledged facade, comparable to the balcony facade (excluding the orientation)

Energy efficiency: no influence
Living comfort: creation of a larger dwelling, long facade.

Executability in occupied state: construction requires cutting and sawing the concrete wall which although easier then cutting away the floor, it is still unlikely to be executed in occupied state.

Altering access

The typology gallery flat is defined by its access route, the gallery. This defining element is both a strong aesthetic element and a low valued way of entering a dwelling. The “by pass” effect, people who walk along the gallery pass closely to the facade which invades the privacy of the rooms situated on the gallery side, makes the gallery side inferior to the balcony side. By altering the access route, different typology dwellings can be created, this will increase real estate value and differentiation or even help embedding the building in its surrounds.

The standard ERA gallery flat has one vertical access point equipped with 2 elevators and an escape stairs, serving 156 dwellings. In comparison, in a typical 6 storey portico flat, a single elevator serves 24 dwellings. By adding extra vertical access points we can reduce the amount of dwellings which are served per ac-
6 adding additional access points
reference project: Knikflats Ommoord
by Biq Architects

7 opening the blind plinth
reference project: Knikflats Ommoord
by Biq Architects

8 adding extra dwellings (optoppen)
reference project: Knikflats Ommoord
by Hans van Heeswijk Architects
cess point, and it also creates different dwellings. In the example shown on the right the additional access point is placed on the end of the building. The benefit of this approach is that the added building mass does not shade an essential facade. On the other hand, when the access point is placed between the 4th and the 5th dwelling (counting from the middle access point) half of the dwellings do not have the “by pass” effect anymore (see diagram). An additional access point would have its own foundation, depending on the exact placement, measures need to be taken to ensure the stability. These access points can be placed in occupied state and could also be used in the building process.

Energy efficiency: no influence
Living comfort: this intervention increases the quality of entering the dwelling by decreasing the amount of dwelling that have to be passed along the gallery.
Executability in occupied state: extra access points are self supporting structures outside the climate facade of the dwelling and can even be utilized improving the renovation process (when placed an extra access point could be used as backup when altering the existing access point and entrance hall)

7 In order to solve the blind plinth problem, the disconnection between the building and the ground floor, the first floor dwelling could be given an access from the ground floor. Storage units can be rearranged in a different configuration resulting in entrance space for each first floor dwelling. A small hole in the floor to facilitate a stair causes no structural problems, and by doing so multiple issues are addressed. The blind plinth will transform in a low rise dwelling facade, there will be more social control and responsibility regarding the ground floor and this intervention will result in more dwelling differentiation.

Energy efficiency: no influence
Living comfort: creation of larger dwelling which are accessible from the ground floor therefor altering the typology.
Executability in occupied state: construction requires cutting and sawing the concrete floor which is due to noise and dust unlikely to be executed in occupied state.

8 It's also possible to add extra dwellings on top of the building, these dwelling can be either have their access point through the original access point or through new ones. Adding extra dwelling on top will create more dwelling without needing new ground, an economical reason, they can be placed in occupied state and aesthetically they could serve as the ending of the building. Selling or renting these more exclusive dwellings could also generate profit which could be used for the renovation of the existing dwelling.

Energy efficiency: no influence
Living comfort: apart from the added dwellings this intervention does not influence the living comfort of the existing dwellings
Executability in occupied state: The reference project shows that when the additional dwellings are fully prefabricated this intervention is executability in occupied state
The concrete structure of the ERA flats is in good condition, not taking in account specific local damage, and can easily endure another century of usage. Multiple structural interventions are possible, however not all of them have the same influence on the criteria given in the research question. It needs to be noted that this chapter does not aim for a completeness of every possible structural intervention, but as stated in the beginning of the chapter based on reference projects of ERA or comparable flat renovations.

“What are possible structural interventions which would increase the energy efficiency and/or living comfort of an ERA flat?”

<table>
<thead>
<tr>
<th>Structural Intervention</th>
<th>Energy Efficiency</th>
<th>Living Comfort</th>
<th>Occupied State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enlarging balcony and gallery slabs</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>Second facade</td>
<td>++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Additional structure balcony side</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Vertical connection dwellings</td>
<td>+++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Horizontal connection dwellings</td>
<td>+++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Additional vertical access points</td>
<td>++</td>
<td>+++</td>
<td>+</td>
</tr>
</tbody>
</table>
The creation of an energy neutral building requires the seemingly integration of all the building components. To achieve such an integration in a renovation firstly the energy flows and the responsible building elements of the existing building need to be mapped after which the Traid Energetic can be used to eliminate these energy flows (Huijbers and Dobbelsteen 2012).

Defining the energy flows
A building has different energy flows that are useful to map when designing an energy neutral building. The most common way to do this is to separate the energy flows of a building in a building, user and construction related component.

**Building related energy use (BREU)**
BREU concerns all the energy that is needed for operating the building. The BREU can be divided in two categories:
- building related energy use
- building-use related energy use
The first one consists of the energy needed to operate the dwelling; heating and cooling, tap water and ventilation. Whereas the second one includes the energy needed to operate the rest of the building (public space) like elevator, pump and lighting in public spaces.

**User related energy use (UREU)**
UREU involves the use of electrical equipment, cooking, lightning inside the dwelling. Because this usage is related to the resident, high difference can occur between identical dwellings.

**Construction related energy use (CREU)**
CREU is the embodied energy in building materials and installations and energy use for building construction, maintenance, renovation and demolition.

As defined in the research question this research will only consider the building and user related energy flows. The division of the energy flows also makes a separation in the amount of influence that a designer has on the energy flows. The building related energy use has a high level of control where the user related energy usages can be very variable depending on the type of resident.
**Trias Energetica**

The Trias Energetica is a concept first introduced in 1971 by Kees Duijvestein and describes a step by step process on how to create an energy efficient building. Today a revised version of the Trias is being used which also includes the project location and the production of waste material in the process. The Trias Energetica follows the following steps:

Firstly, we need to look at the energy potential of the project location e.g. waste heat from surrounding buildings. Then we try to reduce the demand of energy e.g. by the use of insulation and more energy efficient lightning. We reuse all the waste energy e.g. by heat recovery in the shower and ventilation. Only after these steps we start to look at the remaining demanded energy and try to produce this in a sustainable way (Huijbers and Dobbelsteen 2012).

**Types of energy efficient dwellings**

An ERA flat has, although its dwellings are identical, different energy efficient dwellings. This has to do with the fact that some dwellings are located in the middle of the building while others are located e.g. in the top corner and have therefore a more out-facing facade. The diagram above shows the different energetic dwellings and their estimated different performance compared to the standard dwelling. The following chapters will only consider the standard dwelling for reason of intelligibility.

---

**Diagram 4.1: Type of energetic dwellings**

1. Standard dwelling
2. End facade - roof dwelling
3. Roof dwelling
4. Elevator hall - roof dwelling
5. Elevator hall dwelling
6. Elevator hall - GF dwelling
7. Ground floor dwelling
8. End facade - GF dwelling
9. End facade dwelling

---

"How does one create a energy neutral building?"

- **Building**
  - Remaining demand that needs to be generated using sustainable energy
  - Define energy flows
  - Apply trias energetica

- **User**
  - Reduce the energy

- **Construction**
  - Use existing energy

Following the conclusion of the previous chapter the first step to an energy neutral ERA flat is to define the existing energy flows and the building components that are responsible for this performance. This will be done in a similar way as described in the previous chapter. Firstly, the building related energy usages (heating, warm tap water and ventilation) will be mapped by examining the performance of the responsible building components, after that the same will be done for the building-use related energy usages. This will result in a 0-scenario (chapter 4.3) which will be the starting point for the design of an new energy system using the trais energetica (chapter 4.4 and 4.5).

**Heating system**

*Insulating capacity facades*

Most of the dwellings, except from the outer dwellings, have two out-facing facades. The gallery façade has a 50/50 open/closed ratio, whereas the balcony facade is 80/20 open/closed ratio. The closed facade element consist of 5 mm lakboard, 30 mm of PI 156 isoverbel glass wool insulation, 45 mm air cavity and a 8 mm asbestos cement plate on the outside (ERA 1964). The Rc value of this construction is calculated to be 1,8 (see appendix C). The open parts of the facade consist of either single or double glassing with a wooden frame. All the windows on the gallery facade are equipped with single glassing(U=5). The balcony facades are, except from the door, equipped with double glazing(U=3).

Current laws forces architects and builders tot create dwellings with an energy efficiency coefficient of 0.6 this implies a Rc value of at least 5 m²K/W and a U value of 1,65 W/m²K (NEN, 2012). Thus, it can be concluded that the facade performs far below the current energetic standards. On top of that, poor energetic facade can cause discomfort for the residents. Most mentioned by the residents was the cold air around the gallery windows. These windows are single glazed and therefore cause a phenomenon which is called cold down drought.

*Cold bridges*

The cantilevers that support the balcony and gallery slab are prefab concrete which were connected to the load-bearing structure during the casting. Connections like these, where the bear load-bearing structure is exposed to the outside temperature are called cold bridge, which can cause heat leaks and condensation inside the dwelling which could lead to fungus growth that create a unhealthy indoor air quality. The fact that the balcony and gallery facades are not continues and are carried by a wooden plank that is connected to the load bearing structure (see detail) creates another cold bridge along the whole floor length. Especially when insulating a dwelling these cold bridge are of concern as the overall temperature in the dwelling will raise, which in term will cause an increasing “cold bridge effect” (Linden, Ham et al. 2006).

*Infiltration*

The infiltration of a facade is expressed in dm³/air/m²facade/s that flows through the facade. Older buildings have a quite high amount of infiltration which resulted in the fact that you actually never had to open a windows because the air that infiltrated the house was
fig 4.1  section, elevation and floor plan of the gallery facade

fig 4.2  section, elevation and floor plan of the balcony facade
more than enough fresh air. In terms of energy efficiency this is a
disaster, according to the NEN 8088 the estimated infiltration of an
ERA flat is 2,15 dm$^3$/m$^2$/s. The heatloss due to the infiltration
equals:
\[
\text{air flow (m$^3$/s) } \times 1200 \times (T_{\text{inside}} - T_{\text{outside}}) \\
(2,15/1000) \times (20,8 \times 2) \times 1200 \times (20-0) = 2146 \text{ W}
\]
comparatively, average heatloss due to transmission equals:
\[
\text{m$^2$ facade } \times \text{ heat resistants } \times (T_{\text{inside}} - T_{\text{outside}}) \\
(20,8 \times 2) \times 1 \times (20-0) = 832 \text{ W}
\]
So the heatloss due to air flow (ventilation/infiltration) is signifi-
cantly higher than that of transmission. It is therefore of outmost im-
portance that the infiltration value is lowered as far as possible.

*Production and distribution system*

Space heating is provided by 2 central boilers that are situated in
the installation room at the ground floor. Distribution to the dwell-
ings is done in vertical sections, through a duct shaft. Distribution
inside the dwelling is down by radiators located under the windows.
Originally the radiators were connected through a circuit ring cir-
cling the whole dwelling. Because of the energy inefficiency of this
system (all rooms are heated all the time) it was replaced by ra-
diators with separate regulators. (ERA 1964) Because dwellings
are vertically connected with each other measurement of energy
consumption is done by so called evaporators. A glass tube with a
particular liquid is placed on the outside of the radiator, of which the
liquid evaporates above a certain temperature (when the heating is
on) the problem with this system is that the liquid also evaporates
when the sun is shining on it, inducing higher energy bills for the
residents.

*Warm tap water system*

The warm tap water is provided by a separate gas boiler inside ev-
ery dwelling. The majority (90%) of the warm tap water is reserved
for showering. The existing boilers in the ERA-1 are outdated which
results in a low efficiency and failure. A calculation (see appendix D)
based on estimated usages shows that the needed energy equals
5340 MJ/per dwelling/year.

*Ventilation system*

Ventilation is done naturally, inlet on the gallery side through the
opening of windows, on the balcony side through opening win-
dows, the balcony door and air vents. The extraction of air is done
in the kitchen, toilet and bathroom. Natural suction is created at
the roof through use of suction caps which through air ducts connect
the dwellings in a vertical section. The problem with this system is
that due to failure of the suction caps, they do not create enough
suction, people installed ventilator blowing into the extraction duct.
This results in polluted and smelly air being blow into adjunct dwell-
ings (Gunst 2013). The use of natural ventilation especially in the
colder periods of the year has a significant influence on the energy
demand for heating. On a cold winter day the loss of heat due to
direct natural ventilation (outside air is taking directly into the dwell-
ing without pre heating) is a factor 10 compared to the transmission
loss through the facade (Linden, Ham et al. 2006).
**Problem statement**

**Research**

**Design**

**Possibilities**

**Existing system (space heating)**
- central boiler
- dwellings vertically connected
- problems:
  - outdated system
  - uncontrolled failure (due to blockage of the pipes)
  - heat loss in transport
  - noise pollution through the pipe system

**Existing system (tap water)**
- local boiler
- problems:
  - outdated system
  - very inefficient boiler
  - very large boiler for the amount of produced warm water

**Existing system (ventilation)**
- ventilation by natural pressure
- dwellings vertically connected
- problems:
  - the pressure is not always enough, which results in bad ventilation, which results in mold growth in the bathroom and toilet.
  - people installed mechanical ventilation and thereby disturbed the whole system.
  - no systems like heat recovery.

---

**fig 4.3** existing heating system

**fig 4.3** existing tap water system

**fig 4.4** existing ventilation system
Using an excel, that was created for this research, and based on the insulating properties of the facade, the infiltration and estimated natural ventilation and including the internal and external gains it was calculated that the energy usages per year, based on a normal usage (20°) and average minimum outside temperatures, to be 73980 MJ/dwelling/year. (see appendix D)

### Elevators

Each flat of the ERA-1 is equipped with 2 elevators. Because there is no information on the elevators of the the ERA-1, the data of the ERA-7, which is located north of the ERA-1, was used. The ERA-7 was completed only 2 years after the ERA-1, so there is a high probability that its equipment (elevators, light, boilers) has the same energetic efficiency. From the data of the ERA-7 it can be inferred that the 8 elevators of the ERA-1 use 89.600 kWh per year (11.200 kWh/elevator/year). Because the elevators are almost 50 years old they are due for replacement. If the replacement of the elevators is combined with the renewal of the engine and the control system there could be significant energy reduction. (Nagtegaal, 2011)

### Lightning of the public area

Similar to the previous paragraph due to absence of information on the ERA-1, the data from the ERA-7 was used to calculate the energy usage. Recalculating the information of the ERA-7 leads to the following table of different lights and their usages.

(estimated usage hours per year = 5.500)

<table>
<thead>
<tr>
<th>place</th>
<th>number</th>
<th>type</th>
<th>usage kWh/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>gallery</td>
<td>624</td>
<td>TL 18 W</td>
<td>61667</td>
</tr>
<tr>
<td></td>
<td>64</td>
<td>TL 18 W</td>
<td>6336</td>
</tr>
<tr>
<td>elevator hall</td>
<td>32</td>
<td>TL 58 W</td>
<td>10208</td>
</tr>
<tr>
<td>and stairwell</td>
<td>60</td>
<td>PL 18 W</td>
<td>5940</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>84151</strong></td>
</tr>
</tbody>
</table>

Table 4.1 lighting usages (Nagtegaal, 2011)

### Other building-use related energy usages

Because no information was acquired about the other building-use related components (pumps and other installations), the total energy usages will be recalculated using the information of the ERA-7. The ERA-7 uses 282666 kWh per year. This project consists of 356 dwelling divided over 2 flats. Every flat has 2 vertical access points with 2 elevators. A calculation shows that the total independent building related energy usages of the ERA-1 equals:

\[
\frac{(282666 - 146932)}{356} \times 624 + 173751 = 411666 \text{ kWh/year}
\]

(Nagtegaal, 2011)
To be possible to measure or calculated any improvements the current energy usages needs to be established. This is done through information from the resident’s survey, resident’s were asked for an estimate of their monthly energy bill, through average usage estimates of the SEV and through a energy flow calculation based on the existing systems done in the previous chapter. The results, stated in annual energy consumption for the whole complex (624 dwelling) is shown in table 3.3.

**User related energy usage**
In chapter 4.2 only the building related and building-use related energy usages are being calculated. As explained before, the user related energy usage can differ strongly depending on the type of user. For this research it was therefore chosen to adopt the assumption used by the SEV which is 2600 kWh per dwelling for apartments. (Nagtegaal, 2011)

<table>
<thead>
<tr>
<th></th>
<th>survey</th>
<th>SEV</th>
<th>calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gas (GJ)</td>
<td>Electricity (kWh)</td>
<td>Gas (GJ)</td>
</tr>
<tr>
<td>Building related</td>
<td>22028</td>
<td>30360</td>
<td>49495</td>
</tr>
<tr>
<td>Building-use</td>
<td>--</td>
<td>102916</td>
<td>102916</td>
</tr>
<tr>
<td>User related</td>
<td>2283840</td>
<td>1622400</td>
<td>1622400</td>
</tr>
</tbody>
</table>

**Table 4.3a 0-scenario per building**

<table>
<thead>
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<th></th>
<th>p/d</th>
<th>0-scenario</th>
<th>new scenario</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(kWh)</td>
<td>(kWh)</td>
<td>(kWh)</td>
<td>%</td>
</tr>
<tr>
<td>BREU</td>
<td>23668</td>
<td>85,2</td>
<td>23668</td>
<td></td>
</tr>
<tr>
<td>BUREU</td>
<td>659</td>
<td>659</td>
<td>659</td>
<td></td>
</tr>
<tr>
<td>UREU</td>
<td>2600</td>
<td>2600</td>
<td>2600</td>
<td></td>
</tr>
</tbody>
</table>

**Table 4.3b 0-scenario per dwelling**

**Table 4.3c 0-scenario comparison table**

---

Energy consumption

“What is the current energy consumption of an ERA flat?”

Table 4.3a 0 - scenario per building

Table 4.3b 0 - scenario per dwelling

Table 4.3c 0 - scenario comparison table

---

"What are the existing energy related building components and how do they perform?"

<table>
<thead>
<tr>
<th>Building related energy usages</th>
<th>kWh/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>20625</td>
</tr>
<tr>
<td>- facade insulation Rc 2, U 5</td>
<td></td>
</tr>
<tr>
<td>- facade infiltration qv₁₀ = 2,15</td>
<td></td>
</tr>
<tr>
<td>- natural ventilation</td>
<td></td>
</tr>
<tr>
<td>- CV system on gas</td>
<td></td>
</tr>
<tr>
<td>Tapwater</td>
<td>1483</td>
</tr>
<tr>
<td>- gas boiler (no</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Building-use related energy usages</th>
<th>kWh/year/dwelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevator</td>
<td>659</td>
</tr>
<tr>
<td>public lighting</td>
<td></td>
</tr>
</tbody>
</table>

Usage in kWh/year/dwelling

---

Table 4.2 Energy consumption table (Nagtegaal, 2011; Dral, 2013)
0-scenario
For this research the highest values of each elements will be used to construct the 0-scenario, however due to the bias in the survey concerning the energy bill these results will be discarded. The resulting 0-scenario is shown in table 3.4. In the last table the gas components are recalculated to kWh units. This is done both to make the different components comparable and because the energy neutral system does not use fossil fuel, which would make it redundant to state a components value in GJ gas. The 0-scenario will be the reference point for any intervention which will be proposed in the next chapter. The effect of each proposed intervention will be displayed using the 0-scenario table.

The 0-scenario table shows that the the fast majority of the energy consumption (88%) is caused by the heating of the dwellings. Reducing the heat load would therefore be the most urgent issue. This percentage of the total energy consumption is important as it helps to understand which measures are the most efficient, also in terms of investment costs.

“What is the current energy consumption of an ERA

<table>
<thead>
<tr>
<th>Type</th>
<th>kWh/year</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>building related</td>
<td>659</td>
<td>88%</td>
</tr>
<tr>
<td>building use related</td>
<td>2600</td>
<td>2,5%</td>
</tr>
<tr>
<td>user related</td>
<td>2,5%</td>
<td>9,5%</td>
</tr>
</tbody>
</table>

usage in kWh/year/dwelling
4.4 Potential energy components

“What kind of systems/components can be used to create an energy neutral building?”

In this chapter the different potential energy components are explored, this can be used to transform an ERA flat into an energy neutral building. This chapter is ordered by the trais energetica (location, reduce, reuse and produce) combined with the different energy flows (building related, building-use related and user related). The 0-scenario table will be used to calculate the potential energy reduction. This chapter does not strive to give a complete overview of every technique that is available for reducing, reusing or producing energy in the building environment. What it does try to be is a more specified catalog of tools, components and products that can be used to renovate an energy neutral ERA flat in occupied state. The components are therefore selected on their capacity to be used in a renovation in occupied state and are able to be integrated with the already existing ERA system. Every component will therefore, similar to the structural interventions, be evaluated on its influence on the criteria defined in the research question; energy efficiency, living comfort, executability in occupied state. This evaluation was done based on available information and when no sufficient information was available on own judgment.

Location Opportunities and features of the location are of course project specific features and are therefore only applicable to the ERA-1 project. Nevertheless will it demonstrated what location specific features could contribute to a more sustainable building.

Local waste heat In urban environments it is highly possible that nearby buildings, e.g. factories or supermarkets, produce waste heat, this exhaust heat can be used for heating nearby buildings. Unfortunately there are no facilities near the ERA-1 that produce waste heat. However, there are other potentials near the project location that could be used to power the project. On the west side of the location is the A16, the ring-high way of Rotterdam. A highway can be used to produce electricity by the use of piezo electric generators (Innowattech 2013). But cost/return rates of this technology are not yet beneficial enough (Weegen 2012).

Local bio fuel production On the east side of the project there is a horse stable with the capacity of 110 horses. According to Edström (2011) horse manure, in combination with e.g. wood, can be used to power a bio gas boiler. Inside the project boundaries there is 2.6 ha of forest. Because forest patches, especially in urban areas, need to be maintained they produce waste wood in the form of pruning. This wood could potentially be used in combination with the horse manure. Elaborate calculations on the bio gas boiler are shown in the eponymous paragraph.

<table>
<thead>
<tr>
<th>Chapter guide</th>
<th>Reduce</th>
<th>Reuse</th>
<th>Produce</th>
</tr>
</thead>
<tbody>
<tr>
<td>building related</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>building use related</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>user related</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reduce Building related

The building related energy usage consists of the energy needed for the heating of the dwelling, of tapwater and the energy needed for ventilation. The heat load, the amount of heat needed to maintain a certain temperature inside the dwelling, is the most significant contributor to the building related energy usage (93%). Reducing the heat load would therefore be the most important thing to start with when creating an energy neutral ERA flat.
### Table 4.4  
Transmission losses of a single standard dwelling

<table>
<thead>
<tr>
<th>transparent/non-transparent ratio</th>
<th>type of facade intervention</th>
<th>kWh/year/m²</th>
<th>kWh/year/m²</th>
<th>kWh/year/m²</th>
<th>kWh/year/m²</th>
</tr>
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<tbody>
<tr>
<td>B 80/20 G 50/50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B 80/20 G 20/80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B 70/30 G 20/80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B 60/40 G 20/80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| B: transparent/non-transparent ratio balcony facade |
| G: transparent/non-transparent ratio gallery facade |
| Rc: Rc value m²K/W |
| U: U value W/m²K |
| I: Infiltration dm³/m²/s |
| NV: Natural ventilation |
| BV: Balanced ventilation (90% heat recovery) |
| HL: Heat load (energy that is needed for heating) |
| CL: Cooling load (energy that is needed for cooling) |

### assumptions:
- **dwelling type**: standard (2 out facing facades)
- **usages**: 16 hour/day
- **design temperature**: 20°C
- **overhang balcony/gallery**: 1,45 m
Insulating gallery and balcony facade

As pointed out before, the existing facade has very poor insulating qualities (Rc 1.8 and U 5) that need to be improved if we want to achieve the goal of an energy neutral building. Although it seems that more insulation will decrease the energy demand according to Keller (1997), there is an optimum. This has to do with the fact that a highly insulated dwelling can get overheated on a hot summer day. Caution is needed when insulating a dwelling as the cooling load may increase. And taking into account the almost undeniable climate changes, the temperatures in temperate climate zones like Holland are bound to rise. To reduce the amount of solar gain, without using a lesser insulating facade, solar shading can be used to obstruct unwanted solar radiation from entering the building. An ERA flat is already equipped with a static solar shading because of the balcony and gallery slabs. Depending on the type of renovation extra shading could be needed. The insulating properties of a facade are influenced by multiple factors, insulating value and thickness of facade materials, transparent/non-transparent ratio of the facade (although there are types of glazing with high insulating properties, these are still a factor 10 less insulating than non-transparent facade parts), type and placement of solar shading and the infiltration factor of the facade (Huijbers and Dobbelsteen 2012).

Table 4.4 shows the transmission and infiltration losses for a variety of scenarios, the second table (4.5) includes the cooling load and the losses due to ventilation. The tables are calculated on an estimated "normal" usages, of a standard dwelling (2 outfacing facades), actual usages could differ depending on the resident. According to the table, the combination of a new facade with Rc 8; U 1; I 0.15 and a balance ventilation results in the most favorable energy consumption. The difference with the 0-scenario is displayed in table 3.7 on the right. However, in a conversation with Patrick Koch Advisor, Energy and Sustainability at Heijmans Real estate and Housing, it came forward that insulating higher than Rc 5 at this moment is the economic tipping point. Taking this into account together with the fact that an ERA dwelling needs a large percentage of its outfacing facade to be glass it becomes clear that a facade with a lower Rc but a higher U (with the use of triple glazing) would be much more efficient for an ERA flat.

Energy efficiency: very high influence, 52% total energy reduction
Living comfort: Replacing the facade with a better insulated one will give a more stable indoor climate, increasing the living comfort.
Executability in occupied state: according to Mark Spee a well prefabricated facade can be placed in one day.

Insulating roof, end facade and elevator hall facade

Although only 20% of the dwelling has a 3th or 4th outfacing facade, these dwellings can significantly influence the total energy consumption. Insulation of these facades is crucial for achieving a more energy efficient building. As shown in diagram 4.1 (p.77) the difference in energy consumption between a standard dwelling and a dwelling with 3 or 4 outfacing facades is on average 1.5 times larger. When insulating the gallery and balcony facade this difference will increase drastically. Apart from using conventional materials to insulate the roof and end facades, a green facade could be used. The advantage of a green facade, apart from its high insulat-
The dimensioning of the circulation system (the pipes that circulated water through the ground) depends on the type. The main types are a horizontal and a vertical system. In a horizontal system the pipes are laid like a mat at a depth of 1 - 1.5 m below the surface. In a vertical system bore holes are drilled with a depth between the 20 - 100 m (Huijbers, 2012). For the vertical system it can be chosen to use either autonomous probes or energy piles (load bearing piles with integrated circulation system).

The system choice depends on the geological and spatial characteristics of the location, the needed capacity and the investment budget. To give an idea of the needed dimensions a calculation was made for the ERA-1 (700 kW) with the use of a vertical circulation.

The extracted power depends on the type of soil, for this calculation an average of 50 W/m was chosen, the COP depends on the type of heat pump and drilling depth, which was estimated to be 4. This leads to the following calculation:
This would mean that this system would need 175 piles of 60 m depth. The pile need to be at least 6 meter apart from each other leading to a minimum needed area of 80 x 80 m = 6400 m²
When energy piles are used they could be combined with the construction of additional functions like a community center or a parking.

Energy efficiency: very high influence, 63% total energy reduction
Living comfort: a heat pump is mostly combined with a low temperature heating which increase the comfort.
Executability in occupied state: the majority of the installation will be constructed on the ground floor, however depending on the distribution system it could become less feasible to executed in occupied state.

Ventilation
Ventilation is a vital component of the climate system, not only because it provides fresh air for the dwelling but even more because when doing so it can influence the heat load drastically. Fresh air lead in directly from outside, especially in the colder months it causes enormous temperature drops.

Solar preheating
A passive solar heater or conservatory can be used to pre heat cold outside air. The air is guided through the passive solar heater in which it is heated by the power of the sun. Although such a system is an interesting low tech solution, it depends much on direct sunlight. For this reason these kinds of systems always need a backup. A construct like this could reduce the ventilation losses with 40% (Huijbers, 2012). The downside of this system it relies solely on direct sunlight, which means that on a cloudy winter day a backup system is needed

Energy efficiency: reasonable efficient, it does reduce the total energy demand by 12%
Living comfort: preheating of the ventilation reduces the amount of discomfort which can be experienced during the winter when cold air is led directly into the dwelling
Executability in occupied state: Possible in occupied state although it does require interventions behind the climate facade but this only concerns adjustments to the ceiling.

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<th>new</th>
<th>R</th>
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<td></td>
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<td></td>
</tr>
<tr>
<td>UREU</td>
<td>2600</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.8 reduction table solar pre heating ventilation air

Replace
building-use related

Replacing elevators
Replacement of the elevators and their engines and control systems could lead to a reduction of 40.080 kWh/year/complex, which is a 55% reduction of the elevator energy consumption and a 9% reduction of the total independent building related energy usages.
Replacing the elevator will cost around 75,000 euro per elevator (Nagtegaal, 2011).

Replacing public lighting
Replacing the existing lighting by more energy efficient led lighting could lead to an energy reduction of 48,000 kWh/year for the complex or 77 kWh/year per dwelling which is a 12% reduction on the total independent building related energy usages (Nagtegaal, 2011).

Altogether, the potential reduction when replacing the elevators and lighting could be 88,080 kWh per year which is 21% of the yearly independent building related energy usages. However, when additional vertical access points are added to the building this reduction will be diminished.

Energy efficiency: Not very efficient, it does only reduce the total amount by 0.5 percent
Living comfort: Replacing the elevators will increase the quality of the flat.
Executability in occupied state: Possible in occupied stated as it does not require an intervention behind the climate facade, but does require an additional or backup vertical access point.

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<th>R</th>
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<td>(kWh)</td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>659</td>
<td>518</td>
<td>21</td>
</tr>
<tr>
<td>UREU</td>
<td>2600</td>
<td>2210</td>
<td>15</td>
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Table 4.9 reduction table replacing elevator and public lighting

<table>
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<th>R</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(kWh)</td>
<td>(kWh)</td>
<td>%</td>
</tr>
<tr>
<td>BREU</td>
<td>23668</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BUREU</td>
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<td></td>
</tr>
<tr>
<td>UREU</td>
<td>2600</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.10 reduction table User related reduction measurements

After the energy needed for heating the dwelling, the user related energy usages, home equipment and lighting inside the dwelling, are the largest components of the 0-scenario. The resident or user is a very uncontrollable component in a dwelling climate system as it is difficult and undesirable to interfere in peoples lives. This not only counts for the above mentioned user related energy usage but also for the building related energy usage. Nevertheless there are solutions which could help reduce the usage behaviour of the residents. In the report Rigoures by DHV (SenterNovem, 2009) multiple solutions are given for reducing the user related energy usage.

Standby killers
Standby killers can be installed between the home equipment and the power sockets. They prevent equipment from remaining in standby modus, resulting in reduction of the energy usage. Especially audio, video and communicational equipment have a high usage due to standby modus, but with the use of standby killers this can be reduced with 30% The advantages of standby killers is their minimal interference with the residents lifestyle.

Home Energy Managers (HEM)
The use of a HEM can have a profound effect on the residents energy usage. Smart meter do not actually actively intervene but provide residents with information about their usage. This does not only effect the user related energy usage but also the heating component of the building related usage. Experience have shown that the use of smart meter can decrease the user related energy consumption with 10-15% (Nagtegaal, 2011).

Installation of hotfill connection
Some home equipment, like a dishwasher and a washing machine,
require heated water and produce this by means of an inefficient electric boiler. By connecting these equipments to an efficient warm tap water system a 19-33% reduction on the user related energy usage can be achieved.

**Education**

If residents do not know, they will not do it. Educating the residents on how to use their dwelling in an energy efficient way is a very important issue. This not only applies for the user related energy usage but also for the building related energy usage. If a resident for example naturally ventilates when a balance ventilation is installed it would end up costing more energy.

According to SenterNovem (2009) these measurements could lead to a overall reduction of 15% on the user related energy consumption.

**Energy efficiency:** Not very efficient, it does only reduce the total amount by 1,5 percent  
**Living comfort:** Intervening with the resident lifestyle is always a difficult problem and could badly influence the living comfort.  
**Executability in occupied state:** Possible in occupied state, although it does require (small) interventions behind the climate facade.

### Ventilation

**Heat recovery**

To over reduce the ventilation losses a mechanical ventilation with heat recovery could be installed. Heat is extracted for the exhaust and used to heat the incoming fresh air. Such a system can be installed centralized (a single machine serving the whole building) or decentralized (every dwelling has it’s own machine). The advantages of a decentralized system is that is reduces the amount of ducts that need to be installed. A ventilation with heat recovery is most efficient with low air speeds (1 m/s) and needs therefor significant larger ducts. Because research deals with and renovation the decentralized system would be the most feasible both because it reduces the amount of air ducts needed and because the system can be installed per dwelling giving more freedom in the renovation process. Most common decentralized system work with a air treatment unit (1,5x1x0,5m) which can be placed behind e.g. a lowered ceiling in the toilet. This still requires air ducts the guide fresh air for the facade to the unit after which it’s heated and distributed. Another solution is to place autonomous units in the facade. The Provent D-Luxe is such a system where autonomous units which have a heat exchanger inside are placed in the facade (Profel, 2013), advantages of this system is that it can be control per room and it does not requier additional ducts. Disadvantages are that in the kitchen, bathroom and toilet there still needs to be a mechanical ventilation of which the waste heat is no reused. The heat recovery of the centralized and the decentralized with a single unit can be 90% (Huijbers, 2012). The Provent D-Luxe has a heat recovery of 70% (Profel, 2013). Heat recovery systems can be used with a controlled in led (balanced ventilation) resulting in an higher efficiency. The possible reduction is, combined with the transmission and infiltration losses, is calculated in table 3.6.
Exhaust air / water heat pump

The exhaust heat can also be used in a different way, by means of a heat pump system which extracts heat from the exhaust air of the dwelling. The recovered heat can be used especially for warm tap water. This system will not work if a balanced ventilation installed because the heat from the exhaust air is the already being harvested by the ventilation system. The COP of such a system is 3 (Huijbers, 2012).

**Energy efficiency:** considerable efficient, it does reduce the total energy demand by 22% (heat recovery)

**Living comfort:** heat recovery of the ventilation reduces the amount of discomfort which can be experienced during the winter when cold air is led directly into the dwelling

**Executability in occupied state:** Possible in occupied state although it does require interventions behind the climate facade but this only concerns adjustments to the ceiling.

### Heat recovery shower

The shower is responsible for 90% of the daily (heated) tap water usages (see appendix D). Using a heat recovery in the shower could therefore establish a 36% reduction of the total energy usages needed for tap water. There are two conventional ways of implementing a heat recovery system in the shower, firstly, there is the “pipe” system and secondly, there is the shower base system (Nagtegaal, 2011). Because of the flat typology the shower base system is the most feasible for an ERA flat. A special base is installed in the shower through which the shower water is pumped and thereby pre-heated by the wast water. It has to be noted that some of the residents, particularly the elderly residents, complained about the existing shower base which they would rather have replaced by a single drain.

**Energy efficiency:** Not very efficient, it does only reduce the total amount by 2,5 percent

**Living comfort:** Dependson the preferences of the resident (if he preference a shower base or not)

**Executability in occupied state:** Possible in occupied state although it does require interventions behind the climate facade.

### Produce warm water

Although the reducing and reusing interventions could reduce the needed energy significantly, there still remains a certain amount of energy that needs to be produced to create an energy neutral ERA flat. Production possibilities are greatly influenced by the location and therefore are the following possibilities bound to the ERA-1 location. Nevertheless, some of these elements could also be implemented at other ERA projects. The production table will serve as the indication how much and what kind of energy can be potentially created. The problem with the production of energy, when it comes to (gallery) flats, is the low amount of roof and suitable facade space.

Production of energy can roughly speaking be done in two ways; by heating water and using that for either tap water or space heating (biomass boiler and solar collector) or by directly producing electricity (PV panels and windmills).
Biomass Boiler
As a possible replacement of the boilers inside the dwellings providing tap water, a biomass boiler fueled with horse manure from the nearby horse stable combined with the prunings of the greenery maintenance could be implemented. The use of horse manure as fuel for a biomass boiler is a new development. Edström (2011) points out that horse manure is suitable as a combustion fuel for a biomass boiler. The energy value of horse manure depends on the moist content and the type of bedding that is used in the stables. As the manure is inseparable mixed with the bedding material, the amount and type of bedding influences the energy value. Typical bedding types are straw, peat or wood shavings. The amount of manure and bedding that a horse produces can vary between 9 m3 and 28 m3 per year (Edström, Schüßler et al. 2011). For the calculation of the energy potential of the horse stable on the location an average of 14 kg per day per horse (excluding bedding) was estimated. The bedding material was determined as straw. The high energy value of this type of bedding in combination with the horse manure is 20 MJ/kg dry (Edström, Schüßler et al. 2011). As the moist content is estimated at 70%, a horse will have a daily energy production of:

\[ 14 \text{ kg} \times 0.3 \times 20 = 84 \text{ MJ per day} \]

Horse stable “de Prinsenmolen” houses 110 horses. This equivalents an energy potential of 9240 MJ per day.

Edström (2011) also points out that a biomass boiler can not run solely on horse manure, due to the high moister content. First drying the manure will result in loss of caloric value due to aerobic reactions. The problem can be solved by burning the manure together with a certain amount of woodchips. Pruning of forest maintenance equals 45.6 GJ/ha/year (bron nog krijgen van siebe) The project area has 2.6 ha of forest. This means that the annual energy potential from the pruning equals:

\[ 2.6 \times 45.6 = 118560 \text{ MJ} \]

Resulting in a total amount of biomass energy being available:

Ebiomass = 9240 * 356 + 118560 = 3472 GJ / 964444 kWh

Although this sounds promising there are a few problems that need to be solved by design to make this system suitable. Firstly, there is the problem that such a system needs a constant water circulation. Secondly, there is the necessity of having a back up system. The biomass boiler relies on a daily input of manure and woodchips, if for some reason these products would not be available (closing of the horse stable, change in regulations) the complex would end up having no tap water. The question is if that risk is significant enough to install a costly gas fueled back up system.

Energy efficiency: is not seasonal dependent
Living comfort: no influence
Executability in occupied state: possible in occupied state

Table 4.13 production table biomass boiler
Thermal solar collector
A thermal solar collector harvest the power of the sun by heating up water which can be used for space heating or warm tap water. The principle concept is a heat absorbing plate which is heated up by solar radiation, which in turn radiates this heat to tube with flowing water. The heated water is then transported to a storage container from which the warm water can be extracted for warm tap water or space heating. If necessary the water can be reprocessed by a heat pump to achieve the desired temperature. The optimum placement of a solar collector is facing south on an angle of 40°. However, Huijbers (2012) argues that a solar collector is more efficient when placed on a wall (90°) because although it then does not reach its maximum yield, it does generate more hot water during winter and autumn then when placed on a 40° angle.

There are various different types of thermal solar collectors; flat plate collector, evacuated tube collector, energy roof, asphalt collector, wall heat collector. The choice for a system depends on the required output temperature, maximum annual yield and integration possibilities (Huijbers, 2012). For the renovation of an ERA flat, the first two systems are the most feasible because those types consist of separate modules whereas the energy roof, asphalt and wall heat collector are an integrated part of structural building parts.

Flat plate collector
A flat plate collector is the most basic form of a solar collector, various types exist with or without glass, different absorbing materials, and size. The most significant disadvantage of a flat plate collector is the possible output temperature, which is a result of heat loss. The higher the insulation the higher the output temperature. Although a flat plate collector is less expensive than an evacuated tube collector, the output temperature of an evacuated tube collector is much higher which makes it more suitable for e.g. warm tap water (65°C) (Huijbers, 2012).

Evacuated tube collector
The evacuated tube collector consist of two tubes which are pushed into each other, the outer tube is made of glass where the inner tube is the heat pipe. This pipe is made of a solar heat absorbing copper tube filled with a vapor-liquid mixture. Between the two tubes there is a vacuum which provides a maximum insulation. Addition of a special coating enables the absorption of diffuse light. This makes a evacuated tube collector especially useful in tempered climates like the Netherlands (Huijbers, 2012). The predicted annual yield of such a system is 589 kWh/m² for a area of 5 m² with a maximum output temperature of 272°C (Linuo Ritter, 2013).

Energy efficiency: seasonal dependent however it is capable of producing high temperature water
Living comfort: negative effect when placed on the facade (reduction of daylight)
Executability in occupied state: possible in occupied state
PV cells

A certain amount of electricity needs to be generated to provide power for user-related activities; electrical equipment, lightning, cooking as for building related systems; heat pump, elevators, lighting. In fact, the electricity demand is expected to increase as the gas boiler for space heating is replaced with an electrical powered heat pump and the installation of a mechanical ventilation. Roof space is the most suitable place for the placement of PV cells, however the typology of a flat has little actual roof space per dwelling. 13 stories high means every dwelling has 1/13 of their floor space in roof space. The next most suitable facade is the south followed by the west and east facade. The angle and direction in which the PV cells are placed influence the efficiency of PV cells. The average annual yield of PV cells in The Netherlands is assumed to be 100 kWh/m²/year (Huijbers, 2012).

<table>
<thead>
<tr>
<th></th>
<th>total surface</th>
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<th>angle</th>
<th>efficiency factor</th>
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Table 4.15 shows 4 possible arrangements of PV cells on the target project (ERA-1). The first one is the maximum possible yield, all facades are totally covered in PV cells which have the optimal angle (36°). Such a situation is highly unlikely as it would obstructed sunlight from entering the dwellings. A more feasible arrangement would be that 50% of the south, east and west facade would be covered with PV cells. Placing the PV cells on an angle of 36° has a profound impact on the architectural appearance of the building. This angle implies that the PV cells on the vertical facades have to be placed on an autonomous supporting system which is added to the facade. If this is not preferred the cells could be placed vertically, integrated with the facade elements (both transparent and non-transparent). The latter solution will decrease the efficiency of the PV cells as shown in the last two tables of table 4.15.

In terms of distribution and storage of electricity there are 2 main types of systems, an autonomous and a grid connected system. An autonomous system storages its energy in batteries, which means that when the batteries are full the system stops producing electricity, therefore an autonomous systems has an average annual yield of only 40 kWh. An autonomous system is therefore only interesting when used in a remote location. The grid connected system supplies the produced electricity to the existing electricity net, and subtracts electricity when needed. In this way the problem of peak moments and dissimilar generation (sun does not shine at night) is avoided (Engineering-online, 2009). Current Dutch law restrains the process of salderen (the supplied electricity is subtracted from the electricity usage without extra costs) with a maximum of 5000 kWh per small user per year. In the case of an ERA flat this exception does not apply as the whole building is seen as a cooperative larger user. This means that the subtracted electricity costs more than what is received from the supplied energy. However current regulations for cooperative decentralized electricity production are inconclusive. At this moment new regulations are created and implemented to create more opportunities for cooperative electricity production (Agentschap NL, 2012).

Energy efficiency: Does only work when the sun shines and there is the problem of dissynchronized production
Living comfort: negative effect when placed on the facade (reduction of daylight)
Executability in occupied state: depending on way of placement

Wind mill
Generally windmills are unpreferable for utilization in urban environments due to the high noise production. However, a new type of windmill is now being prototyped by Heijmans. The IRWES is a windmill which is especially suitable for placement on the roof of higher residential or office buildings. A 6 x 6 m prototype on th roof of the Heijmans office in Rosmale is expected to produce 25.00 kWh/year. A prototype placed on the ERA-1 is due to higher wind velocities in Rotterdam expected to produce between the 50.000 and 75.000 kWh/year. A single ERA flat can support 6 IRWES windmills, resulting in an annual production of 300.000 - 450.000 kWh. If these expectations are correct then placing 6 IRWES' on the roof would ensure sufficient production of electricity.
### REDUCE

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</tr>
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<tr>
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### PRODUCE

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<td><strong>PV CELL ON ROOF AND SOUTH FACADE</strong></td>
<td>2366</td>
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The conclusion of the previous chapter (textbox p. 97) gives an overview of multiple feasible components which can be used to create an energy neutral ERA flat. However, these components can be combined in different systems, a combination that is very project specific. To proof that a energy neutral ERA flat can be created with these components, this will chapter will elaborate on the energy system which was chosen for the thesis design. The thesis design involves a sustainable renovation of the target project (ERA-1) into an energy neutral building. The energy demand will be stated in terms of the whole ERA-1 complex (624 dwellings). As stated in the beginning of this theme (diagram 4.1 p 77) an ERA flat has different energetic dwellings because of the number and type of outfacing facades per dwelling. In the calculation of the single energy components performances the standard dwelling (1) was always used, however when considering the whole ERA-1 complex the other types need to be taken in account. The differences between the dwellings only occur in their heat load, the other aspects are similar to the standard dwelling. The difference in heat load was calculated by the use of factor compared to the standard dwelling. This factor was extracted using the official energy labels created for these dwellings (Vastgoedteam BV, 2008).

With the output of table 5.1 the 0 -scenario was updated (table 5.2) This 0 -scenario will be the measurement tool of the proposed energy neutral renovation. The proposed energy system will be explained by a couple of figures illustrating the different interventions preformed on the ERA-1, every figure has a table included which displays the effect of an intervention.

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<table>
<thead>
<tr>
<th>Type of dwelling</th>
<th>Number</th>
<th>Factor</th>
<th>heat load</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>352</td>
<td>1</td>
<td>7783072</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>1,9</td>
<td>336087</td>
</tr>
<tr>
<td>3</td>
<td>32</td>
<td>1,7</td>
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</tr>
<tr>
<td>4</td>
<td>8</td>
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</tr>
<tr>
<td>5</td>
<td>88</td>
<td>1,1</td>
<td>2140344</td>
</tr>
<tr>
<td>6</td>
<td>8</td>
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</tr>
<tr>
<td>7</td>
<td>32</td>
<td>1,3</td>
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</tr>
<tr>
<td>8</td>
<td>8</td>
<td>1,4</td>
<td>247643</td>
</tr>
<tr>
<td>9</td>
<td>88</td>
<td>1,2</td>
<td>2334921</td>
</tr>
<tr>
<td>total</td>
<td>624</td>
<td>15530763</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>p/d</th>
<th>0 scenario (kWh)</th>
<th>new scenario (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BREU</td>
<td>24888</td>
<td></td>
</tr>
<tr>
<td>BUREU</td>
<td>659</td>
<td></td>
</tr>
<tr>
<td>UREU</td>
<td>2600</td>
<td></td>
</tr>
</tbody>
</table>

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With the output of table 5.1 the 0 -scenario was updated (table 5.2) This 0 -scenario will be the measurement tool of the proposed energy neutral renovation. The proposed energy system will be explained by a couple of figures illustrating the different interventions preformed on the ERA-1, every figure has a table included which displays the effect of an intervention.

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figure 5.1 Replacing the facade
100

heat pump for tap water

solar collector

1.5 m x 2.0 m

collector tank (400L)

balance ventilation with heat recovery

figure 5.2 warm water system

<table>
<thead>
<tr>
<th>p/d</th>
<th>0 scenario (kWh)</th>
<th>new scenario (kWh)</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>BREU</td>
<td>24888</td>
<td>6473</td>
<td>73</td>
</tr>
<tr>
<td>BUREU</td>
<td>659</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UREU</td>
<td>2600</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

figure 5.3 ventilation system

<table>
<thead>
<tr>
<th>p/d</th>
<th>0 scenario (kWh)</th>
<th>new scenario (kWh)</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>BREU</td>
<td>24888</td>
<td>248</td>
<td>99</td>
</tr>
<tr>
<td>BUREU</td>
<td>659</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UREU</td>
<td>2600</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Heat distribution system is integrated in new facade.

Heated water from biomass boiler can be used in winter.

**Figure 5.4** Additional heating system and distribution

<table>
<thead>
<tr>
<th>p/d</th>
<th>0 scenario (kWh)</th>
<th>new scenario (kWh)</th>
<th>R %</th>
</tr>
</thead>
<tbody>
<tr>
<td>BREU</td>
<td>24 888</td>
<td>-1 297</td>
<td>105</td>
</tr>
<tr>
<td>BUREU</td>
<td>659</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>UREU</td>
<td>2 600</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

**Figure 5.5** Placement of IRWES units on roof
Figure 5.6: Adding PV cells on top of the IRWES units

<table>
<thead>
<tr>
<th>p/d</th>
<th>0 scenario (kWh)</th>
<th>new scenario (kWh)</th>
<th>R (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BREU</td>
<td>24888</td>
<td>-1297</td>
<td>105</td>
</tr>
<tr>
<td>BUREU</td>
<td>659</td>
<td>-250</td>
<td>130</td>
</tr>
<tr>
<td>UREU</td>
<td>2600</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>
Conclusions & Recommendations
In this thesis an answer was sought for the following research question:

What are the design principles for renovating an occupied ERA-gallery flat to an energy neutral building of modern standards and adjust the dwellings to the demands of (future) target groups?

The answer to this question has taken form a list of design principles and design rules which can be used for the design of a sustainable renovation of ERA gallery flat in occupied state. The conclusion is structured by the subquestions of the research question.

“What are the architectural characteristics of an ERA flat?”

- repetition
- prefab elements
- flexible floor plan
- horizontal articulated facade
- rationality and industrialization

“What are the problems, imperfections of ERA flat?”

Embedding in the urban plan
- ground level design
- plinth
- entrance area

Building
- entrance hall
- elevators
- gallery
- anonymity of the facade
- low social cohesion

Dwelling
- insulating properties facade
- interior arrangement and finishing
- balcony dimensions

Social cohesion

some problem like noise nuisance, littering in public places and other irritations can be prevented by a better social cohesion.

architecture cannot force people to get along, but it can create the opportunity to get to know each other.

- the ERA flat should have a public place suitable for community activities.
“Who are the existing residents?”

- **55+**: 17%
- **30-55**: 38%
- **18-30**: 45%

existing resident groups:
(categorized by age, household type and income)

**Age 18 - 30**
- **starters** 1 - 2 person households

**Age 30 - 55**
- **low income** 1 - 2 person households
  - low income family
  - single parents households
- **middle income** 1 - 2 person households
- **high income** 1 - 2 person household

**Age 55+**
- **low income** 1 - 2 person households
- **middle income** 1 - 2 person households

“Which aspects/elements are being valued/devalued in the existing building?”

- + view
- + balcony
- + green environment
- + large living room
- + daylight
- + visual connection front and back dwelling
- + no stairs in dwelling
- - bathroom
- - kitchen
- - noise nuisance
- - outdated finishing
- - balcony
- - interior arrangement
- - low insulation
- - outdated boiler
- - dwelling size
“What are the wishes of the residents concerning their building/dwelling?”

- more energy efficient dwelling  55%
- large bathroom    48%
- large balcony (more depth)  42%
- new kitchen (equipment and finishing)  39%
- less sound nuisance   32%
- larger kitchen    23%

“What are the best (future) target groups?”

Age 18 - 30

 starters  1 - 2 person households   +++

Age 30 - 55

 low income 1 - 2 person households   +++
 low income family  +
 single parents households  ++
 middle income 1 - 2 person households  +

Age 55+

 low income 1 - 2 person households   +++
 middle income 1 - 2 person households  ++

+++  no adaptations required
++  few adaptations required
+   many adaptations required
“What is the existing structure of an ERA flat?”

- Cantilever with possible load 3000 + 800 kg
- 180 mm insitu casted concrete floors and walls
- Prefabricated wooden frame facade (weight: 1400 kg per dwelling)
- Prefab rib-floor
- In-situ casted elevator shaft with 2 elevators
- Emergency stairs serves shafts
- Vertical access point
- Gallery facade
- Gallery slabs
- Driveways + 1 vertical access point

“What are possible structural interventions which would increase the energy efficiency and/or living comfort of an ERA flat?”

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Energy Efficiency</th>
<th>Living Comfort</th>
<th>Occupied State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enlarging balcony and gallery slabs</td>
<td>+</td>
<td>++</td>
<td></td>
</tr>
<tr>
<td>Second facade</td>
<td>++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Additional structure balcony side</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Vertical connection dwellings</td>
<td>+++</td>
<td>+++</td>
<td>-</td>
</tr>
<tr>
<td>Horizontal connection dwellings</td>
<td>+++</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Additional vertical access points</td>
<td>++</td>
<td></td>
<td>+++</td>
</tr>
</tbody>
</table>
“What are the existing energy related building components and how do they perform?”

Building related energy usages kWh/year
Heating
- facade insulation $R_c = 2$, $U = 5$
- facade infiltration $q_{v,10} = 2.15$
- natural ventilation
- CV system on gas
Tapwater
- gas boiler (no

Building-use related energy usages 659
Elevator
public lighting

“What is the current energy consumption of an ERA?”

<table>
<thead>
<tr>
<th>Type related</th>
<th>building related</th>
<th>building use related</th>
<th>user related</th>
</tr>
</thead>
<tbody>
<tr>
<td>kWh/year</td>
<td>20625</td>
<td>659</td>
<td>2600</td>
</tr>
<tr>
<td>% of total</td>
<td>88%</td>
<td>2.5%</td>
<td>9.5%</td>
</tr>
</tbody>
</table>

“How does one created a energy neutral building?”

- define energy flows
- apply trias energetica

remaining demand that needs to be generated using sustain:...
Table: Systems/Components and Their Impact on Energy Efficiency

<table>
<thead>
<tr>
<th>System/Component</th>
<th>REUSE</th>
<th>PRODUCE</th>
<th>REDUCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass boiler</td>
<td>Heat recovery shower</td>
<td>Heat pump</td>
<td>Heat recovery ventilation air-water</td>
</tr>
<tr>
<td>Heat recovery ventilation</td>
<td>User related measures</td>
<td>Replacing public lighting</td>
<td>Replace elevators</td>
</tr>
<tr>
<td>Heat recovery shower</td>
<td>Solar preheating ventilation</td>
<td>Ground - water heat pump</td>
<td>New facade - SCU 0.6 10.15</td>
</tr>
<tr>
<td>Solar collector (evacuated tube collector)</td>
<td>PV cell on roof and south facade</td>
<td>Ground - water heat pump</td>
<td></td>
</tr>
<tr>
<td>Biomass boiler</td>
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<td>New facade - SCU 0.6 10.15</td>
</tr>
</tbody>
</table>

What kind of systems/components can be used to create an energy neutral ERA flat?
On top of the provided recommendations which are given per theme, I would like to add some additional recommendations for those who want to start a similar research or want to continue this line of research.

framework
To enforce and exploit the concept of the modular system with which gallery flats are build, an additional research in the potential difference should be done. This could be done by comparing multiple project of the same system and relief their non-similarities.

survey
The most significant problem of the resident survey was the low respond rate (6%). This low rate is probably the result of the fact that no second mailing was done. According to literature an anonymous survey distributed by mail, with a second mailing has an average respond rate of 15%. Also the survey could be done at multiple locations. In this way location specific aspect could be recognized. The questions in the survey were mainly about the scale of the dwelling, additional research could be done on the experience of the building and the urban environment.

feasibility
An important part that was excluded from this research due to lack of time is the economic aspect of the intervention. Introducing the factor of economics would create a better argument to decided between interventions. For example, a energy related component could be better judged of the payback time could be established. And different techniques could be compared in a more realistic way.
Reflection
At the start of my graduation my goal was to understand all the different aspects which are involved in a sustainable transformation/renovation of an existing building and create a design which would respect and satisfy all these different aspects. I wanted to create a design which would appear to be a “real” project instead of an academic exercise. This directly shows the link between my thesis research and my thesis design. The research was used to understand the different aspects (e.g. architecture, the residents, building process, building technology and economics) and translate them in design principles. These design principles were then used and evaluated during the creation of my thesis design. Due to the fact that the research and the thesis design were done simultaneously, the actual workflow turned out to be a bit more chaotic.

Research

The aim of the research was to map the different aspects involved in the sustainable transformation of an existing building and create generic design principles which could be used when designing a sustainable transformation of an existing building. The framework of the research was provided by a personal fascination, gallery flats. During the beginning of my research this framework was more specified by the choice of a specific type of gallery flat, the ERA flat. The following research question was formed for the research: What are the design principles for renovating a occupied ERA-gallery flat to an energy neutral building of modern standards and adjust the dwellings to the demands of (future) target groups?

This question incorporates the different aspects which were to be analyzed and mapped.

- Building process (occupied state)
- Building technology (energy neutral)
- Architecture (modern standards)
- The residents (demands of future target groups)

In the beginning of the process the research question also contained a specific part concerning the (economic) feasibility of the project. This aspect was later in the process abandoned due to time which was reserved for the research.

The main problem during the research was my attempt to create generic design principles which would apply for all the ERA flats. The wrong assumption in this problem is the fact that the ERA system is a generic system, which means that all the flats produced by this system are to some extent identical. The fact that they are identical to some extent is the key to this problem. As a target project the ERA-1 was chosen for reasons which not involve its relation with other ERA flats. Unfortunately, the ERA-1 is actually the most “un-identical” of all the ERA flats. This discrepancy resulted in a struggle between trying to extrapolate certain findings which derived from the ERA-1 to all the ERA flats. But the lack of knowledge about the other ERA flats forced me in the vague area of assumptions.
Nevertheless, I dare to say that most of the design principles are, with some adaption, extrapolatable to all the ERA flat.

The second difficulty I experienced during the research was the tension between objective concluding from my research results and the more subjective concluding which followed from my design process. The aim of the research was to establish design principles which could be seen as a program of requirements for a renovation of an ERA gallery flat. However, because the research and design were performed simultaneously, many of the research results were intentionally or unintentionally evaluated in the design process resulting in adaptation of the principle. This resulted in argumentation problems when writing my thesis as some aspects of certain design principles did not purely derive from the research and therefore lacked argumentation. This probably would have been less of a problem if I had incorporated “research and design” in my methodology. However, this would make my research less objective.

From research to design

The principles which derived from the research were nearly all incorporated in the design. This is also a result from fact that to a great extent the research and design were done simultaneously. Therefore some of the design principles did not purely derive from objective analysis but rather from a more iterative process between research and testing the findings through design. Salient differences can be found on a more detailed level. This is not surprising as the research strives for a more generic answer whereas the design project is the more specific elaboration.

The initial energy concept proposed by the research turned out to be less usable than expected. This is probably the result of the fact that the energy concept in the research was composed using numeric input (e.g. energy consumption, façade area and sun hours) while the actual implementation of the energy concepts by design revealed some major flaws. On top of that, I had multiple expert meetings, after the research took its final form, in which discrepancies between my research and reality became clear. The energy concept was there for adjusted (in the thesis) during the final stage of my graduation.

Another discrepancy between research and design manifested itself in the philosophy of the ERA flat. As explained in my research the ERA flats are designed in the philosophy of Habraken who proclaims a decoupling between different systems of a building. This should result in a flexible interior in which every type of resident could manifest him- or herself. On the other hand, the research defines certain target groups and maps their preferences. So the question arose, how to transform the dwelling in a more specific dwelling without eroding its ability to be any dwelling.

Process

My graduation studio Explore lab is a lab which is coordinated for and by the students. I could pursue my own fascination without limitation of a studio philosophy. This freedom is both the strength and the weakness of Explore Lab. Its strength is evident, however the same absence of imposed structure from above which is Explore...
Labs strength can cause loss of focus and delay of the graduation process. Although it accounts for only 11 ects or 20% of the graduation, the research has a heavy focus in Explore Lab. It is therefore not surprising that my research evolved in a 100+ pages thick booklet. The only downside to this approach is that these results in less time for the thesis design.

The most profound reflection on my own process and point for improvement for next time would be my super abundance of ambition but not being realistic enough to realize that it was too big a task. The fact that I had to drop the (economic) feasibility aspect of my research felt like a failure because it undermines my statement that “too many students are asked at their graduation how much their design would costs and/or if a feasible project, for which most of them have no satisfying answer. I will not be one of them”. I guess however that I will be one of them after all.
Bibliography
Books, Articals, Reports and Datasets


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Webpages


Appendix A

residents survey
Beste bewoner/bewoonster van de Favrestraat,

Mijn naam is Erik Dral en ik ben een student van de faculteit bouwkunde aan de technische universiteit delft en sinds afgelopen februari ben ik begonnen met afstuderen. Tijdens mijn afstuderen mag ik mij een jaar lang focussen op een onderwerp wat mij erg interesseert. Voor mij is dat bestaande woningbouw, en vooral de duurzame renovatie van de bestaande woningbouw. Nu kan ik in een jaar natuurlijk niet een oplossing vinden voor alle bestaande woningbouw, dus richt ik mij op een specifiek type, namelijk de ERA galerij flat.

De ERA flats zijn ongeveer 50 jaar geleden, die van uw in 1963, gebouwd en zijn dus al bijna over hun “houdbaarheids” datum heen. Dit betekent niet dat ze niet meer bruikbaar zijn, maar dat ze wel eens een grondige renovatie kunnen gebruiken. Mijn focus voor deze renovatie ligt zowel bij het energie neutraal maken van de woningen, de energie rekening zal dan 0 worden, maar net zo belangrijk is het vergroten van het wooncomfort van de huidige bewoners.


Ik wil u graag duidelijk maken dat dit om een volledig theoretisch project gaat. Ik ben niet op de hoogte van eventuele renovatie plannen van u woningcorporatie. Hoewel het hier dus om een project gaat wat nooit gebouwd gaat worden, is uw deelname wel belangrijk zodat er meer aandacht komt voor de woonwensen van de bewoner. Want voor wie zouden we bouwen, als niet voor mensen.

Ingevulde enquêtes kunt u deponeren in de brievenbus van de huismeester. De enquête is strikt anoniem, maar wanneer u vragen of opmerkingen heeft kunt u contact met mij opnemen via het onderstaande emailadres.

Alvast bedankt en met vriendelijke groeten,

Erik Dral

Email: edral@student.tudelft.nl

Onderzoeksmentor: Prof. dr. ir. Anke van Hal
**Bewoners onderzoek ERA flats**

**Favrestraat**

**Wat is uw geslacht?**

☐ man ☐ vrouw

**Wat is uw leeftijd?**

……………………………………………………………………

**Wat is uw nationaliteit?**

……………………………………………………………………

**Wat is uw gezinssamenstelling?**

☐ alleenstaand ☐ gehuwd

☐ anders ………………………………………………………………………

**Heeft u thuiswonende kinderen?**

☐ nee ☐ ja leeftijd(en): ………………………

**Wat is uw beroep?**

……………………………………………………………………

**Wat is uw hoogste opleidingsniveau die u of uw partner heeft voltooid?**

☐ lager onderwijs ☐ middelbaar beroepsonderwijs

☐ mavo, mulo, ulo, lager beroepsonderwijs ☐ hoger beroepsonderwijs

☐ vwo, havo, hbs, gymnasium, lyceum ☐ universiteit

**In welke inkomenscategorie valt het netto-inkomen per maand voor u of voor uw hele gezin?**

☐ minder dan 1.000 euro ☐ tussen 2.000 en 2.500 euro

☐ tussen 1.000 en 1.500 euro ☐ meer dan 2.500 euro

☐ tussen 1.500 en 2.000 euro ☐ weet niet / geen antwoord

**Wat is de maandelijkse huur voor uw woning?** € ……………

**Welke bedrag van de huur is voor verwarming?** € ……………

**Hoeveel zijn uw maandelijkse servicekosten?** € ……………

**Wat is u gemiddelde energierekening?** ☐ per maand ☐ per jaar

*een schatting is ook goed*

Gas € ………… Water € ………… Electriciteit € …………

of totaal € …………

**Hoeveel jaar woont u in deze woning?** …………………… jaar

**Op welke etage woont u?** …………………… etage
Zou u willen aangeven in hoeverre u het eens bent met de stelling, en geef eventueel een toelichting op uw keuze.

<table>
<thead>
<tr>
<th></th>
<th>helemaal niet mee eens</th>
<th>niet mee eens</th>
<th>neutraal</th>
<th>mee eens</th>
<th>helemaal mee eens</th>
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</thead>
<tbody>
<tr>
<td>Ik ben tevreden met mijn woning</td>
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<td><strong>eventuele toelichting</strong></td>
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<tr>
<td>Ik ben tevreden met mijn badkamer</td>
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<td><strong>eventuele toelichting</strong></td>
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<tr>
<td>Ik ben tevreden over mijn keuken</td>
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<td><strong>eventuele toelichting</strong></td>
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<tr>
<td>Ik ben tevreden over de slaapkamer(s)</td>
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<td><strong>eventuele toelichting</strong></td>
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<tr>
<td>Ik zit vaak op mijn balkon</td>
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<td><strong>eventuele toelichting</strong></td>
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<tr>
<td>Ik heb contact met mijn buren</td>
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<td><strong>eventuele toelichting</strong></td>
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<tr>
<td>Ik zou meer contact met mijn buren willen</td>
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<tr>
<td>Ik vind het wonen in een flat fijn</td>
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<tr>
<td><strong>eventuele toelichting</strong></td>
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<tr>
<td>Ik heb de gordijnen aan de galerij kant altijd gesloten</td>
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<tr>
<td>Mijn buren maken veel geluid (overlast)</td>
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<tr>
<td>Ik wil eigenlijk ergens anders wonen</td>
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<td><strong>eventuele toelichting</strong></td>
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<tr>
<td>Ik heb last van omgevingsgeluid (verkeer, spelende kinderen)</td>
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<td><strong>eventuele toelichting</strong></td>
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<tr>
<td>Uw mening</td>
<td>helemaal niet mee eens</td>
<td>niet mee eens</td>
<td>neutraal</td>
<td>mee eens</td>
<td>helemaal mee eens</td>
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<tr>
<td>Ik heb last van geluidsoverlast van medebewoners</td>
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<tr>
<td>In de winter kan het erg koud zijn in mijn woning</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>Indien (helemaal) mee eens op welke plekken is de kou het ergst?</td>
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<tr>
<td>Ik vind mijn woning te klein</td>
<td>☐</td>
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<td>☐</td>
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<tr>
<td>Ik voel me veilig in mijn woning</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>Ik zou mijn woning anders willen indelen</td>
<td>☐</td>
<td>☐</td>
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<td>☐</td>
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<tr>
<td>Ik kan mijn woning goed luchten</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>Ik zou wel meer willen betalen voor een luxere woning</td>
<td>☐</td>
<td>☐</td>
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<td>☐</td>
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<tr>
<td>Ik wil graag in een diverse buurt wonen</td>
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</tbody>
</table>

**eventuele toelichting**

Wat waardeert u het meest aan uw woning?

Wat waardeert u het minst aan uw woning?
Wat zou u willen veranderen aan uw woning? Kruis één of meerdere aanpassing aan.

☐ groter balkon (dieper)  ☐ meer licht in mijn woning  ☐ minder geluidsoverlast
☐ veiliger woning  ☐ grotere badkamer  ☐ grotere woning
☐ een bad  ☐ een keuken met eettafel  ☐ een extra wc
☐ een grotere keuken  ☐ minder slaapkamers  ☐ een kleiner balkon
☐ tweede buitenruimte  ☐ nieuwe keuken  ☐ een grotere woonkamer
☐ energie zuinige woning  ☐ meer contact met mijn buren  ☐ meer slaapkamers

anders:
☐ ....................................................................................................................................................................
☐ ....................................................................................................................................................................
☐ ....................................................................................................................................................................

Wat zou een voor u acceptabele tijd zijn om uw woning te verlaten tijdens een verbouwing?

☐ niet  ☐ minder dan een week  ☐ tussen de 1 en 2 weken
☐ tussen de 2 en 3 weken  ☐ tussen de 3 en 4 weken  ☐ meer dan 4 weken

Wat zou een voor u acceptabele maandelijkse huurverhoging zijn wanneer de boven gekozen woonwensen zouden worden vervuld?

☐ minder dan € 50  ☐ tussen de € 50 en € 100  ☐ tussen de € 100 en € 150
☐ tussen de € 150 en € 200  ☐ tussen de € 200 en € 250  ☐ tussen de € 250 en € 300

heel erg bedankt voor uw hulp aan mijn onderzoek

Misschien heeft u nog opmerkingen die onvoldoende in de vragen naar voren zijn gekomen. Daarvoor is hieronder nog ruimte gereserveerd.

Aanvullende opmerkingen:

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bewerkbaar
Appendix B
Appendix C
Appendix D